Farnham Geological Society

[www.farnhamgeosoc.org.uk]

Farnhamia farnhamensis

A local group within the GA

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Newsletter

February 2006

INSIDE THIS ISSUE

Happy New Year from the Editorial Committee. In the February 2005 editorial, mention was made of the south-east Asia tsunami in relation to the tragic human dimension such natural disasters now have as compared with the catastrophic events that have occurred since the earth began. The recent earthquake in Pakistan and the destruction caused by the hurricanes around the Gulf of Mexico are two more examples of the human dimension of such events. Whilst not advocating a massive world-wide investment to reduce the effects of natural catastrophes on the human race, we should perhaps do more than wait for them to happen – Earth Scientists please note!

The GA Annual Reunion was held in University College, London, and Janet Catchpole organised Farnham's display, making use of the material used in Cardiff in 2004. There was a disappointingly low attendance from our society's members at the reunion; we excel in attendance at the Friday lectures but other activities, including field trips, are not well supported. With a membership of around 130, including many new members, why is it such a problem?

John Gahan has now almost completed the list of speakers for 2006 and Graham Williams has planned a series of one day/weekend field trips which were very popular last year. Graham has also agreed to take over the post of Field Secretary, which has been vacant for some time. The *interregnum* has been covered by Shirley Stephens, who so ably organised the Arran, Hallsannery and Languedoc trips.

Peter Cotton

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The building of Southern England - the Society's Sunday field trips in 2005

Every first Sunday of the month from April until October, 2005, Graham Williams led seven trips to look at "The Building of Southern England". In the first, he followed the Albury traverse to study the links between geology and landscape; subsequently he worked his way up the geological column from early Jurassic to Tertiary. His summary of events is given below.

I. GEOLOGICAL HISTORY

England was at about 15°N in the Triassic, and has drifted northwards ever since. The world was markedly warmer than now during most of this period. Indeed, the temperatures were "tropical" even though England drifted out of the tropics as long ago as the mid Jurassic. It was not until the mid Tertiary, with the formation of the southern polar ice cap, that temperatures cooled. The sedimentary rocks of southern England were deposited in a number of basins. How did they form, and fill with sediment?

The Pre-Cambrian Midland Microcraton is an area of stable rocks beneath England (**Fig 1 - see page 4**)). Younger rock sequences are accreted (stuck on) to it's margins. The Lower Palaeozoic (~ 570-400my) rocks on the NW margin were deposited in the Iapetus Ocean between Laurentia (and Scotland) and Baltica (and England). These rocks were folded and uplifted as a mountain range when the continents collided and closed Iapetus (**Fig.2**) -the Caledonian orogeny. The Upper Palaeozoic (~ 400-290my) rocks on the southern margin were deposited in an early Tethys sea between Gondwana (and France) and Laurentia-Baltica and England) (**Fig.3**). These rocks were folded and uplifted into a mountain range when the continents collided at the end of the Carboniferous (290my) to form the Pangaea super-continent (**Fig.4**) -the Hercynian orogeny.

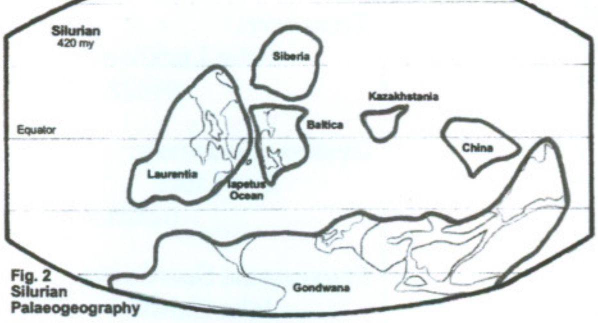


Fig 2: Silurian Palaeogeography

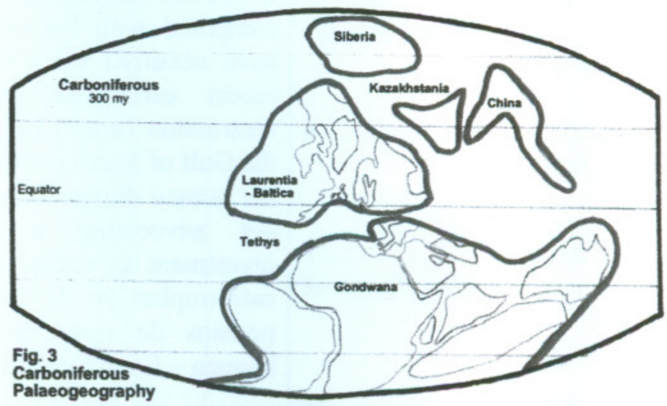


Fig 3: Carboniferous Palaeogeography

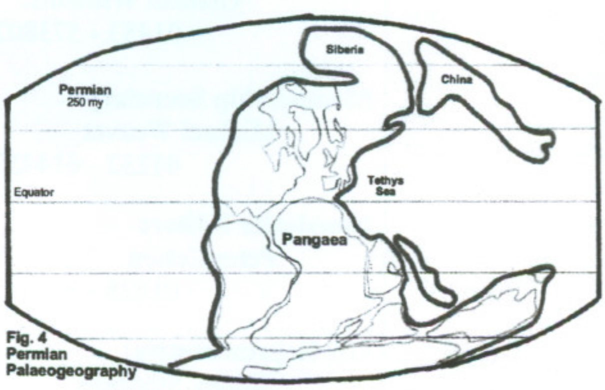


Fig 4: Permian Palaeogeography

In the Permo-Trias, southern England was a hot desert in the middle of a mountainous continent. Pangaea began to break up in the Triassic (~240my); Tethys re-opened between Laurentia-Baltica and Gondwana, and a rift developed between North America and Eurasia, eventually to form the Atlantic Ocean. Rift basins formed around Britain as the crust stretch and thinned; there were large basins along the Atlantic margin and in the North Sea, Irish Sea, and Western Approaches; small basins developed along the southern margin of the Midland Microcraton, including the Bristol Channel, English Channel, Wessex, Wight-Portland and Weald Basins (Fig.l). The small basins subsided through the Jurassic and early Cretaceous; the large Atlantic margin and North Sea basins continued subsiding into the Tertiary.

