IGRM 2021

Programme and Abstracts

64th Irish Geological Research Meeting

25-26 February

MIC
MARY IMMACULATE COLLEGE
COLÁISTE MHUIRE GAN SMÁL

Department of GEOGRAPHY

IGRM 2021

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Welcome to the 64th annual Irish Geological Research Meeting!

When I first proposed MIC Limerick Geography Department hosting the IGRM, this isn't quite what I had in mind! This year's format is, of course, very different to anything we've done before. Hosting the conference online means we miss out on some of the most important aspects of conferences, particularly making it more difficult to catch up during coffee or the icebreaker. Poster presenters will miss out on many impromptu conversations. Some of you may miss talks due to clashes with teaching, as we decided to run the meeting mid-week to reduce screen fatigue.

However, the online format is not without benefits. In eliminating the need for travel and accommodation, I do hope that this year's conference will be more open and accessible to all. It also allowed a little more latitude - and longitude - in the choice of keynote speaker, and I am delighted to welcome Professor Paul F. Hoffman, who will be delivering his lecture to us from Victoria, British Columbia, Canada. Paul, who is best known for his work on the palaeogeography of the Proterozoic tectonics and the Neoproterozoic Snowball Earth, is one of the most influential geologists of our lifetimes, and I am only sorry he can't be here in Limerick with us. I'll get him to Ireland again!

I would like to thank the IGA for sponsoring prizes for the best student talks and posters. Eligible talks and posters are identified with a # beside the name. Thanks to our judges - Michèle Castiaux and Laura Smith of the IGA, Mike Simms of NMNI, and Angela Cloke-Hayes of MIC Geography. The announcement of winners will be made at the close of the conference.

Enjoy the meeting, and I look forward to welcoming you all to Limerick in person the next time we host the IGRM!

Breandán Anraoi MacGabhann, Lecturer in Geography, MIC Limerick

Cover photo: the Cambrian Booley Bay Formation, Co. Wexford.

Programme

Thursday 25 February 2021

1900 KEYNOTE LECTURE: **Professor Paul F. Hoffman**

School of Earth and Ocean Sciences, University of Victoria

Sturgis Hooper Professor Emeritus, Department of Earth and Planetary Sciences, Harvard University

On the freshwater ancestry of marine primary producers: a snowball Earth legacy and implications for the pre-Cryogenian marine fossil record

Programme

Friday 26 February 2021

1	Session Chair: Tiernan Henry and Fani Papageorgiou
0900	**Tellus Programme Update and New Old Data** James Hodgson and the Tellus Team – Ray Scanlon, Mairead Glennon, Emma Scanlon, Judith Mather, Vincent Gallagher, Michal Szpak, Margaret Browne, Mark Muller, Mohammednur Ture, and James Symons
0920	**The potential of Self-Organising maps clustering to characterise a harvested peatland using airborne radiometric data and a digital elevation model.** # David O'Leary, Stephen Monteverde, Oisín Callery, Mark Healy, Colin Brown, and Eve Daly
0940	**Representative groundwater flow parameters in complex systems: fractured bedrocks of Ireland** # John Paul Moore, David Ball, and Michael Gill
1000	**Poster Flash Talks**
1030	BREAK

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Programme

Friday 26 February 2021

2 Session Chair: Patrick Orr and Hilde Koch

1100 **The Joyce Country and Western Lakes geopark project; an asset and a facilitator for education and research.**
Benjamin Thébaudeau, Amrine Dubois Gafar and Siobhán Power

1120 **Hardcore Cork: Promoting Cork's Geological Heritage Through 3d Reconstructions And A Museum Exhibition**
Aude Cincotta and Thomas Heising

1140 **U-Pb ages of Carboniferous sedimentary phosphates from County Clare**
Gary J. O'Sullivan, J. Stephen Daly, John Murray, Aodhán Ó'Gogáin, David M. Chew, Eszter Badenszki, Brendan C. Hoare, Paul C. Guyett, and Foteini Drakou

1200 **First record of a conulariid from the Pennslyvanian (Bashkirian) of Ireland**
Eamon Doyle

1230 LUNCH

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Friday 26 February 2021

3	Session Chair: Koen Verbruggen and Anna Bidgood	
1330	**Marine litter accumulation in cold-water coral habitats: a comparative study of two Irish special areas of conservation, NE Atlantic**	
#	John K. M. Appah, O. Kileen, A. Lim, R. O'Riordan, L. O'Reilly, and A.J. Wheeler	
1350	**Variable stress state with depth in the shallow crust of the North of Hawke Bay, New Zealand**	
#	Effat Behboudi, D.D. McNamara, I. Lokmer, L.M. Wallace, and T. Manzocchi	
1410	**Emplacement and internal deformation of submarine landslides constrained by resistivity image log interpretation**	
#	Benjamin Couvin, David D. McNamara, Aggeliki Georgiopoulou, Lawrence A. Amy, and Joshu J. Mountjoy	
1430	**Replacement of calcite by rare earth carbonates; the formation of bastnäsite.**	
#	Adrienn Maria Szucs, Alexandra Stavropoulou, Claire O'Donnell, Seana Davis, and Juan Diego Rodriguez-Blanco	
1500	BREAK	

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Friday 26 February 2021

4 Session Chair: Bettie Higgs and Luke O'Reilly

1530 **Nitrate Sources in Rivers Shannon and Corrib**
Devin F. Smith, W.B. Lyons, S.A. Welch, P.L. Croot, S. Wheeler, T. Henry, and A.E. Carey

