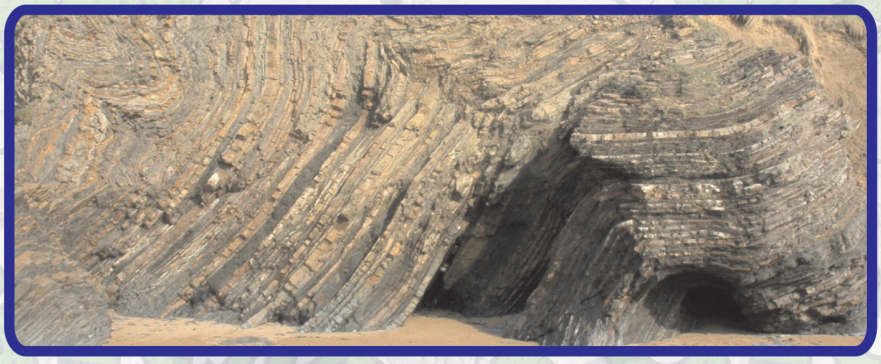
Irish Geological Research Meeting

Celebrating 60 Years of Research by Geoscientists in Ireland

Trinity College Dublin
The University of Dublin

4th and 5th March, 2017

Abstracts Volume



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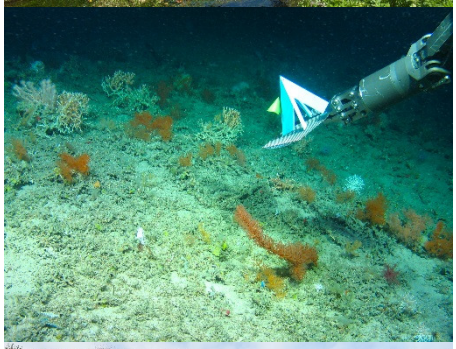
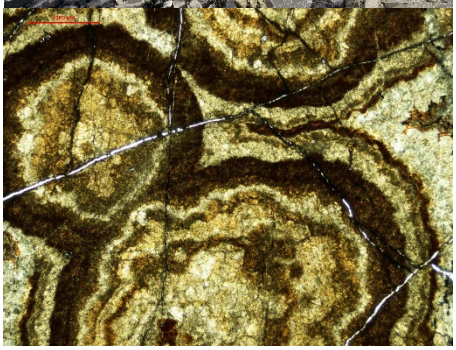
iCRAG
IRISH CENTRE FOR RESEARCH IN APPLIED GEOSCIENCES

Irish Geological Association

iCRAG IRISH CENTRE FOR RESEARCH IN APPLIED GEOSCIENCES

Established in 2015, iCRAG is the national geosciences research centre, bringing together expertise from seven major institutes: University College Dublin, Trinity College Dublin, Dublin Institute for Advanced Studies, University College Cork, National University of Ireland Galway, Maynooth University and Teagasc. Comprising 150 researchers, and collaborating with more than 50 industry partners, iCRAG's principal aim is to ensure research results are, insofar as possible, embedded within industry. In this way, the Centre ensures maximum impact of its research output; both scientifically for the wider geosciences and economically for the island of Ireland.





iCRAG is structured around four major research fields – raw materials, marine geoscience, groundwater and hydrocarbons. Each of these areas is further supported by four research platforms in the areas of geophysics, geochemistry, 3D modelling of the subsurface of Ireland, and the public perception and understanding of geosciences. The Centre is dedicated to facilitating a collaborative environment, allowing for the invaluable cross-fertilisation of ideas between disciplines.

Collectively, iCRAG research will help to unlock Ireland's natural resources through developing improved technical knowledge and innovative techniques, which will then increase the success rate of hydrocarbon, mineral and groundwater exploration. This will, in turn, stimulate and incentivise greater investment in Irish exploration, providing commensurate improvement in Ireland's potential to discover and develop offshore oil and gas resources, and onshore mineral wealth and groundwater supplies. Security of supply of clean water and energy, which together with the enhanced educational and training environment and improved geosciences information that iCRAG will provide, will be the principal societal benefits of iCRAG work.

iCRAG is funded by Science Foundation Ireland, the European Regional Development Fund and industry partners from the applied geosciences sector. With a total funding of €26 million from 2015 to 2020, it represents the largest investment by the State in applied geosciences in Ireland.

For more details of iCRAG and our current **open call for proposals** on "Social Licence of Geoscience Activity and Development of Earth Resources" visit **icrag-centre.org**.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund.

IRISH GEOLOGICAL RESEARCH MEETING

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Trinity College Dublin
The University of Dublin

TECHNICAL PROGRAMME

***Venue:** The Ed Burke Lecture Theatre & Foyer, Arts Block, Trinity College, the University of Dublin (see map on last page of programme outline)*

FRIDAY 3rd MARCH

16:30 – 17:30	***Early Registration and Poster Assembly***
18:00 – Late	'Icebreaker' Reception in 'J.W.Sweetman's Craft Micro-Brewery' by O'Connell Bridge

SATURDAY 4th MARCH

08:30 – 09:20	***Registration and Poster Assembly***

09:20 – 09:30	***Welcome***

Session 1	
09:30 – 09:45	**Nils Suhr** (TCD): 'Isotopic evidence for active weathering in the deeper parts of the critical zone'
09:45 – 10:00	**Bebhinn Anders** (iCRAG/NUIG): 'Variations in sand supplied to a prograding delta: provenance of the Mullaghmore Sandstone Formation, NW Carboniferous basin, Ireland'
10:00 – 10:15	**Kieran Craven** (MU/GSI): 'Supervised classification of continental shelf sediment off western Donegal'
10:15 – 10:30	**Eva Eibl** (UCD/DIAS): 'Silent magma flow follows a tremor-rich dyke formatin during the Bárdarbunga eruption in Iceland'
10:30 – 10:45	**Sean Kelly** (NUIG): 'High resolution monitoring of a coastal, brackish lagoon, reveals long-term stratification dynamics, deep anoxia and irregular mixing events'
10:45 – 11:00	**David McNamara** (NUIG): 'Exploring New Zealand's subsurface using borehole images'

11:00 – 11:30	***Coffee, Tea and Posters***

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Session 2	
11:30 – 11:45	**Jiulin Guo** (iCRAG/UCD): 'Structural model of the Lough Allen basin: implications for shale gas exploration and production'
11:45 – 12:00	**Roisin Kyne** (iCRAG/UCD): 'What controls the formation of Irish-type deposits? A segmented fault array story'
12:00 – 12:15	**Stephen Coakley** (TCD): 'Trace elements as a proxy for basin restriction across an Ordovician carbonate platform, San Juan Fm., Argentina'
12:15 – 12:30	**Nicolas Celli** (DIAS/TCD): 'Waveform tomography of the North Atlantic region'
12:30 – 12:45	**Èlia Cantoni** (iCRAG/TCD): 'Climate change impacts on groundwater recharge to Irish fractured-bedrock aquifers'
12:45 – 13:00	**Zsuzsanna Tóth** (ICRAG/UCC): 'Esker ridges and seismostratigraphic evidence for a southerly ice flow extending onto the present nearshore continental shelf of the Celtic Sea, SE Ireland'

13:00 – 14:00	***Lunch and Posters***

Session 3	
14:00 – 14:15	**Ian Sanders** (TCD): 'Why does $\Delta^{17}O$ correlate with FeO in ureilite meteorites?'
14:15 – 14:30	**Eoin Wynne** (NUIG): 'Metal occurrences , sources and mobilisation processes in groundwater associated with Irish mines'
14:30 – 14:45	**Chris Mark** (TCD): 'Lower-crustal thermochronometry: apatite Pb-profiling by LA-MC-ICPMS'
14:45 – 15:00	**Kishan Soni** (iCRAG/UCD): 'Hierarchical characterisation and modelling of submarine channels: insights from wider literature, 3D seismic data compression-based object modelling'
15:00 – 15:15	**Sabrina Renken** (TCD): '"Bipolar Seesaw" or "Push and Pull"?: Potential further evidence that abrupt climate events in the eastern North Atlantic can also be out of phase with the Greenland Ice Core record'
15:15 – 15:30	**Koen Torremans** (iCRAG/UCD): 'Controls on spatial metal distributions in Irish-type deposits'

15:30 – 16:00	***Coffee, tea and Posters***

Session 4	
16:00 – 16:15	**Raffaele Bonadio** (DIAS): 'Structure of the lithosphere-asthenosphere system in the vicinity of the Tristan da Cunha hot spot as seen by surface waves'
16:15 – 16:30	**Patrick Roycroft** (IFHC/UCD/NMI): 'Cotterite: Historical review; extant specimens; etymology of 'Cotterite'; new observations on the Cotterite texture'
16:30 – 16:45	**Edward Lewis** (IGS/BGS): 'Exploration targeting for gold and base metals in Ireland using semantic technology: Deposit models and prospectivity analysis'
16:45 – 17:00	**Dimitra Salmanidou** (UCD): 'Slope collapse and tsunami generation at the Rockall Bank slide complex, NE Atlantic Ocean'
17:00 – 17:15	**Sean Blake** (TCD/DIAS): 'Modelling and monitoring geomagnetic storms and their effects in the Irish power network'
17:15 – 17:30	**Brendan Hoare** (TCD): 'Ancient subduction recorded in the sub-continental lithospheric mantle of the North Atlantic craton, Greenland'

19:00 – Late	Conference Dinner at the **Harcourt Hotel**, Harcourt St., (a short walk south from TCD)

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SUNDAY 5th MARCH

08:45 – 09:15	***Posters***

Session 1	
09:15 – 09:30	**Dónal O'Farrell** (TCD): 'Chlorine isotope composition of the proto-Iceland plume source mantle'
09:30 – 09:45	**Sarah Donne** (DIAS): 'The Ocean Pressure Profile (OPP): An experiment to try to understand how energy is transferred from ocean waves to the solid Earth in the Northeast Atlantic, west of Ireland'
09:45 – 10:00	**Lewis Whiting** (iCRAG/UCD): 'Early Cretaceous stratigraphic response to hyperextension, Porcupine basin, Irish Atlantic margin'
10:00 – 10:15	**Valentina Rossi** (UCC): 'Significance of melanosomes in fossil vertebrate soft tissues: Insights from morphology and trace element chemistry of melanosomes'
10:15 – 10:30	**Thomas Farrell** (DIAS): 'A geophysical perspective on the Galway Granite'
10:30 – 10:45	**Rebecca Bradford** (GSI): 'GWFlood: Monitoring, modelling and mapping groundwater flood hazards in Ireland'

10:45 – 11:15	***Coffee, Tea and Posters***

Session 2	
11:15 – 11:30	**Mike Simms** (UM): 'An expanding impact crater in Scotland: Implications for the Moine Thrust'
11:30 – 11:45	**Carolina Rosca** (TCD): 'Reconstructing Zn pollution sources in the Irish atmosphere from its biogeochemistry in ombotrophic peat'
11:45 – 12:00	**Peter Heath** (GSI): 'Tellus what's happening! An update on the Tellus Project, future plans and current research'
12:00 – 12:15	**Vassilis Papanikolaou** (UCD): 'Fault representation in Production Simulation Models: Sensitivity to grid structure'
12:15 – 12:30	**Jessica Franklin** (iCRAG/NUIG): 'Exploring the primary controls on sandstone reservoir quality in the Slyne basin, offshore western Ireland'

12:30 – 12:45	**Clare Stead** (TCD): 'Rare Earth Element behaviour in olivine: Insights from partitioning and diffusion'
12:45 – 13:00	**Florian Le Pape** (DIAS): 'Ocean wave-induced seismic noise offshore Ireland: Observations and simulations'

13:00 – 14:00	***Lunch and Posters***

Session 3	
14:00 – 14:15	**Nidia Alvarez Armada** (UCC): 'The colour of ancient insects: Insights from synchroton X-ray fluorescence'
14:15 – 14:30	**John Conneally** (iCRAG/UCD): 'Precursor monoclines and segmented fault geometry'
14:30 – 14:45	**Gary O'Sullivan** (TCD): 'Combined apatite U-Pb and trace element analysis – a detrital provenance case study from the Tarn, France'
14:45 – 15:00	**Deirdre Walsh** (iCRAG/UCD): 'A new workflow for generating low amalgamation, high net:gross geomodels constrained to well data'
15:00 – 15:15	**Aggeliki Georgiopoulou** (UCD): 'High-resolution geological and biological mapping of submarine landslide scarps: Results from the SORBEH project'
15:15 – 15:30	**Pierre Arroucau** (DIAS): 'Towards a better characterization of Ireland's seismicity'

