50th Annual Irish Geological Research Meeting

School of Environmental Sciences
University of Ulster, Coleraine

23rd-25th February 2007

Cover Image: A rubbing of the ammonite *Leptechioceras* preserved in the flinty Liassic hornfels, a metre or two above the Portrush sill.
This locality is important in that it featured prominently in the Neptunists v. Plutonists argument of the late 18th Century. Marine fossils in a crystalline rock seemed to prove the Neptunist view.

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Welcome to the University of Ulster and the 50th Annual Irish Geological Research Meeting. We are delighted to be hosting the meeting as it celebrates its half-century and look forward to a full and enjoyable programme of talks and poster presentations covering all aspects of earth science.

Talks have been scheduled according to broad themes and are listed in the schedule which follows. A dedicated poster session will be held on Saturday afternoon, giving the presenters an opportunity to discuss their research findings in depth. It is particularly encouraging to have a number of contributions from undergraduate students at this year's meeting.

We are delighted to present David Martill from the University of Portsmouth who will give the IGRM lecture on Friday night and Tavi Murray from Swansea University who will give the IGA lecture on Saturday night.

As the campus is some distance from the nearest town and on-campus facilities are limited at weekends, we have made some special arrangements with the Senior Common Room to provide lunches and bar services, opening until 1am on both Friday and Saturday. It will remain open during the day so feel free to use the facilities it offers for meeting etc. There is no parking charge from 5pm Friday to 7am Monday.

As always, the generosity of our sponsors is essential to the success of this meeting as it enables us to continue without registration fees, ensuring the meeting is accessible, especially to students. A list of our sponsors is available at the back of this booklet and on the meeting website.

Thank you all for coming to the meeting and we hope you enjoy your weekend on the North coast.

Meeting Schedule

Friday 23rd February
Venue: Lecture Theatre 1, South Buildings, Coleraine Campus

From 4pm	**Coffee and Registration**
19.45	**Introduction and Welcome**
20.00	**IGRM Guest Lecture** **"The last of the giant pterosaurs: skeletal modifications for flight"** Dr. David Martill, School of Earth & Environmental Sciences, University of Portsmouth
21.30	**Reception in Senior Common Room**

Saturday 24th February

8.45	**Welcome and Introductory remarks**
9:00	**Google Earth Science and Virtual Geological Heritage in Connemara** Ronán Hennessy and Martin Feely
9:15	**Breaking boundaries: Geopark expansion on a trans-national scale** Kirstin Lemon
9:30	**TOPO-Europe: Monitoring the changing Earth we live on** Alan G. Jones and the TOPO-Europe Team
9:45	**Integration of soil fingerprinting techniques for forensic applications - rapid, non-destructive screening of adhered rock and crystalline material for criminal investigations** Antoinette Keaney
10:00	**Geostatistics applied to data integration of multi-source geophysical and geochemical data from the Tellus Project** Jennifer M. McKinley, A. Ruffell, C. van Dam, D. Smyth, C.V. Deutsch and C. Neufield
10:15	**Completion of the national geochemical and geophysical surveys of Northern Ireland** Michael Young and Garth Earls

10:30 **Coffee**

11:00 **A Fluid Inclusion and Stable Isotope Investigation of Alteration and Mineralization in the Rosses Granite Complex, Co. Donegal.**
James Conliffe, M. Feely and K. Faure

11:15 **Preliminary White Mica dates from the Upper Devonian in SW Ireland.**
Meg Ennis, P. Meere and M. Timmerman

11:30 **Vesta comes of age: an appraisal of basaltic meteorite chronology and petrogenesis**
Ian S. Sanders

11:45 **Sedimentary processes on the north-west Porcupine Bank: cold-water coral carbonate mounds and erosional scarps**
Boris Dorschel, A. Wheeler, X. Monteys, V. Huvenne and H. De Haas

12:00 **Fluorescence lifetime study on crude petroleum oils using the frequency domain technique.**
Peter Owens, Alan G. Ryder and Nigel Blamey.

12:15 **Preliminary fluorescence lifetime measurements on hydrocarbon-bearing fluid inclusions from the Porcupine Basin, offshore Western Ireland.**
Nigel Blamey, Alan Ryder, Martin Feely and Peter Owens.

12:30 **Lunch**

13:30 **Electrical resistivity surveying of the Cloyne Cave system and surrounding area.**
John Savage, B. Higgs, R.Unitt and I.A.J. McCarthy.

13.45 **Temporal evolution of long-period seismic activity at Mt. Etna – no apparent link with the 2004 eruption**
I. Lokmer, B. Di Lieto, G. Saccorotti and Chris Bean

14:00 **Controls on the Propagation of Tsunamis in the Near-field of Megathrust Earthquakes**
John McCloskey, Andrea Antonioli, Alesio Piatanesi, Kerry Sieh, Sandy Steacy, Suleyman Nalbant, Jiandong Huang, Paul Dunlop, Massimo Cocco and Carlo Giunchi

14:15 **DEM Simulation of dynamic Fault Slip**
Steffen Abe and C. Bean

14:30 **Fault heterogeneity and earthquake scaling**
Alison Hetherington and Sandy Steacy

14.45 **Behaviour of fully ponded turbidity currents in confined basins: an experimental study**
Marco Patacci, William M. McCaffrey, Peter D. W. Haughton, Jaco Baas and Gareth Keevil

15.00 **Computation of Interseismic Stress from GPS Measurements in the Marmara Region, Turkey**
Emre Evren, Suleyman Nalbant, Sandy Steacy and John McCloskey

15:15 – 17.15 **Poster session**.

IGA Guest Lecture
"Geophysics in the cold: capturing ice stream dynamics"
20.00 Professor Tavi Murray, Department of Geography, School of the Environment and Society, Swansea University

21.30 **Reception in Senior Common Room**

Sunday 25th February

9.00 **Coffee**

09:15 **High-resolution digital image analysis and palaeoecology for dummies**
Breandán Anraoi MacGabhann, Paul D. Ryan, John Murray and Chris Nicholas

09:30 **X-ray microtomographic studies of exceptionally preserved three-dimensional Triassic shrimp**
Aoife Braiden, Patrick J Orr, Paul Tafforeau and Stuart L. Kearns

09:45 **Ecological reconstruction of exceptionally preserved tadpoles from the Miocene Libros fauna, Spain**
Maria E. McNamara, Patrick J. Orr, Stuart L. Kearns, Luis Alcalá, Pere Anadón and Enrique Peñalver-Mollá

10:00 **North African dinosaur faunas during the Cretaceous with an emphasis on Moroccan dinosaurs**
Nizar Ibrahim

10:15 **Waterloo Bay, Larne, Northern Ireland: A potential Global Stratotype Section and Point for the base of the Jurassic System.**
Michael J. Simms and Andrew J. Jeram

10:30	**Discovery of new rugose corals from Lower Carboniferous Waulsortian mud-mounds** Ian Somerville
10.45	**COFFEE**
11:00	**A Miocene fault in SE Ireland revealed by Ar-Ar dating of hydrothermal cryptomelane** David Jordan and R. Burgess
11:15	**Physical modelling of basement controlled normal faulting in wedge-shaped cover sequences** Martin Schöpfer, H. Koyi, C. Childs, J. Walsh and T. Manzocchi
11:30	**A new model of fault zone and fault rock thickness variations** John Walsh, C. Childs , T. Manzocchi, M. Schöpfer and A. Nicol
11.45	**A synsedimentary deformation unit within the Porter's Gate Formation (Early Carboniferous) of Hook Head, Co. Wexford and its possible regional significance** Jenny Brittain
12:00	**Regional evolution of Permo-Triassic basins along the NW European Atlantic Margin** Katerina Stolfova and P. M. Shannon
12:15	**Sediment dispersal across the Pangean Supercontinent: insights from provenance analysis of Mesozoic sandstones, offshore western Ireland** Shane Tyrrell, Peter D.W. Haughton and J. Stephen Daly
12:30	**In situ U-Pb analyses of detrital titanite: a new provenance tool applied to Neoproterozoic metasedimentary cover sequences in SW Scotland.** Claire A. McAteer, J. Stephen Daly, Michael J. Flowerdew and Martin, J. Whitehouse
12.45	**LUNCH**
13.45	**Reconstructing the configuration of the British/Irish Ice Sheet off the north west coast of Ireland.** Paul Dunlop, Rachel Shannon and Rory Quinn
14:00	**Characterization of Quaternary sediments using geophysical techniques in the Tullamore region of Co. Offaly** Xavier Pellicer, Gibson, P.J. and Warren, W.P.

