Farnham Geological Society

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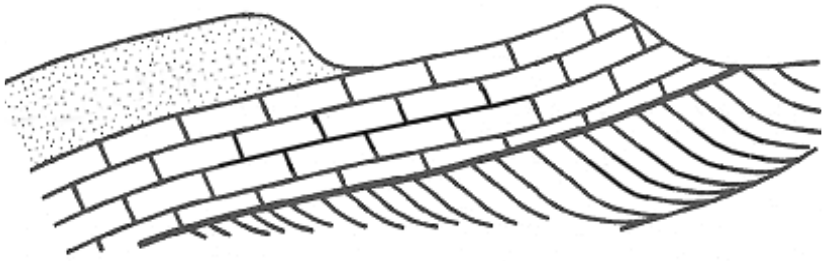
Farnhamia farnhamensis



A local group within the GA

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EDITORIAL

The theme of this letter concerns forgotten specimens collected on field trips. I have been prompted to write about this subject after a clear-out of accumulated items from my garage, amongst which I discovered boxes and trays of rocks and fossils long forgotten. On earlier field trips over the past 20 years I collected a lot of specimens and carefully labelled them. This dedication has diminished over the years, partly because hammering is now discouraged.

What I have found is that memories of the various longer trips at home and abroad come flooding back as I handle the specimens. These memories are of 'fellow trippers', of locations, of the words of wisdom of the leaders and, of course, the social gatherings in the evenings. Properly labelled with date of find, location and a brief summary of the geology enables specimens to be used to recall events. Remember Hamlet who, holding the skull of Yorick, recalls the clown he knew in life – "*Alas Poor Yorick*!".

After reminiscing, comes the difficult bit; what to do with these artefacts briefly brought out from their hidden lairs? Several 'working parties' set up in the Farnham Geological Society over the past 15 years to slim down the Society's collection, firstly in the West Street premises and then in the Godalming Adult Education Centre, approached their task in a determined manner and discarded large quantities of material. But this was not a personal collection and Paul Olver was always around to take specimens into his own collection. I was involved in this time-consuming work and recall the criteria we established for keeping or discarding.

When it comes, however, to taking decisions about one's own collection it's a more difficult matter. After throwing away the unlabelled or uninspiring items I have arrived at a compromise solution. I'm using most of them to form a 'boundary' fence around my little garden area so I can still keep in touch.

Peter Cotton

COMMITTEE

FGS monthly meetings - 2007

Oct 12th – **'Gold giants of the Great Silk Road – Expedition across the Tienshan'**,
Dr REIMER SELTMANN, Natural History Museum, London

** Nov 9th - '**From mud wrestling to metamorphism'**
DR STEVE HIRONS, Birkbeck College

Dec 14th -.'**Making Gold – Nuclear Alchemy'**
DR PADDY REGAN, University of Surrey

** Note: change from programme originally advertised

The Society's annual "*Dinner*" – this year at a lunch time!

It has been the custom for many years for the Society to hold an annual dinner, usually on or around the last Friday in October. Many members have commented that they found it daunting to tackle both the Friday evening traffic and the dark evenings. Your committee has taken these comments on board and has decided to hold this year's annual get-together at a lunch time rather than in the evening. This year's event will therefore take place at **lunchtime on Sunday 28th October** – the venue will again be the Farnham House Hotel, which will be much easier to find in daylight than in the dark. The cost of the 3 course lunch (including coffee/tea) will be £17-50. Please contact the Membership Secretary (Mike Weaver**) immediately** if you wish to attend but have yet to add your name to the list of attendees.

FGS field trip to Anglesey – May 2007

Twenty-seven folk met at the Gadlys Country House Hotel in Cemaes to be guided around spectacular Pre-Cambrian, Ordovician, Silurian and Lower Carboniferous geological sections by Dr Denis Bates. Denis is an eminent Graptolite expert; his PhD research centred on Lower Palaeozoic sediments in Anglesey, and he has maintained a lifelong interest in all aspects of the extremely varied geology of this Island.