1550 **Integrated geophysical investigations of deeper stratigraphy of the Irish Rockall Basin from north to south**
Gaurav Tomar, Christopher J Bean, Brian M. O'Reilly, and Srikumar Roy

1610 **Carbonatites as chroniclers and critical resources: An example of the Gifford Creek Carbonatite Complex, Western Australia**
Paul Slezak, Carl Spandler, and Teimoor Nazari-Dehkordi

1630 **Lightly salted tetrapods: do Pennsylvanian coal swamp assemblages preserve a brackish ecosystem?**
Aodhán Ó Gogáin, Patrick N. Wyse Jackson, and John Murray

1700 CLOSE

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Posters

1 **The Geology Of The Carlingford Igneous Complex**

\# Eimear McKenna, John Reavy, and Kate Kiseeva

2 **Insights into preliminary procedures for estimation of soil pesticide risks in Irish grasslands using HAIR2014 tool**

Alina Premrov, Matthew Saunders, Jesko Zimmermann, and Jane Stout

3 **Catchment Characterisation: Hydrology of the Barna River, County Galway, Ireland**

\# Seán Haughton and Tiernan Henry

4 **A new specimen of *Petalodus* from the Mississippian of north County Kerry, Ireland**

\# Róisín Mooney, Aodhán Ó Gogáin, and John Murray

5 **Removal of Surface Waves From Active Seismic Records Using Seismic Interferometry**

Varun Kumar Singla and Ivan Lokmer

6 **New Mississippian fish microvertebrate assemblages spanning a deepening marine environment, from St. Brendan's Well, Co. Clare, Ireland**

\# Avery Fenton, Aodhán Ó Gogáin, Eamon Doyle, and John Murray

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Posters

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Abstracts

Oral Presentation abstracts
(in order of presentation)

KEYNOTE LECTURE

On the freshwater ancestry of marine primary producers: a snowball Earth legacy and implications for the pre-Cryogenian marine fossil record

Paul F. Hoffman*

School of Earth and Ocean Sciences, University of Victoria
Sturgis Hooper Professor Emeritus, Department of Earth and Planetary Sciences, Harvard University

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Molecular phylogenomic ancestral-state reconstruction suggests that many modern marine primary producers evolved in freshwater over most of their evolutionary history. This is surprising in view of the marine fossil record of cyanobacteria and algae back to at least 2.02 and 1.04 billion years ago, respectively. We can reconcile this apparent conflict by assuming that all modern organisms are derived from the survivors of Cryogenian snowball Earths, when phototrophy was limited to supraglacial meltwaters, meromictic ice-covered lakes, and certain hot springs. This suggests that most pre-Cryogenian marine fossils represent stem groups, lacking direct descendents in living taxa.

Tellus Programme Update and New Old Data

James Hodgson*
Tellus Team – Ray Scanlon, Mairead Glennon, Emma Scanlon, Judith Mather, Vincent Gallagher, Michal Szpak, Margaret Browne, Mark Muller, Mohammednur Ture, and James Symons

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It has been a busy 12 months for the Tellus Programme, Geological Survey Ireland's geochemistry and airborne geophysical national survey. The Covid-19 pandemic has had a major impact on the way Tellus has been able to work and we have had to adapt our approach to survey operations, resulting in modification of our original survey goals. Nevertheless, the survey has continued and we have undertaken new research work and released new data. The data are useful in helping to understand and map Ireland's rocks, soils and waters and are being further developed to produce useful products to the agriculture, mining and environmental sectors. In 2021 we plan to complete the surveys interrupted by Covid-19 as well as carry out a number of new surveys, working towards our goal of national coverage.

We are also pleased to announce the release of a lithogeochemistry dataset for southeast Ireland. This older lithogechemistry dataset, for samples collected in the period 1972 - 1993, has not been previously released. It has been recompiled and is now available for download from the Tellus website. This new 'old' data along with the existing Tellus stream sediment data and planned collection of soil samples from the southeast of Ireland will further assist our geological understanding of this region.

The potential of Self-Organising maps clustering to characterise a harvested peatland using airborne radiometric data and a digital elevation model

David O'Leary[1]*, Stephen Monteverde[2], Oisín Callery[1], Mark Healy[2], Colin Brown[1], and Eve Daly[1]

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Peatlands are recognized as important carbon sequestration centres. Through restoration projects where the water table is raised, they may become carbon neutral or negative. Restoration projects require a knowledge of intra-peat variation across potentially large areas. This is difficult with traditional in-situ point measurements. The integration of multidimensional geophysical datasets, digital elevation models, and modern data analytical techniques may provide a means of accessing intra-peat variation. Here, Tellus airborne radiometric survey combined with a DEM, is used to delineate areas of similar peat within an industrial peatland. Radiometric data are suited to peat studies as peat acts as a low signal environment where variations in the signal are linked to intra-peat variation of thickness, density, and water content. This study uses an unsupervised machine learning clustering to group the site into three zones interpreted as 1) the edge of the bog where peat layer is thinning and influence on the radiometric signal from non-peat soils, 2) the normal peat conditions where peat physical properties appear as a relative constant, and 3) areas where the peat is either thinner or drier. A ground geophysical survey was conducted to verify this interpretation. Future work will see this methodology extended to other peatlands.