The rifts of southern England subsided in the Triassic, and early Jurassic, but were relatively stable in the Middle Jurassic; subsidence renewed in the Upper Jurassic and Lower Cretaceous but ceased in the Upper Cretaceous. Jurassic subsidence was spasmodic; each time, deeper marine conditions were succeeded by shallow marine conditions as sediment filled the basin. In the early Cretaceous, sedimentation kept pace with subsidence and continental (lacustrine, fluvial, deltaic) sediments were deposited. Sediments in the rift basins are about 2 ½ times thicker than equivalent sediments on adjacent platforms. The Triassic rifts were filled with desert sand and, as subsidence increased, by playa lake mud and salt. Playa lakes are ephemeral, and form in low lying areas after intense storms; flash floods transport vast amounts of fine sediment into these lakes. By the end of the Triassic, the once mountainous landscape of Britain had suffered 80my of weathering and erosion, and many areas were low lying. Continued subsidence in the Lias (206-180my) allowed the sea to flood the rift basins, and transgress adjacent low lying platforms, including that underlain by the Midland Microcraton. Nearby land masses in Wales, Devon and Brittany provided mainly fine grained sediment for deposition.

Gondwana started to break up in the early Cretaceous; the South Atlantic and Indian Oceans opened and North Africa separated from North America. The increase in the Earth's heat flow and consequent expansion and uplift of huge new mid oceanic ridges (particularly in the Pacific) caused a rise in sea level through the Cretaceous which inundated vast areas of the continents. At the end of the Cretaceous, uplift of northern Europe elevated southern England above sea level and caused 5my of erosion.

The North Atlantic opened in the early Tertiary as Greenland separated from Norway and Scotland; massive volcanic eruptions along a new rift formed up to 8km of basalt lavas in Greenland; thick volcanic ash sequences accumulated in Denmark and the North Sea and extended into southern England. The North Sea was a major basin during the Tertiary in which over 10,000ft of sediment was deposited. Cold Arctic water entered the North Sea, and in the early Tertiary we see marine organisms characteristic of cool waters, whereas the plants from the adjacent land indicate a warm climate. The sea transgressed southern England during the early Tertiary and deposited shallow marine sands and muds. During the Miocene, the effects of the Alpine orogeny of southern Europe were felt; lateral compression forced "closure" of the Mesozoic Basins with consequent Basin inversion -the sediments were uplifted and gently folded.

Sea level subsided during the Tertiary as the new spreading centres stabilised after their initial "eruption". Australia separated from Antarctica in the early Tertiary; warm oceanic currents ceased to bathe the shores of the Antarctic continent, and a cool circumpolar oceanic circulation began. By 35my Antarctica had cooled sufficiently to prevent summer melt of polar winter snow, and the great ice cap was born. This affected global temperatures and sea level. By 5my the ocean at the North Pole froze permanently and the great Pleistocene ice sheets developed. We are still in this ice age, albeit in a (brief?) "interglacial" period. Since Miocene times, southern England has been subject to weathering and erosion.

2. THE LINKS BETWEEN GEOLOGY AND LANDSCAPE

Since the Miocene uplift, the rocks have been weathered and eroded. The major factors which influence our landscape include:-

Rock type - is the rock hard or soft? What is it's thickness and lateral variation? We expect hard rocks to form hills and soft rocks to form valleys, but this isn't always true.

Rock attitude - horizontal rocks produce incised plateau landscapes as in South Africa; tilted rocks tend to produce steep sided hills; folded rocks produce a mixture of the two.

Rock History - the type, lateral variation and attitude of the sedimentary rocks reflect basin formation, basin fill and subsequent structural movements. Basins subside in fits and start; basin fill depends on the volume and type of weathered material available; hilly landscapes provide more and coarser grained material than flat landscapes. As a basin stops subsiding it fills with sediment; "coastal" sediments prograde from the shore; consequently the middle of the basin tends to have fine grained sediments overlain by coarser sediments as the basin fills. Further subsidence repeats this cycle. Ultimately, tectonic plate collision leads to uplift and folding and effectively kills the basin.

Our **Climate** has varied dramatically from almost tropical to Arctic temperatures; dry or very cold climates weather rocks slowly; warm, wet climates weather rocks quickly. This influences the volume of material available for erosion.

Erosion is a function of gravity, wind and water. Loose, weathered rock can slip downhill; this action is enhanced in cold areas where spring melt lubricates downhill movement. River systems move vast quantities of weathered material in wet climates; wind and flash floods are effective transporters in dry climates.

Base level of erosion - effectively sea level, with erosion above and deposition below. The sea ranged from 2OOm above to 2OOm below current level over the last 2my, resulting in periods of negligible erosion or rapid erosion and valley incision.

The **History** of weathering and erosion is particularly pertinent in southern England. Our mild, wet climate enables moderately rapid weathering and fluvial erosion; but, during the last 2my we have experienced numerous permafrost (slow weathering) and warm wet (rapid weathering) periods. At times the erosive and transport powers of the rivers was enhanced by large volumes of glacial melt water.

The **activities of man** - say no more! ! !