14:15	**IODP 307: A high resolution record of contourite deposition and paleoclimatic forcing on the eastern Porcupine Seabight (Irish continental margin).** Rory O'Donnell, B Dorschel and A.J. Wheeler
14:30	**Deposits of thermohaline currents on slopes west of Ireland - implications for climate change** Lee T. Toms, N. Owen, P.D.W. Haughton, R.J. Edwards and P. Shannon
14:45	**Climate proxy response to late Holocene ^{14}C fluctuations in European stalagmites** Alex Jackson, F. McDermott, L. Baldini, D. Mattey and A. Mangini
15:00	**Closing Remarks, Student Prizes**

Posters

Coffee Breaks and Saturday 3.15pm – 5.15pm

Tectonics and sedimentation in a confined deep-water basin, Alfaro sub-basin, Tabernas, SE Spain.
L .Baudouy, P.D.W. Haughton, and J.J. Walsh

Using seismic velocities to estimate magnitude of denudation.
F. Biancotto, R.J.J. Hardy & S.M. Jones

Middle to Upper Jurassic tectono-sedimentary development of the northeastern Porcupine Basin, offshore Ireland.
C. Bulois and P.M. Shannon

Wide-angle seismic imaging of the Hatton Basin (North Atlantic)
A. Chabert, C. Ravaut, P.W. Readman, B.M O'Reilly, P.M. Shannon.

Monitoring seismic velocity changes in the Gulf of Corinth using Coda Wave Interferometry
L. Cociani, C. J. Bean and M. Möllhoff

Looking down to look up: Results of a DC resistivity study of the grounds of Birr Caste, Co. Offaly, Ireland

L. Collins, J. Spratt, B. Higgs, and A.G. Jones

Simulations and analysis of seismic waves in volcano seismology.
R. Davi, G. S. O'Brien and C. J. Bean

The Triassic – Jurassic boundary in Ireland
R.C. Doyle, J. E. Murphy, C. J. Nicholas, R. Goodhue

Field observations and geochemical investigation of the pre- and post-El Golfo landslide eruptions of El Hierro Island, Canary archipelago
Karina Fernandes, Orla McKenna, Marc-Antoine Longpré, Valentin R. Troll, Thor H. Hansteen

The Porcupine Irish Margins Project: First data examples from an onshore/offshore seismic experiment in SW Ireland
F. Hauser, B.M. O'Reilly and P.W. Readman

Nitrogen and Carbon Isotopes: a New Tool for Palaeontologists?
J. Hellawell, C.J. Nicholas and R. Goodhue

High-resolution spatial variation of soil and sediment content
Heather Kerrigan, Lorraine Barry, Jennifer McKinley, Barry Rawlins, Alastair Ruffell

Local transport and erosion of bedrock geology by recent quaternary glaciation at Knocknaskibbole, Castlebar
Aidan Lavelle

Processing of seismic data from the Irish sector of the Hatton-Rockall Plateau
L. Leacy, R. Hardy, and S. Jones

Crystal size distribution analysis of crystal-rich lava flows from the pre- & post-El Golfo landslide eruptions of El Hierro, Canary archipelago
Orla McKenna, Marc-Antoine Longpré, Valentin R. Troll and Brian O'Driscoll

Seismic evidence for mantle exhumation and serpentinisation in the Porcupine Basin
B.M. O'Reilly, F. Hauser, P.W. Readman and P.M. Shannon

Constraints on crustal structure in SW-Ireland from shear-wave refraction and density data
P.W. Readman, F. Hauser, B.M. O'Reilly, V.C. Do and H.-M. Rumpel

Electrical resistivity surveying of the Cloyne Cave system and surrounding area.
Mr. J. Savage, Dr. B. Higgs, Dr. R.Unitt, Dr I.A.J. McCarthy.

Re and Os isotopic systematics in organic-rich shales from the Clare Basin, Ireland – preliminary results
M. Stanislawska, D. Selby and D. Chew

Field Observations on Phonolitic Lavas at Teide Volcano, Tenerife
S. Wiesmaier, McKenna, C., Caulfield, L., Carracedo, J.C., Troll, V.R.

Abstracts.

DEM Simulation of Dynamic Fault Slip

S. Abe (stefan.abe@ucd.ie) and C. Bean

UCD School of Geological Sciences, University College Dublin

A discrete element (DEM) simulation is used to investigate the properties of dynamics rupture of a rough fault. The model fault has both small scale roughness and heterogeneity at large scales. The small scale roughness is due to the intrinsic properties of the DEM. The large scale heterogeneity is introduced by varying the amount of small scale roughness along the fault. The model, consisting of two elastic blocks separated by the fault, is started from a stress free state and due to a constant shear velocity applied the model parallel to the fault plane evolves into stick-slip dynamics. The properties of ruptures in the model are similar to real seismic events. We observe slip pulses which are comparable to those obtained from inversion of seismic data. Stress drops and rupture velocities are also similar to field observations. The spatial distribution of total slip generated by the model events is best fitted by a fractal distribution. Comparisons between the pre-slip stress and the displacement distribution shows that the extent of the rupture is strongly determined by the distribution of areas with a low stress deficit before the event.

Tectonics and sedimentation in a confined deep-water basin, Alfaro sub-basin, Tabernas, SE Spain.

L.Baudouy[1] (lucie.baudouy@ucd.ie), P.D.W. Haughton[1], and J.J.Walsh[2]

[1] *UCD School of Geological Sciences, University College Dublin, Belfield, Dublin 4*
[2] *Fault Analysis Group, UCD School of Geological Sciences, University College Dublin, Belfield, Dublin 4*

The Tabernas Basin (SE Spain) is a small (15 km wide), deep-water basin that contains evidence for oblique-slip intrabasinal faults that propagated to the palaeo-sea bed. The interplay between tectonics, sea floor morphology and gravity current behaviour gives insight into the processes operating in slope mini-basins with mobile shale or salt substrates. As faults propagated to the sea bed, they defined local areas of rapid subsidence that became deeps in which turbidity currents were preferentially trapped and ponded together with mass transport complexes. The ponded turbidite sheets are either structurally truncated against faults at the mini-basin margins, onlap surrounding slopes or are involved in local unconformities reflecting progressive near fault deformation. Variations in turbidite thickness reflect bathymetry on the floor of the depressions. As activity on the intrabasinal faults waned, the local depocentres filled and turbidites onlapped beyond the area of initial fault containment onto surrounding slopes; the structure of the partially contained turbidites deposited in the expanded basin differ from those in the earlier fully

contained faulted depressions. Continuing tectonic activity following healing of the mini-basin depressions resulted in particularly unstable slopes with episodic large scale slumping, sliding and failure of the onlap wedges.