Representative groundwater flow parameters in complex systems: fractured bedrocks of Ireland

John Paul Moore[1]*, David Ball[2], and Michael Gill[3]

1. Fault Analysis Group & ICRAG, School of Earth Sciences UCD.
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Groundwater in fractured hard rocks (with negligible primary porosity) mainly occurs in fracture systems, making its presence and movement highly heterogeneous, generally complex and difficult to predict. Despite this complexity and uncertainty, continuum or bulk parameter approaches to hydraulic parameterisation, including basing analytical and numerical solutions on Darcy's Law, are still the norm, with limited consideration of the errors arising from associated assumptions. In this talk, a more pragmatic approach to hydraulic investigation and parameterisation is suggested, based on hydraulic connectivity and groundwater flows and levels over time. In a pumping test scenario for example the pertinent hydraulic parameters are those only of the perturbation and response: the cumulative pumped flow, the impact on groundwater levels and pumped flow rate over time, at the particular locations and under concurrent weather conditions. Contrary to bulk parameter approaches, the presented approach explicitly allows for the greater error associated with not assuming that flow and level measurements are just location and time specific samples of the hydraulics of the 4D fluid system being investigated in fracture flow systems. The empirical nature of the approach reinforces the importance of constraints on geological as well as hydraulic controls on flow in complex systems.

The Joyce Country and Western Lakes geopark project; an asset and a facilitator for education and research

Benjamin Thébaudeau[1]*, Amrine Dubois Gafar[1,2] and Siobhán Power[2]

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The Joyce Country and Western Lakes (JCWL) geopark project 2020-2021 is an initiative led by Geological Survey Ireland and funded by Project Ireland 2040 under the Rural Regeneration Development Fund (RRDF) with significant contributions from Údarás na Gaeltachta, Mayo and Galway county councils and other partners. The aim of the project is to apply for UNESCO Global Geopark status at the end of 2021 and become the newest Irish member of this international network by 2023.
The JCWL region is well-known to geologists, particularly in Ireland, Britain, and North America, for having the most complete record of the Grampian-Taconic orogeny. Outcrops of note include Connemara Marble, the Lakes Marble in Cur Hill and the pillow basalts of the Lough Nafooey Arc. In addition, the region also has Ireland's only fjord at Killary Harbour, along with many other glaciological features in the region, and the karst and epikarst landscape on the shores of Loughs Carra, Mask and Corrib.

This talk will introduce how the geopark project aims to foster and facilitate the organisation of student fieldtrips, mapping projects and research projects' fieldwork by providing the link to accommodation providers, landowners, and any other local resources at our disposal.

Hardcore Cork: Promoting Cork's Geological Heritage Through 3D Reconstructions and a Museum Exhibition

Aude Cincotta[1]* and Thomas Heising[2]

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2. 2D/3D/Motion Graphics Designer, Cork.

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The history of Cork city is strongly linked to its landscape and therefore its geology. It is no wonder why the city was named the 'Great Marsh of Munster', it was indeed built on marshy islands of the River Lee. Three main lithologies can be identified in Cork city and its surrounding areas: Devonian sandstones, Carboniferous limestones and Quaternary tills. The geological history of the country can be traced in Cork through the observation of rock outcrops, historical buildings and other structures such as paving stones, fountains and bridges.

Our geoheritage project, funded by Geological Survey Ireland, aims at making geology fun to the general public, especially families. It includes walking tours through the city, highlighting Cork's geological heritage and a small-scale museum exhibition where visitors will interact with the main lithologies. A website will expand upon this by giving users options for exploring Cork's geoheritage through animations, illustrations and interactive narratives. Through this platform we will show how prehistoric Cork might have looked like through 3D, 360°-rendered reconstructions of the three palaeo-environments. Visitors will also be able to explore key geoheritage sites via the 3D reconstructions and be directed to the locations on the walking tours through the website.

U-Pb ages of Carboniferous sedimentary phosphates from County Clare

Gary J. O'Sullivan[1], J. Stephen Daly[1], John Murray[2], Aodhán Ó'Gogáin[2], David M. Chew[3], Eszter Badenszki[1], Brendan C. Hoare[3], Paul C. Guyett[3], and Foteini Drakou[3]

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We present U-Pb ages of authigenic apatite from Carboniferous phosphate nodules, phosphorites and phosphate cements developed in the Clare Shale Fm and underlying carbonate units in north Co. Clare. Our samples are from outcrop at St Brendan's Well near Lisdoonvarna, and from a borehole drilled to the north of Kilfenora. We can demonstrate that phosphate chemistry is consistent with petrographic interpretations, meaning that the age information contained within phosphate corresponds to very early diagenetic processes, and thus to its chronostratigraphic position.

Ages of phosphate are significantly different in the lower part of the Clare Shale Fm. Sampled at Kilfenora, the base of the formation (the Cahermacon Member) yields Serpukhovian U-Pb ages. The Cahermacon Member is overlain by the Phosphate Member and phosphorite grainstones from the latter at both Kilfenora and St Brendan's Well yield much younger lower Bashkirian U-Pb ages. We therefore propose that a significant disconformity is present immediately below the Phosphate Member across northern Clare, corresponding to the Serpukhovian-Bashkirian stage boundary, and thus the Mid-Carboniferous (Mississippian-Pennsylvanian) boundary.

Integration of U-Pb isotopic and trace element information to prove fidelity of phosphate ages to early diagenetic processes has not been demonstrated before. This promising new technique could provide viable stratigraphic ages from phosphatic sediments.