Fig 1 An iconic view - South Stack Lighthouse

Fig 2 Denis Bates and the FGS

1 Geology

1.1 Pre-Cambrian

Towards the end of the Pre-Cambrian, Anglesey was part of an accretionary orogenic belt at the SE margin of the Iapetus Ocean, where oceanic crust was subducting south-eastwards beneath the Mona micro-continent. This micro-continent was part of the Avalonian Arc, a series of small land masses which stretched along the NW margin of an ancient Gondwana continent, in the southern hemisphere.

The rocks are predominantly turbidites. Subduction zones are characterised by frequent earthquakes which destabilise coastal margins and cause sediment debris laden currents to flow downslope (a sea-slide as opposed to a

land-slide!). As the current slows, coarse material and then finer material is deposited, frequently in a classic "Bouma" sequence. A coarse sand rests on an irregular surface, eroded by the current; the sand fines upwards; it is sometimes laminated sometimes convoluted, reflecting the turbid nature of the current; the sand passes up into finely laminated silt and then mud. If the periods between flow are sufficiently long, then a normal oceanic mud deposited from suspension may succeed the Bouma cycle. Turbidites are coarser grained proximally (ie near shore, closer to the origin of the "sea-slide") and finer grained distally. Thus, proximal sediments consist of thick sands with thin inter-beds of mud; distal sediments show thin, fine grained sands and silts, with thick mud beds.

The Pre-Cambrian rocks started as sediments, but were subsequently folded and metamorphosed in the orogenic belt; gross sedimentary features are well preserved; finer sedimentary features are well preserved in the sands, and very rarely trace fossils are preserved; the mud has become schist and show few sedimentary structures. The succession includes:

South Stack Group - turbidite sequence with classic "Bouma rhythms"; the sequence is sand dominant, which suggests a proximal depositional location.

New Harbour Group - mud dominant turbidite sequence, which suggests a distal depositional location. The mineralogy indicates that the sediments were displaced from around an island arc. There are occasional tuff (volcanic ash) horizons and rare spilites (basic lava extruded onto the sea bed).

Gwna Group - includes the product of a **MASSIVE** undersea debris slide, the Gwna Melange. The earthquake(s) which caused this slide not only destabilised soft shallow marine sediments, but also dislodged solid bed-rock. Rock fragments were deposited within a matrix of sand and silt - one fragment is at least a kilometre in size! The fragments include limestone, basaltic lava, mudstone, quartzite, and rare granite.

Gabbros and Serpentinites occur within the New Harbour Group. These are basic and ultra basic igneous rocks derived from oceanic crust, and may represent the exhumed remnants of the Avalonian island arc.

1.2 Ordovician and Silurian

In the early Ordovician, a marine transgression deposited conglomerate beds over an irregular surface of deformed Pre-Cambrian and Cambrian rocks. Succeeding Ordovician sediments consist of shallow marine sand and silt beds, separated from late Ordovician deep marine graptolitic mud by a mid Ordovician discontinuity; locally late Ordovician rests directly on Pre-Cambrian rocks. Silurian strata are represented by a small area of graptolitic shale at Parys Mountain.

1.3 Devonian

The closure of the Iapetus Ocean at the end of the Silurian "welded" England and Wales to Scotland-Greenland-Newfoundland as the Avalonian arc (and the rest of Gondwana) collided with Laurentia and Baltica. This collision deformed the Pre-Cambrian (again), Ordovician and Silurian rocks. The rocks were strongly folded and cleaved, and weakly metamorphosed. Terrestrial desert conditions prevailed over the new continent, with the deposition of conglomerate, river bed sand and lake mud. This was predominantly a period of land erosion.

1.4 Lower Carboniferous

In the early Carboniferous, the sea transgressed an eroded land surface, and thick sequences consisting predominantly of limestone, were deposited in a warm shallow tropical sea. Four cycles of deposition have been described, each consisting of a sandy bed followed by a thick limestone and then a thin calcareous mud.

