

International Glaciological Society

2 July, 2023

IGS
Limerick
2023



Symposium on The edges of glaciology

Programme

It's a long time since I saw you
It's a long, long time ago;
But the sun is shining down on me,
I know where I must go;
In the mountains and the valleys,
I'm a long long way from home;
But I'll be with you always.
Wherever I may roam.

Sunday

7.00 a.m. Bus leaves Stables for Skelligs excursion.

7.30 p.m. – 9.00 p.m. Icebreaker, Scholar's (in Stables complex, 16 on the campus map).

Skellig Michael

Skellig Michael¹ refers to a pair of islands (Great Skellig and Little Skellig) which rise vertically from the sea floor in the Atlantic, some 12 km off the west coast of Kerry. They were famously the home to a small monastic settlement, starting around the time of St. Patrick in the fifth century A.D.

The monastery was occupied continuously for centuries, certainly up to the middle ages, although it was attacked several times in the ninth century by the Vikings. In one of these raids, the then abbot was carried off and starved to death. After its abandonment in perhaps the twelfth or thirteenth century, it continued to be a place of pilgrimage for centuries.

The islands form a rump of the mountains of Kerry known as the MacGillycuddy Reeks, which formed during the Variscan orogeny in the Devonian, following the closure of the Iapetus Ocean. This ancient ocean closed when two continental land masses collided, forming the Iapetus suture zone. In Ireland this extends from the Shannon estuary in the west to Clogher Head in the east. Before that time, North and South Ireland were part of two different continents.²

The monks maintained themselves by eating fish and birds and their eggs, presumably. They also had a vegetable garden. The steep topography makes one wonder what the source of phosphate was, and evidently this would be the bird guano.



Figure 1: Little Skellig seen from the Great island.

¹See, for example, D. Lavelle, *The Skellig Story*, The O'Brien Press, Dublin, 1993.

²Some might say it should have stayed that way.

Monday

8.00 Registration

8.45 Introduction. James Gleeson, MACSI

9.00 Francisco Navarro, Madrid

Geodetic mass balance 1957-2000, 2000-2013 and 2013-2019 of Hurd and Johnsons glaciers, Livingston Island, Antarctica

9.30 Nicolas Jullien, Fribourg

Ice slab thickening drives surface runoff expansion from the Greenland Ice Sheet's percolation zone — and vice versa

10.00 Matthew Siegfried, Colorado

The life and death of a subglacial lake in West Antarctica

10.30 coffee

11.00 Ian Hewitt, Oxford

Glacier sliding modulated by cavitation

11.30 Marianne Haseloff, Madison

Constraining subglacial properties from time-dependent data

12.00 Doug MacAyeal, Chicago

Elastica's snowy edge: spontaneous roll-up of a ruck in a thin, sliding snow sheet

12.30 lunch

2.00 John Woodward, Northumbria

Super slippery surfaces: theoretical implications for the dynamics and flow stability of glaciers and ice sheets

2.30 Rebecca McCerery, Northumbria

Hunting for super slippery surfaces in subglacial environments

3.00 Dustin Schroeder, Stanford

Limits on the orbital sounding of terrestrial ice sheets and near-surface reflectors

3.30 tea

4.00 Yongji Wang, Princeton

Discovering the rheology of Antarctic Ice Shelves via physics-informed deep learning

4.30 Ginny Catania, Austin

Using big data to understand calving in Greenland (invited)

7.00 Dinner: Stables barbecue.

Tuesday

9.00 Felix Ng, Sheffield

Isotopic diffusion in ice enhanced by vein-water flow

9.30 David Prior, Otago

Anisotropy of the Priestley Glacier lateral shear margin, Antarctica

10.00 Olga Sergienko, Princeton

Dynamics and steady-state stability of marine ice sheets with arbitrary basal and lateral shears

10.30 coffee

11.00 Kristin Schild, Maine

Can we use ApRES to calculate iceberg ablation rates?