Using seismic velocities to estimate magnitude of denudation

F. Biancotto (biancotf@tcd.ie), R.J.J. Hardy & S.M. Jones

Department of Geology, Trinity College Dublin

Accurate estimations of the temporal and spatial variation of uplift and denudation can improve our knowledge of how processes (like mountain building and mantle convection) affect and modify the Earth's surface. In this project, we focus on the Slyne basin, offshore Ireland, which has been affected by rift flank and epeirogenic uplift. Measuring uplift directly is generally impossible because reference levels are usually destroyed or at least modified by processes of erosion. A way to address this problem is to evaluate the magnitude and distribution of denudation at regional unconformities. Most common methods used exploit the thermal or mechanical properties of rocks, such as apatite fission track, vitrinite reflectance, sonic velocity modelling, but they all have the disadvantage to be restricted to boreholes locations. In addition there is often a large scatter in these sparsely distributed measurements. We show in this study that inversion of seismic velocity profiles from seismic reflection datasets can be a useful tool to spatially constrain the distribution and the magnitude of denudation. The subject is very important to oil exploration in the region in order to calibrate maturity models.

This project is supported by the Irish Petroleum Infrastructure Programme Group 4.

Preliminary fluorescence lifetime measurements on hydrocarbon-bearing fluid inclusions from the Porcupine Basin, offshore Western Ireland.

Nigel Blamey[1] (Nigel.Blamey@nuigalway.ie), Alan Ryder[1], Martin Feely[2], and Peter Owens[1].

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[2] *Geofluids Research Centre, Dept. of Earth and Ocean Science, National University of Ireland, Galway, Ireland.*

Fluorescence Lifetime Imaging Microscopy (FLIM) shows considerable advantages over conventional fluorescence microscopy for the quantitative analysis of Hydrocarbon bearing Fluid Inclusions (HCFI). This is particularly true in cases of complex sample substrates where sample turbidity and morphology can severely distort the fluorescence image or data. Our laboratory in Galway published the first fluorescence lifetime study of HCFI in 2004, where

the qualitative assessment of changes in oil composition in HCFI could be achieved by comparison with data from bulk crude oils. In 2005 a new FLIM system was acquired which enables the high resolution (both spatial and temporal) imaging of HCFI using the frequency domain (FD) method for the first time in Ireland. As part of a current project to develop a quantitative method to analyse HCFI by FD lifetime measurements, four HCFI samples from the Irish Porcupine Basin were studied in detail. The HCFI were hosted in quartz grains in sandstone and UV-fluorescent light (~360 nm) observation showed two principle UV fluorescent colours (yellow and bluish/greenish white). Yellow fluorescent HCFI occurred as primary inclusions within cement while the bluish/greenish white fluorescent HCFI were associated with secondary cross-cutting trails and thus postdate the yellow fluorescent HCFI. Fluorescence lifetimes for the full emission spectrum were then measured. Short lifetimes (1.4 – 3.0 ns) are associated with the yellow fluorescent HCFI, and occur at shallower depths. The longer lifetimes (6.0 – 9.4 ns) correlate with bluish/greenish white fluorescence. The short lifetimes originate from immature oils whereas the longer lifetimes are more representative of mature oils. The HCFI show an evolution in petroleum development within the Porcupine Basin from immature oil during cement growth to mature petroleum that was trapped in secondary fractures within sediment grains.

X-ray microtomographic studies of exceptionally preserved three-dimensional Triassic shrimp

Aoife Braiden[1] (aoife.braiden@ucd.ie), Patrick J Orr[1], Paul Tafforeau[2],[3] and Stuart L. Kearns[4]

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[3] *European Synchrotron Radiation Facility, Grenoble Cedex, France,*
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Three-dimensionally preserved arthropods were collected from Triassic shoreface clays near Frome, Somerset, England. Initial SEM analyses of a fractured cross-sectional abdominal surface of one specimen revealed detailed preservation of muscle fibres (replicated in calcium phosphate), and the gut (thought to be infilled by ingested clay). Specimens were then imaged using high-resolution x-ray microtomography (at 0.7µm and 5.3µm per voxel) at the European Synchrotron Radiation Facility, Grenoble, France. Studies of the

entire fossil (approximately 20mm long) confirmed that not only is muscle replicated throughout the specimen, but that individual muscle blocks, and on a micron-scale their fibres, can be identified. Similarly, the wall of the gut continues in three-dimensions and is replicated in detail (rather than being simply an infill of the original structure). X-ray microtomographic studies also revealed similar high fidelity preservation of extremely labile tissues such as digestive organs and nervous tissue in situ, within the body cavity. Using these datasets, detailed three-dimensional computer reconstructions were produced, thus allowing virtual dissection and examination. X-ray microtomographic studies of such rare, small, fossils, (particularly when used in conjunction with histological sections and decay experiments of comparable modern fauna), are invaluable in understanding the relative timing and taphonomic processes involved in such exceptional preservation.

A synsedimentary deformation unit within the Porter's Gate Formation (Early Carboniferous) of Hook Head, Co. Wexford and its possible regional significance

Jenny Brittain (jen_brittain81@hotmail.com)

Department of Geology, University College, Cork

A synsedimentary deformation unit within the Houseland Sandstone Member of the Porter's Gate Formation is described for the first time from three locations around the Hook peninsula. This deformed unit exhibits many of the characteristics of previously documented deformation units of a similar stratigraphic age in the Lower Limestone Shales of Pembrokeshire, South Wales. The deformation in Wales is considered to be comprised of a combination of ball and pillow structures and slump structures associated with possible seismic activity along the Ritec Fault during the Early to Mid Carboniferous. It is possible that the deformation at Hook Head and in South Wales may be contemporaneous and represent a significant regional sedimentary deformation event. To test the viability of this hypothesis, the units must be correlated. Detailed, integrated palynological sampling and sedimentary logging of the relevant Irish and Welsh sections has been undertaken to that end.

Middle to Upper Jurassic tectono-sedimentary development of the northeastern Porcupine Basin, offshore Ireland.

C. Bulois (cedric.bulois@ucd.ie) and P.M. Shannon

UCD School of Geological Sciences, University College Dublin, Belfield, Dublin 4

The northeastern part of the Porcupine Basin has been the focus of extensive hydrocarbon exploration for almost 20 years, leading to the discovery of the

Connemara (Quadrant 26) and Spanish Point (Quadrant 35) petroleum accumulations hosted in Upper Jurassic sandstone reservoirs. This part of the basin is structurally complex, with fault structures of various ages and orientations. The predominant structures in the area have a regional NE-SW orientation, with minor N-S and E-W structures. Regional syn-rift basin development took place in the late Middle through Late Jurassic, followed by post-rift Cretaceous and Cenozoic sedimentation. Petrophysical logs from wells in the region are integrated with seismic profiles in order to constrain the details of the regional Jurassic tectono-stratigraphic evolution. A Middle Jurassic (?Bajocian-Bathonian) succession, comprising a thick sandy sequence, was deposited in a fluvial-lacustrine environment within an early onset warp rift setting. This passes upward into an Upper Jurassic (Kimmeridgian-Portlandian) marginal marine succession whose deposition was strongly controlled by repeated extensional faulting. In tectono-stratigraphic terms, the distribution of both sequences suggests a general rift setting. Within the Upper Jurassic succession, evidence of several rift pulses, within linked sub-basins, has been identified. The project is funded by the Petroleum Infrastructure Programme.

Wide-angle seismic imaging of the Hatton Basin (North Atlantic)

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The HAtton DEep Seismic (HADES) project was designed to investigate the crustal and sedimentary architecture of the Hatton Basin and Hatton Continental Margin in the North Atlantic, west of Ireland. Results from this wide-angle seismic experiment on the Hatton Basin are presented here. One hundred ocean bottom seismometers (OBS) were deployed along a 363 km profile oriented N-W into the basin. Due to the very dense coverage of the data and the short spacing between each OBS (2-3 km) we applied a two-step tomographic approach on these data. First, we used a 2-D first-arrival traveltime inversion to define a velocity model using the refracted waves. This model was then used as an input model to define the Moho interface using pronounced PmP reflections. Our final model resolves considerable detail in the sedimentary and crustal layers that can be correlated with variations in the gravity and magnetic fields and provides a good image of the basalt features in the basin using data

recorded at long offset. Recently acquired seismic reflection data on the Hatton Basin have been reprocessed and integrated with the result of the tomographic inversion in order to better understand the geology in the Hatton region. This project is funded by the Geological Survey of Ireland and the Irish Petroleum Infrastructure Programme.