2 Locations

On ***day one*** we walked a traverse from Cemaes Bay to Ogof Gynfor (ogof = cave). On the north side of Cemaes Bay there is an impressive outcrop of Gwna melange, with boulders of limestone, mudstone, quartzite and basalt, up to a metre in size, in a sandy, muddy matrix (fig 3). It must have been a major catastrophe to shift this lot, but then we climbed the cliff to Penrhynmawr to see a limestone; Denis pointed out that this limestone was a "boulder" in the Gwna Melange, one kilometre long!! The limestone seemed surprisingly featureless, but on close examination revealed the remains of small stromatolites.

We proceeded over the cliff top to Llanbadrig Church (Badrig = Patrick) which had its origins in the 5th century, and is associated with tales of St Patrick's landing on his journey from Ireland. Across the bay at Ogof Gynfor, a cliff shows early Ordovician sandstone and conglomerate unconformable on a very irregular eroded surface of the Gwna Melange (fig 4).

Fig 3 Gwna Melange

Fig 4 Ordovician unconformable on Gwna Melange

Day two was a visit to Holy Island. The north part of Holy Island is dominated by Holyhead Mountain which consists of Holyhead Quartzite, part of the South Stack Group. There are vast quarries from which a small railway line used to transport material to build the Great Breakwater which transformed the village of Holyhead into a major harbour and port. North of the Great Breakwater we saw an outcrop of deformed, folded South Stack Formation, whilst across a little bay, at the end of the Breakwater, we saw New Harbour Group rocks which consisted of highly deformed and contorted schist, originally deposited as interbedded silt and mud. Immediately, two of the great enigmas of Anglesey Pre-Cambrian geology were illustrated:

- Firstly, no contact is visible between the South Stack and the New Harbour, and this is true all over Anglesey. Consequently there are problems determining whether one formation overlies the other, or whether they may even be laterally equivalent, deformation having brought together proximal and distal turbidites.
- Secondly, the New Harbour (fig 6) appears much more highly deformed than the South Stack (fig 5); does this mean that the New Harbour underlies the South Stack, was more deeply buried and therefore suffered greater deformation and metamorphism? The answer to this question became clearer later in the day at South Stack Lighthouse (see below).

Fig 5 "Rounded" South Stack Fm fold

Fig 6 Tight folds in New Harbour Gp

The Rhoscolyn anticline crosses the southern half of Holy Island, and brings to the surface a large body of serpentinite, which we saw in a small quarry near Bryn-teg (bryn = hill, teg = beautiful). "Verde antique" serpentinite from here was used in Holyhead church, and reputedly for a table top for Napoleon. The rock is a basic / ultra basic igneous body which was dominated by olivine; deformation and metamorphism has transformed much of the olivine to green serpentinite (fig 7).

Fig 7 Serpentinite

Fig 8. "kink" folds in conjugate pair

At Port Dafarch, west of Trearddur Bay, there is a fine section of New Harbour schist with various types of deformation. Several different cleavages have been recognised which indicates several phases of deformation; there are sharp angled little kink folds, often in conjugate pairs (fig 8), which suggests deformation under relatively "cool" temperatures; there are tight, curved folds (fig 6) which look as if they have "flowed" into place, which suggests deformation under "warm" temperatures. There is also a Tertiary basaltic dyke intruded into the schist; it is part of a massive dyke which crosses Holy Island, sometimes 30' wide, sometimes split into several sub-parallel dykes. It is related to the opening of the North Atlantic between Scotland and Greenland, about 55 ma.

At South Stack lighthouse is the classic section of the South Stack Formation (fig 9). It shows a thick, continuous sequence of sand dominant turbidite units. In the lower part of the section, the beds are thin and highly contorted. In the upper part of the section the sandstone beds are thick, and show gentle folding. Clearly both sections endured the same environment of deformation and metamorphism. However, the great sandstone bodies act as competent units, hard to deform, whereas the thin sandstone beds and the mudstone beds are more easily deformed. The equation of higher deformation = older sediments and deeper burial does not apply here. The degree of deformation is controlled by bed competence.