11.30 Iain Wheel, St Andrew's

Investigating calving dynamics at Jakobshavn Isbræ using a 3D full-Stokes calving model

12.00 Peter Nekrasov, Chicago

Interaction of flexural-gravity waves with periodic ice shelf structures: a proposed explanation of rolls on Arctic ice shelves

12.30 lunch

2.00 Adrian Luckman, Swansea

How do suture zones allow ice shelves to grow so large? Introducing the RiPIce Project

2.30 Bernd Kulesa, Swansea

Integrated geophysical exploration of the Joerg Peninsula suture zone, Larsen C Ice Shelf, Antarctic Peninsula

3.00 Katie Miles, Aberystwyth

Physical properties and structure of meteoric and suture zone ice from boreholes on Larsen C Ice Shelf, Antarctica

3.30 tea

4.00 Doug Benn, St. Andrew's

Calving laws and lawlessness (invited)

5.00 Posters and drinks

7.00 Dinner: Pavilion

Wednesday

Mid-week excursion: bring rain gear!

7.00: Bus departs from Stables

7.40: Drumlins of south Clare, near Lissycasey

9.00: Boat to Scattery Island; picnic lunch

12.00: Bus to Kilkee; bus parks at Marine Parade 52°40'40" N, 9°39'03" W (henceforward 52.40.40; 9.39.03 *etc.*).

12.30: Greyhound. Refreshments.

Walk (distance in km)

2.00: to Diamond Rocks (1.4).

2.20: to cliff top (1.5).

2.50: to Bishop's Island (1.2).

3.15: Peroration. Group photo.

3.25: to St. Kee's well (0.4).

3.35: to quarry (0.75).

3.55: to Dunlicky Castle (2.1).

Bus:

2.30 Bus to cliff top 52.40.33; 9.40.38.

~ 3.00 Bus to car park near Bishop's Island
52.40.23; 9.41.15.

~ 3.30 Bus to St. Kee's well 52.40.12; 9.41.31.

~ 3.40 Bus to quarry 52.39.53; 9.41.45.

~ 4.05 Bus to Dunlicky Castle 52.39.21; 9.43.13.

5.00: Bus to entrance to Williams farm 52.38.52; 9.43.52 and roadside view of Maigh Mhín ring fort. Continue on to barbecue at 52.39.39; 9.40.11 (V15F621).

5.30+ Barbecue

7.30 Departure to Limerick.

9.00 Arrive UL.

Drumlins near Lissycasey

The bus takes us out past Shannon airport, and we drive through drumlinised topography on the motorway. After the turn-off at Ennis,³ keep an eye out on the right for Clare Abbey, a ruined 12th century Augustinian abbey. Unfortunately, we don't have time to stop and nose around, as the tide at Kilrush will not wait for us.

Leaving the roundabouts behind, we start to climb towards Lissycasey, and pass through more drumlinised topography. There are bigger waves on the planets: ocean tides, Rossby waves, flood waves; but these are some of the biggest waves you are likely to experience. The enduring mystery of their formation is still being investigated after 200 years.

Figure 2 shows a glacial map of south Clare, with ubiquitous drumlins indicating the flow of ice from east to west. It is an interesting and subjective feature of such maps that drumlins are always indicated as isolated objects, but as we drive through them, you will see that this is a simplified picture, at least in this part of the world. As we approach Kilrush, on the south of the peninsula to the left, just before the inlet at Moyasta, and above the island (Scattery Island), we can see a sequence of terminal moraines.

³Muhammad Ali had a great-grandfather (John O'Grady) from Ennis, whose son Abe emigrated to Kentucky and married a freed black slave. There is a memorial in the town, which Ali visited in 2009.