3. WHAT DID WE SEE ON OUR FIELD TRIPS?

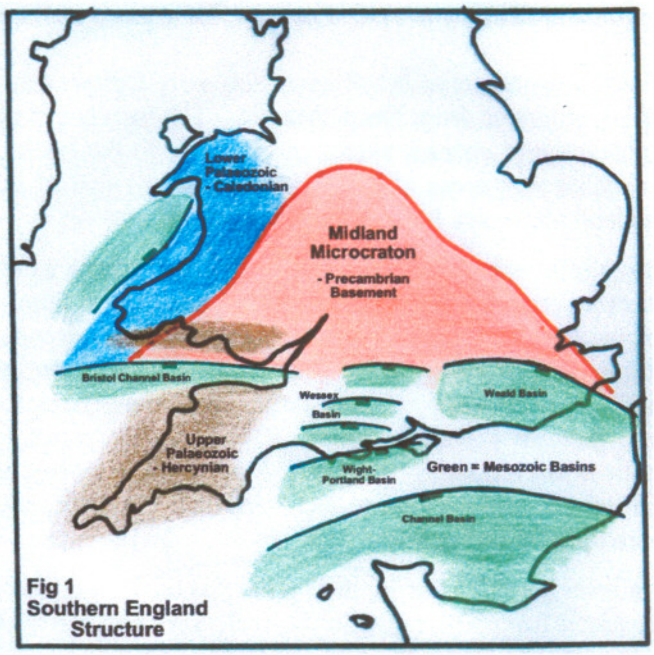


Fig 1 Southern England Structure

On our **Albury traverse** we looked at basic principles in landscape formation, and at the links between geology and landscape.

In the **Lias of Dorset** we saw how two periods of subsidence, in the Lower Lias, and the Upper Lias, led to two "shallowing" sedimentary cycles; deep marine muddy sediments are succeeded by sandy silts as the basin filled and the sea shallowed. The lowest part of the Lias is characterised by interbedded mud and limestone (**Fig.5**), the latter being introduced by currents perhaps due to earthquakes caused by the rift basin subsidence. The basin configuration affected life; well oxygenated waters supported a diverse pelagic population of marine dinosaurs, fish, ammonites, belemnites, planktonic bivalves, algae, and a benthonic (sea bed) population of molluscs, snails, brachiopods, starfish, sea lilies, worms, forams, ostracods, crustaceans etc. But**,** there were pools of stagnant, deoxygenated water in the deep rifts; reducing conditions inhibited benthonic life and allowed iron sulphides such as marcasite and pyrite to form. We found planktonic fossils that had lived in surface waters and sunk to the bottom when they died, and a death assemblage or graveyard of benthonics, which were swept in by a current, or perhaps lived on a log which became waterlogged and sank. The Chocolate birthday cake and subsequent Dorset Cream Tea and Ice Cream went down well !.

We visited the **Middle Jurassic limestones of the Cotswolds**. At Leckhampton we saw the finest continuous exposure of Inferior Oolite in Britain (**Fig.6**), and at an SSSI site at Kemble we examined the Great Oolite. Shallow, well oxygenated seas supported a diverse fauna, but constant wave and storm attrition broke up many of the shells and redistributed them as sediment. Much of the limestone is composed of ooliths and pisoliths -small spheres consisting of concentric layers of calcite around a central nucleus. Ooliths grow where water saturated with calcium carbonate is drifted backwards and forwards over a shallow sea floor (less than 20ft) by waves and tidal

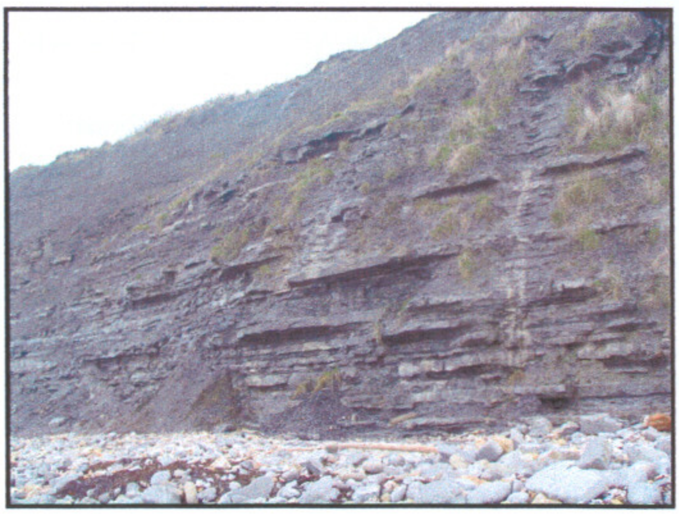


Fig. 5 Lower Lias, Lyme Regis

Fig. 6 Inferior Oolite, Leckhampton

currents. The particles form mobile sands, and develop cross-bedding, ripple drift and sand wave structures. After deposition the sands are cemented by calcium carbonate to form limestone. Ladies' and gentlemen's teams studied the Kemble section to determine the geological sequence and depositional environment; the ladies won, but everyone enjoyed the Thorntons chocolate prizes!

We returned to **Dorset for the Upper Jurassic**. There were two main phases of basin subsidence and fill. The first began in the Callovian, with the deposition of the Oxford Clay followed by shallow marine Corallian sands and limestones (**Fig.** 7). The second began in the Kimmeridgian with the Kimmeridge Clay succeeded by shallow marine Portland dolomitic sands and limestones and then Purbeckian coastal, lagoonal and terrestrial sediments. The deep rift basins formed protected, stagnant areas in which clays and organic matter accumulated. The sea bed fauna was restricted and their fossils are rare, but an abundant planktonic fauna and flora lived in the well oxygenated warm surface waters, and their fossils are common. The shallow marine sediments have an extensive sea bed fauna, particularly molluscs, and there is a fine assemblage of fossil burrows, tracks and trails, including crustacea (crab and lobster) burrows. We were forced to listen to the reminiscences of our tame oil geologist. He demonstrated oil seeps, a fossil oil field, and described how organic matter in the Lias provided the source of the oil in the seeps and in the nearby Wytch Farm oil field. At Dungy Head and Lulworth we saw how, in the Miocene, rocks from the rift basin had been pushed back over the basin forming fault onto the basin platform margin -these rocks are now almost vertical. At the end of a hot day, the ice creams were very welcome!

