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I have been very grateful to the hard work and commitment of the Committee during the year. Their efforts have resulted in the delivery of a full programme of lectures and field trips. The circumstances of working remotely have required additional email communications, updating of the website and producing the newsletter/journal. Communicating with new members and keeping track of our finances.

Under normal conditions the committee meets 3 or 4 times per year but under these situations we have met virtually about 6 times. The strength of a Society like ours is measured by those who volunteer their time and I am indebted to those on the committee.

The introduction of a newsletter last year has been a useful tool for communicating upcoming events and news. It also provides an opportunity for members to write and share, please contribute.

If you have any comments or suggestions, we would love to hear from you. On behalf of your committee, thank you again for your support.

Graham P Hickman
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Moher, more and yet more Carboniferous in Ireland

By Charles Hiscock

Ireland, despite its small area, can boast representative rocks and formations from most of the geological periods, from the Precambrian gneiss of south east County Wexford to the Tertiary basalts of County Antrim, overlain in much of the island by post-glacial deposits. However, it is the Carboniferous outcrops that provide about 65% of the land area with the rocks ranging from sandstones, shales to limestone.

Towards the end of the Devonian period, during which Ireland was part of north west Europe, the continent sank and was covered by a warm calcium-rich sea. Great areas of coral reefs were formed which eventually created the Lower Carboniferous Visean limestone (315-325 mya) that outcrops across Ireland, in the Bristol area, Mendip and the rest of the UK. This was followed by extensive deposition of sandstones and shales during the Upper Carboniferous Namurian era (299-315 mya). As the period advanced, so the sea became shallow until eventually swamps and tropical forests provided the organic matter that became the coal deposits of the Coal Measures. During the Triassic period, wide ranging and intense erosion occurred in a desert environment which stripped off most of the coal measures and much of the sandstones and shales. This left Ireland with very small outcrops of Coal Measures, principally in Counties Carlow and Tipperary of central south east Ireland with larger outcrops which were mined in Counties Leitrim, Kilkenny and Cork.

Today, much of the Carboniferous outcrops are covered by bogs which have formed since the last ice age and by soils which have been exploited for agriculture. However, there are some extensive outcrops of limestone, sandstones and shales and it is these which I will be visiting in the following paragraphs. Fig. 1 is a generalised map of the Carboniferous outcrop in the area of Counties Clare and Galway (courtesy of the Burren Centre, Kilfenora, County Clare).

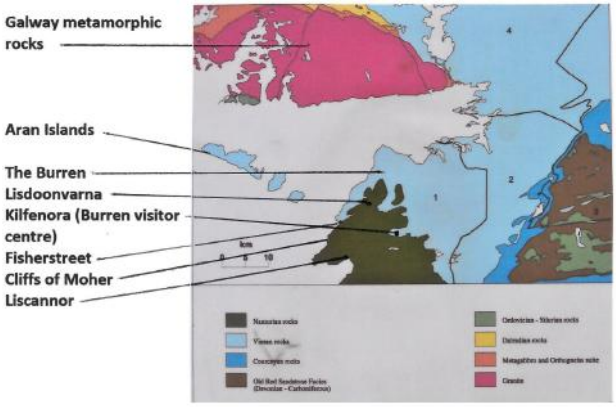

Fig 1: Generalised geology map of Counties Clare and Galway

Cliffs of Moher, County Clare

The Cliffs of Moher on the Atlantic coast of County Clare are famous for being some of the highest sea cliffs in Europe. Rising to 214 metres/702 feet at their highest point, Knockardakin, they stretch for over 8 kilometres from Liscannor to Fisherstreet near Doolin Pier on the southern edge of the Burren. A distinctive feature of the cliffs is that the drop into the Atlantic Ocean is generally vertical, caused by the almost level bedding of the rock layers that make up the cliffs giving the more intrepid (or foolhardy!) the chance to sit on the edges of the almost flat rock platforms, dangling their legs over the edge.

The Cliffs of Moher were laid down during the Namurian era (299-315 mya) of the Upper Carboniferous period with the Cregg Limestone Formation to the south of the visitor centre and the Gull Island Formation to the north at a time when warm seas covered most of the present western European landmass.