Fig 9 Type section of the South Stack Formation, at South Stack lighthouse

Figs 10 Parys Mountain Copper Mine

On the cliff top above South Stack there is the remains of a large middle and late Palaeolithic stone-age village, consisting predominantly of the bases of 20 or 30 circular stone huts once roofed with straw. The stones are local, almost entirely from the South Stack Formation.

Day three, and off to Parys Mountain (Fig 10). In the 18th century, Parys Mountain was the largest copper mine in Europe. Reputedly, there has been mining since Roman times, and perhaps even earlier. Massive sulphide mineralisation accompanied by intense silicification and pyritisation of surrounding igneous and sedimentary rocks formed copper, lead and zinc ores, with minor concentrations of gold and silver. Quartz and pyrite dominate, with chalcopyrite, galena, sphalerite, and compounds of lead, bismuth, arsenic, and antimony - a lethal mix! The ore deposit is thought to have been deposited on the late Ordovician to early Silurian sea bed from

heated solutions percolating through the rocks and exiting as "black smokers". In the heart of this complex, an outcrop of Silurian shale yielded the monograptid ***Campograptus lobiferus,*** an exciting discovery made by Barry Eade. This species is characteristic of the early Silurian Llandovery epoch.

At Lligwy Bay, Carboniferous Limestone outcrops in a small cliff and along the beach. The surface of the limestone shows palaeo-karst features - emergence above sea level and exposure to meteoric water (rain) leads to dissolution of carbonate and the formation of a very irregular surface. Conglomerates were deposited in the hollows and upon this surface. The conglomerates include quartz sand and grit, and large pebbles of various Pre-Cambrian formations, igneous rocks, and possibly some Ordovician and Silurian rocks. To the east of this section the conglomerates disappear, and the cliff consists of limestone. There is a fractured and tilted zone, with a deep fissure which has red mud in the bottom. There has been speculation that this "Lligwy disturbance" is a fault zone and that red Devonian sandstone has been thrust up from below. On the day, we preferred the theory that the fissure had been a cave, where the roof had collapsed, and that the red mud was typical cave floor mud (rather like Wookey Hole in the Mendips).

Denis had done us proud - a striking landscape, with fascinating and often enigmatic geology beautifully discussed and explained. Denis could be regarded as a "high-powered" academic, but FGS folk found him eminently charming and approachable, and we tried to express our gratitude in the normal way and with a bottle of Jameson (Irish Whisky for an Irish gentleman).

Dr G M Williams - photos by D Bates, I Hacker, J Phillips, G Williams

FGS field trip to Southern Ireland, June 2007 – an archaeological perspective

Southern Ireland is a country with a rich heritage and we were able to see many examples of its ancient past on our travels. But Irish and British archaeology are very different. As far as we can tell, Palaeolithic man did not reach Ireland during the Pleistocene and other fauna are also missing from this period. There are no sites like Pakefield (750ka BP), no fossil finds like Boxgrove, Swanscombe, Paviland or Pontnewydd Cave (450ka BP). Is this because the deep channels in the Irish Sea prevented migrations?

The first people in Ireland are Mesolithic, around 8000-7500 BC, the Loch Lomond re-advance perhaps a factor, and in Derry there is the famous site of a dwelling (9100 BP), one of the oldest in Europe. Although arriving a bit later here, the Neolithic and Bronze Ages are similar to NW Europe and Britain but, although copper is found in Ireland as we know from the Copper Coast, there are no recorded Bronze Age mines (except in a misleading Kerry guide book!). We saw many standing stones, a stone circle and possibly a barrow or two of these periods in our travels and passed several Iron Age forts, but time did not permit visits.

The Iron Age is also later here, probably introduced by Celtic settlers around 650 BC, full use of iron awaiting a second wave of Celts around 300-250 BC.

There was no Roman occupation (British Governor Agricola wanted to invade Ireland in 81 AD but was turned down by Emperor Domitian) and the Irish Iron Age continues well into the 5th C AD virtually unchanging until the Early Christian period and the spread of Christianity attributed to St Patrick (son of a Roman official, a monk, then a bishop, in France) who was sent to Ireland by the Pope in 432 AD. So Ireland was privileged to continue without Roman rulers and life went on as before, although interrupted by Viking raids and occupations, until 1169 when the Anglo-Normans were invited to Ireland by the (exiled) King of Leinster, effectively giving the country to Henry II!!