Monitoring seismic velocity changes in the Gulf of Corinth using Coda Wave Interferometry

L. Cociani (Lorenzo.Cociani@ucd.ie), C. J. Bean and M. Möllhoff

Seismology and Computational Rock Physics Laboratory, UCD School of Geological Sciences, University College Dublin, Belfield, Dublin 4, Ireland

Studing fault and fracture in-situ properties is a fundamental issue for a better understanding of many geological and geophysical phenomena. A seismic wave travelling across a fault is shifted in its phase, the degree to which this happen is controlled by the fracture compliance. We focus on the temporal evolution of this property by high resolution monitoring of seismic velocity variations in the Gulf of Corinth. In this work we apply Coda Wave Interferometry to families of repeating earthquakes recorded in the period 2000-2005 to monitor small temporal changes in the faults of the Corinth rift, which is possibly the fastest extensional rift in the world. This technique allows us, using the sensitivity of the tail of the seismogram or coda, to estimate with extreme precision the time delays between repeating earthquakes. Velocity variations observed in the period 2000-2001 are possibly related with stress changes in the fault system of the gulf.

Looking down to look up: Results of a DC resistivity study of the grounds of Birr Caste, Co. Offaly, Ireland

L.Collins[1] (lcollins@cp.dias.ie), J. Spratt[1], B. Higgs[2], and A.G. Jones[1]

[1]*Dublin Institute for Advanced Studies, Ireland*
[2]*University College Cork, Ireland*

The telescope at Birr Castle, in virtually the dead centre of Ireland at Offaly, was the largest telescope in the world for over 70 years (1840s onwards). Irish astronomers wish to continue this historical tradition and install a modern radio telescope in the grounds of the castle. However, stability requirements necessitate anchorage of concrete pillars to basement, at an unknown depth below the overburden. A DC resistivity survey was conducted in August, 2005, to determine depth to basement, with a Campus Tigre resistivity meter and multicore cable. Measurements were made every 5 m, with 28 electrodes deployed simultaneously. The data were modelled using the Res2dinv program,

and the results indicate that basement is at a depth of 9-14 m with an easterly dip.

A Fluid Inclusion and Stable Isotope Investigation of Alteration and Mineralization in the Rosses Granite Complex, Co. Donegal.

J. Conliffe[1] (j.conliffe1@nuigalway.ie), M. Feely[1] and K. Faure[2]

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The Rosses Granite Complex, Co Donegal is marked by pervasive sericite alteration, localized greisenization and beryl mineralization. Fluid inclusion and stable isotope analysis has been used to identify the source of the fluids responsible for alteration and mineralization of the granite. Two main phases of fluid activity have been identified in the main biotite granites; an early fluid event akin to fluid boiling which was followed by a later influx of cooler meteoric fluids. Fluid boiling occurred at 360 ± 50°C and is related to the widespread sericitization of plagioclase which is present to some degree throughout the Rosses Granite Complex. This boiling event was followed by an influx of relatively low temperature (<300°C) meteoric fluids.
Fluid inclusion analysis from greisen samples and associated beryl mineralization indicate alteration and mineralization occurred between 200 and 360°C. δ18Owater and δDwater values from muscovite and beryl range from 3.8 to 8.9‰ and -34 to -66‰ respectively, consistent with a magmatic source for mineralizing fluids. A late influx of meteoric waters (δ18O = -1.4 to 3.3‰) is associated with reabsorbtion of vein beryl and deposition of vein quartz.

Simulations and analysis of seismic waves in volcano seismology.

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One of the fundamental aims of volcano seismology is to characterise the magmatic system and to determine the evolution of this system. The analysis of seismic waves is used to determine the internal structure of volcanoes and to determine the source processes. Unlike traditional earthquakes the source processes inside active or restless volcanoes can be generated by a variety of different mechanisms, e.g. fluid transport, gas slug ascent. By understanding the source processes we can better constrain the evolution of the volcano plumbing system. By using a combination of computational seismology and computational fluid dynamics I aim to constrain possible source processes. Initial work has focused on seismic wave propagation in volcano conduit models. The resultant

synthetic seismograms where analysed to determine the role of the topography and conduit geometry.

Sedimentary processes on the north-west Porcupine Bank: cold-water coral carbonate mounds and erosional scarps

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[3] *Geological Survey of Ireland*
[4] *National Oceanography Centre Southampton, UK*
[5] *Royal Netherlands Institute for Sea Research, Texel, The Netherlands*

The Porcupine Bank is located ca. 200 miles west of Ireland separating the Porcupine Seabight from the Rockall Trough. Mounds associated with cold-water corals have formed in many places on the NW slope of the Porcupine Bank and often occur associated with erosional features. The Porcupine Bank is relatively starved of terrigenous sediment in comparison with the rest of the Irish margin. Sedimentary features such as ripples, scour marks around drop stones and scars are indicative of this strong and often erosive bottom current regime at mound relevant depths between 700m and 1050m water depth. Cold-water corals, with the potential for carbonate mound formation, are common in the study-area and dwell on many outcrops of consolidated sediment and dropstones. At a few sites, the cold-water corals form giant carbonate mounds with evidence for limited contemporary re-colonisation of mound relicts.
Here we present results from remotely operated vehicles (ROV), side-scan sonar and multibeam surveys. Based on recorded video images, the distribution of corals (alive and dead), outcrops, ripples, dropstones and human impacts was mapped with multibeam and side-scan sonar data providing the necessary spatial information. The coral and sedimentary facies distribution and shed light on the processes involved in the formation of carbonate mounds, erosional scarps and their possible relationships.

The Triassic – Jurassic boundary in Ireland

R.C. Doyle, J. E. Murphy, C. J. Nicholas (nicholyj@tcd.ie), R. Goodhue

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The Triassic-Jurassic boundary is considered to be one of the five major extinction events of the Phanerozoic. The global paucity of well-preserved successions across this interval has limited any comprehensive evaluation. In Ireland, however, a near-continuous sedimentary succession of marginal marine to marine facies spanning the Triassic-Jurassic boundary is exposed on the

foreshore at Larne, Co. Antrim. As part of an undergraduate research project we undertook limited large-scale mapping and facies analysis. Three stratigraphic sections through the boundary interval were logged in order to examine the depositional palaeo-environments and changes across this interval. Samples were also collected for XRD and ICP-MS analysis, in order to determine their mineralogical and chemical compositions. Our sedimentary logs reveal low energy depositional environments existed at Larne, shifting from shallow-marine during the Triassic to deeper marine into the Jurassic, signifying a transgressive episode. XRD analyses indicate that there are no evoporitic minerals in the Triassic units at Larne. XRD analyses also revealed that the general mineralogy of the Triassic and Jurassic sequence does not seem to vary greatly through time, despite an apparent shift in depositional palaeo-environments. Instead, changes appear to occur more gradually, perhaps supporting the possible transitional nature of the T-J Boundary.

Reconstructing the configuration of the British/Irish Ice Sheet off the north west coast of Ireland.