15:30 – 15:45	***Announcement of Student Prizes, Close of Meeting***

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IGRM 60

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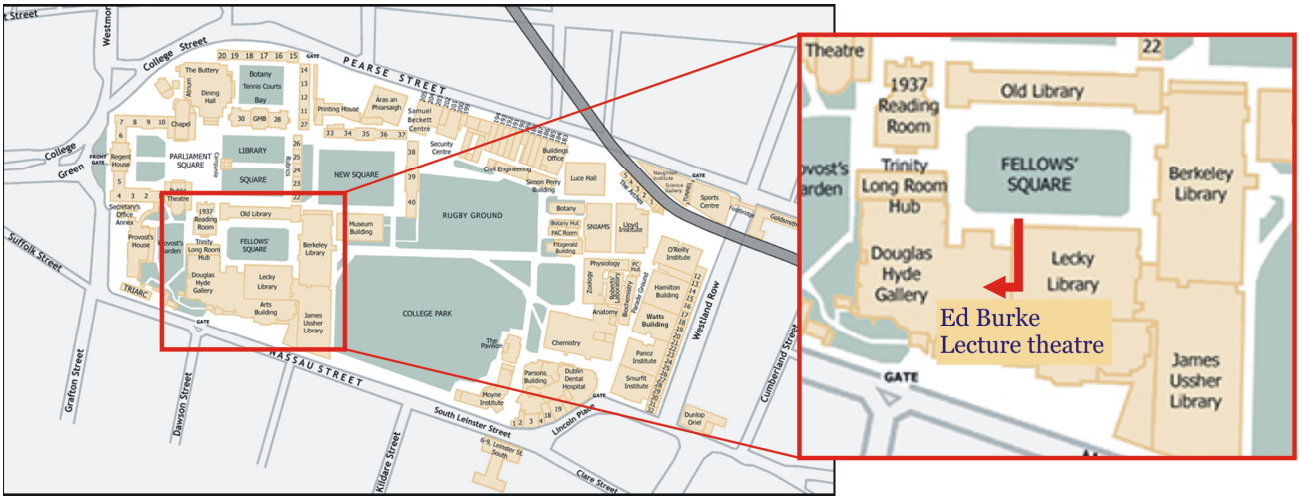
The conference venue for both talks and poster presentations is the Edmund Burke Lecture Theatre & Foyer in the Arts Block, main TCD Campus. Entrance is through the glass doors beneath the Lecky Library, situated on the southern side of Fellows' Square, directly opposite the Old Library with its prominent 'Book of Kells' banners. Once through the doors, turn immediately right and down the steps to the Ed Burke area:



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Oral Abstracts

(in order of presentation)

IGRM 60

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GSNI Geological Survey of Northern Ireland Celebrating 70 years: 1947–2017

BOLIDEN Tara Mines

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Isotopic evidence for active weathering in the deeper parts of the critical zone

Suhr, N.[1]*, Widdowson, M.[2], McDermott, F.[3], Kamber, B.S.[1]

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[2] *Department of Geography, University of Hull, Cottingham Road, Hull, HU6 7RX, UK*

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The critical zone (CZ) is part of the outermost layer of the Earth in which complex interactions between rock, soil, water, air and living organisms occur. It extends from the vegetation canopy to the bottom of the ground water active zone. Most chemical weathering studies to date have focused on the shallowest, most strongly weathered parts of the CZ. These studies have documented complex soil formation. Chemical weathering in the deeper parts of the CZ, where rock transforms into saprolite, however, have not been studied often, even though there is increasing awareness that solutes in rivers and oceans derive from mineral breakdown in regoliths within the deep CZ. Here we present U series systematic on a sub-recent regolith from Chhindwara, India. It displays a clear overall loss of U (elevated Th/U) and preferential 234U-deficit (low 234U/238U activity) attributable to chemical weathering. Importantly, the 234U-deficit in this profile explains the substantial 234U-excess in seawater and provides evidence for active continental nutrient supply to the oceans. Having documented the clear mineralogic and chemical difference between the breakdown of primary minerals (and glass) to clays in saprolite and the formation of secondary oxi-hydroxides in regolith and laterite, it is now possible to clearly separate the effects of these unrelated mineralogic reactions on the topical metal stable isotope systematics. In this study, the contrasting fractionation in Zn isotopes was investigated.The results provide evidence that the formation of clays in the Chhindwara saprolite does not lead to significant isotopic fraction of δ66Zn and lies within the "crustal average" of 0.2-0.3 ‰. Thus, the continental nutrient supply of Zn to rivers and oceans is not accompanied by enhanced isotopic fractionation, whereas δ66Zn values that depart from the "crustal average" of 0.2-0.3 ‰ are likely unrelated to the natural supply of Zn from continents.

Variations in sand supplied to a prograding delta: provenance of the Mullaghmore Sandstone Formation, NW Carboniferous Basin, Ireland

Anders, B.[1]*, Tyrrell, S.[1,3], Murray, J.[1,3], Graham, J.R.[2], Mark, C.[2,3], and Chew, D.[2,3]

[1]*Earth and Ocean Sciences, School of Natural Sciences, National University of Ireland, Galway, Ireland*

[2]*Department of Geology, Trinity College Dublin, Dublin [2], Ireland*

[3]*Irish Centre for Research in Applied Geosciences (iCRAG)*

**corresponding author: bebhinn.anders@nuigalway.ie*

The aim of this study was to investigate the sedimentary infill of the NW Carboniferous Basin (NWCB), initially focussing on the Viséan Mullaghmore Sandstone Formation (MSF), Co. Sligo. The specific objective here is to constrain links between sediment supply and the depositional architecture of this ancient fluvial/deltaic system through sedimentological and provenance analysis thus helping to reconstruct the palaeogeography of the NWCB and its hinterland, while shedding light on the evolution of this sedimentary system through time.

Detailed sedimentological logging and high resolution sampling has carried out through a complete section of the MSF. A multi-proxy provenance approach, using optical microscopy, scanning electron microscopy, major and trace element whole rock data, U-Pb zircon and Pb-in-K-feldspar analysis, has been employed. This approach integrates provenance information from labile and stable mineral phases (feldspar and zircon respectively), maximising insight into variations in sand supply. Results suggest a large-scale sedimentary supply system, with derivation from multiple sources to the north of the NWCB during the mid-Viséan, including sediment from elsewhere in NW Ireland, NW Scotland and, potentially, eastern Greenland. The provenance signal appears to fluctuate throughout the sampled interval with supply varying from a 'mixed' to a more unimodal signal, coincident with changes in facies.

This project is funded through the Geological Survey of Ireland shortcall programme (project code: 2015-sc-029).

Supervised classification of continental shelf sediment off western Donegal

Kieran Craven[1,2]*, Stephen McCarron[1], Xavier Monteys[2]

[1] *Maynooth University Geography Department, Maynooth, Co Kildare*

[2] *Geological Survey Ireland, Dublin 4*

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Managing human impacts on marine ecosystems requires natural regions to be identified and mapped over a range of hierarchically nested scales. In recent years (2000-present), the Irish National Seabed Survey (INSS) and Integrated Mapping for the Sustainable Development of Ireland's Marin Resources (INFOMAR) (Geological Survey Ireland and Marine Institute collaborations) have provided unprecedented quantities of high quality data on Ireland's offshore territories. However, the increasing availability of large, detailed digital representations of the seafloor requires the application of objective and quantitative analyses

This study presents results of a new approach for sea floor sediment mapping based on an integrated analysis of INFOMAR multibeam bathymetric data, backscatter data and sediment groundtruthing over the continental shelf, west of Donegal. It applies the image classification software eCognition to provide a supervised classification of the surface sediment. This approach can provide a statistically robust, high resolution classification of the seafloor. Initial results are promising and indicate a methodology that could be used during physical habitat mapping and classification of marine environments.

Silent Magma Flow Follows a Tremor-rich Dyke Formation during the Bárdarbunga Eruption in Iceland

Eva P. S. Eibl[1,2], Christopher J. Bean[2], Kristín S. Vogfjörd[3], Yingzi Ying[1], Ivan Lokmer[1], Martin Möllhoff[1,2], Gareth S. O'Brien[4], Finnur Pálsson[5]

[1]*School of Earth Sciences, University College Dublin, Belfield, Dublin 4, Ireland*

[2]*now at: Geophysics Section, School of Cosmic Physics, Dublin Institute for Advanced Studies, 5 Merrion Square, Dublin 2, Ireland*

[3]*Icelandic Meteorological Office, Bústaðavegi 7 - 9, 108 Reykjavík, Iceland*

[4]*Tullow Oil, Leopardstown, Dublin 18, Ireland*

[5] *Institute of Earth Sciences, University of Iceland, Askja, Building of Natural Sciences, Sturlugata 7, 101 Reykjavík, Iceland*

**corresponding author: eva.ps.eibl@hotmail.com*

Volcanic eruptions have an effect on inhabitants, livestock, industry and environment. In order to mitigate the effect of an eruption, for example by timely evacuation, early-warning tools are developed. Volcanic eruptions are mostly preceded by an increase in number or magnitude of an observable. In seismology this observable can be an increase in number and magnitude of earthquakes. In August 2014 Bárdarbunga volcano in Iceland showed signs of unrest, as earthquakes propagated away from the volcano at 3 to 8 km depth. Two weeks later, at about 48 km distance, an eruption started.

This earthquake propagation was accompanied by a long-lasting, emergent seismic signal that is called tremor. This tremor is usually interpreted as being linked to and generated by the flow of magma. However, during the Bárdarbunga eruption we detected no tremor along the dyke while magma flowed laterally. Instead we conclude that tremor is linked to the gradual opening of a dyke at shallow depth and that the magma itself is flowing silently. We base this conclusion on results from array processing (using a cluster of seismometers), an amplitude location method and numerical simulations.

High resolution monitoring of a coastal, brackish lagoon, reveals long-term stratification dynamics, deep anoxia and irregular mixing events

S. Kelly[1], [2]*, E. De Eyto[2], M. Dillane[2], R. Poole[2] , G. Brett[1], and M. White[1]

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Low dissolved oxygen concentrations are of increasing concern in aquatic environments, with hypoxic conditions predicted to become more common with environmental change. Lough Furnace, Co. Mayo is an example of a rare and protected macro-tidal coastal lagoon of high ecological importance.

Physico-chemical parameters for Furnace were assessed using daily observations (2009-2014) from an undulating CTD profiler and through observations of exchange flow with Clew Bay. Permanent vertical stratification exists, with a strong halocline formed by freshwater input from catchment runoff and deeper tidal advection of saline coastal water. Anoxic conditions persist below 6m.

A simple salinity budget, based on observations of volume fluxes in/out of the main Lough and assuming 100% exchange between in/outflow, suggests a minimum residence time in the Lough of 3 months; limited exchange between upper and lowers layers suggests that this residence time is significantly underestimated.

Analysis of wind forcing on the stratified Lough structure indicates that vertical mixing between the upper and lower layer may occur during prolonged periods of low freshwater runoff and elevated wind speeds. The ability to identify and forecast such events is especially important for stably stratified water bodies with deep anoxia, with implications for resident ecological communities.

Exploring New Zealand's Subsurface Using Borehole Images

D.D. McNamara[1]*, A.G. Griffin[2], M.J.F. Lawrence[2], C. Massiot[2], S. Milicich[2], J. Williams[3]

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Borehole imaging has been used since the 1950's to capture vital geological information on the lithology, structure, and stress conditions of the Earth's subsurface. In New Zealand borehole image logs are utilised to explore a number of geological settings related to resources and hazards.

Analysis of image logs from East Coast Basin petroleum wells, combined with other geophysical logs, allows assessment of the in-situ the stress field. This data has provided insights into sedimentary basin overpressures and offers insight into what effects subduction zone dynamics have on the stress distribution in the shallow crust.

Borehole image logs in geothermal wells in the Taupo Volcanic Zone (TVZ) provide the first, direct, structural orientation measurements in New Zealand geothermal reservoirs. While data confirms a structural pattern aligned to regional tectonics, heterogeneities are characterised and assessed for impact on geothermal fluid flow pathways. Analysis of stress induced borehole features displays a local scale variation in the horizontal stress field orientation of this extensional tectonic area.

Lastly borehole images acquired during the Deep Fault Drilling Project have captured the structural architecture of the Alpine Fault, providing insights into the damage zone surrounding the principal slip surface of this plate bounding fault.

Structural model of the Lough Allen Basin: implications for shale gas exploration and production

Jiulin Guo* & John Walsh

Irish Centre for Research in Applied Geoscience (iCRAG), University College Dublin, Belfield, Dublin, Ireland

**corresponding author: Cole.jguo@icrag-centre.org*

The Lough Allen Basin of NW Ireland preserves a considerable thickness of Lower Carboniferous shales widely recognised for their shale gas potential. A 3D tectonostratigraphic model has been developed for the basin from available seismic, aeromagnetic data and geological mapping constraints. The model shows that the basin is principally of Lower Carboniferous age, with associated growth sequences extending from perhaps uppermost Devonian times through to the top of the Lower Carboniferous. Displacement transfer between opposed dipping basin-bounding faults generates complex internal fault systems, characterised by rhombohedral and conjugate geometries. The Carboniferous basin geometry is largely controlled by pre-existing structure with normal faults parallel and adjacent to major pre-existing Grampian-Caledonian terrane boundaries. The two main bounding faults have been subjected to multiple reactivations which extend into Tertiary times during which sinistral strike-slip reactivations of several hundreds of metres arise from Alpine-related N-S compression. Our study of the basin suggests that fault reactivation has created a complex system of faults and fractures, some of which will be conductive, with many seismically mappable faults breaching overlying sequences. This structural complexity far exceeds that of US shale gas basins, with potential negative implications for flow connectivity from prospective shale-gas reservoirs to shallower groundwater aquifers.

What controls the formation of Irish-type deposits? A segmented fault array story

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Using 3D models of the Lisheen and Silvermines deposits, we constrain the nature and scale of fault segmentation, relay ramps geometries and breaching as a means of understanding the controls exhibited by these structures on mineralisation.

3D models of both deposits show the presence of segmented fault arrays with varying degrees of relay ramp breaching. The degree of breaching is determined by the scale of the segmented fault array (fault separation vs. displacement) and exhibits control over the localisation of ore-forming fluids. Larger scale, intact relays separate ore zones, while smaller scale, strongly breached relays provide conduits for up-fault fluid flow.

3D analysis has led to the following conclusions: 1) ramps with fault separations 600-1000m are not breached and focus fluids laterally into segmented faults, 2) ramps with fault separations 300-600m are incipiently breached both focusing fluids laterally into the segmented faults but also into the breaching fault itself and 3) ramps with fault separations <300m are fully breached act as conduits for upwelling fluids. Thus, at multiple scales, these segmented fault arrays are responsible for the emplacement and spatial location of mineralisation within Lisheen and Silvermines and play a key role in the development of Irish-type Zn-Pb deposits.