Fig. 7 **Corallian, Bran Point**

Fig. 8 **Ashdown Sand, Cliff End**

Lower Cretaceous rocks in Sussex were our next destination Southern England was a low lying swamp with rivers, lakes and deltas The Weald rift basin subsided gradually; sedimentation kept pace with subsidence, to maintain terrestrial rather than marine environments. Initially, gently meandering braided river systems deposited a predominantly sandy sequence (Hastings Beds), with lakes and reed swamps providing muddy intervals. Subsequently a more extensive lake formed, and the deposition of a predominantly muddy sequence (Weald Clay) At Harrison's Rocks, we studied the Lower Tunbridge Wells Sand and successfully determined the environment of deposition and the climate of the time - a coastal braided river system passing up into fluvial channels and then a mud plain, in a climate with warm wet winters and hot dry summers. Again, the ladies beat the gents, but everyone scoffed the prizes!! At Cliff End and Fairlight Cove we saw the Hastings Beds; deltaic and braided fluvial sequences predominated, with ripples, sand waves, channels on small (**Fig.8**) and large scales and a fabulous example of a point bar. Layers of carbonised remains evidenced fossil forest fires. Thin clay beds yielded abundant fresh water molluscs, snails and some ostracods (water fleas); there were in-situ rhizomes of Horsetails. Although we knew where the Iguanodon footprints were , we didn't see them because the tide wasn't low enough - another time, perhaps

We visited the **Western Weald for the Middle and Upper Cretaceous**. In the mid Cretaceous, rift subsidence was replaced by global sea level rise. As sea level rose, the Lower Cretaceous Wealden sequence was transgressed by coastal and shallow marine Lower Greensand, then by deeper marine Gault Clay, Upper Greensand and Chalk. Thus, sands are succeeded by clayey silts (the Gault is ~75% silt), silty limestone (the Upper Greensand is -20% silt), muddy (Lower Chalk) and then clean limestone (Middle and Upper Chalk). As the sea spread there was less land to weather, erode and provide sediment, so the clastic material decreases and becomes finer grained up sequence. The Upper Chalk may well have formed in -1000ft of water. Most of the Chalk consists of the microscopic remains of planktonic algae - coccoliths. We started with a champagne breakfast at Waverley Abbey, where we heard about monks and monasteries and John Gahan told us about the Abbey's building stones, which we subsequently visited in outcrop. The Lower Greensand section showed sand waves and spectacular developments of ironstone. At Selborne, Susan Williams told us about Gilbert White, the great 18th century naturalist, and we saw his home. Next, we proceeded to a fine Upper Greensand section where we worked out it's depositional environment. Finally, at Lower Froyle Chalk quarry (**Fig.9**) there was another geological competition, which turned out to be a draw between the ladies and gents teams - more edible prizes!

Finally, we saw the **Tertiary in Kent**. Miocene uplift in southern England resulted in ~5my of erosion of southern England and removed most of the Tertiary sediments. The surviving sequence in the London Basin is well exposed in North Kent (**Fig 10**). Towards the end of the Palaeocene (60my) shallow marine sands and silts (Thanet, Woolwich, and Oldhaven Beds) were succeeded by deeper marine muds (London Clay). The influx of cold Arctic water caused by the opening of the North Atlantic restricted faunal diversity. Most of the Thanet and Woolwich fossils are cold water forms. This faunal restriction lasted through the lower London Clay, where very few calcareous forms can be found. Cold water and abundant dissolved silica (perhaps from the volcanics) allowed massive diatom blooms (plankton with silica shells). As the new ocean circulation stabilised, there was improved mixing of sea waters and in middle London Clay times an extensive marine fauna developed with numerous calcareous forms. At Herne Bay, the Thanet and Woolwich Beds have abundant molluscs, many still articulated, showing that the depositional environment was very quiet; however, the porous sediments allow the passage of fluids which leach the shells,

Fig. 9 Lower Chalk, Froyle

Fig. 10 Thanet & Woolwich Beds, Kent

and they are almost too fragile to collect. We heard a story of how, in the 1960s, geologists and civil engineers combined to stabilise Herne Bay's London Clay cliffs. It was an unusual situation; the Lower London Clay contains montmorillonite (degraded volcanic ash) which expands remarkably when mixed with water. At Herne Bay, water entered the system via cracks at the cliff top; clay expansion led to massive pressure increase, and explosive cliff failures. The cliffs were graded, drainage to the sea was installed, and a sea wall stabilised the cliff base. At Wardens Point, Sheppey, we saw the Upper London Clay. Here, cliff failure is more "normal" - gentle degradation with the formation of mud "glaciers". The ladies took on the gents at fossil hunting. The abundant fossils included plants, seeds and fruits, molluscs, snails, worm tubes, fish bones etc. It was neck and neck, with the gents leading by a large piece of wood versus a small rare brachiopod, until one of the ladies found a lobster to clinch the result!

Graham Williams

Newspaper snippet: A fleshy fossil

A 425 million-year-old shellfish fossil has been discovered with all its 'fleshy bits' intact in Herefordshire. Never before have all the soft parts of an articulate brachiopod been preserved. Dr Mark Sutton of Imperial College, London and colleagues from Oxford, Leicester and Yale, discovered the ancient brachiopod.

Sutton has created a 3-D computer model of the clam-like organism by taking hundreds of photographs as he shaved away slices of rock encasing the fossil. It is exceptionally preserved because the Herefordshire site was subjected to a sudden volcanic eruption, burying sea-floor creatures in a thick layer of ash which set quickly like cement - as happened in Pompeii.

BBC Focus Magazine, Autumn 2005

FGS Field Trip to North Devon – 5 to 9 September 2005

After much hard work by Shirley Stephens in organising this trip, 12 members left Fleet on Monday 5th September in a hired minibus driven by Mike Weaver and George Harrison (**Fig 1**), veterans from the minibus trip around Arran in April of this year. We headed westwards, our final destination for that day being the Hallsannery Field centre a few miles south of Bideford where we were to stay for 4 nights. This centre has been used by the society on previous occasions but regretfully it is now closing as a field centre providing accommodation.