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Evidence from the terrestrial glacial record indicates that the limits of the last British/Irish Ice Sheet must have extended far out onto the continental shelf in the Northwest of Ireland. Data from the Irish National Seabed Survey (INSS) provides the first real opportunity to investigate this hypothesis in detail. This study utilised INSS multibeam swath bathymetry imagery along with backscatter and acoustic sub-bottom data sets to investigate the glacial record on the continental shelf off the North West coast of Ireland. The main objective was to determine whether the last British/Irish ice sheet occupied the shelf, and if so, to reconstruct its configuration and extent. The results show a complex seafloor morphology comprising of both relict and modern bedforms and we present the first evidence of former glaciation in the region. A range of submerged glacial landforms and sediments are evident that are most likely associated with a Scottish ice mass that invaded this portion of the continental shelf. The configuration of landforms close to the shelf edge suggests that ice extended as far as this and then rapidly ablated. The results provide the first evidence of at least one widespread shelf glaciation in the area and constrain ice sheet extent in this region.

Preliminary White Mica dates from the Upper Devonian in SW Ireland.

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Preliminary 40Ar/39Ar step-heating experiments have been carried out on a number of white mica separates from Upper Devonian sandstones in the Munster Basin. The samples were collected from the Gun Point and Old Head Sandstones Formations on the Beara Peninsula in SW Ireland. The micas in these samples are fine grained and approximately parallel to cleavage. The micas analysed here were picked from the 250µm to 170µm size fraction. The Upper Devonian sequences of the Munster Basin are considered to be derived from the Caledonian belt to the north and east, however 40Ar/39Ar analysis of the micas has produced dates (396 +/- 3 Ma) that indicate a younger source for the sediment. Further analysis is to be carried out on a full suite of mica separates from across the Munster Basin in order to examine these results on a larger scale. An in situ laser ablation analysis of cleavage parallel microstructures such as mica-beards and chlorite-mica aggregates is also being undertaken with the aim of directly dating Variscan cleavage formation in southern Ireland.

Computation of Interseismic Stress from GPS Measurements in the Marmara Region, Turkey

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It is now widely accepted that the modelling of co-seismic stress increases, together with the secular (interseismic) stress loading due to tectonic motions, can provide useful information on the state of stress on faults which has implications for seismic hazard. In this work, we focus on the interseismic part of the problem. To calculate the interseismic stress, researchers generally use simple models (e.g. deep or virtual dislocations) which tend to give fairly uniform values along faults. One of the questions that we are addressing here is the extent to which actual/observed measurements (e.g. GPS velocity fields) may be used to calculate tectonic loading along the faults. In this study, we test 3 different approaches to computing secular stresses in the Marmara region, Turkey. We compare the resolved stresses calculated using the a-) deep-dislocation method, b-) virtual-dislocation method and c-) stresses directly derived from observed GPS velocities. Our results show that the resulting interseismic stresses from the 3 different methods are similar in magnitude (where maximum secular Coulomb stress is around 0.018-0.02 bars/yr); but the distribution of the resolved stress changes dramatically in GPS based calculations.

Field observations and geochemical investigation of the pre- and post-El Golfo landslide eruptions of El Hierro Island, Canary archipelago

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El Hierro is the youngest of the Canary Islands and lies at the westernmost end of the chain where the Canarian hot-spot is thought to be situated. The island is characterised by a distinct three-armed rift system between which sectors of the edifice grew unstable and collapsed to form giant amphitheatre-like depressions, such as the El Golfo embayment. We hypothesise that the non-negligible mass removal to which the volcano is subjected during giant landsliding may decompress the magma plumbing system and induce changes within it. Our strategy to test this hypothesis is to conduct a comparison between pre- and post-landslide volcanics. In the field, we carefully logged a ~700m-thick lava pile of the failed volcano exposed in the steep landslide scarp. Furthermore, we mapped the Tanganasoga vent complex, a prominent post-collapse centre of volcanic activity resting unconformably against the landslide scarp. A clear increase in the occurrence of crystal-rich (clinopyroxene and olivine) flows takes place in the upper pre-collapse sequence. Major element analyses were obtained for a sample set (whole rocks and fused groundmass) from both the pre- and post-landslide lava sequences. This data was used to compare geochemical characteristics of pre- and post-collapse volcanics.

The Porcupine Irish Margins Project: First data examples from an onshore/offshore seismic experiment in SW Ireland

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An earlier wide-angle seismic line in the Porcupine Basin, leg 4 of the Rockall and Porcupine Irish Deep Seismic experiment (RAPIDS4), undertaken in 2002 has resolved the deep structure below a very highly extended crust. Additional wide-angle seismic data were gathered during another experiment in May 2004 by GEOMAR at the University of Kiel. A total of 5 profiles were collected using up to 25 ocean bottom seismometers to record seismic energy generated by two or three 32-litre airguns. The airguns were fired at one-minute intervals, resulting in over 2000 shots per profile. The Dublin Institute for Advanced Studies (DIAS) deployed seven land stations in southwest Ireland and recorded all of the shots during the month-long duration of the marine experiment. The results so far show that, in general, data quality is somewhat variable and seems to depend primarily on the number of airguns used for recording. On the better sections,

clear primary and secondary arrivals can be seen out to about 180 km. In this presentation we will describe the project and some first data examples.

Nitrogen and Carbon Isotopes: a New Tool for Palaeontologists?

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The trophic level of organisms within an ecosystem can be distinguished on the basis of their nitrogen and organic carbon isotope ratios, due to the internal isotopic fractionation of each organism at every stage of the food web. These isotopic fractionations have been used successfully by various authors to model trophic structure in present day and Neogene ecosystems. In this current study δ15N and δ13Corg are being used to investigate the community structure and palaeoenvironmental changes within a much older fossil ecosystem. The Early Eocene fish of Fossil Lake in the Green River Formation of SW Wyoming are part of an exceptionally well-preserved diverse aquatic community. Fluorapatite skeletal material of fossil fish specimens analysed from throughout the stratigraphic succession indicate that isotopic signatures can be used to define the trophic structure of extinct communities and for chemostratigraphic investigations. However, the pathways taken by nitrogen and carbon isotopes during organic matter degradation are still poorly understood. Experiments are now underway to determine whether the isotopic ratios of fish are affected during death, burial and early diagenesis. We hope to clarify this using modern fish in order to understand any taphonomic changes that may have occurred in Fossil Lake.

Google Earth Science and Virtual Geological Heritage in Connemara

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Past collaboration between Galway County Heritage Forum and the Department of Earth and Ocean Sciences in Galway has brought about publications on the building stones of Galway city and the geological heritage of the Twelve Bens and Roundstone. A new approach to the realm of virtual heritage has been undertaken, using Google Earth as a visualisation platform for exploring the shared geological and railway heritage of Connemara. A virtual field trip along the now disused 49 mile long Galway-Clifden railway line allows users to explore the rich geological heritage of Connemara. 3D models of railway buildings and bridges, coupled with photographs and documented accounts of journeys by travellers on the line, permit a broader appreciation of the relics of this natural and cultural landscape. ‘Disembarking’ at any of the eight stations along the route allows users to explore the geology of that locality. The

integration of 3D LiDAR data into the tour augments the methodology of communicating geological information digitally. Accessible via a standard HTML webpage, the diverse functionality of Google Earth, with integrated hyperlinked placemarks, info-windows, image overlays and three-dimensional SketchUp and ArcScene models will serve as an informative resource in both the region's educational and heritage domains.

Fault heterogeneity and earthquake scaling

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We investigate whether stress drop is independent of earthquake size in a self-similar 2D cellular automaton that includes heterogeneity and realistic stress concentrations. We find that very small ranges of heterogeneity lead to approximately constant stress drop scaling whilst large ranges lead to significant deviations from the constant stress drop model. Further, fractal distributions of strength show greater deviation from constant scaling than random ones. As most earthquake studies have involved limited magnitude ranges, we also analyse the effects of sub-sampling the data and find that restricted data ranges produce results consistent with constant stress drop scaling. Our results suggest that departures from constant earthquake scaling are real and reflect the heterogeneity of natural fault zones, but may not tell us much about the physics of earthquakes.