Trace elements as a proxy for basin restriction across an Ordovician carbonate platform, San Juan Fm, Argentina

Stephen P. Coakley*[1], Balz S. Kamber[1], David A. Fike[2], Catherine V. Rose[1]

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[2]*Department of Earth and Planetary Sciences, Washington University in St. Louis, St. Louis, MO 6313O, USA.*

**corresponding author: coakleys@tcd.ie*

Sulphur isotope records (δ34S) provide important insight into biogeochemical cycling and are used to reconstruct surface redox conditions and microbial activity over geological time. However, δ34S records often exhibit stratigraphic and lateral variability between coeval locations, which is poorly understood. Records from carbonate associated sulphate (δ34SCAS) in the Lower to Middle Ordovician San Juan Formation of the Argentine Precordillera vary by as much as 10‰ from coeval records. These data have been interpreted as representing a global ocean with low sulphate concentrations and a deep-water euxinic reservoir.

The San Juan Formation records a transgression with variable wave-reworked, reef-associated, and undisturbed carbonate facies. We present trace element data with paired δ13C, δ18O and δ34SCAS records from the Cerro La Silla section. The rare-earth element and yttrium (REE + Y) data lack a positive europium (Eu) anomaly, indicating either an oxidising ocean that prevents Eu transport from hydrothermal sources, or a basin isolated from the open ocean and from hydrothermal Eu inputs. These REE + Y data also show a signature considered typical of a partially restricted basin, which may provide an alternative explanation for variability in the coeval δ34SCAS record through the Lower to Middle Ordovician.

Waveform Tomography of the North Atlantic Region

Nicolas Celli[1,2*], Sergei Lebedev[1], Andrew Schaeffer[3], Carmen Gaina[4]

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The enormous volumes of newly available, broadband seismic data and the continuing development of waveform tomography techniques present us with an opportunity to resolve the structure of North Atlantic and Arctic at a new level of detail. Dynamics of the Mid Ocean Ridge and the Iceland Hotspot, evolution of the passive margins, and the nature of the upper-mantle flow beneath these regions are some of the important fundamental problems that we can make progress on using new, more detailed and accurate models of seismic structure and anisotropy within the lithosphere and underlying mantle. We assemble a very large waveform dataset including all publicly available data in the region, from both permanent and temporary seismic networks and experiments conducted in Northern and Western Europe, Iceland, Canada, USA, Greenland and Russia. The tomographic model is constrained by vertical-component waveform fits, computed using the Automated Multimode Inversion of surface, S and multiple S waves. Each seismogram fit provides a set of linear equations describing 1D average velocity perturbations with respect to a 3D reference velocity model within an approximate sensitivity volume between the source and receiver. The equations are then combined into a large linear system and jointly inverted for a model of shear- and compressional-wave speeds and azimuthal anisotropy within the lithosphere and underlying mantle. The isotropic-average shear speeds reflect the temperature and composition at depth, offering important new information on both regional- and basin-scale lithospheric structure and evolution. Average S-wave velocity profiles for the oceanic lithosphere as a function of its age show significantly slower lithospheric cooling in the North Atlantic compared to the global trend. This comparison offers an insight into the dynamic effects of the hotspot activity in the North Atlantic region.

Climate change impacts on groundwater recharge to Irish fractured-bedrock aquifers

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The hydrogeology of Ireland is characterized by fractured bedrock aquifers with low storativity, which are often overlain by glacial tills. To estimate groundwater recharge a set of recharge coefficients have been established based mainly on the properties of the till cover, especially its hydraulic conductivity and thickness. These coefficients are then applied to the hydrologically-effective rainfall to calculate potential recharge. Finally, a recharge cap is applied for those aquifers with limited storage capacity to assess actual recharge.

Climate change is expected to impact on groundwater recharge as a consequence of variations in temperature, rainfall distribution and intensities. For this reason, the sensitivity of the recharge estimates to different meteorological and geological variables has been investigated. The meteorological variables include rainfall amount, its intensity and seasonality, whilst the geological variables include the recharge coefficients and recharge caps. The recharge estimations and sensitivity analysis were carried out by combining a GIS tool and water budgeting methods. The results from three study catchments with contrasting hydrogeology suggest that in some areas of the country, geological factors will have a greater influence on the recharge amounts than future climate variations.

Esker ridges and seismostratigraphic evidence for a southerly ice flow extending onto the present nearshore continental shelf of the Celtic Sea, SE Ireland

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New evidence is presented supporting a southerly flowing ice mass extending beyond the present coastline onto the Irish continental shelf in the Celtic Sea during the last glaciation. The Celtic Sea likely experienced ice-marginal oscillations and multiple phases of ice cover from different sources of the British-Irish Ice Sheet. Ice flow directional information is however sparse in the south of Ireland. The nearshore area in the Celtic Sea between Dungarvan and Waterford Harbour was mapped using seismo-acoustic data, and the multibeam bathymetry data produced by the INFOMAR programme. The acoustic data reveal evidence of glacial activity in the area: several valleys and depressions cut into the bedrock, and a buried esker-like ridge at the base of a ~20 m deep depression. This ridge is oriented in an N-S direction and its length can be traced for 6 km. Two other elongate linear ridges are observed on the seafloor in the bathymetry data NNE and NNW from the buried ridge. These are oriented in a NNE-SSW and N-S direction and are 6-7 km long. We interpret these ridges as eskers deposited behind the northwards retreating ice margin or a locally formed lobe in an inward-transgressive manner.

Why Does Δ17O Correlate with FeO in Ureilite Meteorites?

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Ureilite meteorites are abundant, carbon-rich, harzburgite-like meteorites, interpreted as mantle residues from a partially melted asteroid. The mantle was heterogeneous. FeO/MgO varies from one ureilite to another (0.03 to 0.35) and so does FeO/MnO (3 to 57). The two correlate suggesting that FeO in olivine was variably reduced to molten metal by carbon and lost. The discovery later that Δ17O also varies (-2.5 to -0.2) and correlates with FeO/MgO challenged the reduction model. Variation in Δ17O must be a primary feature inherited during parent body accretion so FeO/MgO must also be primary. But why do they correlate? Guided by similar Δ17O-FeO/MgO-MnO/MgO trends among chondritic meteorites it is proposed that the ureilite parent body accreted nebular ice with high-Δ17O, Mg-rich silicates with low Δ17O, and varying amounts of metallic iron. Water from the thawing ice then oxidized the metal yielding secondary FeO-rich minerals (e.g. fayalite, magnetite) with high Δ17O. Thus, FeO/MgO, FeO/MnO and Δ17O correlate because they rose in unison by amounts that varied spatially, depending on the local amount of metal that was oxidized. Once established at low temperatures, the FeO - Δ17O correlation was largely unaffected by high-temperature processing. In conclusion oxidation, not reduction, better explains the ureilite enigma.

Metal occurrences, sources and mobilisation processes in groundwater associated with Irish mines

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Multivariate Statistical Analysis [MSA] can be employed alongside conventional graphical techniques to very effectively differentiate water chemistry samples into distinct clusters. This approach can identify chemical signatures associated with low or even trace concentration parameters, which are often masked by major ion chemistry. This project aims to build on both low-blank analytical capabilities and reconnaissance datasets for a suite of metals in Irish groundwaters through analysis of high-quality mine datasets. Work is presently focussed on the recently closed Lisheen mine, County Tipperary. An expansive hydrochemistry dataset, collected underground during mining operations, has been refined to isolate samples representative of the surrounding carbonate aquifer (e.g. fissure inflows and rock face seepages). The presence of dissolved metals in the samples, including As, Pb and Ni, permit preliminary analyses of spatial variations in metal occurrences while further groundwater sampling at selected boreholes across the mine site is underway to compile a high-quality hydrochemistry dataset for MSA, and also to account for seasonality. Interrelationships uncovered between the metal analytes can be interpreted in the broader lithostratigraphic and structural context of the host bedrock in the vicinity of the mine, allowing the potential identification of geogenic metal sources and groundwater flow paths within these aquifers.

Lower-crustal thermochronometry: apatite Pb-profiling by LA-MC-ICPMS

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Tectonics has been revolutionised by the development of thermochronometers. Thermochronometers are diffusion-based, temperature-sensitive radioisotope clocks which quantitatively retain the daughter isotope when the host mineral cools through a temperature window in the lithosphere, yielding time-temperature information that can facilitate thermal history modelling.

For the deep crust, the state of the art is the 40Ar/39Ar technique, which utilises the decay of 40K to 40Ar. The technique is sensitive to temperatures up to ca. 400-500 °C depending on the host phase, affords great precision, and K-hosting mineral phases are common in crustal rocks. However, the incorporation of excess (parentless) Ar can produce geologically meaningless thermal histories; Ar diffusion is pressure-dependent in some circumstances; and most K-phases do not behave as a single diffusion domain with respect to Ar, greatly complicating thermal modelling. The development of an alternative diffusion-dominated thermochronometer that is sensitive to mid- and lower crustal temperatures is thus highly desirable.

We report a new analysis and thermal history modelling protocol for core-rim Pb-profiling in apatite, a technique sensitive to temperatures of ca. 375-550 °C on geological timescales and cooling rates, illustrated by pilot data from a sample collected from the eastern Alps. We discuss the potential uses and limitations of the technique.

Hierarchical characterisation and modelling of submarine channels: insights from wider literature, 3D seismic data and compression based object modelling

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Classification schemes for defining the structure of submarine channel systems must consider the size, connectivity, fill type and stacking of elements deposited at different hierarchical scales in association with various regimes of confinement. This work focusses upon defining an exhaustive hierarchical classification scheme for these systems and parameterising them from relevant sources. The data will ultimately be used in constraining input to object-based modelling workflows to model such systems. Preliminary results derive from analysis of 3D seismic data from the Taranaki Basin, offshore West New Zealand, and by compiling observations published in the wider literature. Seismic analysis has focused on a well imaged channel-lobe system from the Late Miocene-early Pliocene Mangaa Formation deposited in a local topographic low bounded by the syn-sedimentary Cape Egmont and Parihaka faults. Two hierarchical levels are evident in the dataset: discrete channel elements within a channel complex within a moderately-significantly confined topography. Quantitative analysis has centred on measuring connectivity between individual hierarchical elements using amalgamation ratios, volumes fractions along with their fractional widths and thicknesses. The literature analysis is used to place the measurements from this particular system within a wider context, and to consider likely character of sub-seismic hierarchical levels.

This research was supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

'Bipolar Seesaw' or 'Push and Pull'?

Potential further evidence that abrupt climate events in the eastern North Atlantic can be also out of phase with the Greenland Ice Core record.

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During the last glacial period (~110 ka to 11 ka) millennial-scale abrupt climate change events have occurred regularly and are referred as Dansgaard-Oeschger-Events (D-O Events) and Heinrich Events (HE). The events are usually characterised by quick temperature rises followed by a slow cooling in the Greenland Ice Core as well as in sediments of the North Atlantic. The Antarctic Ice Core archive also reveals these events, but their amplitudes are suppressed and more uniform. Furthermore, they are delayed by about 200 a. This phenomenon is often described as the "bipolar seesaw". However, recent work documented likewise anti-phase pattern in the central North Atlantic (Rasmussen et al., 2016).

Similar results have been found now for HE 4 and 2 in sediment cores from the Porcupine Bank, eastern North Atlantic. While planktonic foraminifera census data reveal abundance schemes as expected for HE, Mg/Ca derived temperature rises are delayed by some distinct time. However, H3 seems to be in phase as well as further IRD events. This circumstance might be related to the strong influence of the British-Irish-Ice-sheet (BIIS) while HE 4 and 2 are connected to the Laurentide-Ice-Sheet (LIS). However, sedimentological processes and potential method limits have to be considered, too.

Controls on spatial metal distributions in Irish-type deposits

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We analysed metal distributions at the Silvermines and Lisheen Pb-Zn(-Ag) deposits to gain insights into the local controls on mineralisation, the location and position of feeder zones and to track fluid pathways along faults and through the host lithology from proximal to distal areas of mineralisation. Many structures are seen to control metal distributions and ratios, amongst which segmented normal faults, dextral oblique slip reverse faults and NW trending strike-slip faults.

Distinct points along segmented normal fault arrays are seen to serve as feeders to many of the orebodies, characterised by elevated Ni, Ag, Cu and As and low Zn/Pb ratios. Minor mineralisation occurs in certain units that were brought into juxtaposition with the Waulsortian Fm host rocks across normal faults. High tonnage orebodies in the deposits without typical feeder signals are interpreted as distal orebodies. Using the metal distributions and structural framework, we are able to identify potential fluid flow pathways.

Structure of the lithosphere-asthenosphere system in the vicinity of the Tristan da Cunha hot spot as seen by surface waves

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The deep mantle plume origin of the hotspot volcanism at the Tristan da Cunha island is supported by anomalous geochemical data and global seismological evidences. However, the existence of a plume has not yet been confirmed, mainly due to lack of local geophysical data in the area. We study the shear wave velocity structure of the lithosphere-asthenosphere system beneath the Island, obtaining geophysical data from an Ocean Bottom Seismometers experiment which was carried out in 2012 in the vicinity of the archipelago. Rayleigh surface waves phase velocity dispersion curves have been obtained using a recent powerful implementation of the inter-station cross-correlation method, and used to invert for the 1D shear wave velocity structure beneath the study area and to obtain phase velocity tomographic maps.

Our results show a pronounced low shear wave velocity anomaly between 70km and 120km depth beneath the area; the lid shows high velocity, suggesting a cold, depleted and dehydrated shallow lithosphere, while the deeper lithosphere shows a velocity structure similar to young or rejuvenated Pacific oceanic lithosphere, with pronounced low velocities suggesting thermal effects and partial melting.