First record of a conulariid from the Pennslyvanian (Bashkirian) of Ireland

Eamon Doyle*

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The recent discovery of a conulariid (cnidaria, scyphozoa) in the Central Clare Group (Pennsylvanian, Bashkirian) of County Clare, Ireland is the first known find of any conulariid in Ireland for over one hundred years, and the only known record from Pennsylvanian aged rocks in Ireland. The specimen is not preserved in life position and exhibits signs of post-mortem exfoliation due to weathering and/or microbial degradation as well as possible annelid, sponge or bryozoan borings. This taphonomy suggests exposure on the seafloor for some time before burial, indicating a period of low or negative sedimentation during the overall high rate of sedimentation of the Central Clare Group. Despite the overall poor preservation of the specimen it preserves details of the typical mineralised thecal structure that has given rise to doubt over the phylogenetic position of conulariids, currently assigned by most to the scyphozoans.

Integrated geophysical investigations of deeper stratigraphy of the Irish Rockall Basin from north to south

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The Irish Rockall Basin is vastly unexplored as compared to the UK sector, where extensive flood basalt lava flows, sill complexes and volcanic centers of Late Cretaceous-to-Early Eocene age have been described, which belong to the North Atlantic Igneous Province (NAIP) (Archer et al., 2005). An integrated study of seismic, gravity and magnetic methods elucidates the deeper stratigraphy of the Irish Rockall Basin. Because of the sill intrusion, deeper image of the Rockall Troug is often poor, therefore we performed gravity modelling along with the seismic to investigate the deeper part in the basin. We perform first arrival travel time tomography on a downward continued data set of three seismic profiles to model the velocity of the sedimentary structures down to 6 km depth. The modelling results indicate that the Moho depth varies from 12 km to 20 km depth beneath ~10 km thick sediments in the basin. This allows us to measure the crustal stretching factor β. We observe the minimum stretching factor in the basin between ~7 in the north to ~6.5 in the south. These values are within the range needed for mantle serpentinisation (O'Reilly et al., 1996; Perez-Gussinye and Reston, 2001). Furthermore, we observe four volcanic ridges in the south part of the basin, which are ~20 km wide and ~ 3 km thick, possibly comprising the Barra Volcanic Ridge System (BVRS) (Scrutton and Bentley, 1988). Results indicate several failed rifting attempts times in late Mesozoic/early Cenozoic times, generating significant basic

volcanism, associated with the NAIP. We resolve new volcanic ridges (of late Mesozoic/early Cenozoic age) in the southern part of the Rockall Basin, which could be of late Cretaceous age like those found on the conjugate Canadian margin.

Variable stress state with depth in the shallow crust of the North of Hawke Bay, New Zealand

Effat Behboudi[1,2]*, D.D. McNamara[3], I. Lokmer[1,2], L.M. Wallace[4,5], and T. Manzocchi[1,2]

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Knowledge of the in situ stress state is critical for a better understanding of deformation, tectonic regime, and earthquake processes in seismically active margins such as the Hikurangi Subduction Margin (HSM), New Zealand. In this study, we quantify stress magnitudes and orientations from borehole data to infer possible tectonic regimes experienced in the northern HSM. Relative stress magnitudes indicate the contemporary tectonic regime in the shallow crust (above ~600m) is predominantly normal ($S_v \geq S_{hmin}$). However, as depth increases, relative stress magnitudes suggest a compressional tectonic regime ($S_{Hmax} > S_v \approx S_{hmin}$). The S_{Hmax} orientation inferred from borehole breakout azimuths below ~600 m is 064° ± 18° (NE-SW). This S_{Hmax} orientation is consistent with ENE-WSW maximum contraction directions, long-term ENE-WSW convergence of Pacific plate under New Zealand's north island, and shallow crust (<600 m) NE-SW striking normal faults in the region. However, this S_{Hmax} orientation is inconsistent with the NE-SW strike trend of upper-plate, blind compressional faults identified from seismic reflection data. This suggests that the deeper tectonic regime is oblique with a strong NE directed strike-slip component. Normal stress tectonics in the shallower depths may be related to rapid uplift and collapse, or extension localised to the tops of large scale antiforms.

Replacement of calcite by rare earth carbonates; the formation of bastnäsite

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The interaction of rare earth bearing (La, Nd, Dy) aqueous solutions with calcite crystals at was studied at ambient and hydrothermal conditions (25-220 °C). This reaction resulted in the solvent-mediated surface precipitation and subsequent pseudomorphic mineral replacement of calcite by rare earth carbonates. Calcite grains were replaced from their periphery inwards, and the newly formed REE-bearing carbonates follow the crystallisation sequence lanthanite [$REE_2(CO_3)_3 \cdot 8H_2O$] -» kozoite [orthorhombic $REECO_3(OH)$] -» hydroxylbastnäsite [hexagonal $REECO_3(OH)$]. The specific rare earth involved in these processes and the temperature have a significant role in the polymorph selection, crystallisation pathways and kinetics of mineral replacement. La- and Nd-bearing kozoite, grows oriented onto the calcite surface, forming an epitaxy, due to their structural similarities. This phase forms elongated crystals on [100], with the {011} and {0-11} as major forms. The epitaxial relationship is (104) [010]cc||(001) [100]koz and is strongly dependent on the ionic radius of the rare earth in the structure of kozoite. These results have strong implications for the understanding of mineralisation reactions occurring in REE-bearing carbonatite deposits during hydrothermal and metasomatic processes, the most important resources of rare earths in the world.