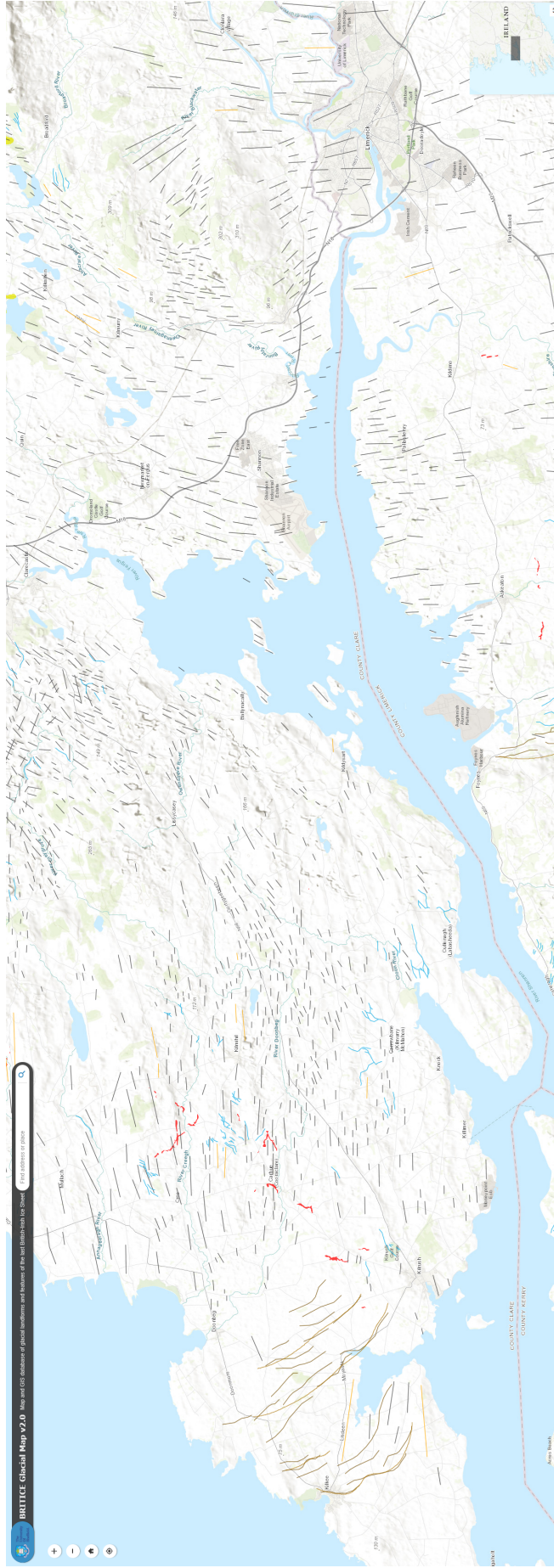


Figure 2: A glacial map of south Clare: drumlins are shown as black lines, moraines in brown, eskers in red, meltwater channels in blue. Image courtesy of Chris Clark, from the online BRITICE Glacial Map that is open access; see briticemap.org.



Figure 3: A figure in a wall of the monastic ruins.

Scattery Island

Scattery Island, Inis Cathaigh in Irish, is named for the fabled beast who was driven from the island by St. Senan, whose name is everywhere in these parts; it seems likely he gave his name to the Shannon river and estuary. Senan lived in the sixth century, and founded a monastery on Scattery Island, whose ruins, mostly probably dating from the 11th century or thereabouts, are well preserved.

The island is no longer inhabited, but at its peak had perhaps as many as 140 residents. These were largely pilots for the Shannon estuary, together with their families. Ruins of the cottages still remain, including an old post box; the island was abandoned in 1978. The teacher for the school would row out from Kilrush in the morning, and back in the evening. On the other side of the island (walk behind the ruined cottages parallel to the shore and keep going) there is an artillery battery, dating from the 1800s, built as a defence against French invasion.

As regards geology, the following quotation is taken from the paper by Roberts *et al.*⁴: “Scattery Island has been previously interpreted as a thrust moraine formed

⁴D. H. Roberts *et al.*, 2020 The deglaciation of the western sector of the Irish Ice Sheet from the inner continental shelf to its terrestrial margin. *Boreas* **49**, 438-460.



Figure 4: Inside the round tower.

during deglaciation at $\sim 17\text{--}16$ ka with ice pushing from east to west, subparallel to the estuary (McCabe 2008)⁵. It may represent a continuation of the Kilkee–Kilrush Moraine Complex further north. The lowest lithofacies is a folded and thrust laminated clay with large clasts. This unit is clearly waterlain (either glaciolacustrine or glaciomarine) with an ice-rafted component (McCabe 2008). Above the lower deformed clay up to 6 m of crudely stratified to massive, coarse cobble gravel forms the main coastal sediment exposure on the west coast of the island . In places stratified, discontinuous sand pods are interbedded with the gravel. The sand and gravels undoubtedly relate to increasingly proximal glacialfluvial and ice-marginal conditions as ice re- advanced to form the Scatterry Island moraine.”