Cotterite: Historical Review; Extant Specimens; Etymology of 'Cotterite'; New Observations on the Cotterite Texture

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'Cotterite' is a varietal name for an extremely rare form of quartz that displays a distinctive pearly metallic, but not vitreous, lustre. Originally discovered in a horizontal vein of calcite, quartz and ferruginous mud that crosscut Carboniferous limestone in a quarry at Rockforest (near Mallow, County Cork, Ireland) by 'Miss Cotter' in 1875/76, this quartz variety has been the subject of only two scientific papers, the second of which was by Professor Robert Harkness (then of Queen's College Cork) who named the variety in 1878. Genealogical research reveals that the mineral's dedicatee was Grace Elizabeth Cotter (1830–1879), first-born daughter of Reverend George Edward Cotter (third son of the 2nd Baronet Cotter of Rockforest) and Grace La Touche. Both father and daughter were involved in distributing specimens to Irish and British institutions. Currently, some 34 cotterites from Rockforest are extant. There are also two quartz's labelled as cotterite from Nova Scotia (Canada) and two from Devon (England). New observations reveal that cotterite's lustre results from light reflections off partial delamination structures and micro-fracture crazing patterns within the many late-stage lamellar-style quartz growth layers that comprise cotterite quartz's pyramidal faces.

Exploration Targeting for Gold and Base Metals in Ireland using semantic technology: Deposit models and Prospectivity Analysis

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Geodata are essential in mineral exploration; data acquisition is an expensive and time-consuming process making it vital to understand and extract maximum value from this data. Geodata will continue to grow in importance as exploration will focus on areas where deposits are concealed.

Semantic technology is a well-known and trusted tool in pharmaceutical process design and in financial prediction. Semantic technologies encode meaning into content and data enabling a computer system to effectively "understand" the data they process. This makes them potentially ideal to be used in mineral exploration, as it allows automation of typically labour intensive and time consuming prospectivity studies.

Utilising the 250k GSNI and 100k GSI Seamless Geology with Tellus data we have used semantic based prospectivity analysis for Base Metals and Gold, incorporating collated mineral deposit models from peer reviewed literature. This new methodology can easily and quickly integrate disparate datasets highlighting the potential of the data for new analysis and identifying potential opportunities for exploration. Using semantic technology in mineral exploration will enable better identification of potential for mineral deposits using existing geodata sources, maximizing value of data acquisition costs.

Slope collapse and tsunami generation at the Rockall Bank Slide Complex, NE Atlantic Ocean

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Sediment deposits of large submarine landslides are evident on the continental margins and the slopes of oceanic islands in the Atlantic Ocean. The Rockall Bank Slide Complex (RBSC) is an extensive system of submarine mass failure escarpments on the seabed of the Rockall Trough, northwest off the Irish coastline. The RBSC comprises the largest region of slope failure in the Irish Atlantic margin, extending in an area of 18,000 km^2. Failure at the region has possibly occurred in different episodes of collapse (at least three major episodes are suggested), which may have held a significant tsunamigenic potential. In this study, we numerically investigate slope failure at the region and its impact for tsunami generation. Tsunami propagation and onshore inundation are also considered. The numerical coupling of two algorithms: a landslide and a tsunami model, is performed. To account for the complex rheological flow behaviour, the VolcFlow code is used for the modelling of the slope failure episodes. The numerical wave model VOLNA is then implemented for the simulation of the landslide induced tsunamis; tsunami wave generation and oceanic propagation are considered. The results of the simulations are presented and discussed.

Modelling and Monitoring Geomagnetic Storms and their Effects in the Irish Power Network

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Geomagnetically induced currents (GICs) are a well-known hazard associated with the interaction of the Sun and the Earth's magnetosphere. They occur in transmission networks worldwide, and have been known to disrupt power transmission and damage transformers during particularly large geomagnetic storms. Countries at high and mid-latitudes are known to experience these phenomena more often than other countries.

Since 2012, TCD and DIAS have set up multiple magnetic observatories around Ireland in order to monitor Ireland's geomagnetic field during solar storms. Using the magnetic data from MagIE, along with a detailed resistivity model of Ireland derived from multiple MT measurements, we have studied GICs in the Irish power network during multiple large geomagnetic storms. These storms include the St. Patrick's Day 2015, the Halloween 2003 and March 1989 events.

During the largest of the storm period's studied, the geomagnetic field in Ireland was changing at a rate of 955 nT/min. The peak electric field in Ireland was calculated as being as large as 3.8 V/km. This field in turn drove GICs of up to 23 A in the Irish power network.

Ancient subduction recorded in the sub-continental lithospheric mantle of the North Atlantic Craton, Greenland

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The introduction, distribution and residence time of halogens in sub-continental lithospheric mantle (SCLM) is essentially undetermined. Ultramafic lamprophyre (UML) magmatism occurs in SCLM regions during rifting and produces hybrid melts of asthenospheric and metasomatic SCLM components. These rocks provide an excellent opportunity to investigate the halogen composition and provenance of metasomatic agents in the SCLM. Here, we present novel, elemental (F, Cl, and Br) and isotopic (δ^{37}Cl) halogen data of UML from the North Atlantic Craton (NAC), Greenland. The UML display δ^{37}Cl compositions of +0.54‰ to +0.80‰ [versus SMOC (standard marine ocean chloride)], consistent with recycled material in the UML source region. The Br/Cl composition of the UML ranges from 0.0047 to 0.0049, precluding derivation from an asthenospheric source. This implies a high Br/Cl SCLM component. The data are consistent with a scenario in which halogen-enriched fluids were liberated from a subducting plate beneath the NAC during the Palaeoproterozoic, leading to the percolation of halogen-enriched fluids into and metasomatism of the NAC. This signature remained stable within the SCLM until it was sampled by UML magmatism during Late Jurassic rifting. This implies that SCLM has the capacity to record and preserve halogen signatures related to subduction metasomatism on billion-year timescales.

Chlorine Isotope Composition of the Proto-Iceland Plume Source Mantle

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Ocean Island basalts (OIBs) sample mantle that has not undergone extensive melting, and some OIBs have compositions indicating variable addition of subducted material. Reported chlorine isotope compositions (δ37Cl) for OIBs enriched with recycled material (EM1, EM2, HIMU) vary from -1.2 to 3.5‰ relative to Standard Mean Ocean Chloride (SMOC) (John et al. 2010). However, the elemental and isotopic halogen composition of the primitive undegassed mantle reservoir remains poorly defined.

We present isotopic (δ37Cl) and elemental (F, Cl) halogen compositions of melt inclusions in 62-58Ma Baffin Island picrites. The Padloping Island basalts are unenriched, indicating minimal addition of recycled components, and have the highest known terrestrial 3He/4He values (~50Ra), making them ideal candidates to assess the halogen inventory of undegassed primordial mantle. δ37Cl values span a relatively restricted range from -0.97‰ to 0.21‰, while Cl concentrations range from 141 to 194ppm.

The isotopic and elemental halogen composition of the Baffin Island magmas will be used to determine the halogen inventory of the undegassed mantle end-member and will permit assessment of the relative contributions of recycled halogens to other mantle-derived magmas. Overall, this work will contribute to a more robust understanding of the whole-Earth halogen budget.

The Ocean Pressure Profile (OPP): An Experiment to Try to Understand How Energy is Transferred from Ocean Waves to the Solid Earth in the Northeast Atlantic, West of Ireland

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There exists a strong mechanical coupling between the ocean water layer and solid Earth. Under certain sea state conditions energy from ocean waves generate pressure fluctuations at the seafloor, inducing continuous background seismic ground vibrations from ~1-20 sec known as microseisms. These microseisms are recorded worldwide but the Northeast Atlantic Ocean is a well known source area for these signals so Ireland is ideally located for their study.

Terrestrially recorded microseism have previously been used as a proxy for ocean wave characteristics (Donne et al., 2014). Recent work carried out in collaboration with the School of Mathematical Sciences (UCD) has allowed for the expansion of the original theory for microseism generation in terms of the necessary sea state conditions (Pellet et al., 2016 (submitted)). Here we present a unique ocean based experiment, the Ocean Pressure Profile (OPP). The aim of this experiment is to measure the pressure fluctuations, generated by ocean waves, throughout the water column off the Northwest coast of Ireland in an attempt to uncover information about how energy is transferred from ocean waves into the solid Earth. This information has applications for numerical simulations we wish to carry out where source term characteristics are required and will also allow us for the first time to compare and contrast theory and measured pressure profile information.

Early Cretaceous stratigraphic response to hyperextension, Porcupine Basin, Irish Atlantic Margin

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The Porcupine Basin, located on the Irish Atlantic Margin, is recognised as a prospective basin for deep-water petroleum plays. It displays a strong north-to-south lateral strain gradient along with evidence for hyperextension. Mid-Late Jurassic rifting was followed by a protracted phase of thermal subsidence during the Cretaceous. However, a feature of the Cretaceous stratigraphy is the presence of prominent unconformities that cap deeply eroded and structurally-rotated lowermost Cretaceous successions. The latter are mainly preserved perched on the main basin flanks and are passively overstepped by the younger Lower Cretaceous infill. Identifying the relationship between the laterally variable basin centre stratigraphy with the basin margins is critical for understanding the evolution from normal to hyperextension to major thermally-controlled subsidence.

The present study uses a combination of 2D and 3D seismic data and well information to identify, correlate and examine the character and distribution of the post-rift successions. Seismic and depositional mapping across the basin, provides an enhanced understanding of the syn-rift to post-rift sedimentary evolution and tests the hypothesis that fault-controlled extension led directly to underfilled deep bathymetry. The results provide important clues to the timing, distribution and potential reservoir quality of deep-water sedimentary systems in hyperextended basins.

Significance of melanosomes in fossil vertebrate soft tissues: insights from morphology and trace element chemistry of melanosomes

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Melanosomes are important components of integumentary tissues in modern vertebrates and have been reported from various vertebrate and invertebrate fossils ranging in age from the upper Palaeozoic to the Cenozoic. Much previous work on fossil melanin has focussed on reconstructions of integumentary colour in fossils. Modern vertebrates, however, also possess melanin in internal tissues; the impact of these internal melanosomes on interpretation of fossil soft tissues – and fossil colour – has not been assessed. Here we present the first systematic analysis of the anatomical distribution and abundance of melanosomes in different vertebrate taxa. The abundance of melanin in tissues of extant amphibians, reptiles, birds and mammals was assessed using histological sections. Melanin extracts from these tissues were analysed using scanning electron microscopy (SEM) and synchrotron X-ray fluorescence (XRF). Our results reveal that melanosomes are abundant in internal organs of extant vertebrates. These internal melanosomes always differ in trace element chemistry, and, in some taxa, in geometry, to melanosomes from the skin. These findings can be applied to fossils to allow integumentary and non-integumentary melanosomes to be discriminated, thus allowing more accurate interpretations of internal anatomy and integumentary colour in fossils.

A Geophysical Perspective on the Galway Granite

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We present a new 3D model of the electrical resistivity structure of the crust within which the Galway granite resides. The new model, derived from 3D inversion of magnetotelluric (MT) and audio-magnetotelluric (AMT) data, constrains the shape of the electrical resistor that maps out the shape of the intrusion. The model is interpreted to show previously unknown deep structures beneath the central block of the Galway granite, along which magma ascended. We briefly comment on how magmatic ascent along these structures fits in with the mapped lithologies and geological structures.

Also presented are palaeoclimate corrections to geothermal heat-flow density at two Galway granite locations. The new resistivity model of the Galway granite is integrated with the palaeoclimate corrected heat-flow, and with heat-production and thermal conductivity data, to calculate temperature at depth within the granite. Our calculations show that temperature at depth within the Galway granite are higher than previously calculated.

GWFlood: Monitoring, modelling and mapping groundwater flood hazards in Ireland

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The phenomenon of groundwater flooding represents a significant flood hazard for many rural communities in Ireland. Groundwater flooding is primarily governed by geological factors and is most commonly associated with the low-lying pure carboniferous limestones prevalent in the west of the country. These limestones are often extensively karstified which gives rise to high diffusivity and limited surface drainage. In addition, the shallow water table combined with low soil and aquifer storage makes these karst areas particularly susceptible to groundwater flooding. Recent flood events have reinforced the need for a greater understanding of groundwater flooding as a geohazard, and improve our ability to quantify the location and likelihood of flood occurrence. In response to this need and the unprecedented flooding in recent years, Geological Survey Ireland has established a new collaborative groundwater flood programme (GWFlood) with University of Dublin Trinity College. The key objective of the GWFlood project is to monitor, model and map groundwater flooding in Ireland to an unprecedented extent. This new programme will provide the fundamental technical knowledge to enable key stakeholders to develop appropriate flood hazards maps, mitigation measures and allow for informed flood assessments to be made in future.

An expanding impact crater in Scotland: Implications for the Moine Thrust

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The Lairg gravity anomaly, in northern Scotland, has been interpreted as a crater 40 km across from which the Stac Fada impact deposit (1.2 Ga old) further west was ejected. Reanalysis of the gravity data (from BGS) shows that the central negative anomaly is surrounded by a ring, 50 km across, of positive anomalies. We interpret this as the eroded remnant of a Peak Ring Crater. Outer rim diameter of other peak ring craters is twice that of the inner ring, implying that the putative 'Lairg impact structure' is 100 km across. Such a crater would impinge directly upon the outcrop of the Stac Fada Member if the relationship between the two has remained unchanged, yet immediately pre-impact strata appear largely unaffected by the impact. We infer from thus that the crater was formed tens of km east of its present location and subsequently was relocated closer to the present Stac Fada Member outcrop by Caledonian thrusting associated with the collision of Laurentia with Baltica. It suggests that a significant component of thick-skinned tectonics may exist beneath the east side of the Moine outcrop, in contrast to the predominantly thin-skinned tectonics evident along the Moine Thrust Belt further west.