Fig 1: Mike, George & the minibus

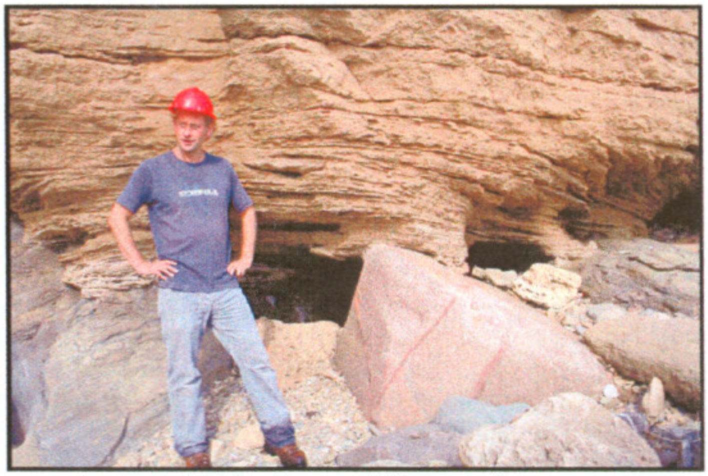


Fig 2: Ran and the erratic

On the way down a stop was made at Saunton Sands where our guide for the next 5 days, Dr Ranald Kelly (Ran) was awaiting our arrival. He took us on to the beach to show the unconformity between the exposures of Devonian age Picton Shales at the foot of the cliff and the overlying Quaternary Sandstones which are in turn topped by glacial deposits from the Anglian Ice Age 450 thousand BP. Further proof of the glacial episode was by way of the many erratics lying on the beach; the one shown in the photo (**Fig 2**), with Ran acting as a marker, is thought to have travelled from Scotland.

For the next 2 days the group was to study the coastal exposures of Carboniferous strata along the coast from Westward Ho! through to Hartland Point, and then south to beyond Bude at Milhook. A brief outline of the geological history of this area is given below.

Before the super continents of Laurasia and Gondwanaland came together to form Pangea in Carboniferous times around 300 Ma the area now known as North Devon was on the southern margin of Laurasia. To the north were the Old Red Devonian Mountains and it was the erosion of the mountains that provided most of the material that flowed south to fill the huge Culm Basin located on the continental shelves of the two converging super continents. The particular part of this synclinorium of relevance to the study of the North Devon cliffs has been named Lake Bude. During late Devonian and early Carboniferous times this basin was filled with deep water sediments in the centre and thick shallower water sediments of sands and muds at the margins. The various stages of basin fill are highly complex but in essence a series of sediment wedges pro-grading southwards, were formed from the erosion of the Welsh mountains.

Whilst the basin was being filled the two super continents collided leading to the creation of the Variscan mountains and the compression of the intervening basins to produce dramatic folding and faulting of the sediments in Lake Bude. The eroded surface of these mountains is now visible in the cliffs of Westward Ho, Hartland Quay and Milhook and it is the folding and faulting that took place at depth that the group was to study in the next two days.

Starting from Westward Ho! and walking along the beach, the following sequences, as illustrated in the following 3 photographs (**Figs 3, 4, 5**), can be seen.

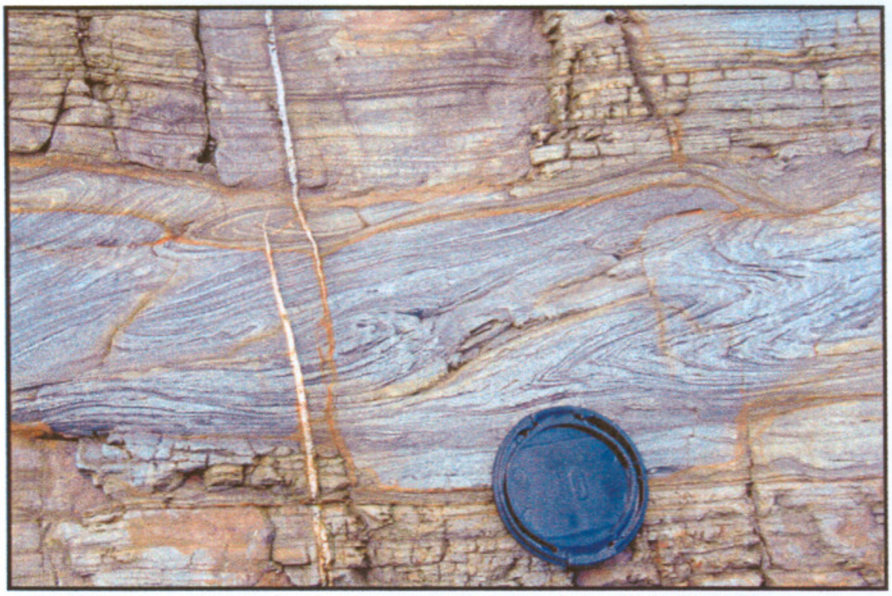


Fig 3: An exposure in the basal member of the Bideford Formation showing contorted mudflows and thin layers of sand

Fig 4: Sandstone wedges which are probably the result of turbidite flow into the basin.

At the end of the walk westwards a sudden break in the sequence occurs with the arrival of a massive cross bedded sandstone. This is the site of an Anglian Ice Age river now captured by the sea (**E**).

Fig 5: River profile

The next stop was Hartland Quay round the corner from Hartland Point where lunch was taken in the pub gardens supplemented by ice creams. The descent to the beach revealed the superb chevron folding in the cliffs (**Figs 6, 7**).