⁵A. M. McCabe, *Glacial Geology and Geomorphology: the Landscapes of Ireland*, Dunedin Academic Press, Edinburgh, 2008.

Kilrush to Kilkee

We leave Scatterry Island to return to the marina in Kilrush, and from there drive to Kilkee, a distance of some 13 kilometres. Figure 5 shows the detail of the local

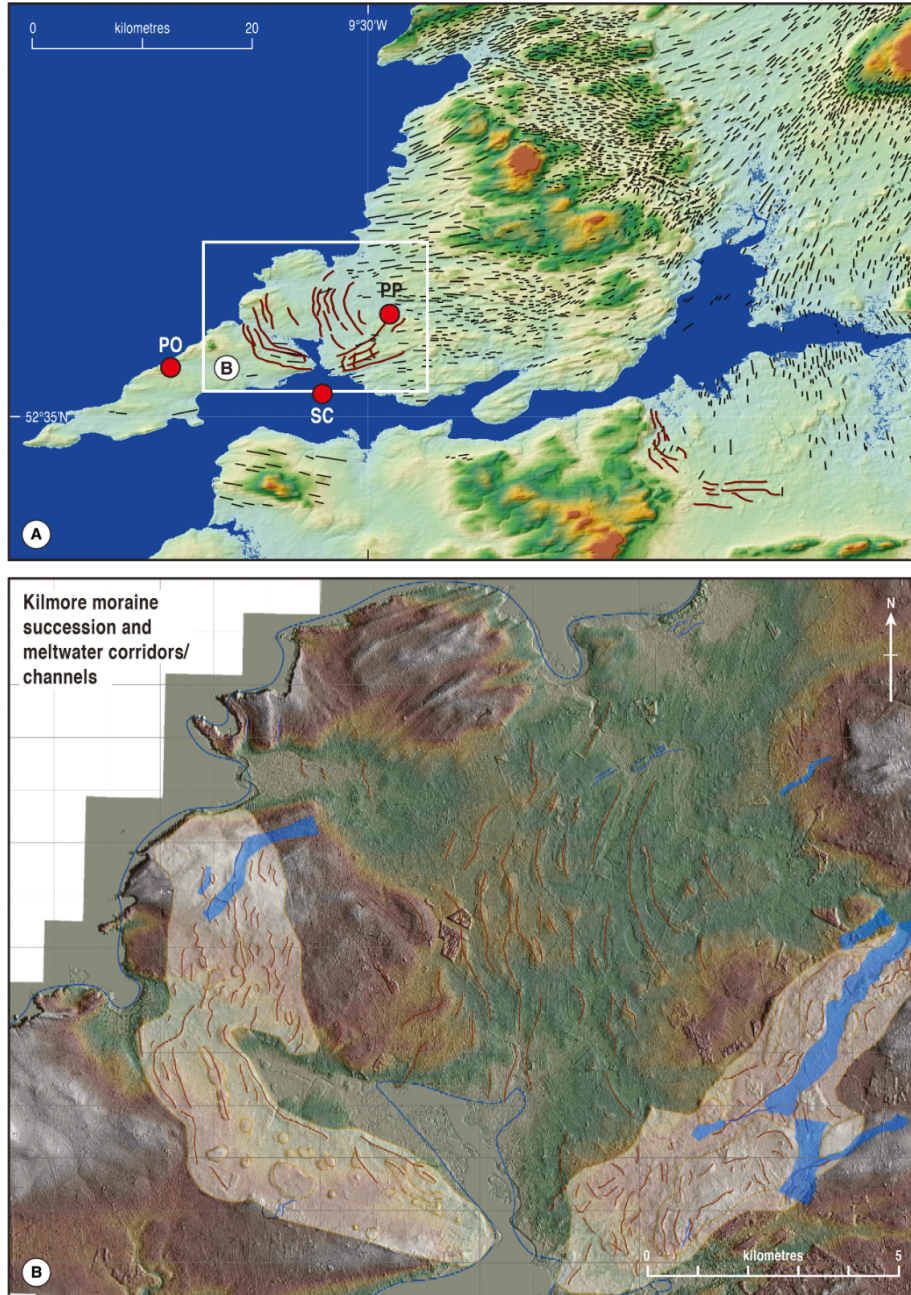


Figure 5: Map of south Clare, showing end moraines and drumlins. The lower figure shows a digital elevation map of the inset in the upper figure, indicating two moraine sequences between Kilrush (near left of scale bar) and Kilkee, whose bay is visible to the left of the left-hand moraine. Taken from D. H. Roberts *et al.*, *op. cit.*