But no Romans in Ireland (or very few) also meant no Roman buildings like the ones we find throughout Europe and Britain, and no Roman mortar! The Anglo-Norman Reginald's Tower in Waterford (1185) is thought to be the first building in Ireland where mortar was used, a sorry mix of blood, lime, fur and mud, and so despite over a thousand years of use in Britain and Europe the technology, unbelievably, had not crossed the Irish Sea.

So from Neolithic times (Knowth and Newgrange c. 3100 BC) until the 12th C AD the Irish built in wood or stone and in rural areas people still do. Early churches were of wood or built using dry-stone corbelling just as their ancestors had done. Dating any of these buildings, without other evidence, is almost impossible, there are few inscriptions or documents, an unchanging typology. This is why early Irish chapels can often only be dated to sometime between 6th and 12th C and why "beehive" buildings similar to those on Skellig Michael (see below) and those we saw at Slea Head on the Dingle Peninsula, may be Neolithic to Early Christian or even, perhaps, recently built, for shepherds, or as byres, coops or stores.

The **Gallarus Oratory** (Fig. 1) on the Dingle Peninsula is a small chapel for private devotions, once part of a monastery and settlement, destroyed in Viking and Norman attacks. Beautifully preserved, and the best example of dry-stone corbel construction of about 30 other early west coast oratories, it is cautiously dated to 6-7th C.

Fig. 1 Gallarus Oratory

Fig. 2 Skellig Michael (monastery on the top)

Barry Eade gave us its history and explained the technique of dry-stone corbelling in which each lower course of stones in the walls acts as a bracket to support the overhang of those above, eventually the walls come together at the eaves where capstones seal the ridge. [*Editor's note: It is interesting to note that this self-same principle was used by the Mayans in Mexico's Yucatan and is known as the "Mayan Arch"*]. Each stone slopes down to the outside to shed water. The tiny chapel, 8 x 5 x 5m high has only one small window and a door, but was probably large enough for 4 or 5 monks at prayer. Nearby is a Celtic cross with an ogham inscription (a Celtic script, from 3rd C AD, of 20 letters represented by "tally marks" each side of a line or corner).

We took a boat from Portmagee to the Skellig Islands 8 miles off the coast of Kerry. The largest island is **Skellig Michael** (Fig. 2), a pinnacle of rock rising over 700' above the Atlantic where the original buildings of a "hermit" monastery, dedicated to the archangel Michael, are reached up a 1000 year old stairway of 670 steps (Fig. 3). The corbel built buildings of the 6th C monastery all survive (Figs. 4 - 5), and include 2 oratories, a granary, 5 round topped "beehive" cells (clochans), each the home of 3 or 4 monks; a sixth cell, even more remote, was for total solitude! Inside each there were sleeping platforms, shelves and small storage recesses. Every building is slightly different, some round others less so, one with a quartz cross over the doorway, a larger "beehive" the kitchen. Although cruder (and perhaps older) than the Gallarus Oratory these too are completely waterproof. Their small cemetery (Fig. 6), with ogham marked stones, is close to a 12th C mortar built chapel.

Fig. 3 The 1000 year old stairway

Fig. 4 The Monastery

The monks were self-sufficient, collecting water in cisterns, living on fish, seals, birds, eggs and vegetables from their tiny gardens, and trading with passing boats for cereals, tools and skins for vellum. The community was attacked by the Vikings (in 812 and 823), but this remote and spectacular island was only finally abandoned in the 13th C for another site as Ballinskelligs.