Reconstructing Zn pollution sources in the Irish atmosphere from its biogeochemistry in ombotrophic peat

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The global demand for Zn has increased dramatically during the last 3 decades. This has resulted in significant pollution of the Earth's surface environment, evident as increases in Zn concentrations in the top layers of many surface archives, such as ice cores, snow packs, soil sections, peat cores, and lake sediment cores. Because Zn is a ubiquitous metal in a vast range of industrial products, ranging from sun-screen, plastics, car tires, anti-corrosion skins etc., there is a diversity of Zn sources, making it difficult to unravel and quantify different con-tributions deposited into a particular site.

The aim of this study was to reconstruct the airborne Zn pollution from local and transregional sources over Ireland – one of the most significant Pb-Zn mining nations in Eu-rope. To this end, we have investigated the depositional history of Zn over the last 500 years into the ombotrophic (rain-fed) peat of the Liffey Head bog, Wicklow Mountains. Our results show a continuous increase in anthropogenic Zn from 0.9 ppm to 4.1 ppm between 1525AD and present day. We also investigated the isotope composition of the deposited Zn and found an evolution from originally heavy (δ66ZnJMC Lyon=0.8‰) to significantly lighter (δ66ZnJMC Lyon=0.2‰) values in the most recent peat, in general agreement with findings of other peat studies around the northern Hemisphere. These observations, combined with other metal con-centration histories (Pb, Cd, Ag) will be discussed in terms of source, Irish mining history, and Zn mobility within the core.

Tellus what's happening! An update on the Tellus Project, future plans and current research

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Tellus has had a busy 2016. The low level airborne geophysical survey has completed two survey blocks this year around counties Galway and Waterford. Meanwhile the geochemical survey teams have been hard at work on the west coast in counties Mayo and Galway. This brings the project ever closer to national baseline coverage and target of surveying the northern 50% of the country by 2017.

In October 2016 Tellus released a book 'Unearthed - impacts of the Tellus surveys of the north of Ireland'. The book launch also included a stakeholder consultation session and a questionnaire. The feedback we received was a valuable insight to what stakeholder want regarding sample mediums, survey areas and types of analysis.

New geophysical data will be released in spring 2017 from the airborne survey of county Galway last year. Spring 2017 will also see the aircraft start surveying counties Donegal and Mayo while the ground survey teams will be operating in the west and central Midlands.

The Geological Survey Ireland research programme currently has ten short call projects underway using Tellus data. This year there are also opportunities for graduates to gain experience in our field teams. More information and data to view and download free of charge at www.tellus.ie.

Fault Representation in Production Simulation Models: Sensitivity to Grid Structure

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It is widely known how important faults are for the entrapment of hydrocarbons and reservoir compartmentalization, since they may act as conduits, baffles or barriers to flow. Faults in flow simulation models are usually treated as 2D surfaces rather than 3D volumes, since strong gridding limitations do not allow complicated fault geometries to be represented into conventional simulation grids. This work focuses on the geometrical flexibility available for fault representation in flow models, using the standard GRDECL, the Stair-Step and the GSG format. This flexibility is tested on a number of 3D models, representing fault geometries with different geometrical characteristics. Results demonstrate how each format has a different impact on how faults are incorporate into the grid and on subsequent flow. The Stair-Step format is able to represent every fault geometry in the simulation grid. Questions arise, however, about the ability of stair-stepped models to accurately represent across-fault juxtapositions. A focused experiment was designed with the scope of understanding how differently do the GRDECL and the Stair-Step formats behave with regards to juxtaposition accuracy and flow. Initial results suggest that deviation between the two formats results from the grid-block geometry and the permeable/impermeable unit distribution.

Exploring the primary controls on sandstone reservoir quality in the Slyne Basin, offshore western Ireland

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This study aims to test and assess the link between sand source(s) and reservoir quality in order to move towards first order quantitative modelling of sedimentary systems and their detrital products. The project is initially focused on the Slyne Basin, offshore west Ireland, where Triassic reservoir sandstones of varying quality have been identified at a range of depths, including those of the Corrib gas field. Localised variations in reservoir quality are linked to intensely chloritised zones which are of particular interest.

A multi-proxy approach is being employed to ensure rigorous provenance analysis linked to detailed assessment of diagenesis. Detailed petrographic characterisation will be conducted using optical microscopy, SEM and RAMAN, EDS, and autophase mapping. Heavy mineral analysis, U-Pb zircon geochronology and Pb isotopic analysis of feldspar are being utilised to identify and constrain the relative contribution from possible source areas.

Results to date, based on the Pb isotopic analysis of K-feldspars from near contemporaneous sandstones with different reservoir characteristics, reveal similar basement source areas, but variable relative contributions. The combination of high resolution multi-proxy provenance analysis and detailed petrographic studies will reveal if this disparity is a clear provenance signal or is related to feldspar type and/or burial depth/diagenesis.

Rare Earth Element Behaviour in Olivine: Insights from Partitioning and Diffusion

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Despite potential for petrological utility, the controls on rare earth elements (REE) uptake into olivine is poorly understood. Here we present REE data for olivine from seven olivines from the Skaergaard Layered Intrusion, spanning a Mg# range of 1 to 59. We examine the temperature and compositional controls on REE partitioning into olivine, and discuss their effects on crystal lattice parameters. Most notably, we find a strong connection between the Fe content of olivine and the elasticity of the crystal lattice, whereby an increase in Fe is associated with a more flexible lattice, allowing for increased REE partitioning into the crystal.

We also apply a novel 2-dimensional laser ablation mapping approach (Petrus et al., submitted) to selected Skaergaard olivines. The resultant REE map is used to assess the cause of LREE contamination in both solution and laser ablation olivine data.

Ocean wave induced seismic noise offshore Ireland: Observations and Simulations

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In order to understand what controls the generation and propagation of ocean induced ambient seismic noise from ocean to land, we look at acoustic and seismic data recorded on the seafloor and how it compares with numerical simulations. The preliminary results from the OBS stations deployed across the shelf offshore Donegal and out into the Rockall Trough show spatial and temporal variability in the recorded signal. For instance, the data behave differently when recorded on the continental shelf or deeper in the Rockall Trough. Data variability reflects changes in the generation source process, including meteorological information, but also in the geological structure affecting signal propagation. In addition, 3D simulations of acoustic/seismic wave propagation appear significant to better understand what control the acoustic/seismic coupling at the sea floor as well as the effect of the water column and sediments thickness on signal propagation. This project is part of the Irish Centre for Research in Applied Geoscience (ICRAG), funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund.

The colour of ancient insects: Insights from synchrotron X-ray fluorescence

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Insects are adapted to live in almost all ecological biomes. One of the most striking adaptations of insects include colour patterns on their cuticle, which are produced primarily by pigments such as melanin. Many fossil specimens also exhibit patterns on their cuticles, but the origins of these patterns and the pigments responsible are unknown. We resolve these issues using non-destructive synchrotron-X-ray fluorescence (XRF) to characterise the spatial distributions of trace elements in the cuticles of fossil and modern insects. We mapped the concentrations of 11 trace elements in cuticle regions of different colours that correspond to different pigments. Analyses of variance and principal component analyses of the concentrations of each element reveal a strong taxonomic signal whereby concentrations of trace elements are similar in taxa from the same family. Critically, this taxonomic signal is overprinted by a strong colour-specific signal, whereby cuticles of different colours differ in chemistry within individual species and families. Understanding pigment- and taxon-specific variation in trace element chemistry will greatly enhance our ability to interpret the original pigmentary colours of fossil insects, thus informing models of the evolution of colour and its ecological functions in insects through time.

Precursor monoclines and segmented fault geometry

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Precursor monoclines or fault propagation folds have commonly been observed on normal faults. Much previous work has analysed these structures in outcrop or from analogue modelling studies, there are few natural examples which have been studied in detail in 3D. Here we present examples of intact monoclines in these cases the geometries of the monoclines and the underlying fault array are highly comparable, and features which have been cross-cut by later developed faulting. In cases where the monoclines are breached the initial ductile folding can accommodate a substantial amount of the total displacement on the structure, profiles of the total displacement on the structure indicate that it is geometrically coherent. The presence of a monocline at early times in the faults development leads to the presence of a long narrow zone of strained rock above the tip of the underlying fault, as the displacement continues to increase this allows for the easy propagation of a large number of overlapping segments resulting in a highly segmented array. The geometry of the final fault array is therefore heavily influenced by two factors, the segmentation on the underlying fault array which controls the large scale segmentation and the presence of the precursor monocline which controls the smaller scale of segmentation.

Combined apatite U-Pb and trace element analysis – a detrital provenance case study from the Tarn, France

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Here we present a successful test of determining source-rock lithology from the river Tarn, France, by means of detrital apatite trace element and U-Pb analysis. The river Tarn and its tributaries sample simple, well-defined Variscan source areas in the Cévennes Mountains consisting of granitoid batholiths and greenschist- to amphibolite-grade metapelites, disconformably overlain by minor Neogene basic volcanics.

Apatite from the granite versus the metapelitic sources can be distinguished primarily by using the abundances of the Rare Earth Elements, the actinides, and Sr and Mn. An apatite population yielding trace element and U-Pb ages consistent with the Neogene basic volcanics was also identified, despite this unit comprising only c. 1% of the catchment area, demonstrating the remarkable fidelity of detrital apatite to source area composition. In addition, as apatite cannot survive incorporation into magmatic bodies or metamorphism above mid-greenschist-facies, U-Pb dating of the detrital grains also enables an estimation of the volume of recycled apatite in the Tarn detritus as any pre-Variscan ages must be derived from recycled material in the catchment area..

The successful synergy of U-Pb and trace-element analysis demonstrated in this study shows that detrital apatite has a great potential for wider use as a detrital chronometer whose trace element composition can be linked to highly specific source lithologies.

A new workflow for generating low amalgamation, high net:gross geomodels constrained to well data

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Many deep marine turbidite reservoirs are often characterised by poorly amalgamated sand bodies interbedded with low permeability shales. Although these systems often have high net:gross ratios, the low connectivity of the sandstones has a strong control on reservoir performance but is often poorly reproduced in reservoir geomodels. The ability to generate geologically realistic reservoir models that honour the available well data is an important step in predicting reservoir behaviour.

A new class of object-based model uses a so-called "compression" method in order to reproduce poorly amalgamated but high net:gross ratio sequence typical of many lobe reservoirs. The compression method allows the net:gross and amalgamation ratios to be separate inputs into the modelling workflow. A major limitation of the compression method, like traditional object-based models, is that the models cannot honour particular observations made at wells. The recently-developed multiple-point statistics approach is pixel-based so models can be easily conditioned, and uses a training image to recreate the desired geological architecture. We have developed a new workflow that combines the compression algorithm with the multiple-point statistics method in order to create geologically realistic models that have realistic levels of sand amalgamation at high net:gross ratios yet honour the available well data.

This research was supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

High-resolution geological and biological mapping of submarine landslide scarps: results from the SORBEH project

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Seafloor mapping is traditionally performed from down-looking ship-board or ship-towed equipment. However, this approach does not image adequately steep structures such as submarine landslide scarps, thus limiting our appreciation of the geology and heterogeneity of the rupture surface, which are potential integral parameters in our understanding of the initial rupture and propagation of a submarine landslide. As part of the SORBEH project (Slope Collapses on Rockall Bank and Escarpment Habitats) we used a different approach by combining forward-looking multibeam mapping, video imagery and seafloor sampling. Mapping of a near-vertical scarp of the Rockall Bank Slide Complex offshore western Ireland was achieved by mounting a multibeam echosounder on the front of the Remotely Operated Vehicle (ROV) Holland I. ROV video transects across the same scarp were then performed which were used to create 3D representations using structure for motion (SfM) photogrammetry techniques. During the video transects, several sediment and rock samples were collected which were analysed in order to provide groundtruthing. This technique revealed a surprising complexity over a relatively small region; some of the observations are: a) at least three different lithologies with different strengths; b) terraces, vertical sections, overhangs and buttresses characterise the morphology of the scarp; c) diverse habitats are associated with the geological complexity. This technique provides unprecedented insight to collapsed sedimentary sequences which were previously only accessible via deep coring.

Towards a better characterization of Ireland's seismicity

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The seismicity of Ireland is characterized by low magnitude, infrequent natural earthquakes and a large number of quarry and mine blasts. The progressive increase in the number of permanent seismic stations covering Ireland, as well as the various temporary seismic array deployments that were undertaken since 2010, led to a significant improvement in local seismic event detection capability and location accuracy, which is of primary importance to determine the baseline level of natural seismicity that is required for assessing the impact of natural resource exploitation and extraction. Here, we present new results obtained with those recent, high quality datasets. We manually picked seismic phase arrival times on all available waveform data and relocated the 62 known natural events that occurred in Ireland from 2010 to 2015, and more than 1,500 quarry blasts for the period 2013-2014. Using a waveform template matching algorithm, we also identified more than 200 additional, previously unknown natural earthquakes. This large number of newly detected events, mostly located in the region of Donegal and in the Irish Sea, provide an enhanced view of the seismic activity of Ireland.

Poster Abstracts

Irish Sea Suitability Mapping for Novel Offshore Foundations - ISSMANOF

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Since the completion of the Arklow Bank windfarm in 2004, the offshore renewable energy sector in Ireland has stagnated. Current vagaries about the geological context to any such offshore infrastructural development may significantly impact any future developments. The fiscal implications of poor background knowledge of ground conditions before construction are well demonstrated by previous projects. This complexity of sub-surface conditions in the Irish Sea reflect its Quaternary history of ice-sheet dynamics, marine transgression and Holocene erosion.