Carbonatites as chroniclers and critical resources: An example of the Gifford Creek Carbonatite Complex, Western Australia

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Carbonatites are uncommon igneous rocks comprising >50% primary carbonate minerals. Their unique mineralogy, which often includes REE-bearing minerals with affinities for U and/or Th, makes them important sources for critical metals as well as excellent geochronological archives. The Gifford Creek Carbonatite Complex (GCCC), located in Western Australia, is composed of carbonatites, phoscorites, silica-rich alkaline veins, and their associated alteration assemblages. These rocks contain abundant monazite and apatite, making the complex prospective for Pr and Nd. Uranium–Pb analyses on carbonatitic zircon yielded an emplacement age of ~1370 Ma. However, U–Pb analyses on monazite and Sm–Nd isochrons from monazite-apatite pairs resulted in a range of dates, some as young as 815 Ma, nearly 550 Ma younger than the ages yielded by zircon. The monazite and apatite $\varepsilon_{Nd}(t)$ data demonstrate this large time span is not recording additional magmatism. Instead, it represents partial recrystallisation/resetting of these minerals in a closed system. This means the GCCC is recording multiple geologic events beginning with its emplacement at ~1370 Ma, which corresponds to the break-up of Nuna, to tectonism related to the assembly and disassembly of Rodinia.

Nitrate Sources in Rivers Shannon and Corrib

Devin F. Smith[1]*, W.B. Lyons[1], S. A. Welch[1], P. L. Croot[2], S. Wheeler[2], T. Henry[2], and A. E. Carey[1]

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Efforts to comply with the European Water Framework Directive have focused on reducing nitrate concentrations in Irish rivers and prompted research investigating nutrient fluxes and sources. Stable isotopes of nitrate ($\delta^{15}N\text{-}NO_3$ and $\delta^{18}O\text{-}NO_3$) serve as natural environmental tracers at the catchment scale to discern river nitrate sources and transformation. During four campaigns conducted in 2018–2020 we sampled eleven rivers in catchments of the Rivers Shannon and Corrib to discern sources of nitrate in the mainstems and tributaries. Our $^{15}N\text{-}NO_3$ (5.05‰ – 10.75‰) and $\delta^{18}O\text{-}NO_3$ (-1.09‰ – 6.13‰) signature data suggest that nitrate has two main sources in the Rivers Shannon and Corrib: manure and soil organic nitrate (SON). Correlation of $^{15}N\text{-}NO_3$ with landcover showed peatland-dominated subcatchments had SON signatures ($R^2 = 0.33$) and pastureland-dominated subcatchments had manure signatures ($R^2 = 0.58$). Nitrate fluxes ranged from <0.01 kg/d to 95 kg/d in the Rivers Shannon and Corrib and their tributaries. Results expand knowledge of the positive relationship between nitrate flux and agriculture in Ireland and revealed the subcatchments where peatland-derived nitrate fluxes are dominant. Rivers with peatland-derived nitrate, including the upper Shannon, should be monitored to determine if extreme precipitation leads to nitrate flux increase.

Emplacement and internal deformation of submarine landslides constrained by resistivity image log interpretation

Benjamin Couvin[1], David D. McNamara[2], Aggeliki Georgiopoulou[3], Lawrence A. Amy[1] and Joshu J. Mountjoy[4]

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Submarine creeps are slow-moving mass movements occurring on the seafloor. Their internal mechanics is still little understood. In this study we analyse borehole resistivity image data from four submarine landslide examples from around the world in order to describe and compare their internal structure and their fine-scale deformation, and to understand better their mechanical behaviour. Data has been analysed from mass-transport deposits (MTD) at IODP drilling sites C0018 (Nankai Trough), U1520 and U1517 (Hikurangi Margin), and U1324 (Gulf of Mexico). At all sites, dip directions and dip angles of bedding planes and fracture planes were interpreted from sinusoidal resistive or conductive anomalies in borehole image logs. We find that, while at all sites bedding dips are generally low angle and do not show any particular folding trend, fracture dips display distinct patterns from one sedimentary unit to another. At sites located on active margins, fracture orientations show trends that are specific to each MTD unit and that are distinctly different from those in the background sedimentary sequences. Results suggest that deformation took place in the MTD deposits after their initial emplacement. At sites U1517 and U1324, fractures are more numerous at specific intervals. Such fracture clusters were not observed at the Nankai Trough slide or within the Ruatoria debris flow (Site U1520). We interprete brittle deformation at Nankai and Ruatoria to be induced by gravitational relaxation of the slide mass after initial emplacement.

Marine litter accumulation in cold-water coral habitats: a comparative study of two Irish special areas of conservation, NE Atlantic

John K.M. Appah[1]*, O. Kileen[1], A. Lim[1], R. O' Riordan[1], L. O'Reilly[1], and A.J. Wheeler[1,2]

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Marine litter threaten the development of marine organisms globally, but little is known about its distribution and impacts in the deep seas. Cold-water corals (CWCs) have come under threat from anthropogenic activities such as marine pollution. They are vulnerable marine ecosystems that are protected under the EU Habitats Directive with some designated as Special Areas of Conservation (SAC). The present study aims to understand the importance of CWC habitats on the distribution of marine litter within two SACs on the Irish Atlantic margin. Data on marine litter were collected in summer from remotely operated vehicle surveys in the Porcupine Bank Canyon (PBC) and the Belgica Mound Province (BMP). The survey depth ranged between 582-2,126 m in the PBC and 800-1,100 m in the BMP. The density, abundance and composition of litter were characterised and quantified. Sixty-two litter items were observed in the canyon while 49 were detected in the BMP. Fishing gear (80.7%) was the most abundant litter item identified in the PBC followed by plastics (11.3%) whereas plastics (55.1%) and buoy (14.3%) were commonly found in the BMP. Comparatively, we notice that the composition of litter is different in both SACs, drawing the need for different management strategies.