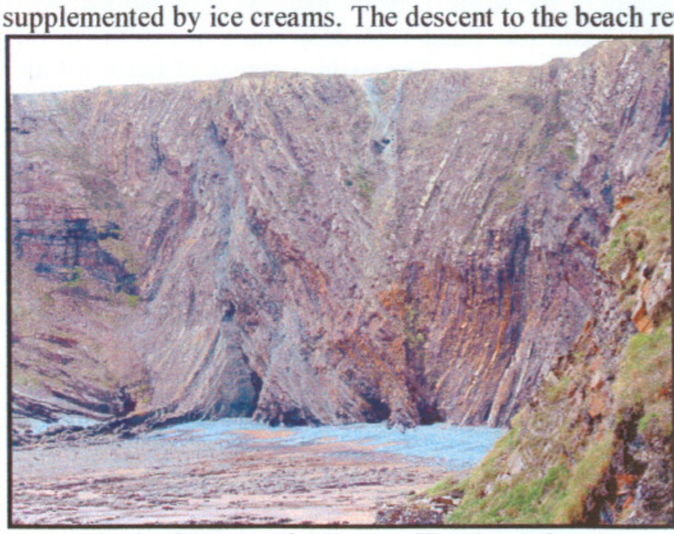


Fig 6: Chevron folding at Hartland Quay

Fig 7: Close up of folding

Fig 8: Arch

There was also a sea-cut arch (**Fig 8**), which from underneath showed a fine example of a turbidite succession showing flute marks where the surface had been gouged by the flow. It also showed flame or injection structures where one layer of sediment had forced its way into the overlying layer.

In the evening at Hallsannery, Ran talked about *'Near-earth-surface'* thermal heating. One of the accommodation houses on the estate uses this system, the heat being supplied from a pipe that loops round the garden at a depth of 8 feet. A heat exchanger, about the size of a fridge, extracts this heat to provide hot water and under floor heating. Heat extracted from the soil/rock in Winter is replenished by Summer sunshine. This system was installed whilst the house was being built; for a house in a built up area a deep hole would need to be bored to tap the heat from the ground over a 30 feet stretch. Ran is converting his Victorian terrace house and reckons that the investment will break even in 12 years, or earlier if the property is sold with the installation already installed.

The following morning a long drive southwards to Milhook some 3 miles south of Bude where exposures of older Crackington Formation lying beneath those at Westward Ho! and Hartland Quay are to be seen. On view here there is a section of zig-zag folds tipped over by about 90 degrees so that their axes are horizontal, rather than vertical (**Fig 9**). Close inspection, especially of the dip and cleavage indicated that the sides dipping to the north were upside down, that is the crests of the folds were pointing southwards rather than northwards as would be expected by the overall movements in the area. There are various possible explanations, but as the anomaly is bounded north and south by two faults, it was decided that the most likely, was that the complete section, after tipping by 90 degrees was rotated on a vertical axis by 180 degrees by the two faults in which movement occurred laterally in opposite directions.

Fig 9: Chevron folding of Crackington Beds

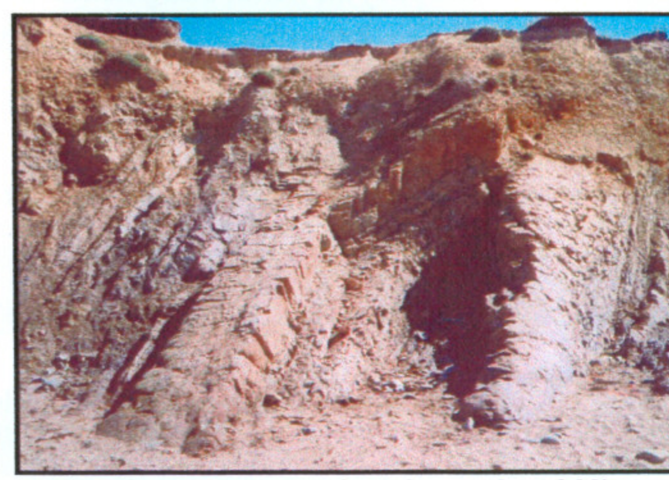


Fig 10: An example of rarely seen box folding

Back northwards along the coast to Widemouth where the youngest beds of the whole sequence, the Bude Formation, are to be seen. The photo (**Fig 10**) shows an excellent example of rarely seen box folding.

After lunch we travelled to Peppercombe to see the Permian outlier, a red sandy breccia, lying unconformably in a hollow (two "half grabens") in the Bude Formation. The clasts are angular, varied in size and are not well cemented. The Permian dating is by lithography and analogy; indicator fossils have not been found. At the base of this exposure some root-like structures were seen. These are composed of carbonate and could be trace fossils or roots substituted by carbonate, or branching fractures filled with calcite by percolation of solutions from above.

The fourth day of our visit was to Dartmoor. It was wet when we got there after a long drive south from Hallsannery. A climb to Haytor through the mist allowed the study of one of the best known geological features of Dartmoor. There are many tors on both Dartmoor and Bodmin Moor and their formation is by a combination of deep weathering - some 3 ½ Km of sediments removed – of the original batholith which was the granite mass formed at depth 270 m.a. and the exhumation of the underlying granite. The weathering concentrated down the cooling joints to produce these high tors which are jointed both horizontally and vertically. The composition of the Dartmoor granite is of large crystals of quartz, biotite and feldspars together with locally abundant hornblend.

The next stop was at Burrator where there is a huge reservoir. Two small quarries by the roadside displayed examples of contact between the granite and the original country rock. Veins of granite and hornblend cut into the country rock whilst late-stage quartz-tourmaline veins cut into the granite.

Friday saw the party driving back home via Watchet on the Somerset coast. Before going down to the beach a stop at the Watchet railway station allowed us to see both the Jubilee Wall (**Fig 11**) built by local youngsters under the guidance of Dr Eric Robinson incorporating all the local stone; and a steam train en route to Minehead (**Fig 12**).