Fig.5 FGS hear a fascinating story

Fig.6 The Graveyard

On the Ring of Kerry, near Bunavalla Harbour, we saw several examples of "ring forts" more correctly "rounds" or "raths", usually Iron Age in Britain but in Ireland many date to the Early Christian (say 500 - 1200 AD). They are easily the most common earthwork in Ireland, almost all sited in good low-lying farmland, not really "forts" but defended farmsteads with earth banks and ditches topped with fences to keep out marauders and wolves. Some banks are stone faced but those with substantial walls, as we saw at **Cahergal** (Fig. 7) and a few fields away at **Leacanabuaile**, are "cashels", often with towers and souterrains, and probably the residence of someone of status. Some of the earliest monasteries were built within raths and cashels before stone was used.

Fig. 7 Cahergal "Cashel"

Fig. 8 Lusitania Memorial

Fig. 9 Slade Castle

Fig.10 Ballycarberry Castle

We saw several castles of various ages. On the **Head of Kinsale** there was a medieval gatehouse and wall, a watchtower, and Iron Age promontory hill fort and (obtrusive) modern wire fence all guarding a golf course.

Nearby though there is a simple memorial to the 1198 people, including 128 from the USA, who lost their lives on May 7th 1915 when the British liner **Lusitania** was torpedoed by a German submarine 8 miles off Kinsale Head (Fig. 8), the attack perhaps a prompt to the USA to join the war.

On Hook Peninsula we looked at **Slade Castle** (Fig. 9), a sad 15th C tower house alongside a pretty but pungent harbour and later on **Hook Head** an Anglo-Norman watchtower (1172) now Europe's oldest working lighthouse. Nearby was the ruined church of St Duhan.

We explored **Ballycarberry Castle** (Fig. 10, a fortified manor house (1396) near Cahersiveen and tried to date the additions to the building as it changed into a stately home and then was abandoned. We even found a castle during an evening stroll around **Dungarvan** harbour, probably 12th C polygonal shell keep, modified by Cromwell, now being "renovated" in a strangely inappropriate style.

On our way to Cork airport we visited **Youghal**, a beautifully situated historic walled town on the Blackwater estuary, given by Queen Elizabeth to Sir Walter Raleigh, whose house Myrtle grove is still to be seen within the town walls; the town and house were later sold to the Earl of Cork. Under Cromwell the town was a Protestant garrison.

Finally some of us did some research into the black ale first produced at St James's Gate, Dublin in 1759 to compete with the whisky, gin and poteen then favoured. Arthur Guinness' "porter" became the chosen drink of the chaps at Covent Garden and Billingsgate markets, who gave it its name. By 1769 it was being exported and it still is, (from the same site but now covering 26Ha, and now to over 120 countries), and, I am told by Derek Jerram, who knows about these things, some is also brewed abroad. Not until the 1920's is "stout" used (so named because it was "fuller bodied" than other ales), and our research confirmed that the source of St James's Gate water is not, as popularly supposed, the River Liffey but the Wicklow Mountains and that the product is at its very best when imbibed in its own beautiful country.

Mike Rubra – photos by Ian Hacker & Graham Williams

FGS field trip to Cork and the Ring of Kerry, Ireland – June 2007

Twenty-four folk arrived in Killorglin, Kerry to enjoy a week's Geology and Archaeology with Dr Denis Bates. Four days were spent around the "Ring of Kerry" and three days around Dungarvan, west of Cork. Our geologists and archaeologists saw some particularly rare and interesting items and no-one will ever forget the comical puffins, the soaring gannets, wild arum lilies, orchids and fuchsia hedges in full flower (Figs 1 – 3).

Fig. 1 Wild Arum Lilies

Fig. 2 Fuchsia field hedge

Fig. 3 Skellig Michael Puffin

The archaeology included the 6th century Skellig Michael monastery, Gallarus oratory, circular stone forts of Cahergal, and numerous forts and manor houses; Mike Rubra's accompanying paper (see previous article) provides an informed view of these features. The Geology included Cambrian Ediacara (rare soft bodied) fossils, Ordovician volcanics, fossiliferous Silurian sediments, terrestrial fluviatile and lacustrine Old Red Sandstone (Devonian) sediments, with the oldest Tetrapod (four-legged) tracks in the world, and Carboniferous reef limestone.