Lightly salted tetrapods: do Pennsylvanian coal swamp assemblages preserve a brackish ecosystem?

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The Pennsylvanian was an important time in the colonisation of land and the establishment of tetrapod-dominated terrestrial ecosystems. Our understanding of these early ecosystems is dominated by lagerstätten-quality coal swamp assemblages, some of which have been interpreted as being deposited in abandoned oxbow lakes (e.g. Jarrow (Ireland), Newsham (England) and Linton (Ohio)). These sites have traditionally been interpreted as autochthonous assemblages, preserving tetrapods living in freshwater riverine and lacustrine settings. This is based primarily on the presence of terrestrial plant material and an assumption of shared physiology between early tetrapods and modern lissamphibians.

This 'traditional view' is open to question. The sedimentology of the Jarrow and Newsham Coal Seams refute the idea that the tetrapods from these assemblages were preserved within an abandoned channel. Fossil tubeworms (microconchids) are found in abundance at Jarrow and Linton, suggesting that the depositional environment was influenced, at least in part, by the marine. This is further supported by the cosmopolitan nature of the fish fauna from Jarrow. Additionally the Jarrow, Linton and Newsham tetrapod faunas are dominated by taxa which have been considered to be partially euryhaline. Therefore it is suggested that the faunas of Jarrow, Newsham and Linton may represent brackish, estuarine communities.

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Abstracts

Poster Presentation abstracts
(in list numerical order)

The Geology of the Carlingford Igneous Complex

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The Carlingford Igneous Complex (CIC), Co. Louth, is part of the British-Irish Palaeogene Igneous Province[1], and characterised by bimodal mafic/felsic magmatism, a layered gabbro intrusion[2], and a cone-sheet swarm.
The main purpose of this fieldwork was to provide a detailed geological map showing the spatial distribution of each lithology, understand the construction of the complex and produce a 3-dimensional model.
Petrographical investigations (Raman Spectroscopy Mapping) were used to detail the accessory mineral budget as well as identify mineral phases of the gabbro layers. From the combination of data it became possible to produce a series of cross-sections and an interpretation of the geological history. The intrusion sequence deduced from mapping is (1) granite, (2) gabbro, (3) cone-sheet swarm, however abundant field evidence shows the co-existence of mafic and felsic magmas since multiple granite injections occurred during the emplacement of gabbro. Four distinct gabbro units have been identified. Within each unit there is evidence for modal and rhythmic layering, within each unit being defined by an olivine and augite-rich base and a plagioclase-rich top. The inward-dipping mafic sheets form a cone-sheet geometry and were emplaced from varying sections of a centrally located stratified magma chamber.

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Insights into preliminary procedures for estimation of soil pesticide risks in Irish grasslands using HAIR2014 tool

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This study aims to contribute to the modelling of risks for pesticide use in Irish agriculture under the larger PROTECTS research project (https://protects.ucd.ie/). The procedures for estimating pesticide terrestrial risks (i.e. earthworm terrestrial risk-indicators) in Irish grassland soils using the HAIR2014 tool [1] for Glyphosate active ingredient (AI) usage are assessed. The current work to refine HAIR2014 for Irish conditions includes (among others) upgrading the spatial (GEO) database, climate data inputs and 'crop-regions' for Ireland. Future developments include refinements on soil- and land-use (LU) inputs, as well as on the AI usage/application data-inputs derived from national-survey data on of plant-protection products (PPPs) usage for Ireland. A compound-database for the selected AIs will also be developed. The aim is to generate outputs that will inform an area-based risk assessment (based on PPPs usage, LU and other conditions), as well as developing recommendations for potential future soil-monitoring and sampling needs in Ireland.

ACKNOWLEDGEMENTS: Thanks go to Irish Department of Agriculture, Food and the Marine (DAFM) for funding the PROTECTS project, as well as to Mr James Quirke and Mr Mike Broderick (DAFM).

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Catchment Characterisation: Hydrology of the Barna River, County Galway, Ireland

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The observation, documentation and analysis of hydrological data are key for understanding flow regimes which occur at the catchment scale. The hydrological dynamics present in Galway Bay consist of a complex mix of arterial and subterranean freshwater flow regimes which support a diverse range of terrestrial, intertidal, and marine ecosystems. The Barna River Catchments represents one of the many surface water systems which overlay the Galway Granites on the northern side of Galway Bay. The Barna River, which flows from North To south directly between the main boundaries of the greater Galway urban area and rural County Galway, is a small and relatively complex regime. The complexities of this system were analysed through a combination of observational field methods and remote research techniques. The proximity of Galway City to the Eastern branch of the river, in tandem with moderately intensive land use, were found to have impacts on the natural dynamic of the flow regime. Flooding, soil saturation, possible water contamination were observed with more frequency with closer proximity to urban areas. The variability observed in precipitation amounts across the wider Galway region during this study also highlighted how and why localized flash flood events are notoriously difficult to predict.