Fig 11: The Jubilee Wall on Watchet Station

Fig 12: A steam train at Watchet station

On the beach Ran assured us that somewhere along the cliff was the junction between the top of the Triassic (the Rhaetic) and the Liassic base of the Jurassic beds. The Triassic sequence of beds is the result of the flooding of the Permian desert landscape by the marine transgression which accompanied the break-up of Pangea. The beds are red and whitish but are completely unfossiliferous following the mass extinction that had occurred when 95% of marine and terrestrial invertebrates were wiped out. Proceeding westwards along the beach in the direction of "younging" black beds begin to dominate the cliff exposure and a faint smell of oil is present – with the "nose of faith." On breaking open a piece of shale Ran produced an ammonite fossil showing that life had re-established itself at the beginning of the Jurassic.

Janet Phillips, John Bradbury, Joan Farquharson & Peter Cotton

Reconstructing Quaternary rivers

Summary of November's lecture given by Dr Christopher Green, Royal Holloway College

Dr Green began by tracing the development of understanding about the nature of river terraces and their associated sedimentary characteristics observable in the types of pebbles and gravels present. In the early 19th century much regard was paid to the effect of *'Noah's flood'*, but this gave way to an archaeological approach which suggested that uplift accounted for the presence of river terraces. By the 20th century the more detailed study of the terraces of the London Basin suggested that the driving force was the rise and fall of the rivers themselves because of, for example, changes in climatic conditions. In the 1960s and 1970s, geologists were applying their thinking to the problem and analysing in detail the composition of the terraces to ascertain the provenance of the various sediments. Dr Green then referred to his own studies of the rivers draining Salisbury Plain, and from this analysis of their sediments he concluded the theory suggesting that the stones used for the construction of Stonehenge had been brought to the plain by glacial action could not be correct because none of the material associated with the Preseli Blue Stones could be found in the pebbles of these rivers.

Dr Green admitted to being a life-long pebble counter - up to half a million pebbles!- the technical term for this activity is *'Clast lithological analysis'*. He gave a list of the sorts of information to be gathered from pebbles including their provenance, the catchment geography and geology, weathering, erosion and a whole host of other data about changes that have occurred in the catchment area. Dr Green admitted, however, that there were many problems encountered in these studies such as variability of fluvial processes over the course of the river, the displacement of material after its initial deposition etc.

He completed his talk by describing in more detail some of the features he had found in the route of the Proto-Thames flowing through Hertfordshire into East Anglia and the North Sea. One particular phenomenon was the presence of *'pipes'* of terrace material created by the scouring out of the chalk basement. Some of these pipes are very large and create problems for the stability of new road constructions. An important part of the study of the old Thames course was the analysis of the terrace material into three distinct types: pebble gravels (far travelled material from places such as the Midlands which contain a lot of quartz), quartzite and glacial gravels. This analysis led to the conclusion that possibly the Proto-Thames had a very wide catchment area including Wales, the Midlands and the Weald whose drainage pattern would have been Northwards to the Thames.

Peter Cotton

Volcanoes & volcanic processes along the Izu Bonin Arc, Japan

Summary of October's lecture given by Dr Rex Taylor, National Oceanographic Centre, Southampton

The subject of this lecture concerned what is probably the most complex section of Pacific Ocean's *'Ring of Fire'*, namely the 300km stretch running southwards from the northernmost island of Japan, Hokkaidu, along the Japanese eastern coast down to the East China Sea. Dr Taylor's specific area of investigation, in collaboration with the University of Tokyo, has been the Izu Bonin arc, which lies to the East of Tokyo and runs into the Marianas Arc to the south. In this area the Pacific Plate is subducting under the oceanic Philppine Plate, which in turn is subducting under the continental crust of Asia.

The purpose of this investigation is to ascertain in great detail the variables in the subduction parameter which include the nature of the subduction crust, its age, structure and thickness. In addition, the rate of subduction, which in this area can be up to 12cm per annum, and the angle of descent of the subducting plate along the Benioff zone. There are 15 main centres for investigation and Dr Taylor mentioned the islands of Oshima, Sumisu-Jima, and Torishima sited along the Izu Bonin Arc. Eruptions have taken place in most of these islands over the past 20 years. Oshima has experienced 9000 years of activity, and Dr Taylor showed a dramatic picture of a series of scoria bedding draping layers of pyroclastic fall in a cliff exposure.

Reference was made to an aerial view of the region available from the internet and displayed by Dr Taylor. He also described the difficulty of finding exposures because of the jungle nature of the terrain and also because the Japanese have an annoying policy of coating exposures with sprayed cement; coastal exposures are still however available.

Dr Taylor then showed some interesting diagrams of trace minerals found in the oceanic crust which, when water is removed from the subducting plate, are released. The geochemistry is very complex but, by using calculations based on ratios of different isotopes of lead, a better understanding of the subduction process can be gained; in addition, core samples are taken from the subducting plate. This assists in the recycling of material between crust and mantle.

Peter Cotton

FGS monthly meetings - February to July 2006

Feb 10	*'Climate Modelling and the Rock Record'* Prof. BRUCE SELLWOOD, University of Reading.
Mar 10	*'William Buckland – First professor of geology'* (2006 is 150th anniversary of his death) Dr CHRIS DUFFIN, Deputy Head, Streatham and Clapham High School.
Apl 14	*'MakingGold – Nuclear Alchemy'* Dr PADDY REGAN, Reader in Nuclear Physics, University of Surrey.
May 12	*'The amazing all-new Wealden dinosaurs'* DARREN NAISH, School of Earth Sciences, University of Portsmouth
June 9	*'Really remote sensing – unveiling the geology of Titan'* Dr RICHARD GHAIL, Imperial College, University of London.
July 14	*Members evening.*

FGS field trips - 2006

April 2 - Severn Bridge; **29 April to 13 May** - Languedoc region, France;

June 2 to 4 - North Shropshire; **July 2** - Gloucester ; **August 6** - Avebury & Marlborough Downs;

September 3 - Swanage & Brownsea Island ; **October 6 to 9** - Western Normandy, France

Industrial utilization of natural materials

ROCK SALT

Cubic halite crystals

What is it composed of?