This project aims to address this issue utilising extensive geophysical and sampling data gathered by the INFOMAR project. INFOMAR, which began in 2006, has the task of mapping all of Irish territorial waters less than 200m in depth. ISSMaNOF has used these existing and publicly available datasets to carry out preliminary site selection investigations for potential OWFs, based on current and future foundation constraints. Firstly a large scale investigation of the entire Irish Sea area was done, which was followed by four site specific investigations. As part of this, detailed seismic analyses and interpretations were conducted, revealing new information about the Quaternary history and potential geotechnical characteristics of the western Irish Sea sediments, and therefore the implications of future OWF developments.

Multiscale seismic waveform tomography of western Ireland's offshore basins

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The offshore basins west of Ireland are of great interest for hydrocarbon exploration and for their role in the formation of the North Atlantic margin. In this work, we seek to characterise Irish offshore basins by building quantitative models of seismic properties at different scales, from the ocean down to the basins. First, at the North Atlantic scale, we present new models of anisotropic shear-wave velocity in the crust and the upper mantle, obtained by asymptotic waveform inversion of S and surface waves. The reconstruction of the shear-velocity isotropic average and of its anisotropy enables to distinguish between the effects of thermal or compositional variations and those of anisotropic fabric. The former can be interpreted in terms of lithosphere thickness and temperature, while the latter gives us insight into past and present deformation. Second, we present preliminary results of a basin-scale study using adjoint waveform inversion of long-streamer seismic data. At this scale, waveform inversion can provide high-resolution images of multiple parameters such as seismic velocities, density or anisotropy, that can be linked to properties of great interest for reservoir characterisation, such as rock porosity and fluid content. Moreover, we expect these images to provide new insights into the nature of debated structures, including the Porcupine Median Ridge, and therefore to contribute to the understanding of the tectonic history of the basins. This research was supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and is co-funded under the European Regional Development Fund.

Clumped C-O isotope temperature constraints for carbonate precipitation associated with the Irish-type Lisheen and Navan Zn-Pb orebodies

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Mineral C-O isotope values are controlled by crystallization temperature and the isotopic composition of the fluid. However, the heavy isotopes of these two elements are known to bond in carbonate minerals measurably more frequently than expected by stochastic distribution. The extent of this "clumping" appears directly correlated with temperature which, unlike conventional d18O values, is independent of fluid δ18O. Measured Δ47 – a measure of distance from stochastic behaviour – thus provides an independent measure of crystallization temperatures, with errors at hydrothermal temperatures better than ±20°C. As δ18O isotope ratios are also simultaneously determined, fluid δ18O may be directly calculated rather than modelled.

We have measured Δ47 in paragenetically-constrained, carbonate generations from both the Lisheen and Navan Zn-Pb deposits. Coarse white dolomite from Lisheen white matrix breccias from the hanging-wall of the Island Pod show significant, non-systematic, temperature variations of ~100 to 170˚C over ~80 m depth range providing calculated fluid δ18O of 5.7 to 14.8‰. Post-ore pink dolomite at Lisheen and crosscutting calcite veins formed at significantly lower temperatures (~40 to 70˚C) than ore-stage carbonates. Δ47 in calcite from sphalerite-bearing veins in the hanging-wall of the Randalstown Fault at Navan yield temperatures of 60-110 ˚C, consistent with existing fluid inclusion constraints.

SISAL: A community-driven initiative to construct a global database of speleothem data

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Speleothems can provide extremely high-resolution records of changes in climate that have the potential to be used to document regional changes in mean climate and climate variability on annual to centennial timescales. Many climate models now explicitly include isotopic tracers, and thus the isotopic records from speleothems can be used for model evaluation. There are 400+ published speleothem records providing information covering part or all of the last 21,000 years and a number of these extend much further back in time. Previous attempts to compile speleothem data have not provided a globally-comprehensive synthesis, nor have they provided assessments of measurement or chronological uncertainties. SISAL (Speleothem Isotopes Synthesis and Analysis) is a new community-based working group sponsored by Past Global Changes (PAGES) to synthesise speleothem data globally and develop a public-access data base to be used both to explore past climate changes and in model evaluation. The working group will bring together speleothem scientists, speleothem-process modellers, statisticians and climate modellers, to ensure that the database serves the needs of these communities. This presentation will explain the motivation for SISAL, outline the philosophy behind the data synthesis, and present preliminay results from the SISAL working group.

Passive seismic imaging at deposit to regional scales using integrated waveform techniques

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The objective of this iCRAG project is to develop and apply new passive-imaging methods applicable at scales from tens of meters to kilometers (deposit scale to lithospheric scale). For the passive imaging, we aim to use all available seismic sources, i.e., ambient noise, tectonic earthquakes and quarry and mine blasts. Seismic waves propagated from quarry blasts offer high-frequency energy not available in the ambient noise field. Above 1 Hz there is little ambient noise but, in contrast, quarry blasts yield energetic arrivals at frequencies from a few Hz to tens of Hz. We use two approaches: the first one involves the analysis and waveform inversion of auto-correlation functions to resolve seismic discontinuities at depth and the second approach uses cross-correlations of high-frequency waves from local seismic events to refine seismic-velocity distributions. The methods will be applied in Boliden-Tara mine area, with abundant existing data for method validation and with important targets to imaging. Further applications of the methods elsewhere should contribute significantly to the mineral exploration in Ireland.

Imaging the Earth's anisotropic structure with Monte Carlo inversion of surface-wave dispersion data

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Rayleigh and Love surface-wave dispersion curves are a useful tool to study seismic anisotropy because of their different sensitivity to vertically and horizontally polarized shear-wave velocities, and their dependence on propagation azimuth.

In this study we develop a Monte Carlo inversion of surface-wave phase-velocity curves for radially and azimuthally anisotropic structure of the crust and upper mantle, suited for the analysis of regions where interstation dispersion measurements are available at given station pairs or arrays of stations.

The results of the inversions are probabilistic 1D, depth-dependent, anisotropic shear-velocity profiles; the problem of non-uniqueness is therefore addressed by providing a quantitative probabilistic measure of the solution space instead of a unique best-fitting model. We apply the inversion method to phase-velocity curves in a few regions of the Earth, including locations in Ireland and the Hangai dome region in Mongolia. Our models provide constraints on the Moho depth, the Lithosphere-Asthenosphere Boundary, and the alignment of the anisotropic fabric and the direction of current and past flow, from the crust down to the deep asthenosphere.

Paragenetic studies of the high-grade Island Pod Zn-Pb orebody, Lisheen

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Irish-type deposits are a series of Zn-Pb orebodies which formed from the carbonate replacement of Lower Carboniferous limestone, triggered primarily by fluid mixing.

This project aims to use isotopic (Zn-Cu-S and clumped O-C) techniques to identify geochemical haloes and increase our understanding of hydrothermal fluid processes in these deposits.

Initially, the focus is on the Island Pod orebody, Lisheen. Relative to the main orebody, the Island Pod is unusual in several ways: it is high grade (0.3 Mt 20% Zn, 1.6% Pb), with local thick intercepts of >40% Zn recorded; only minor extensional structures are present and they are not typically associated with the highest quality ore; and mineralization does not occur at the Waulsortian/ABL contact, but only higher in the stratigraphy.

Island Pod samples studied so far suggest a common paragenesis: early euhedral pyrite → dolomite displaying grain size reduction → disseminated sphalerite → disseminated pyrite. Noteworthy textures include (1) branching galena in non-colloform sphalerite and dolomite, and (2) possible dolomite and sphalerite intergrowths. More detailed paragenetic study will follow from a recent thorough sampling of the Island Pod. Subsequently, isotopic analysis will yield additional information about the dynamic processes responsible for mineralization.

Evaluation of upslope pinchouts in modern and ancient turbidite systems: implications for stratigraphic trapping

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Upslope stratigraphic traps within deep water sand bodies have become a prime target for hydrocarbon exploration. Commercial discoveries in which upslope stratigraphic traps play an important role include the Ghanaian Jubilee Field, the North Sea Buzzard Field and the Foinaven Field. Similar plays with upslope stratigraphic traps have also been identified in the Cretaceous and Tertiary of offshore Ireland and have the potential to yield significant discoveries. However this play type is high risk, relying on a completely detached reservoir and a robust trap. The greatest risk associated with pinchout plays is the leakage of hydrocarbons upslope through slope-conduit deposits. A new PhD project will review the continuity of sands and gravels in a range of modern and ancient turbidite systems, aiding the screening of potential discoveries within this play type. Seismic is critical for identifying hydrocarbon prospects but may not detect the presence of thin “thief sands” extending upslope due to the limits of seismic resolution. Here we show initial results from seismic forward modelling to show how full or partial pinchouts are imaged in seismic sections.

Copper Metallogenesis in Upper Palaeozoic sedimentary rocks of Southwest Ireland

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A renewed effort to understand the genesis of base metal ore deposits in the Irish Midlands and Southwest Ireland sprung from novel targets of exploration companies. This study focuses on historically mined, sediment-hosted (SSC) and vein-type copper deposits. We aim to identify the dominant structural and geochemical controls of Cu mineralisation in Upper Palaeozoic sedimentary sequences. Central to this is determining whether there is a genetic link between the Cu deposits of SW Ireland and those of the southern sector of the Irish Midland Orefield.

The project has produced detailed maps of the mineralised vein systems and their structural relationship, as well as a comprehensive petrographical study and fluid inclusion analysis of selected samples from Allihies mines (West Cork). The structural and petrographical observations are compared with those from vein-hosted and sediment-hosted deposits of Mizen Head and Sheep's Head peninsulas. Interpretation of GIS-supported satellite imagery and drone footage served as a key tool for visualization of large scale structures.

Initial findings indicate that the mineralized veins follow a general E–W to SE–NW trend, related to the development of orogenic (Variscan) and post-orogenic fault systems. Most of the copper lodes consist of quartz with syn-genetic chalcopyrite with minor bornite, chalcocite and tetrahedrite. The homogenisation temperatures (Th LV-L) of the quartz-hosted fluid inclusions range between 110 and 210 °C.

The internal architecture and morphology of a complex esker system in County Tyrone, Northern Ireland

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Eskers are elongate ridges of glaciofluvial sand and gravel deposited in subglacial, englacial and supraglacial drainage channels. They provide vital information on the nature of channelized drainage and sediment transport and deposition within subglacial conduits, and serve as a valuable source for aggregate extraction. Esker networks are often mapped to reconstruct drainage pathways and there have been several detailed studies of their internal structure. However, sedimentological investigations have typically been isolated in their scope (e.g. focusing on individual ridges or certain esker types), and so our understanding of the processes controlling their formation is incomplete. In this study, we use ground penetrating radar and sedimentology to determine the internal architecture of a complex esker system in County Tyrone. The 15-km long esker evolves from a complex, anabranching series of ridges in the south to a single ridge further northwards. The results provide insights into how the esker was formed and allow relationships between esker morphology and sediment deposition to be explored.

Formation of Littoral and Offshore Irish Placer Resources (FLIPeR)

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Heavy mineral sands are common constitutes of igneous and metamorphic coastlines globally. Their distribution and occurrence are controlled by source, energy environment and natural tendency to sort by individual mineral densities. Marine placer deposits form when heavy mineral sands accumulate offshore in high energy environments where conditions are optimal for sorting these heavy minerals. Therefore, understanding the sediment transport pathway of the sands is imperative in identifying target locations for this project.

Ireland's potential for economically viable heavy mineral sands is yet to be fully explored. A recent reconnaissance survey of the Achill and Belmullet targets (Mayo) yielded encouraging results displaying a significant volume of heavy minerals onshore at a number of beach locations. Initial sampling has identified sand rich in magnetite with ilmenite, rutile, tourmaline, epidote, monazite and zircon also present. While the source of the deposits is yet to be revealed (i.e. onshore or offshore), fieldwork and earlier marine research surveys indicates a strong offshore component.

Geochemical data available from both Tellus and INFOMAR will be evaluated to help constrain the location of offshore targets before conducting a marine survey in July 2017. Methods for data collection for offshore targets will employ multibeamechosounder seabed mapping, magnetometer, seismics, ROV video-seabed inspection, coring and sampling. In addition, it is hoped that the data will aid in the understanding of how these deposits concentrate and how environmental controls dictate placer formation.

The effects of inversion structures on the Irish Orefield from regional to mine scale

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Variscan related deformation has been well studied in the SW of Ireland. However, much less is known about its manifestation in central Ireland and particularly its impact on Irish Zn-Pb deposits. Detailed 3D datasets for the Irish Orefield reveal that compression has inverted the main ore-controlling extensional faults and may have remobilised and augmented Zn-Pb mineralization.

Through the use of open-access and industry datasets, field mapping, 3D modelling, drill core sampling, petrographic analysis and published literature, this project will explore four main topics relating to inversion: 1) How inversion is manifested regionally throughout the Irish Orefield, 2) How ore-controlling normal faults and lithologies have responded to inversion at the mine scale, 3) The links between various breccia's and inversion-related deformation, and 4) The effects of inversion on potential remobilisation of the mineralisation.

Inversion-related structures modify the original geometries of ore bodies and are important complicating factors when exploring for new deposits. This study will provide key insights into the principal spatial, rheological and temporal controls on the inversion of Carboniferous normal faults and associated mineral deposits within the Irish Orefield. Ultimately, recognising these controlling structures is essential for the success of greenfield exploration campaigns within Ireland.

Towards a better understanding of sand delivery to passive margin basins

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In sedimentary systems, a range of processes controls the composition of the detrital mineralogy (e.g. weathering, recycling, diagenesis), and occur during transport, during intermediate storage in the hinterland, and after burial. While post-depositional alteration can be easily constrained, modification that occurs prior to final deposition is more difficult to decipher. This modification should manifest in the sedimentary record as variations in minerals of differing stability, with certain phases preferentially removed by weathering. These issues could be especially relevant to passive margin basins where the nature/duration of storage could be influenced by sea level fluctuation. Because of this, sediment composition within a given system could vary with sedimentological facies, with consequent implications for the prediction of sand character.