Ediacara Fauna

The earliest multi-cellular creatures appeared in the Vendian (late Pre-Cambrian) perhaps about 600 Ma and include the discoid form *Nimbia occlusa*; at least 30 types of animal evolved, apparently all soft bodied, and the fauna reached its peak between 565-540 Ma, right up to the beginning of the Cambrian, when there seems to have been a mass extinction, and they nearly all disappeared. To find fossils of soft bodied creatures is truly remarkable; we know of the great exceptions - the Middle Cambrian Burgess Shale and the Jurassic Solenhofen

Limestone. Roger Mason is credited with finding the first British example of the Ediacara fauna at Charnwood Forest - *Charnia masoni* - but rare occurrences had been recorded since 1872. The best known and most diverse faunas occur in the Ediacara Hills near Adelaide, on the White Sea coast of northern Russia and at Mistaken Point in Newfoundland. Examples have been found in every continent (except Antarctica). At Booley Bay at the base of the Hook Head Peninsula, there is a thick sequence of almost unfossiliferous turbidite sediments. These were believed to be of late Pre-Cambrian age, and rumoured to contain Ediacara faunas. Barry Eade, our fossil hunter supreme, was unleashed (!!) , and he found a number of the large (10-15 cm) *Ediacaria booleyi* (figs. 4, 4a), and also a few specimens of the tiny discoid form *Nimbia occlusa.*

Recent research on the Booley Bay sequence by Moczydlowska & Crimes (1995) has found an acritarch (planktonic algal forms) assemblage of late Cambrian age. Thus, Booley Bay has the youngest occurrence of Ediacarans in the world.

Ordovician volcanics

There are spectacular outcrops of mid to late Ordovician volcanic rocks between Tramore and Dungarvan. At least two volcanoes erupted into and onto sea floor mud which continued to be deposited during the volcanicity. Subsequently the rocks were deformed by the Caledonian (400-420 Ma) and then the Hercynian (270-300 Ma) orogenies. The section at Garrarus Strand was particularly complex. Initially a basaltic-andesitic magma was emplaced; then rhyolitic (acid), gas rich magmas produced explosive eruptions (ash and volcanic bombs) and then viscous lavas; finally sills and dykes were intruded. The varying "competence" or hardness of these rocks meant that subsequent deformation resulted in extremely complicated structural relationships between the different volcanic bodies.

Silurian

The Silurian consisted of fossiliferous sandstone, limestone and mudstone sequences, and at Clogher Head in the Dingle included a feature which is rare and remarkable in the Silurian of Britain and Ireland. During the Caledonian orogeny there were volcanic eruptions which produced ignimbrites (fig. 5), hot ash and volcanic glass from a massive volcanic explosion, and rhyolitic lavas. The other known examples of Silurian rhyolitic volcanoes are in Pembroke and Somerset.

Devonian

After the Caledonian orogeny (closure of the Iapetus Ocean between Avalonia (including England) and Laurentia-Baltica) a mountain range occupied central Ireland. To the south a vast alluvial plain developed with deposition of fluvial (river) and lacustrine (lake) sands and shales into the fault controlled Munster Basin. We saw a number of particularly unusual features:

- A conglomerate with clasts (rock fragments) up to 20cm across, but the clasts were only a few millimetres thick!! Water-lain mud had dried out, developing large mud cracks; mud flakes from between the mud cracks had been lifted by a flash flood, transported and redeposited in a sandy matrix (fig. 6); the soft flakes were then compressed further during burial to form a 2-dimensional conglomerate!! This feature provides so much information about the landscape and climate of the time.
- Fish evolved during the Silurian; their descendants took their first tentative steps onto land during the Devonian; these were the Amphibians who, for a short period, were the dominant land animals. On Valencia Island there are 50 or so tracks which have been left by these amphibians (fig 7). This is perhaps the oldest of only about 6 occurrences of such tracks in the world - to see these was a really special moment. This animal was about 1m long (fig. 8).
- A slate slab from the Valencia quarry illustrated spectacular water escape structures; thin beds of fine sand had been deposited in a predominantly muddy sequence; then shortly after burial, the water which had been retained in the sediment was squeezed out and disrupted the sand beds leaving "micro-volcanoes" of disturbed, turbulent looking sediment.