topography, which consists of a series of moraines formed by the retreat of the Irish Ice Sheet after the last glacial maximum. Ice sheet coverage in Ireland has typically been portrayed as not completely covering the whole island, but the BRITICE project suggests that at last glacial maximum, the ice sheet actually extended in all directions far out over the continental shelf.

Roberts *et al.* state that “The terrain between Kilkee and Kilrush exhibits several linear and elliptical ridges running west to east that form a broad belt of hummocky terrain that can also be traced running northeast between Kilrush and Cooraclare. We term this the ‘Kilkee–Kilrush Moraine Complex’. To the southwest of Cooraclare well-developed hummocky terrain with occasional flat-topped mounds occurs up to 41 m a.s.l. Pynes Pit, located 1.7 km southwest of Cooraclare, is a sand and gravel quarry within one of these flat-topped mounds. Overall these landforms and sediments record moraine production and delta deposition at an ice margin that at times terminated in a glacial lake.”

The Greyhound

We will stop in the Greyhound in Kilkee for refreshments, which can range from coffee to soft drinks, Guinness, other beers, or wine; but any spirits, you will have to pay for yourselves. There should also be some of Mrs Moore’s fruit cake to sample. We will be there from about 12.30 till 2. For those averse to indoors pursuits of dubious merit, it is recommended to walk (north-east) along the coast as far as the memorial to PKA Andy Baur overlooking Chimney Bay; this takes about an hour there and back. Walk down to the beach, then go right, up on to the sea wall, past the pier, along the road to picnic tables, down and over the footbridge and veer left to avoid the golf course; at the top of the short climb you can cut across the peninsula (George’s Head) if you want, and then keep close to the cliff path. Near the memorial (~ 100 m inland from it) there are a couple of very small circular enclosures which may be tiny examples of ring forts or perhaps just animal enclosures. I think one of them may be a putting green.

We leave the Greyhound around 2 p.m. to walk up the cliffs. Eventually we will get to Dunlicky Castle. The walk is divided up into segments (see the itinerary), so that those so inclined can get the bus for parts of the way. Turn left from the pub and down to the road by the beach, and continue along the road to a car park and the Diamond Rocks café; this takes about 15 minutes. On the sea wall of the beach you will see a mural of the revolutionary Che Guevara, who visited Kilkee in 1961, and according to a plaque on the Strand Hotel (in the opposite direction along the beach), he stayed there. The story is that his plane (to the Soviet Union) was fogbound at Shannon, and he came out to Kilkee looking for connection with his Irish ancestry.

At the Diamond Rocks there is a statue of Richard Harris, actor and musician, who came to prominence in the 1963 film ‘This sporting life’ where he played a professional rugby league player in the north of England. Veterans of the 2008 IGS meeting in Limerick and its post-symposium tour will recall Paul Dunlop on the bus recounting the story of the film ‘The field’, largely shot near the village of Leenane beside Ireland’s fjord, Killary Harbour, and which starred Harris as Bull McCabe.

He was born in Limerick, but came out to Kilkee to play in the west Clare racquets championship, which he won for several years in the late 1940s. He was last seen on screen as Dumbledore in the first two Harry Potter films.

From the café, it is a 15 minute walk up to the high point. It is fairly dramatic, and there is a good path, with one fairly steep section (with a handrail). On the way there is one side track down a stairway to a sinkhole. From the top, we descend to the road, where the bus will be waiting. From here, we walk mostly along the road to Bishop's Island.

Bishop's Island



Figure 6: The Bishop's Island.