The well-constrained sequences of the Carboniferous Clare Basin present an ideal test case in which to investigate these concepts. Outcrop samples, linked to high-resolution logging, will be analysed using 1) detailed petrography of heavy minerals and framework components; and 2) multi-proxy provenance tools (U-Pb in zircon and apatite, Pb isotopes in K-feldspar). Heavy mineral indices sensitive to weathering (e.g. apatite-tourmaline), combined with identification of sources, should enable a better understanding of the impact of intermediate storage on the detrital mineralogy. These data will also help reconstruct the palaeogeography and the infill of the basin, for which there are currently contrasting models.

Linking naturally-occurring sources of arsenic with contamination of groundwater resources in the Longford-Down Terrane of North-East Ireland

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Arsenic (As) contamination of groundwater drinking resources affects up to 200 million people worldwide. The primary sources of arsenic in the environment are natural but the mineralogical sources and remobilisation processes which lead to its accumulation in some groundwaters are not fully understood.

Recent investigations have shown arsenic to be an emerging element of concern in Irish groundwaters, exceeding the recommended limit of 10 µg L-1.The work presented here focuses on an area of known elevated groundwater As, along the contact between Silurian-Ordovician greywacke and shale units of the Longford-Down Terrane, and the felsic Palaeogene SlieveGullion Complex in Co. Louth. Three drill cores were retrieved in the area by the Geological Survey of Ireland. Bulk geochemical data (ICP-MS & ICP-AES) alongside preliminary Scanning Electron Microscopy work coupled with energy dispersive X-ray spectroscopy of secondary iron oxyhydroxides are discussed, aimed at identifying potential mineralogical source(s) for the arsenic. A total average As content of c. 3 ppm for all bulk-rock samples is similar to estimated upper crustal abundances of 2 – 5 ppm. Several samples of greywacke and basalt are more elevated, ranging between 10 – 16.9 ppm, however, these also are within typical upper crustal abundance ranges.

Microseism Source Distribution Observed from Ireland

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Ocean generated microseisms (OGM) are recorded globally with similar spectral features observed everywhere. The generation mechanism for OGM and their subsequent propagation to continental regions has led to their use as a proxy for sea-state characteristics. Also many modern seismological methods make use of OGM signals. For example, the Earth's crust and upper mantle can be imaged using 'ambient noise tomography'. For many of these methods an understanding of the source distribution is necessary to properly interpret the results.

Ireland has a highly energetic ocean wave climate and is close to one of the major source regions for OGM. This provides an ideal location to study an OGM source region in detail. Here we present the source distribution observed from seismic arrays in Ireland. The region is shown to consist of several individual source areas. These source areas show some frequency dependence and generally occur at or near the continental shelf edge. We also identify a body wave component of the OGM wavefield related to more distant sources and use it to track a storm crossing the North Atlantic.

Towards a subsurface training and outreach centre in west Clare

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A geosciences training and outreach centre in west Clare, Ireland, is in the initial phases of development. For geoscientists working with or in industry, the value of the Pennsylvanian geology of the area lies in its analogy with hydrocarbon-bearing, deltaic to deep-water sedimentary successions on several continental margins, such as in the Gulf of Mexico. A programme of behind-outcrop drilling involving UCD and Statoil has acquired over 1,350 m of core from 12 boreholes behind the sea cliffs of the Loop Head peninsula. The new subsurface data have high value as an analogue dataset for use in training and reservoir characterisation. The cliffs are also visited by tourists and special interest groups. It is envisioned that the centre will involve the local community and wider public, facilitating links between natural resources, energy and environment. Transport of cores and training materials to the centre, where they will be available to visiting field parties, is planned for this year. Progress to date, including public engagement and consultation, and future plans will be outlined.

The Celtic Tiger and underdeveloped geoarchaeology in Ireland: exploring the impact of traditions of practice between states in the USA and EU

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Ireland has high standards of practice in cultural resources management (CRM/contract archaeology), but is one of several EU states with little current research in geoarchaeology, and almost no CRM applications of this beyond geophysical survey. This is despite the Celtic Tiger boom, with so much CRM work that archaeologists were imported from across the EU, and disregarding the experience of neighbouring states, which have included geoarchaeological assessment as standard practice for over two decades. Free online guidelines are available, but there are still no Irish recommendations for CRM geoarchaeology (beyond geophysical survey). Ireland is not alone in ignoring what other states consider to be a basic practice, but it is unique in having once had the funding potential to develop the best standards in the world.

To investigate why international disciplinary standards are not applied to state-based CRM, despite superstate guidelines and the movement of the same individual professionals across borders for work, I interviewed stakeholders in the EU and USA. In both unions, standards of practice are set by the profession itself, based on local traditions reflecting local research, political structures, understanding of public vs private, and the presence or absence of individual advocates.

Pyroxene standards for SIMS oxygen isotope analysis and their application to Merapi volcano, Sunda arc, Indonesia

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Measurement of oxygen isotope ratios in silicate minerals such as olivine, pyroxene, feldspar, and quartz is increasingly performed by Secondary Ion Mass Spectrometry (SIMS). However, the large compositional spectrum of some minerals results in matrix effects during SIMS analysis, which must be corrected through repeated analysis of compositionally similar standards to ensure accurate results. To widen the applicability of SIMS to pyroxene commonly found in igneous rocks, we performed SIMS δ18O homogeneity tests on new augite and enstatite reference materials. The tests verified that the new standards lack crystallographic orientation bias and that they are homogeneous on the 20 µm scale. We subsequently tested our new standards on pyroxene crystals from Merapi volcano, Indonesia. The δ18O values for Merapi pyroxene obtained by SIMS (n=204) agree within error with the laser fluorination (LF) δ18O values for Merapi pyroxene but differ from bulk mineral and whole-rock data obtained by conventional fluorination. The bulk samples are offset to higher δ18O values due to incorporation of inclusions that in part reflects crustal contamination processes. The Merapi pyroxene SIMS data, in turn, display a frequency peak at 5.8‰, which allows us to estimate the δ18O value of the primary mafic magma at Merapi to ~6.1‰.

The Transition Zone - investigating the extent and importance of the bedrock–subsoil interface

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The Transition Zone is the broken, weathered interface between bedrock and overburden. It may be formed by chemical weathering, physical processes, or both. Typically, it has a different permeability to the overburden and bedrock. It can, therefore, act as a significant pathway for groundwater flow and contaminant transport. Transition Zone processes may be of particular importance in poorly productive bedrock aquifers where the transmissivity of the Transition Zone may be greater than the bedrock transmissivity. The Transition Zone in Ireland has been studied on a site-specific basis by several research groups in recent years. However, the properties, extent and geospatial variability of the Transition Zone in Ireland are, as yet, poorly understood.

Geological Survey Ireland is presently investigating the extent, dimensions and hydraulic properties of the Transition Zone across different Irish geological units as part of the Groundwater 3D project. This work involves data collation, field mapping, and core and section logging. Future work will include geophysical surveys. An online Transition Zone Story Map has been created and is updated on an on-going basis (http://arcg.is/23H0Mmm). The story map presents photographs of the Transition Zone with their locations and geological data. It will be a useful tool to promote awareness of the Transition Zone and focus future characterisation of this important interface.

iTHERC:integrated imaging of the Irish and North Atlantic crust and lithospheric mantle.

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The thermal and compositional structure of the Earth is a fundamental constrain required to understand the planet formation and evolution. Furthermore, the insights offered by a robust thermo-chemical imaging of the lithosphere are crucial in the assessment of mineral and geothermal resources. The aim of iTHERC project is to obtain thermal and chemical models of the Irish and surrounding North Atlantic crust and lithospheric mantle. A Vast amount of different kinds of data constraining the lithosphere thermo-chemical structure are now available including, waveform tomography, active seismic profiles, electromagnetic observations, geochemical data and mineral physics constraints. Taking full advantage of such a diverse dataset requires a multi-disciplinary approach that implements all the available information in a self-consistent framework. We will perform an integrated, geophysical-petrological, thermodynamically self-consistent, modelling (forward and inversion) using, and further developing, existing software (LitMod) and other specialized open source codes for geodynamic modelling. In particular, the thermodynamically driven approach used to compute physical properties in the mantle will be extended to the crust. The resulting models will shed light on the processes responsible for the formation and evolution of the Irish lithosphere and will also offer as a foundation for a finer, crustal-scale assessment of Ireland's on- and off-shore mineral, hydrocarbon and geothermal resources.

Exhumation in the Irish Atlantic Margin: a review

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Understanding the timing, magnitude and causes of uplift and erosion events in sedimentary basins is critical for estimating the chance of success and volumetrics of oil and gas prospects. The prospective Irish Atlantic Margin is composed of several basins which have been affected by various exhumation events during their long life time. Several published and unpublished studies in the last forty years have tried to constrain and quantify these events using a large variety of datasets and methods. We present here a comprehensive review of published and unpublished exhumation data, basin by basin. The inboard basins and Irish platform have experienced a large amount of uplift and erosion in the Tertiary while the Porcupine Basin is not believed to have been affected much. A Neogene event is recognized on several datasets but its cause, magnitude and even existence is subject to debate. New low-temperature thermochronology methods such as AHe and modern inverse modelling and the new data that will be acquired and made public by the industry in the next few years (Dunquin, Druid) might bring new constraints on the exhumation history of the Irish Atlantic Margin.

Fresh insights into the origin of the 'Porcupine Arch', offshore Ireland

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Hyperextended basins west of Ireland contain a number of central arches and ridges that have been variously interpreted as fault blocks, serpentinite extrusions or igneous complexes. The Porcupine Arch (PA) is a deep-level (>10 km) domal feature associated with a prominent free-air gravity anomaly high (>50 Mgal) and high P-wave velocities (>7 km/s). Detailed seismic mapping of igneous sill complexes in the Porcupine Basin (PB) suggest a possible connection with the PA. The sills are forming a thick (>5 km) inter-connected network extending from the PA into the flanking Cretaceous stratigraphy, suggesting that the PA may be the top of a large (ultra)mafic intrusion that fed the sills. This is fully consistent with geophysical modelling (gravity and velocity), internal seismic characteristics of the PA, primitive bulk composition of the Porcupine sills, common gas chimneys around the PA, as well as regional Cenozoic uplift documented in the PB. Similar ultramafic intrusive complexes are common along the North Atlantic margin, including the UK Rockall Trough. These findings emphasise that higher heat-flow may have prevailed over a substantial portion of the basin and this could impact significantly on the extent and timing of petroleum generation, which can be tested by basin modelling.

Geochemical and Temporal Characterization of Holocene Cold-water Corals from Offshore Ireland

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Biomineralized skeletons of cold-water corals (CWC) may potentially be used as proxies for past environmental change within the oceans. This study focuses on a previously unstudied 5-meter long sediment core from the Western Porcupine Bank, at a depth of 740 meters, and features samples of the cold-water coral species, Lopheliapertusa. In-situ techniques were used to produce high-spatial resolution textural and geochemical maps of a coral skeleton, in order to investigate its intra-seasonal proxy potential. Raman spectroscopy was used for the first time in CWC biomineralization and was found to be an effective tool for diagenesis testing. SEM imaging and LA-ICP-MS also were utilized to study the coral skeleton. Using an existing transfer equation for Li/Mg to seawater temperature, in-situ measurement of Li/Mg ratios, in one coral radio-carbon dated to be 6,320 +/- 30 years b.p., are consistent with modern amplitudes of seawater temperature fluctuations in the NE Atlantic. Although promising, more work is needed to develop a Li/Mg temperature calibration based on in-situ rather than bulk analyses, which may result in accurate deep ocean paleoseawater temperature reconstruction.

The occurrence of anthelmintic residues in Irish karst and fractured bedrock aquifers: a pilot study

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Agro-chemicals such as veterinary drugs have become a critical component in animal husbandry in Ireland. Application of such agro-chemicals can potentially lead to their occurrence in groundwater. This work presents the preliminary findings of a pilot study on the occurrence of anthelmintic residues in Irish karst and fractured aquifers. Anthelmintics are one of three groups of agro-chemicals being investigated as part of this overall iCRAG (Irish Centre for Research in Applied Geosciences) project. A Solid Phase Extraction Ultra High Performance Liquid Chromatography Tandem Mass Spectrometry (SPE-UHPLC-MS/MS) method was developed and applied in a pilot study for the determination of 36 anthelmintic drugs in water samples from high risk sites targeted in terms of source and pathway factors. Up to five different anthelmintics were detected in four of fifty-two groundwater samples (8%) and four of twenty surface waters (20%) analysed. Detections were of the order of 1-31 ng L-1. Sites with groundwater detections had zones of contribution including areas of high and extreme groundwater vulnerability, associated with shallow Quaternary deposits or karst conduit flow. Future sampling will determine whether the absence of detections at other apparently high risk sites may be due to the timing of sampling in relation to groundwater recharge events.

Global thermochemical imaging of the lithosphere using satellite and terrestrial observations

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Conventional methods of seismic tomography, topography, gravity and electromagnetic data analysis constrain distributions of various rock parameters at depth, all depending on in situ temperature and composition. However, modelling multiple data provide a multifaceted image of the true thermochemical structure of the Earth that needs to be consistently integrated. A combination of gravity, electromagnetic, geodynamics, petrological and seismic models alone is insufficient due to the non-uniqueness and different sensitivities of these models, and the required internal consistency of all parameters describing the Earth involved. In fact, global Earth models based on different observables often lead to rather different, even contradictory images of the Earth. A breakthrough in global and consistent imaging of the fine-scale thermochemical structure of the Earth's lithosphere and underlying mantle is needed. Thermodynamic links between seismic velocities, density, resistivity, viscosity, melt, water, temperature, pressure and composition within the Earth can now be modelled accurately using methods of computational petrology and data from laboratory experiments. The growth of large terrestrial and satellite data over the last few years, together with the advancement of petrological and geophysical modelling techniques, now present an opportunity for global, thermochemical 3D imaging of the lithosphere and underlying upper mantle with unprecedented resolution.