The area of the Cliffs was the warm sub-tropical delta of a large river that originated in a plain to the north and west of present-day Ireland. The river supplied much silt, sand and mud, particularly during flood events at times of high rainfall, which blocked the channels of the delta causing the river to flood and develop new channels to the sea. The lowest deposits of sediment became lithified into sandstones and shales forming the foundations of the Cliffs. River erosion, tectonic movements and changing sea levels caused the deltaic sediments to be inundated by the sea and covered by marine sediments. In the Cliffs, five cycles of deposition can be recognised; each cycle commencing with a layer of black shale on the underlying formation followed by beds ranging from a few centimetres to metres in thickness. The lowest shale bands are rich in trace fossils and are superbly displayed in the upright Liscannor flagstones that line the viewing platforms.

Fig. 2: Liscannor flagstone with trace fossils

The flags show the burrows and feeding trails of marine worms, crustaceans or arthropods. The traces meander seemingly at random as the animals fed on or near the surface of the sediment. Closer inspection shows the traces have two lateral furrows along each edge and most show a median ridge or furrow, presumably the imprint of the tail of the animal (Fig. 3).

Fig. 3: Close up showing Scolicia traces

They have been assigned to the ichnogenus *Scolicia* (Hantzschel W. 1989). Many of the large flagstones display fossil ripples on which the trace fossils can be seen while small circular burrows are also present on the flags but difficult to spot (Fig. 3). Just below O'Brien's Tower, built in 1835 for the Victorian tourists, is the sea stack Branaunmore. Once attached to the cliffs but now some distance away, the distinctive cycles that exist in the Cliffs can be seen although binoculars are needed to appreciate the geology (Fig. 4).

Fig. 4: Braunanmore sea stack

The flat even layers of the basal beds have been quarried nearby at Moher and Liscannor quarries since late Victorian times and used for paving and decorative stone facings all over Ireland. The town of Lisdoonvarna not far from the Cliffs has Liscannor flags as paving in the streets and the town square. The flagstone slabs have been used inside the Cliffs of Moher visitor centre along the walkways at the top of the cliffs to keep the public away from the edge. Here they are set vertically with the trace fossils facing the visitors that view the Cliffs, but most do not give the superb trace fossils display a second glance.

Fig. 5: Fossil ripples with trace fossil scolicia

Sadly, it was felt that, apart from the visual presentation in the visitor centre, the geology of the Cliffs was given scant attention at the cliff top and there was no information about the traces or ripples on the flags (Fig. 5).

The Cliffs of Moher are a spectacular natural feature on their own but there is also the huge number of birds that live on them. Large numbers of Puffin, Razorbill, Guillemots, Fulmar, Kittiwake and Shags nest on the Cliffs, some only returning in the early spring to breed. On the sea stack, the white lines marking the bedding planes of rock is the guano that has built up over a long time from the nesting and roosting birds. Less common are Greater Black Backed Gulls and Peregrine Falcons. Flowers such as Ragged Robin, Kidney Vetch, Sea Pink, Sea Campion and many orchids can be found along the cliff top. The natural wonders of the Cliffs of Moher seem timeless, but the fierceness of the Atlantic Ocean is gradually eating away what seems an impregnable fortress of rock, attacking the softer layers so that the harder beds eventually collapse into the sea.

References: 'Cliffs of Moher, County Clare, Ireland Guidebook' & Hantzschel W. 1989 'Treatise on Invertebrate Paleontology, Part W – Miscellanea, Supplement 1 'Trace Fossils and Problematica'

Doolin, County Clare

The Cliffs of Moher stretch north from the visitor centre for about 3 miles to Fisherstreet, all the time gradually losing height until they are only about 100 feet high just south of the village harbour (Fig. 6).