Carboniferous

Hook Head peninsula is composed predominantly of flat lying Carboniferous limestone; it is well exposed in a raised wave cut rock platform. Enormous numbers of fossils, mostly fragmented, are preserved in a lime mud matrix (fig 9). There are abundant Crinoids (including a complete calyx), Corals (solitary and colonial), Brachiopods, and many fragile, lace like, Bryozoan fronds. It was easy to imagine the tropical reef environments which prevailed at the time.

Fig. 4, 4a *Ediacaria booleyi* (15x10cm)

Fig. 5 Welded tuff (ignimbrite)

Fig. 6 "Mud-flake conglomerate"

Fig 7 Tetrapod tracks

Fig. 8 The Valencia Tetrapod, a large newt-like amphibian

Fig. 9 Crinoid & lace-like Bryozoan fronds

Fig. 10 Gentle Hercynian folds

Fig. 11 Landscape formed by Devensian glaciation and Flandrian sea level rise.

Tectonics

The Cambrian, Ordovician and Silurian rocks were deformed by the Caledonian and Hercynian orogenies. These rocks were folded, tilted and suffered a low level of metamorphism with many of the muddy sediments being changed to phyllite and even schist.

The Devonian and Carboniferous rocks tend to be less distorted, often still flat lying, and show little sign of metamorphism. An example of gentle folding near Kinsale is shown (fig 10). The sharper-eyed examined the cracks and fissures, some of which were cemented with quartz. This suggests different times of formation, reflecting different tectonic regimes, perhaps extensional rather than the compressive Caledonian and Hercynian orogenies. Many of the fissures were formed in the Triassic, during the initial phases of the opening of the Central Atlantic, when large rift basins were formed offshore to the South of Ireland.

Pleistocene, Ice Age

The last great ice advance was in the Devensian (aka Midlandian in Ireland) between 115,000 and 10,000 years ago. Central Ireland was occupied by a vast ice sheet and there was a separate ice cap with valley glaciers over the mountains of Kerry. The glaciers eroded wide valleys, the lower parts of which have been flooded by the Flandrian transgression as the sea rose during the last 10,000 years as the ice melted. The glaciers left eroded Roches Moutonees, lateral and terminal moraines, and where they passed over Carboniferous limestone there are solution hollows and lakes. The image (fig. 11) shows ice eroded hills in the distance, an eroded and subsequently drowned valley, moraine in the foreground central right, and in the foreground a large erratic left by the ice.

Graham Williams – photos by Ian Hacker, Ann Sayer, Susan & Graham Williams

Solution to Peter's puzzle – No. 4

C	O	S	M	O	S	■	■	I	C	I	N	G
R	■	Y	■	U	■	P	■	S	■	■	■	A
Y	A	N	G	T	Z	E	G	O	R	G	E	S
S	■	C	■	■	■	R	■	S	■	U	■	■
T	I	L	L	■	■	I	S	T	H	M	U	S
A	■	I	■	■	■	O	■	A	■	A	■	A
L	A	N	G	U	E	D	O	C	■	R	■	L
L	■	E	■	■	■	S	■	Y	■	A	■	T
I	N	S	I	T	U	■	■	■	I	B	I	D
N	■	■	■	R	■	H	■	M	■	I	■	O
E	■	C	L	I	M	A	T	E	■	C	W	M
■	■	O	■	A	■	L	■	R	■	■	■	E
F	O	L	K	S	T	O	N	E	B	E	D	S

Proposed extended field trips – 2008

Date	Days	Venue
April 4 - 7	4	The Lizard peninsula
May 4 - 11	8	Majorca
July 4 - 7	4	Cardigan Bay, Wales
October 3 - 12	10	Brittany & East Normandy

In addition, there will be one-day trips to: Overcombe, Dorset (June 1), Devils Jumps (evening of June 20), Mupe Bay or Ringstead Bay, Dorset (August 3) and The Medway, Kent (September 7)