Enhancing crustal and sedimentary structure of North Atlantic rift basins in hyperextended passive margins

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This iCRAG project involves investigations of sedimentary basin structure up to lithospheric scales across the conjugate continental margins of the North Atlantic. Initially, the research will focus on the Porcupine and Rockall basin system, where transitions between moderately extended to hyperextended continental crust are known to occur. It will use existing crustal-scale models of component basins in the region acquired by DIAS and other research groups, and long streamer seismic reflection data acquired by the Irish Petroleum Affairs Division, together with released industry geological/geophysical data. These will be used to constrain the study and test the derivative models, using various strategies. The overarching objective of the project is to understand the large-scale geological processes, which most significantly impact on the transition in extensional regime, across the proximal to distal regions of hyperextended continental margins. Fundamental to the aims of the research is the linkage between seismic stratigraphic observations and those in the tectonically-strained crust and deeper lithosphere. Insights into the structural architecture of basins, regional controls of sedimentation patterns and heat flow history are anticipated outcomes.

This research was supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

An integrated study of the Hatton Basin: its role in regional North Atlantic petroleum systems

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This project will focus on constraining the tectonic and thermal evolution of the Hatton Basin to understand its role in the formation of the North Atlantic passive margins, and its potential to host working petroleum systems. The datasets used for this study will include crustal-scale tomographic models developed by DIAS and other research institutes as well as long streamer seismic reflection profiles, potential field data and additional geological information (i.e. well data). These data will be integrated to better understand the large-scale sedimentary architecture and crustal structure of the Hatton Basin by means of seismic stratigraphic interpretation, basin analysis and gravity/magnetic field modelling. The results are expected to provide new insights into deep crustal and lithospheric processes that impact on the regional distribution of sedimentary sources and transportation pathways in the North Atlantic region. The identification of prospective reservoir structures and the analysis of source rock maturity will also be addressed in the long term to assess the potential for hydrocarbon resources in the Hatton Basin.

This research was supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

A New Earthquake Catalogue for Ireland and its Offshore Regions for the Years 2010-2015 based on Waveform Cross-Correlation

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The monitoring of earthquakes occurring in Ireland and its offshore regions has been conducted by the Dublin Institute for Advanced Studies (DIAS) and the British Geological Survey (BGS) since the 1970's. However, since 2010, the Irish National Seismic Network (INSN, operated at DIAS) has undertaken the role of earthquake monitoring in Ireland with the deployment of six permanent seismic stations, situated around Ireland. In addition to these six stations, several temporary seismic arrays have been operational in the same time period. By combining the data sets of the INSN with those of the temporary arrays, we obtain an improved set of locations for the existing catalog events. We also use cross-correlation of template earthquake waveforms with continuous data to identify repeating seismic events that may not have been detected by more conventional means. Although this method is limited to identifying earthquakes with similar locations and source characteristics, the total number of earthquakes in the catalogue from the years 2010-2015 has increased from 60 to 280.

Modelling and Monitoring Ireland's Surface Electromagnetic Fields for Space Weather Applications

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Solar storms can disturb the Earth's geomagnetic field, producing induced electric fields (IEF) and geomagnetically induced currents (GIC) at the Earth's surface that can cause interruptions in electrical power distribution networks. The large associated economic costs of these events can be reduced by accurately modelling and monitoring IEF and GIC, which are dependent on solar storms and the geology beneath the power transmission network.

This research aims to develop and implement a new methodology for modelling and monitoring Earth's surface electric and magnetic fields, improving the prediction of GIC, and reducing the impact of solar storms in Ireland and the UK. We propose to use magnetic data from permanent magnetic observatories, and from once-off geophysical measurements made at locations of interest.

We present a prior analysis evaluating the potential of the proposed methodology, and show, from synthetic results, the influence of subsurface geological structures on the surface electric and magnetic fields.

Accessing and Utilising INFOMAR's Seabed Mapping Data to Support Research

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Ireland's national seabed mapping programme, INFOMAR (INtegrated mapping FOr the sustainable development of Ireland's MARine resource) is jointly coordinated by the Geological Survey of Ireland and the Marine Institute.

The programme has gained a world class reputation for developing seabed mapping technologies, infrastructure and expertise. Currently in its second phase, and eleventh year, the programme continues to provide pivotal seabed mapping data products, e.g. databases, charts and physical habitat maps to support Ireland's Integrated Marine Plan.

The resulting information products include bathymetry, backscatter, shaded relief, UKHO charts, seabed classification and ground-truthing datasets.

INFOMAR's free data policy supports a thriving maritime economy by promoting easy access to seabed mapping datasets that underpin; maritime safety, security and surveillance, governance, business development, research and technology innovation and infrastructure.

This poster will demonstrate to users how to gain access to INFOMAR data which is freely available on the web at http://www.infomar.ie and showcases examples of how the data has been utilised. We hope to inspire and encourage researchers of all levels to utilise the datasets available to produce new and exciting research.

An integrated multi-isotope approach (87Sr/86Sr, $\delta^{18}O$, $\delta^{2}H$, $\delta^{13}C$, $\delta^{15}N$) to constrain Early Medieval diet and migration in Ireland

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Multiple isotopes (87Sr/86Sr, δ18O, δ2H, δ13C, δ15N) have been employed to constrain diet and provenance of Early Medieval populations in Ireland. The project demonstrates how geochemical mapping of 87Sr/86Sr in contemporary soils, plants and stream water can be used to assess potential archaeological migration, since geographical variation in 87Sr/86Sr is governed by geological and environmental processes. Preliminary results show that δ2H values measured by High-Temperature Conversion (HTC) with a glassy carbon reactor are consistently offset compared to those obtained using a chromium-packed reactor. Using the conservative estimate of 2SD, one individual has been identified as an outlier from the entire dataset for both Cr and glassy-C δ2H. High δ15N values for both animal and human bone collagen suggests an 15N enrichment in the biome that potentially reflects the effect of manuring. This project exemplifies the potential multidisciplinary ties between areas of geoscience and has been sponsored by the GSI-Geoscience Fulbright studentship.

A new high-resolution radon map of Ireland

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Radon is a naturally occurring radioactive gas and represents a significant radiological hazard to the general population. Radon may accumulate in buildings and has a proven link to a higher incidence of lung cancer. In Ireland alone it is estimated that every year over 250 lung cancer cases are related to radon.

The currently used radon map of Ireland is based solely on indoor radon measurements. It illustrates the probability of having an indoor radon concentration above a national reference level of 200 Bq m-3. The map is divided into grids of 10x10 km, where a High Risk Area is defined when the probability of exceeding the reference level is 10%, or higher.

Here we present a new high-resolution radon hazard map which utilises a combination of indoor radon concentrations and four separate geological datasets (bedrock geology, quaternary geology, soil permeability and aquifer type). Logistic regression models have been used to predict the probability of having an indoor radon concentration above 200 Bq m-3. The new map gives a more accurate representation of radon hazards at a national level. According to our modelling the population living in a High Risk Area is calculated at 1.3 million (28.7% of total population).

Equilibrium Conditions of Sediment Suspending Flows on Earth, Mars and Titan

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Sediment entrainment, erosion and deposition by liquid water on Earth is one of the key processes controlling planetary surface evolution. Similar modification of planetary surfaces by liquids associated with a volatile cycle are also inferred to have occurred on other planets (e.g., water on Mars and methane-ethane on Titan). Here we explore conditions for equilibrium flow – the threshold between net sediment erosion and deposition – on different planets. We use a new theoretical model for particle erosion-suspension-deposition that shows a better fit to empirical data than standard theory since it takes into account both flow competence and capacity, and particle size distribution effects. The results show that whilst lower gravities on Titan and Mars decrease the bed shear stress required for particle transport, it also proportionally effects the bed shear stress of moving fluid, such that similar slope gradients are required for equilibrium flow. These results may help explain why planetary surfaces share striking similarities in their present and past landscapes and shows that particle size distribution is critical to sediment transport dynamics. Interestingly, particle distribution may vary between planets depending on the particle compositions and weathering regimes, imposing differences in equilibrium conditions.

Bottom trawling at Whittard Canyon: seabed modification & sediment plumes

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Fishing vessels are attracted to the Whittard Canyon area due to the abundance and diversity of species found there. Both midwater and bottom trawling are commonplace right across the region, including deep canyon channel floors. Bottom trawling which uses heavy fishing gear is identified here as a possible cause of changes to the seafloor roughness. Vessel Monitoring System (VMS) data is used to quantify fishing intensity over the last ten years. An Arc Chord Ratio rugosity index is calculated for the Whittard area and correlated with VMS data. Over higher slopes or rougher ground the heavily fished locations show more homogeneous rugosity than those lightly fished.

VMS data has also shown bottom trawling activity on the adjacent interfluves/shelf, coinciding with the appearance of highly energetic, turbid, plumes within the canyon branches. Lipid biomarker analysis of organic matter from intensive and lesser trawl affected sites showed a clear distinction in quality and quantity. Low concentrations of phytoplankton derived lipids, high sedimentary signatures and variable bacterial signatures suggest reworking, resuspension and episodic change at canyons affected by the trawl sites at the adjacent shelf. Such anthropogenic activities raise implications for sediment transport behaviour and for local habitat distributions and function, across the continental margin.

3D Model of The Pre-Glacial Trench Central Dublin

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Farrington (1929) identified the existence of a pre-glacial channel just north of the River Liffey. Broadly speaking the channel diverts from the present day Liffey at Hueston Station towards James Gate, loops back across to the northen part of the city and reaches the coastline at Annesley Bridge. It is unclear whether widely varying sea levels, tectonic movements or some weakness in the underlying rock gave rise to the channel. This project has set out to determine the possible depositional environment and to characterise the engineering properties of the fluvio-glacial deposits found in the channel. This was achieved by generating a fully interactive 3D model over a section of the channel.

The process involved collecting all relevant borehole data. Hand drawn cross-sections were produced to cover the study area. The data was then inputted into gINT where the logs were simplified. From this database 3D boreholes were generated. Based on the logs and cross-sections stratigraphical layers were defined and projected in the model. The engineering properties of the fluvio-glacial deposits were characterised by analysing insitu SPT tests and related PSD lab tests. Hyperlinks to original logs, reports (where possible) and the project logs were created for each borehole.

UisceAille – Development of a focussed Integrated Catchment Management toolkit for use in secondary schools encompassing public outreach, citizen science and GIS mapping.

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In Ireland, a substantial amount of our rivers, lakes and groundwater systems are at risk of pollution both now and in the future. While the role of public engagement in catchment management is becoming increasingly recognised in academic, governmental and social spheres, it is only just beginning to be fully implemented and realised in Ireland. A key gap identified by the 2014 EPA Research Report – Towards Integrated Water Management (TIMe) is a lack of Integrated Catchment Management (ICM) focussed primary or secondary school initiatives. Having reviewed best practice in ICM, Environmental Education (EE), geological and hydrological outreach and strategies for community engagement and place based learning, this overall project aims to help inform the foundation of ICM by utilising a Participatory Action Research (PAR) approach that allows for the fostering of an ICM curriculum. By combining local knowledge with freely available environmental datasets and open source GIS software, the UisceAille project, which is supported by the Burren GeoparkLIFE program, will result in an educational toolkit that will enable educators to explore an alternative approach to local stakeholder engagement. Ultimately the program devised will align itself with the execution of the EU Water Framework Directive (WFD) within Ireland.

Research Programme, Geological Survey Ireland

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The Geological Survey Ireland recently published its Research Roadmap outlining the priorities and strategy for its research programme for the coming years. This document highlights the role the Geological Survey plays as a research funder, collaborator and performer in the geoscience sector in Ireland. The Survey is in a unique position to provide focussed, impactful funding for excellent geoscience research and technology development. It also supports national research facilities and research groups in both academia and industry and, importantly, links research outputs with government policy.

The key priority areas for the coming years are: (i) Sustainability and management of Earth's resources, (ii) risk mitigation for geological hazards and (iii) public perception of geoscience and citizen science. These are globally important topics and although research may focus on Irish datasets or locations, it is envisaged that research funded or co-funded by the Survey within these challenges would be applied internationally and/or include international experts in the area.

The Roadmap will also form part of the Geological Survey's overall strategy for geoscience in Ireland and will inform national science policy. This presentation will include a summary of funding awards and opportunities available from the Geological Survey Ireland in 2017.

Formation and properties of water from quartz and hydrogen at high pressure and temperature

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Quartz, as the most stable low-pressure polymorph of silica (SiO2), is widely abundant in Earth's crust and mantle, exhibiting relatively high chemical stability. Although silica is only slightly soluble in water at ambient conditions, producing silicon-based weakly acidic compounds, Shinozaki et al. (2014) have shown recently that water itself can be formed by dissolution of SiO2 in H2 fluid under high-temperature and pressure conditions. Here, we have simulated this process via molecular-dynamics techniques based on a reactive force-field description of the SiO2/H2 interface. Diffusion of the H2 fluid into the quartz crystal lattice was observed upon increasing temperature and pressure, followed by interaction of dissociated, atomic hydrogen with oxygen atoms in the SiO2 lattice, disrupting the lattice and leading to the formation of water. Interestingly, water is evolved in the sub-surface region of the silica, and it remains confined there, isolated from the hydrogen fluid, which corresponds precisely to the ice-like spectroscopic patterns observed experimentally. The over-pressured water formed from quartz and H2 is a possible trigger for nucleating enigmatic deep earthquakes in the continental mantle lithosphere, and may explain, in large part, the origin of water on Earth.

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