North African dinosaur faunas during the Cretaceous with an emphasis on Moroccan dinosaurs

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Recent discoveries in Morocco, Tunisia and Egypt have shed further light on the palaeobiogeography and evolution of some poorly understood dinosaur groups. North-African dinosaur assemblages are of critical interest to palaeontologists because they are very different from those found on Cretaceous Northern landmasses in their faunal composition. Very large predatory taxa are found in great numbers while large herbivores are rare or absent, which makes it very difficult to understand these ecosystems. The dinosaurs of North Africa have been a subject of some research projects recently. They may help to document important phases in the rearrangements of continents that were underway 100-150 million years ago, when Africa was breaking away from former contacts to the Iberian Peninsula, and to South America. More work is needed to establish the faunal composition of dinosaurs through the Cretaceous across North Africa.

Localities in Eastern Morocco are the main focus of a new Moroccan – Irish research project.
The Kem Kem beds in Morocco are a rich source of vertebrate fossils from the late Cretaceous. A variety of dinosaurs as well as crocodiles, turtles and fish are present, and these can be compared to finds from other localities, such as the similarly aged Baharyia Formation of Egypt.

Climate proxy response to late Holocene 14C fluctuations in European stalagmites

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Climatic conditions in the late Holocene were affected by changes in solar irradiance, as indicated by centennial-scale variability in cosmogenic isotope fluxes recorded by ice cores. New 14C (solar irradiance proxy) and oxygen isotope (climate proxy) data have been acquired for Holocene stalagmites from Grotte de Clamouse (S.E. France) and Attahöhle (Germany), and have been combined with new results from the Central Alps. Unlike previous studies that relied on tree-rings to provide 14C, we have measured both solar irradiance and climate proxies directly on the same calcite to assess unambiguously the temporal relationship between solar irradiance and climate change. Importantly, 14C shifts at ca. 2.7 ka in speleothems have an amplitude comparable with the contemporaneous atmosphere, implying minimal delay between atmospheric 14C and its encoding in the speleothem. The response of climate proxy (δ18O) to Holocene solar forcing varies on a regional scale within Europe. A new analysis of the relationship between the modern North Atlantic Oscillation (NAO) and rainfall δ18O from meteorological stations across Europe provides a new framework within which to rationalise the spatially variable response of climate to solar variability, and requires an amplification mechanism with a bipolar mode of variability similar to that of modern NAO.

TOPO-Europe: Monitoring the changing Earth we live on

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Continental topography is at the interface of processes taking place at depth in the Earth, at its surface, and above it. Topography influences society, not only as a result of slow landscape changes but also in terms of how it impacts on geohazards and environment. Although natural processes and human activities

cause geohazards and environmental changes, the relative contributions of the respective components are still poorly understood. To address the needs in an ever-changing Earth we live on, European geoscientists need to come together as never before in coordinated programme of observation, analysis, modelling, and interpretation. This programme is named TOPO-Europe, and it has recently been accepted as a EUROCORES theme.

TOPO-Europe addresses the 4-D topographic evolution of the intra-plate regions of Europe through a multidisciplinary approach linking geology, geophysics and geotechnology. TOPO-Europe integrates monitoring, imaging, reconstruction and modelling of the interplay between processes controlling continental topography and related natural hazard. Key objectives are to provide an interdisciplinary forum to share knowledge and information in the field of the neotectonics and topography evolution of Europe, to promote and encourage multidisciplinary research on a truly European scale, to increase mobility of scientists and to train young scientists.

Irish geosciences can and should play a significant role in TOPO-Europe.

A Miocene fault in SE Ireland revealed by Ar-Ar dating of hydrothermal *cryptomelane*

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Accumulating evidence suggests that Ireland witnessed uplift, denudation and faulting during the Cenozoic. However, the only onshore faults of known Cenozoic age in Ireland are found in the north east of the country, inferred by their crosscutting relationships with late-Mesozoic and Cenozoic stratigraphy. Where Palaeozoic lithologies predominate, a few Cenozoic faults are suspected based on fluvial and topographic geomorphology and Apatite Fission Track analysis. Occasionally, the age of fault movement can be determined via the isotopic dating of mineralisation that formed during faulting. For example, the potassium bearing Mn oxide cryptomelane that is found in some fault-hosted epithermal deposits, where mineralisation typically coincides with tectonic

activity, can be accurately dated by the K-Ar and 40Ar/39Ar methods. The Shankill Fracture Zone, one of several possibly related faults that cut the Leinster Granite Batholith of south east Ireland, contains epithermal mineralisation, including a hydrothermal fault breccia cemented by cryptomelane. 40Ar/39Ar dating of cryptomelane from the breccia yielded a Miocene mineralisation age of 12.1 ± 1.6 Ma (2σ), believed to be coincident with tectono-hydrothermal activity along the Shankill Fracture Zone.

Integration of soil fingerprinting techniques for forensic applications - rapid, non-destructive screening of adhered rock and crystalline material for criminal investigations

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The criminal mind is becoming increasingly familiar with clean-up procedures at the scene of a crime and following criminal activity. Police officers and forensic scientists are being faced with smaller and smaller amounts of trace evidence to analyze therefore the techniques which are carried out upon what remains are crucial – as the amount of material available for investigation is diminishing. The amount of evidence obtained can be used to establish alibi veracity and thus the implications of this type of investigative research can clearly be seen. Investigative research into the analysis of trace mud splashes on different substrate material attempts to utilise the amount of information which can be obtained at this micro scale. The nature of soil formation is very complex and is reliant upon a number of varying factors from bedrock to climate for a given area, it is this complexity which makes analysis of soil at a micro level important for establishing criminal movement and provides an individual soil signature for different locations around the world. Analysis of these splashes become increasingly more important when a number of analytical techniques can be used to establish their origin, non-destructive techniques are therefore a top priority in this type of investigative research.

High-resolution spatial variation of soil and sediment content

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The strategy of large-scale (1km) sampling has been questioned both by geomorphologists and forensic scientists alike as being unrepresentative, with

the suspicion being that variation within the 1km grid could be significant. Studies assessing small-scale (metre) variation are, however, very limited and thus a comprehensive analysis of such variation is required. Sampling was carried out on a visually homogenous field site at 5m intervals on a grid of 45m x 45m. A total of 200 samples were collected, comprising a deep (20cm) and surface sample for each point. Results at this stage are preliminary and focused on grain size, colour assessment and analyses by near-infrared spectroscopy, all of which show potentially notable variation in the samples, as revealed by spatial analysis completed thus far. On-going analysis through various destructive and non-destructive methods of these samples, as well as those collected from an additional field-site, will provide further insight. Confirming evidence for small-scale variation, such as is indicated, will have an impact upon sampling strategies for forensic investigations, as well as for geochemical exploration.

Local transport and erosion of bedrock geology by recent quaternary glaciation at Knocknaskibbole, Castlebar

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The varied and complex geology just north of the town of Castlebar, Co. Mayo, results from significant periods of deformation, magmatism and faulting over nearly 600 million years. The metamorphic rocks are Dalradian: the oldest is the Lough Anaffrin Pelitic Member (Appin Group) which is overlain by the Slievenagark Formation (Argyll Group). The Conloon Phyllite Formation occurs in a downthrown fault block and has a similar mineralogy to the Slievenagark Formation. The rest of the Dalradian rocks are thought to belong to the Argyll or Southern Highland groups. Granite and granodiorite intruded the Dalradian rocks. The earliest granite was pre-orogenic or syn-orogenic since it has the same foliation as the host rock. Devonian sandstones and conglomerates have faulted contacts with the Dalradian rocks and Lower Carboniferous sandstones lie unconformably on the schists of the Slievenagark Formation in the south of the area (Ballynacarriga). Outcrops of granite, granodiorite and the quartzitic schists of the Slievenagark Formation were shaped by glacial erosion. The bedrock geology is represented as clasts in the glacial till which is particularly thick in the west of the area. The clasts also provide additional information on glacial transport directions where they can be identified and compared with known sources.