One of the more interesting aspects of the coastline is the erosional mechanism whereby numerous sea stacks are formed. Evidently caves are eroded and then tunnels. As these widen, eventually the rock mass above collapses, leaving the sea stack. Bishop's Island (figure 6) is one such sea stack, lying 100 m offshore, and so called because of the two ruins of small stone buildings on the island. These are the remnants of a small monastic settlement dating from early Christian times, and consist of a Gallarus type oratory (church) and a *clocháin*, or beehive dwelling hut.

In his book⁶, Wakeman writes: "Two very ancient dry stone buildings and two plain pillars are plainly visible at no great distance from the opposite cliff. The oratory is about 5.5×3.6 metres and the walls almost a metre thick, with a lintelled east window and south door. West from it lies a circular clochaun, 35 metres in circumference, with a domed roof built in stages externally, and a lintelled door to the east."

⁶W. F. Wakeman, *Archaeologia Hibernica*, Hodges and Figgis, Dublin, 1891.

Dunlicky Castle





Figure 7: Dunlicky Castle. Present day view and 19th century postcard. Illaunonearraun in background. Alignment of the two images is due to Felix Ng.



Figure 8: Another view.

Figure 7 shows a superimposition of the remains of Dunlicky Castle in postcards from the nineteenth century and as the same spot appears today. The castle was built for Turlough McMahon in the 1500s but was already in ruins by 1675. The reason seems to be that, although it was situated on a very exposed position, the structure was weak because the mortar was made of burnt and broken sea shells with sand and gravel. Nevertheless, parts remained intact up until the mid-twentieth century, when it became the pitiful stump it is now.

There is a short published description of the state of the castle in 1879 by Hewson⁷. Hewson refers to a photograph but it seems not to have been published. There is a later, more expansive pair of articles by Thomas Westropp⁸, who refers to Hewson's article, with (apparently) a completely wrong citation. Westropp's first article contains a lot of interesting information on Kilkee itself, and also on Bishop's Island.

A more recent and extensive account is by Chapple⁹. He quotes a description by Thomas O'Gorman in 1800 of the castle standing on a narrow neck of land with a large (6 m high) rampart extending from the walls to the cliff edges on both sides: thus, a promontory fort. Chapple includes a photograph from 1868/9 in which the tower seems complete, and four arches are visible, rather than the three in figure 8, and there is a sketch from 1857 in which an (east) face is visible on the other side of the tower.

⁷G. J. Hewson, *The Journal of the Royal Historical and Archaeological Association of Ireland*, (IV) **5** (42), 266-268.

⁸T. J. Westropp, *Kilkee (Co. Clare) and its neighbourhood. Part I. Kilkee to Cross. North Munster Antiquarian Journal* **2** (4), 212-228, 1913. Part II. *Kilkee to Cross. North Munster Antiquarian Journal* **3** (1), 38-52, 1913.

⁹R. M. Chapple, *Reconstructing the past: charting the destruction of Doonlicka Castle, Co. Clare*, *North Munster Antiquarian Journal* **40**, 53-62.



Figure 9: A Google Earth view of the sea stack Illaunonearaun. The ring fort Maigh Mhín is visible in the centre towards the bottom.

Maigh Mhín

After we leave Dunlicky Castle, we will hope to turn right, which will take us past a good view of the sea stack Illaunonearaun, and then just as the road bends to the left and away from the coast, there is a view from the road of a ring fort, which I call *Maigh Mhín* (flat plain). This is the Irish name for the local townland. I have been up to this ring fort, but it is not that exciting; it appears to be a circular earth rampart, with the remnant of a ditch (fosse) outside. We won't visit for technical reasons.¹⁰

There are something like 700 ring forts in Co. Clare alone. Ring forts are the most common monuments on the Irish landscape and are known by a variety of names, including *rath*, *dún*, *lios*, *cashel* and *caher*. They consist of an area, usually circular, enclosed by one or more earthen banks or, occasionally, by fosses, or by stone walls. They generally vary in size between 25 and 50 metres in diameter and were erected as protected enclosures around farmsteads, mainly during the Early Christian Period (*ca.* 500-1100 AD).¹¹ One of the best known is Caher Commaun, which lies further north in the Burren, an area of exposed limestone. That ring fort is a massive

¹⁰Ireland is rather bad for public liability. I asked the farmer if I could bring 50 people to look at it, and he said, not without public liability insurance. If someone falls over and breaks a leg, they can actually sue the farmer as if it is his fault. In Ireland there are unbelievable instances of such litigation. For example, a child aged nine was awarded €16,000 because it was locked in a room in a play centre for half an hour when it was five.