A new specimen of *Petalodus* from the Mississippian of north County Kerry, Ireland

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Petalodontiforms are a clade of cartilaginous fish, which were major components of Late Paleozoic marine fish communities. With the exception of rare body specimens, petalodontiforms are known mostly from disarticulated teeth. This is particularly true for *Petalodus*, which is one of the most common and cosmopolitan genus of petalodontiform. The teeth of petalodontiforms are distinct as they possess large petal- or shovel-shaped crowns with deep roots.

Here, a new specimen of petalodontiform (TCD. 31087) is reported from a disused coastal quarry at Doon Point, near Ballybunion in north County Kerry. The quarry section reveals a series of interbedded basinal limestones and shales which are assigned to the Corgrig Lodge Formation and considered latest Viséan in age (within the Brigantian regional substage). TCD. 31087 preserves a (rarely seen) series of teeth which were scanned using micro-computed tomography. Resultant CT-slices were rendered in SPIERS to produce 3D models from which the anatomical characters were described. The crowns of the teeth are petal-shaped and labio-lingually flattened, with concave lingual surfaces. Cristae are present towards the base of the crowns, with the crown-base over twice the width of the roots. TCD.31087 is identified as *Petalodus cf. ohioensis* and the relative completeness of the specimen allows for tooth variation within *Petalodus* to be assessed, which is highly important for petalodontiform taxonomy.

Removal of Surface Waves From Active Seismic Records Using Seismic Interferometry

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The imaging of the subsurface using the reflection data of active seismic sources is hindered by the presence of surface waves, where these waves mask the reflection events owing to their significantly large amplitudes. The conventional methods for removing the surface waves (such as f-k "velocity" filtering) often fail in the presence of shallow structural complexities found commonly in onshore sites. Seismic interferometry is a data-driven method that offers a viable alternative for removing the surface waves. In this method, the reflection data of several sources is considered and for each source, the signals at a pair of receivers are cross-correlated. The cross-correlated signals of all the sources are then summed up (or "stacked") to obtain the “interferometric” signal for the considered receiver pair. The interferometric signal, being dominated by surface waves, is then adaptively subtracted (or "filtered") from the original records. This study highlights the limitations of the conventional interferometric approaches and proposes an alternative technique that can remove the surface waves more effectively.

New Mississippian fish microvertebrate assemblages spanning a deepening marine environment, from St. Brendan's Well, Co. Clare, Ireland

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The upper Mississippian limestones of the Burren region record a complex pattern of sea-level cyclicity, thought to be at least in part influenced by glacioeustatic fluctuation. The termination of carbonate deposition in the Serpukhovian is associated with a presumed deepening event, culminating in widespread deposition of the organic-rich Clare Shale Formation. This transition is well displayed at St. Brendan's Well, near Lisdoonvarna in Country Clare, and the carbonate units (Slievenaglasha and Magowna formations) immediately underlying the Clare Shale Formation were investigated for phosphatic microfossils, principally fish microvertebrate material.

Three new fish assemblages are reported here from the top of the Slievenaglasha Formation (Lissylisheen Member) and the bottom and top of the Magowna Formation. The latter unit is quite condensed at St. Brendan's Well and only c.69cm thick. All three sample horizons are dominated by conodont, chondrichthyan and actinopterygian material; however, a noticeable difference in faunal composition and abundance is evident moving stratigraphically upwards through the sequence, most likely due to deepening conditions. Of special note within the fish fauna is the xenacanthiform *Triodus*. This particular taxon is present in the base

and top of the Magowna Formation, interpreted as representing relatively shallower and deeper marine conditions, respectively. Xenacanthiforms have traditionally been considered to be restricted to freshwater ecosystems, which is not supported by this study.

The Jarrow microsaur is actually *Keraterpeton galvani*

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The Jarrow Assemblage (Langsettian, Pennsylvanian) from the Leinster Coalfield preserves an important collection of early tetrapods in coal and shale. Despite the importance of this fossil assemblage in our understanding of early tetrapod evolution and terrestrilisation, it remains understudied. This is principally due to the taphonomy of the fossil specimens which have been highly altered. As a result, published faunal compositions for the Jarrow Assemblage commonly include taxa which have not been formally described, but which have been tentatively interpreted by those authors as potentially new taxa. This is the case for colosteid, embolomere and microsaur vertebrate group material from Jarrow.

NMS.1967.13.2, which preserves an articulated skull and vertebral column, is the only Jarrow specimen which had been assigned in the literature to the microsaurs, as *Microbrachis*. In this study, NMS.1967.13.2 was scanned using micro-computed tomography allowing a 3D model to be rendered in SPIERS. CT-slices reveal that the specimen has vertebrae with high, fan-like neural arches. This is not a feature of microsaurs, but is a characteristic of nectrideans. The presence of long tabular horns in the skull and a long retroarticular process in the lower jaw indicate that NMS.1967.13.2 is, in fact, *Keraterpeton galvani*, one of Huxley's original tetrapods from Jarrow. This finding demonstrates that microsaurs are absent from the Jarrow Assemblage.