Processing of seismic data from the Irish sector of the Hatton-Rockall Plateau

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The Hatton Continental Margin is located at the furthest Western frontier of the Irish continental shelf, approximately 450km off the Irish coast in both British and Irish waters. To date most of the exploration of the Hatton Continental Margin has taken place in the British sector where single-channel seismic data reveals "windows in the basalt" showing sediments of unknown age. In 2004, a high resolution multi-channel seismic survey was undertaken by PIP, GSI and the Rockall Consortium. The data was originally processed onboard to brute stacks with a 4ms sampling interval. By acquiring multi-channel data seismic velocities can be used to determine the velocity, thickness and depth of any sedimentary section observed through basalt windows. In this study we have reprocessed the seismic data for high resolution analysis and present first results from this processing. Velocity analysis of the data will reveal information about the lithologies seen on the seismic sections and the new knowledge of crustal structure will provide evidence of the tectonic history of this area.

Breaking boundaries: Geopark expansion on a trans-national scale

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Marble Arch Caves European Geopark, Marlbank, Florencecourt, Co. Fermanagh

There are currently 30 European Geoparks, found in over 10 different European countries, each one designated due to its significant geological heritage. Each Geopark may have a different geological foundation but each one has the same commitment to promote awareness of the local landscape and to provide environmental education. Marble Arch Caves European Geopark is one of only two European Geoparks on the island of Ireland and is currently the smallest Geopark within the European Geopark Network. It is however aiming to change all that by expanding across the international border into County Cavan and in doing do becoming the first trans-national Geopark. Such an expansion will allow the common limestone landscape found within both Cavan and Fermanagh to be jointly promoted and will increase the appeal of the area to both academics and tourists alike. The coming year will provide new opportunities for study and recreation within the region as some of the hidden landscapes of Fermanagh and Cavan are allowed to shine as part of the first truly international Geopark.

Temporal evolution of long-period seismic activity at Mt. Etna – no apparent link with the 2004 eruption

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Between December 2004 and August 2005, more than 50,000 long-period events (LP) were recorded, encompassing the effusive eruption which started in September 2004. A large number of these events exhibit similar waveforms, indicating the involvement of a non-destructive, repeatable source process. The spectral and particle-motion analyses imply that the source is most likely related to the resonance of a fluid-filled buried cavity. We use the SOMPI method based on the autoregressive models of linear systems to determine the resonance characteristics of the source (source Q). These Q factors tell us about the time evolution of the physical properties of the fluid driving the source process. In our dataset, the most energetic part of signal consists of two eigenfrequencies, spanning the interval 0.5 – 0.8 Hz. We observed there was no significant change in their relative values throughout the considered time period. It tells us that there was likely no significant change in the type of fluid or amount of gas involved in the source processes. Surprisingly, it seems to suggest that the LP-generating process was not related to the renewal of effusive activity at Mt. Etna in September 2004. This is significant as LP events are routinely used to 'predict' eruptions.

High-resolution digital image analysis and palaeoecology for dummies

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Recent technological advances have facilitated even greater resolution of palaeontological and palaeoecological analysis. Such studies on soft-bodied fossils have previously been limited to in situ field measurements, however many remains of this type are not amenable for this kind of investigation. However, many of these specimens may instead be studied by combining high-resolution digital photography (now widely accessible) with basic image and statistical analysis. As an example, digital photographs were taken with a 6 megapixel camera of a surface from the Booley Bay Formation, Co. Wexford, which preserves hundreds of sub-centimetre swing marks. The image processing freeware GIMP was used to overlay a grid onto suitable areas of the photographs, and the image analysis freeware SCION Image was used to scale the photographs, and to record the position, orientation, and details of the morphology of each of more than 600 specimens over a combined area of less than 400cm2. Statistical analysis of the results demonstrates that these are clustered on the surface, and have a consistent preferred orientation linked to the palaeocurrent. This technique is applicable to any surface on which position,

orientation and morphological data, at a high degree of precision, could be useful.

In situ U-Pb analyses of detrital titanite: a new provenance tool applied to Neoproterozoic metasedimentary cover sequences in SW Scotland.

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Investigating the provenance of sedimentary rocks can provide insight into crustal evolution and palaeogeography. Ideally an integrated, multi-method approach should be used as no one technique (e.g. U-Pb dating of detrital zircon) can be described as the definitive provenance tool. This contribution presents, for the first time, an in situ U-Pb single grain study of detrital titanite. This new technique has been applied to investigate the provenance of two probable Neoproterozoic metasedimentary cover sequences in SW Scotland, the Colonsay Group and the Iona Group, for which we also have whole-rock Sm-Nd and U-Pb detrital zircon data. The data yield younger maximum depositional ages (c. 942 Ma and c. 1482 Ma, respectively) than previous detrital zircon studies and support the hypothesis that the main source of detritus, the c. 1780 Ma Rhinns Complex, was not affected by the Grenville Orogeny. One sample (from the Dun Gallain Grit Formation of the Colonsay Group) exhibits a markedly different titanite age distribution to that of zircon. Various possibilities exist for this difference including additional source terranes, which did not develop significant zircon in comparison to titanite. Alternatively the titanite may be recording metamorphic events in the source(s).

Controls on the Propagation of Tsunamis in the Near-field of Megathrust Earthquakes

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We report on progress on our multi-disciplinary study of the potential for another megathrust earthquake near Sumatra and the likelihood of this producing another devastating tsunami. Here we focus on the controls on tsunami generation and propagation in the near-field of such an earthquake using numerical simulations of subduction and tsunamigenesis on the Sumatran forearc. We calculate the seafloor displacements and tsunami wave heights for about 100 complex earthquake ruptures whose synthesis was informed by reference to geodetic and stress accumulation studies and whose stochastic distributions of slip are chosen to conform to absolute limits on post-seismic strain which preclude the isolation of areas of high slip on the megathrust. Remarkably, results show for the first time that, for any near-field location: 1) the timing of tsunami inundation is independent of slip-distribution on the earthquake or even of its magnitude and 2) the maximum wave height is directly proportional to the vertical coseismic displacement experienced at that location. Both observations are explained by the dominance of long wavelength crustal flexure in near-field tsunamigenesis and we, therefore, argue that they may be general for all coastal sites in the near-field of great megathrust earthquakes.

Crystal size distribution analysis of crystal-rich lava flows from the pre- & post-El Golfo landslide eruptions of El Hierro, Canary archipelago

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El Hierro, the youngest of the Canary Islands, is thought to currently overlie the Canarian hot spot. This island has not been studied in great detail relative to other ocean islands around the world yet its volcanic history has been marked by the occurrence of several giant landslides, the most recent of which is the El Golfo landslide. Whilst steep scarps produced by this landslide expose the structures and lava sequences of the pre-collapse volcano, post-collapse volcanics are found in distinct areas. Using crystal size distribution (CSD) analysis, this study aims to quantitatively compare the textures of the pre- and post-collapse lavas. Four key samples, characterised by the abundance of large clinopyroxene and olivine crystals, were selected from pre- and post-collapse flows. Two thin sections per sample were scanned at high resolution. Outlines of the clinopyroxene and olivine crystals were traced in Adobe Illustrator, using different layers for each crystal type. The dimensions of the crystals were then measured using a computer program. This information was incorporated into the CSDCorrections program, generating a series of CSD graphs. Analysis of the graphs allows the recognition of the different crystal populations and provides important information on magma reservoir time in deep reservoirs.