Fig. 6: Cliffs of Moher south of Doolin Pier

The footpath from the visitor centre viewing platform leads along the cliff top, very close to the edge of the cliffs and in one place has fallen into the sea making the walk particularly scary. The harbour for Fisherstrreet is Doolin Pier where, during our walk, the waves were breaking well up the Cliffs at high tide. It is at Fisherstreet that a contrast in the geology becomes evident. Running down through a shallow valley, the River Aille follows the unconformity between the shales and siltstones of the Cliffs of Moher, the Clare Shale Formation, and the limestones of the Burren Formation (of which more later). To the south of the river mouth, the dark level beds of the Upper Carboniferous shales and siltstones of the Gull Island Member exposed in the cliffs are eroded well back compared to the limestone cliffs exposed at Doolin Pier where the level bedding forms low vertical cliffs (Fig. 7).

Fig. 7: Sea cliff, Doolin Pier

The River Aille runs off the hills inland from the Cliffs over the impermeable shales and siltstones, collecting small tributaries as it approaches the sea. As if to confirm the dramatic change in geology with the river very low due to the long dry period, the water could be seen but when it reached the limestones just seawards of Doolin bridge (Fig. 8), it disappeared through swallets leaving a virtually dry riverbed (Fig. 9), not appearing again until the sea was reached.

Fig. 8: River Aille below Doolin Bridge

Fig. 9: River Aille below Doolin Bridge

At about 325 mya, the basin deepened rapidly causing the deposition of limestone to cease. The only sediments that were laid down for 5 million years were the bones and teeth of fish and marine creatures forming thin layers of phosphate material which, at Doolin, was up to 2 metres thick. In the 19th and early 20th centuries, this phosphate was mined for fertiliser, being for a time the richest source of phosphate worldwide. Following this quiet period, the river deposited large amounts of silt and sand to form the deep layers of the Clare Shale Formation.

At Doolin Pier, limestone beds dip west at a very shallow 2-5 degrees and display the typical limestone pavement features of clints and grykes (Fig. 10). At Doolin Pier, the flora that is associated with the microclimate of limestone pavements such as Purple Cranesbill, Bird's Foot Trefoil, Sea Pink, Rock Rose and Tormentil are particularly fine as they exploit the grykes to extract moisture and nutrients from the otherwise dry environment.

Fig. 10: Limestone pavement, Doolin Pier

The Burren National Park, County Clare

The headland of Carboniferous Limestone at Doolin Pier is the most south western tip of the famous area of Ireland known as the Burren (from the Gailteach *Boireann* meaning 'great rock). It covers an area between the villages of Lisdoonvarna, Corofin, Ballyvaghan and Kilfenora where, at the latter, is an excellent visitor centre with displays and videos about the Burren. Exceptionally, there is a full description of the geology of the Burren accompanied by geological survey maps which allow one to put the area into perspective to the rest of the Carboniferous outcrops of Ireland. The Burren is formed mainly of early Carboniferous limestone of Visean age (approx. 325 mya). The Burren Formation itself is subdivided into 7 separate members composed variously of limestone, sandstones and shales. Later, about 318 mya, the Visean rocks were covered by sediments of the Namurian Clare Shale Formation up to a depth of about 1000 feet which protected the underlying limestones for millennia until the onset of the Pleistocene glaciations.

While large areas of Carboniferous limestone are not unusual throughout the British Isles with limestone pavements present in parts of the UK, it is the effect of glaciation that has shaped the Burren (Fig. 11) making it one of the finest glacio-karst landscapes in the world (*glacio* -of ice, *karst* – from the karst region of Slovenia where similar features are present). About 1 million years ago, the Ice Age commenced during which glaciers advanced and retreated many times over Ireland with the last couple extending right across the Burren. Thus, the scenery we see today is the result of the last glaciation of about 10,000 years ago. The effects of the earlier ones have been destroyed. However, since that time the effect of rain, acid solution and the flora has opened the cracks in the limestone to form the characteristic grikes (Fig. 12) in which many plant species, some rare, can retain a foothold. There are no permanent surface rivers in the Burren but underground water has opened up cracks and joints in the limestone forming extensive cave systems.