Trust and perception: key challenges facing geoscientists in practice and in Irish society

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Fostering and increasing public trust in geoscience is essential to empower stakeholders to make better informed decisions about the various complex environmental issues facing society. This project assessed public perception of, and trust in, geoscience and geoscientists by investigating how members of the public view geoscience and geoscientists in Ireland. Through a series of semi-structured interviews, trust in geoscientists was explored and compared to other professionals such as environmental scientists. Statements were extracted from the transcripts of the interviews and compiled into a shortlist, incorporating the key areas of trust, scientists, geoscience, environmental science, and engineering. The statements were chosen to represent the full spectrum of opinions surrounding trust in and perception of scientists and formulated a Q-sort survey which was circulated to various stakeholders. The results from the Q-sort survey, coupled with the thematic analysis of the semi-structured interviews provide a basis for reflection by the geoscience community. It is hoped that the outcomes will offer insights into how the geoscience community can enhance their standing in the public eye, can foster public trust and recognition, and be seen as informed and reliable actors in Irish society.

Rainfall as a trigger for Volcanic Activity: Analysis of Historic Eruption Records

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Rainfall can influence the strength of a rock in terms of its compressive strength, its elasticity, and its ability to withstand stress. There is a large body of work that documents a relationship between rainfall and volcanic eruptions due to this effect on the volcano's lithology. Studies tend to rely on very specialised and high-resolution datasets such as seismic data on volcanoes that have extensive, long-term monitoring stations. This project was undertaken to determine if it was possible to detect a relationship between rainfall and volcanic activity for a broad range of volcanoes using low resolution, easy to access data. It was found that Klyuchevskoy Volcano showed the most potential for there being a relationship between precipitation and eruptions out of the four volcanoes analysed. It had the highest proportion of eruptions preceded by extreme rainfall, a preference (to the $+1\sigma$ level) for eruptions occurring during the wet season, and a potential regional relationship between precipitation and eruptions. With better precipitation data, this method can possibly be applied to many volcanoes around the world. With the onset of anthropogenic climate change increasing the frequency of extreme weather events and influencing global precipitation patterns, it is important to understand if this will then result in a corresponding increase in rainfall induced volcanic activity.

The Geology of the Glentrasna area, Co. Galway

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The Glentrasna area was chosen for this undergraduate research as it affords study of a great variety of intrusive units. An early suite of gabbros and quartz diorites, part of a Grampian age continental arc system, shows complex internal contacts with the quartz diorite intruding and disrupting the gabbro. This suite was later intruded by the Caledonian Galway Granite which was emplaced northward in several stages. This mapping project focuses on the complex geological interactions that are associated with these intrusions. Field-based aspects of this project include the mapping of approximately 14 sq. km around Glentrasna, an analysis of magmatic fabrics including megacrystic alignments, solid state quartz ribboning and an extensive study of the zone around the prominent Shannawona Fault. Distinct granite units have been identified that reflect the punctuated phases of magmatism that occurred during batholith emplacement from the southwest.

Use of 3D photogrammetry for advancing seabed mapping techniques for deep-water habitat classification in Submarine Canyons

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Submarine canyons and cold-water corals (CWC) are key components of ocean ecosystems due to their complex geomorphology and their role in nutrient supply dynamics. As three-dimensional structural habitats, there is a need for robust and accessible technologies to enable more accurate representations and assessments of these environments. The use of Remotely Operated Vehicles (ROV) and Structure-from-Motion (SfM) photogrammetry combined represent an effective and non-destructive method that yields high-resolution reconstructions of deep-sea environments such as cold-water coral habitats and submarine canyons. This research focused on the application underwater photogrammetry to improve seabed classification techniques on the Porcupine Bank Canyon (PBC), located at approx. 300 km offshore Ireland. We have developed a classification scheme in different habitats within the canyon which will aid the understanding of the main environmental patterns of distribution of CWC within the canyon. Three binary classification methods were applied, namely: Multiscale geometrical classification (MGC), Colour and Geometrical classification (CGC) and Object-based classification (OBIA) for the baseline method.

The application of these methodologies brought novelty to the study because, although these approaches are well stablished in other fields such as terrestrial image analysis, they had not yet been applied to marine environments. We analysed the classification accuracy results, overall performance and the potential loss of information when using 2D and 3D data. Our results showed that 3D the MGC method outperforms the CGC methods. However, each method has advantages for specific applications pertinent to the wider marine scientific community. Results suggest that advancing from commonly employed 2D image analysis techniques to 3D photogrammetry classification methods is advantageous and may provide a more realistic representation of cold-water coral habitats.

The Impact of Thermal Plumes on Aquifer Properties and Ground Water Quality

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ATES technology has yet to be introduced to the UK and Ireland. The Sherwood Sandstone aquifer presents a suitable opportunity in the Belfast. However, this aquifer is also used for potable water supplies in the Belfast area, so impacts of ATES require investigation.

The thermal plumes discharged into the "warm well" of an ATES system are not only likely to reduce aquifer porosities & permeabilities by facilitating inorganic precipitation and secondary mineralisation but also by promoting microbial activity within the aquifer, with the additional biomass adding to the reduction of aquifer porosities. This in turn may affect the overall efficiency and sustainability of the duplet Geothermal installation and reduce the sustainable yield of the groundwater body for water supplies. The influence of thermal plume temperature ranges on sustainability requires investigation and modelling.

This research study will combine the baseline characterisation of the aquifer system by completing a series of active well geophysical measurements, hydraulic tests, hydro chemical sampling and microbial profiling with the long-term monitoring of experimental thermal injection tests at varying temperatures. Down hole temperature monitoring will be conducted using multi-mode fibre optical cable as part of a distributed temperature sensing system and bio geophysical monitoring of microbial activity using borehole magnetic resonance logging. Collected monitoring data will be integrated into heat transport models using FeFlow.

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