¹¹See <https://www.clarelibrary.ie/eolas/coclare/archaeology/ringforts.htm>.



Figure 10: Maigh Mhín ring fort on the ground.

three-walled stone structure, located on the edge of an escarpment, overlooking a ravine (which may be a former meltwater channel). It was excavated by a team from Harvard in 1934, and remains the only such fort in Clare to have been excavated.

Cahercommaun is well worth a visit, but is inaccessible to tour buses because of the two severe corkscrew bends on the single track road north from Kilnaboy. Similarly, access is obstructed from the village of Carran to the north. Carran itself is famous for the Carran *polje*, or turlough, an ephemeral lake which appears in the winter, and well viewed from the roadside pub. This karst region is full of underground cave systems, and the turloughs form when the subterranean drainage system effectively overflows.¹²

The various names for ring fort fins their expression in the place names of towns and villages. Thus *lios* makes its way to Lissycasey and Liscannor, similarly we have Rathkeale and Rathdrum, Dunlicky and Dunseverick, Cahir, Cahirciveen and Cashel.

¹²One of the more whimsical, but plausible, ideas concerning the landscape is that Tolkien took the name of Gollum from the huge cave system *Poll na gColm*, usually anglicised as Pollnagollum, meaning Colm's (or Gollum's) hole, or cave. Tolkien visited the area with his friend C.S. Lewis, and was certainly there frequently in the late 1940s and early 1950s, when he was writing *The Lord of the Rings*. Whether he visited in the 1930s (*The Hobbit* was published in 1937) is less clear. Incidentally, Poll na gColm was apparently first explored by T. J. Westropp (see footnote 8) in 1880.

Thursday

9.00 Giacomo Traversa, NRC Italy

Ablation areas in Antarctica: a hyperspectral analysis by in-situ and remote sensing observations

9.30 Valeria Di Biase, Utrecht

Antarctic firn aquifers: detection algorithm based on Monte Carlo simulations using satellite and regional climate model data.

10.00 Ted Scambos, Colorado

Ice shelf aquifers of melt and brine: a lot to explore

10.30 coffee

11.00 Nathan Teder, Adelaide

How swell instigated the Wilkins and Voyeykov calvings in 2007–2008

11.30 Hanwen Zhang, Oxford

Supraglacial lake drainage by tidally induced hydrofracture in Amery Ice Shelf grounding zone

12.00 Geoff Evatt, Manchester

A reassessment of ice cliff dynamics

12.30 lunch

2.00 Supratim Guha, Indian Institute of Technology, Roorkee

Quantification of topographical and morphological factors affecting glacier thinning in different Himalayan zones

2.30 Iain Moyle (Toronto), Andrew Fowler (Limerick), Mike Chapwanya (Pretoria), James Fannon (Met Éireann)

Drumlin: the movie

3.30 tea

4.00 Collin Schohn, Iowa

Stress-dependent rheology of warm, watery ice in tertiary creep

4.30 Neal Iverson, Iowa [invited]

Till under glaciers: dilation, pore-pressure feedback, and rate-weakening friction

6.00 bus into town from Stables. We then walk¹³ (1.3 km) from the Locke bar past St Mary's Cathedral, King John's Castle, and the Treaty Stone, to the Strand Hotel.

7 for 7.30 Conference dinner, Strand Hotel, Limerick

¹³Or you can stay on the bus.

Friday

9.00 Mikayla Pascual, Austin

Topographic and surface mass balance controls on Greenland glacier dynamics
in a coupled ice-sediment model

9.30 Luke Zoet, Madison

Constraining subglacial till properties from acoustic techniques

10.00 Adrian Luckman, Swansea

Diverse glacier surge dynamics in Svalbard suggest complexities in underlying
processes

10.30 coffee

11.00 General discussion

12.30: Lunch (Pavilion), followed by

2.00 exit