Fig. 11: Pavement and erratic in the Burren

Fig. 12: Clints and Grykes, the Burren

A legacy of the glaciers is the abundant boulders, glacial erratics, (Fig. 13) that lie on the limestone surface and can be seen over much of the Burren. In addition, the area has been occupied by humans over millennia with many cairns and chamber tombs scattered across the Burren using the abundant glacial erratics, such as the one at Poulnabrone north of Kilfenora. A chamber tomb that is much less obvious, again using a large flattish boulder as the cap stone and situated in a large depression in the limestone, can be seen near the sea at Doolin Pier.

Fig. 13: Glacial erratic boulder, the Burren

Rosses Point and Hill of Knocknarea, County Sligo

Travelling due north up the west side of Ireland from Doolin and giving the metamorphic and igneous areas of Connemara and Galway a miss, one continues to pass over Carboniferous limestone for a distance of about 100 miles. About 4 miles north west of the town of Sligo, at the headland called Rosses Point, the Carboniferous limestone is exposed in the cliffs that form the northern and southern 'bookends' to the sandy beaches. Here however, the thin limestone beds are interleaved with dark shales and frequent bands of blue/ black chert. The chert is abundant as beach pebbles and although the surfaces give the impression of fossils, it is not possible to make any identification. Within the limestone there are abundant fossil corals, brachiopods and trace fossils; a high proportion of which are preserved in the black chert and often found as beach pebbles (Fig. 14). At the back of the beach on the north side of Rosses Point is the Lower Carboniferous Dartry Limestone Formation, a medium grained limestone with frequent continuous black chert bands. Immediately under Rosses Point is a similar grey crinoidal limestone with chert bands, the Ballyshannon Limestone.

Fig. 14: Lithostrotion pebble (Rosses Point)

Not far distant from Sligo are two isolated karstic hills, Benbulbin, a few miles to the north, and Knocknarea about 5 miles south west. Both stand up high above the surrounding country with steep, in places vertical, scarp faces which are the result of the last glaciation. Except for the well-equipped mountaineer or rock climber, Benbulbin is inaccessible but not so Knocknarea. The latter rises near the village of Strandhill and can be accessed from a narrow road that climbs over its eastern end where a dedicated car park enables the explorer to start walking. The footpath immediately starts to rise, gently at first, as a rough track with small step-like terraces as each bed of limestone is reached. Alongside the track on both sides are dry stone walls composed of rough, unshaped limestone blocks, a high proportion having abundant fossil corals mainly *Lithostrotion,* and *Syringopora* species and crinoidal remains. As the hill is climbed, so the gradient becomes much steeper and the surface is littered with loose limestone, much of the loose material being fossil corals. Knocknarea can be said to be a large fossil coral reef. However, where the fossils have been replaced by silica the structure of the fossils is etched out of the limestone by erosion. A specimen of *Michelinia* species picked up from the path demonstrates the siliceous preservation and subsequent erosion (Figs. 15 and 16). Like the limestone at Rosses Point, Knocknarea is formed of the Lower Carboniferous Dartry Limestone Formation with abundant bands of blue/black chert formed when the sediments were compacted and lithified.

Fig. 15: Coral Michelinia sp (Knocknarea)

Fig. 16: Detail of Michelinia

The isolation and elevation of Knocknarea appealed to Neolithic people as much as it does now except they used it for ceremonial and religious purposes and about

3400 BC built the great cairn on the top, the legendary grave of Queen Maeve of Connacht who was an Iron Age chieftain about 300AD. Also, there are 8 other cairns, passage tombs, enclosures and monuments built on the hill around the same time. One particular feature of the great cairn is that, as well as limestone, the variety of stones and boulders include many of which are of igneous and metamorphic origin. Maybe the people who used the cairn as a ritual and ceremonial site came from as far afield as Galway, Connemara, and brought offerings in the form of their local often colourful, stone.

Reference – Knocknarea – Westrup R – Sligo – County Geological Site Report & Rosses Point – The Natural History of Sligo and Leitrim.

Whatever the interest of the visitor to Ireland, there are a wealth of attractions matching those of countries across the world and this corner of the Emerald Isle with its attractions can satisfy most requirements. When the attractions have been visited and one leaves the tourist honeypots, it is a peaceful, restful and friendly place.