Rock salt is composed of the mineral **halite** (chemical composition, sodium chloride) and is a common member of **evaporite sequences** that include various potassium chlorides and sulphates, together with gypsum and anhydrite. Clay may occur as an impurity within halite layers.

How and where was it formed?

Halite, along with other evaporite minerals, is precipitated on extensive or **total evaporation of saline waters** under hot, dry climatic conditions. The order of crystallization of evaporite minerals depends on the **ionic concentration and solubility product** of the different mineral constituents. In general, carbonates (mainly $CaCO_3$) are precipitated first, followed by anhydrite ($CaSO_4$) and halite (NaCl), and finally various potassium and magnesium salts. Sea-water contains about 3.5% of dissolved salts. Typical modern environments include **shallow marine lagoons** and wide, extensive **coastal salt flats** (sabkhas).

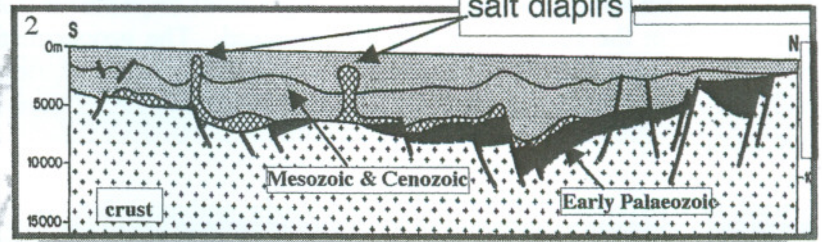
Geological occurrence

Ancient evaporite sequences were formed in **land-locked or restricted marine basins and lagoons** that slowly sank to allow the accumulation of thick deposits on the evaporation of replenished saline waters. The **Permian and Triassic periods** include considerable evaporite deposits as much of the continental landmass was under arid tropical conditions, just north and south of the equator. Late Permian shallow seas in the European area (e.g. the **Zechstein Sea**) invaded the arid landmass and underwent periodic evaporation in sinking lagoons and gulfs.

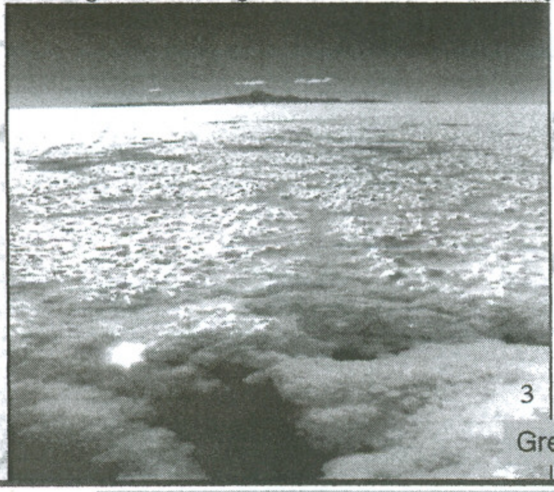
Thick evaporites accumulated in the Cheshire and Stafford basins with the main production areas now being around Winsford and Middlewich.

Industrial usage

Rock salt is a raw material for the **chemical industry** (for chlorine and caustic soda production), **a food preservative** and a **de-icing agent** on roads during winter. Although solid rock salt is mechanically mined, much is extracted in solution as saline brine from considerable depths.



N-S section of N.Danish Basin showing Zechstein salt diapirs intruding younger sediments



Great Salt Lake, Uyuni, Bolivia

4 Sub-surface salt dissolution at interface of salt-bearing strata and groundwater, Triassic Northwich halite deposits, Cheshire

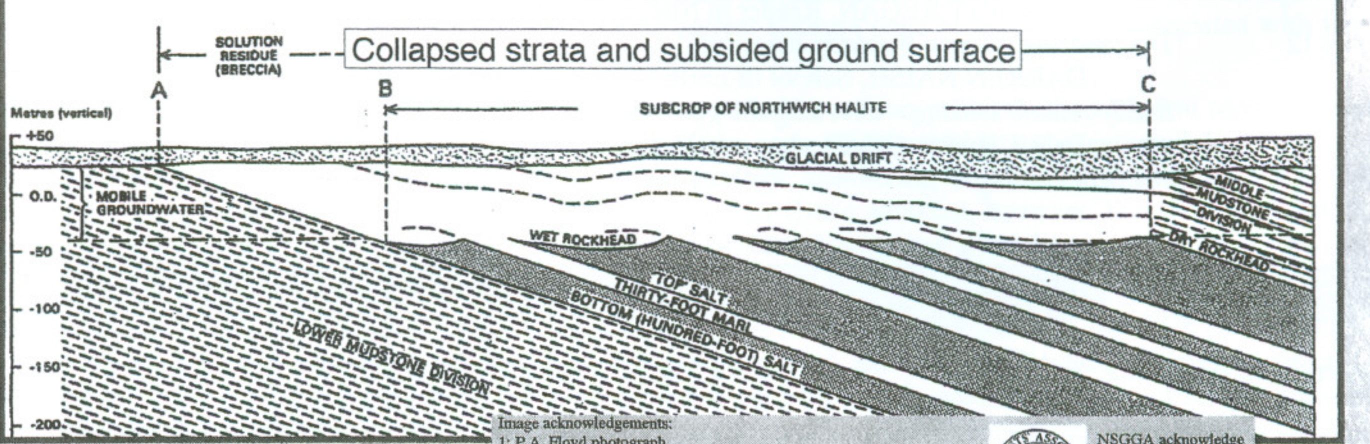


Image acknowledgements:
1: P.A. Floyd photograph
2: Geological Atlas of Western & Central Europe, 1990 by Ziegler (p.60), Ddrukkerij Verweij, The Netherlands
3: Rokus van den Bout photograph
4: Industrial Minerals 1995 by Manning (p.80), Chapman & Hall, London

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