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Remote learning at Wells Cathedral School

by David Rowley (Head of Geology at Wells Cathedral School)

Introduction

There are approximately 200 schools and colleges teaching A level geology. The course is broad and scientific emphasising the distinctiveness of geology in its own right as well as its interconnections with the other sciences and geography.

The last two years have proved challenging for society and in this article, I will reflect on the ways in which one school in particular was affected by and coped with the peculiar circumstances of 'remote learning'.

Wells Cathedral School is where I have taught geology (and geography) for over thirty years. (For those unfamiliar with the terminology it may be worth mentioning that 'senior school' begins in Year 7, GCSE year is Y11 and A levels are completed in Y13.) It is a wonderfully busy, thriving school of boys and girls, day pupils and boarders, British and overseas pupils, from 3 years old – 18 years old. Around a quarter of Wells pupils are talented specialist musicians who balance their musical & academic commitments within a 'conventional' school of hockey, rugby, cricket, Duke of Edinburgh's Award, CCF, drama, outdoor education and much else besides.

Introduction of Lockdown

In March 2020 just prior to Government restrictions coming into force, teachers from W.C.S. went to their classrooms, gathered textbooks, folders and other resources and prepared to start teaching from home.

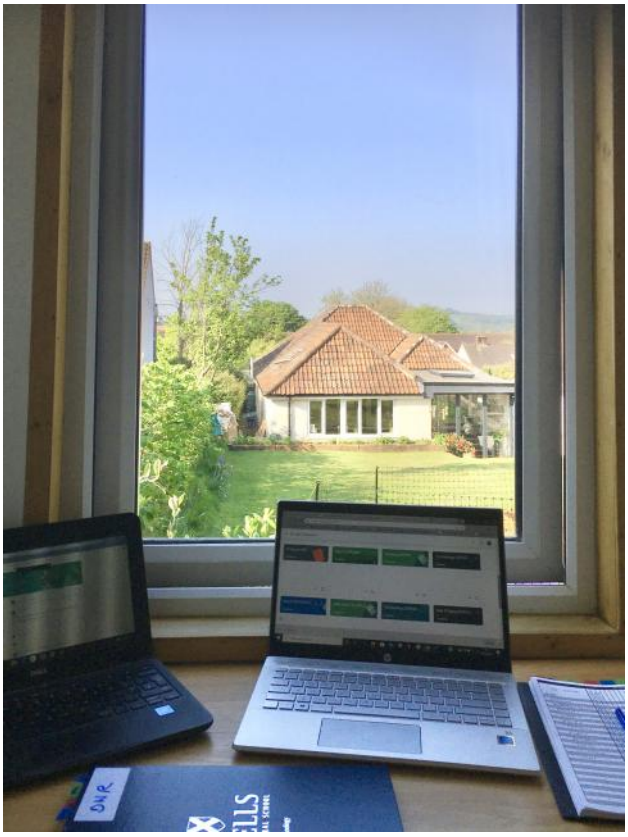

Fig. 1: the classroom

Our school's 'bring your own device' policy (which requires pupils to bring a Chromebook/laptop to all lessons) had been in place for three years and was about to play a crucial part in our ability to engage with pupils remotely and deliver worthwhile & stimulating lessons.

The 'Google Classroom' is an application allowing teachers to post worksheets, instructions and resources online for both lessons and homework. Remote learning required us to make full use of the Google Classroom as well as 'Google Meet' (the equivalent of Zoom).

We were fortunate that the use of the Google classroom was already part of our usual working practice, and that the skills required for us to use presentations, documents and spreadsheets were well established among (most) pupils and teachers.

So, with all this in place, how did the school adapt, what was the learning experience like, and what were the challenges?

School-wide adaptations

One way systems, year group bubbles, social distancing, hand sanitising & mask wearing became the norm. Meetings and assemblies were livestreamed to tutor groups and classes in their 'bubbles'. Teachers were not allowed to linger in the staffroom, pigeonholes could be checked but social areas were out of bounds. Teachers retreated to their classrooms for sandwiches at lunchtime while pupils were admitted to and seated in the dining