Geostatistics applied to data integration of multi-source geophysical and geochemical data from the Tellus Project

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The Tellus Project, managed by the Geological Survey of Northern Ireland (GSNI) and funded by the Department of Enterprise Trade and Development and the EU's Building Sustainable Prosperity Fund, involves the most concentrated geological mapping project ever undertaken in Northern Ireland. The data comprise multi-source airborne geophysics collected by a specialist geophysical survey aircraft and a geochemical survey of soil and streams. The fact that the airborne geophysical and geochemical data are generated at varying spatial resolutions means that they are not immediately comparable. This research uses geostatistics to provide information on the scale of spatial variation in the geophysical and geochemical data. A Bayesian Updating Approach is used to integrate geochemical data sampled on a coarse grid of one sample per 2sq km with airborne geophysical data collected on a much closer net of 70x200m. In summary, this technique uses geostatistics to improve the resolution of widely sampled data by integrating different, more closely sampled, data. The technique thus indirectly improves the resolution of the soil geochemistry and of the associated geological mapping. The advantage of the technique is that multiple variables of different types and different sources (in this case radiometric and soil geochemistry) can be simultaneously integrated and applied to mapping variables of interest.

Ecological reconstruction of exceptionally preserved tadpoles from the Miocene Libros fauna, Spain

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The Miocene Libros lacustrine sequence in NE Spain hosts an exceptional fauna (including insects, adult and larval frogs, salamanders, birds, snakes) and flora within profundal, organic-rich, finely laminated mudstones. Larval frogs (tadpoles) are abundant and exhibit variations in developmental stage, orientation with respect to bedding, articulation and the extent, and type, of preserved soft tissues. Soft tissues are defined predominantly by a carbonaceous bacterial biofilm; jaw sheaths, however, are organically preserved and the former positions of the brain and nerve cord are defined by calcium carbonate. Based upon the position of eyespots, presence and ultrastructure of jaw sheaths, composition of gut contents and the shape of the body and tail, the Libros larvae are assigned to the benthic lentic ecomorphological guild. This, the first ecomorphological reconstruction of a fossil larval anuran, supports phylogenetic evidence that benthic lentic ecology is a conserved ranid feature.

The last of the giant pterosaurs: skeletal modifications for flight

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Pterosaurs were the flying reptiles of the Mesozoic Era. They made their first appearance in the Late Triassic as relatively small (crow sized) animals and persisted until the end of the Cretaceous, when their demise coincided with that of the more famous dinosaurs. During the late Jurassic some pterosaurs underwent skeletal modifications that permitted them to increase their wing spans, and by mid-Cretaceous times at least two groups of pterosaurs achieved gigantic proportions with wing spans in excess of 6 metres. By the very end of the Cretaceous the very last of the pterosaurs had wing spans of between 9 and 11 metres and perhaps even as large as 14 metres.

Such large dimensions posed considerable strain on the pterosaur air frame, and this is reflected in the way that the skeleton was constructed. The pterosaur skeleton was modified to be both light and strong. Weight reduction was achieved by reducing the amount of bone in each skeletal element, loss of some skeletal elements, loss of teeth in some forms, and the development of a pneumatic system within the skeleton. Strength was provided by modification of the cross sectional shape of most of the long bones of the limbs, geometric organisation of internal bone trabeculae and by a variety of changes to the osteohistology of the skeleton, included the helical bandaging of microlamination in long bones. Airframe engineers and material scientists could do well to study pterosaurs.

Geophysics in the cold: capturing ice stream dynamics

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Fast flowing ice streams occupy only 10% of the Antarctic coastline but deliver ~90% of ice from the Antarctic interior to the coast. Their flow rate controls the volume of ice stored in the ice sheet. Glaciologists are faced with the problem that many processes which control ice motion occur kilometres beneath the surface at the interface between the ice and the underlying substrate. However, ice is an ideal environment for the application of many geophysical techniques and these techniques have led to significant advances in our understanding of glaciers and ice sheets. Surface and airborne radar has a long pedigree in glaciology and has been used extensively to map beds of ice streams. Cold ice, such as that in Antarctica is easy for radar energy to penetrate and recent advances have meant that it has been possible to image structures within the ice and use the reflectivity at the bed to capture aspects of the basal water system. Radar energy does not normally penetrate the beds of ice masses – which are often wet sediments. However, reflection seismic surveys allow us to image deeper into the basal environment. Using the impedance contrast across the basal interface it is possible to determine whether basal sediments are frozen or unfrozen, and whether they are actively deforming or the ice is sliding over the bed. These questions are key to understanding the dynamics of an ice stream. As an ice mass moves over its bed, seismic energy can be released that provides information on the nature of the basal environment. These events record different source types and relative friction between regions of the bed (so-called “sticky” and “slippery” spots). Considerable work is required to fully exploit the potential of this technique which requires integration with GPS measurements, locating events, and modeling of source types. Geophysical techniques are an ideal tool for exploring the inaccessible environment beneath ice streams. In this presentation I will outline geophysical success stories in understanding ice stream dynamics, highlight some remaining challenges and identify areas where the continued exploitation of geophysics in the cold has great potential.

IODP 307: A high resolution record of contourite deposition and paleoclimatic forcing on the eastern Porcupine Seabight (Irish continental margin).

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The Belgica Mound province is the site of numerous remarkable cold-water carbonate mounds that range for 45km. and extend as high as 170 metres above the seabed. These mounds and their enclosing contourite drifts located on the eastern margin of the Porcupine Seabight act as high resolution paleoceanographic recorders. In April 2005 the IODP (Integrated Oceanic Drilling Programme) drillship Joides Resolution visited Irish waters to partake in a unique venture to drill these structures. A number of sites were sampled in and around the moribund Challenger Mound as well as an adjacent drift body. This study aims to use these drill cores to unlock the paleoenvironmental record contained within the contourite core by means of a detailed Particle Size Analysis across some 92 metres of core. With the development of a solid stratigraphy this work will provide a record of fluctuating current regimes & sedimentary styles throughout the Pleistocene & Holocene. To this end we will use a number of geochronological techniques to further constrain temporal rates. On-going analysis will help to isolate various components and identify sedimentation styles controlled by IRD, contour currents, distal turbidites, aeolian fall-out etc. This information allied with provenance data will hopefully identify the dominant processes acting within the Porcupine Seabight and provide answers on the relationship between grain-size, sedimentary processes and climate in the NE Atlantic region over the last circa 1.2Ma.

Seismic evidence for mantle exhumation and serpentinisation in the Porcupine Basin

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New wide-angle seismic data along a 230 km profile that runs across a deep structural feature (Porcupine Arch) within the Porcupine Basin are presented. Sixty-five ocean bottom seismometers were deployed at ~ 3 km intervals and airgun sources fired at 100 - 150 m intervals along it. Results of forward modelling indicate that the continental crust is extremely thin (locally < 2 km) across the basin centre, and in places may be absent. The sedimentary succession is up to 12 km thick and comprises three distinctive seismic layers. The uppermost two layers are interpreted as a post-rift succession of

Cretaceous and Cenozoic strata deposited following a major phase of Jurassic lithospheric extension. The lower layer is interpreted as a succession of predominantly Jurassic syn-rift sediments, whose large-scale geometry reflects the response to the focussing of extensional strain, produced by a simple shear mode of differential lithospheric extension. A strong asymmetry in crustal geometry is probably related to this mode of extension. Crustal thinning is greater than in the adjacent Rockall Basin. Local exhumation of continental mantle lithosphere may have occurred in parts of the Porcupine Basin, as suggested by very low Pn velocities. This project is funded by the Geological Survey of Ireland and the Irish Petroleum Infrastructure Programme.

Fluorescence lifetime study on crude petroleum oils using the frequency domain technique.

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Petroleum oils are complex mixtures of aliphatic, aromatic, and high molecular weight organic compounds. Due to their heterogeneous nature the chemical analysis of petroleum oils is complex and time consuming. Fluorescence techniques have been used for many years as a fast and non-destructive tool in the analysis of crude oils; however, a quantitative, reliable, and reproducible technique has yet to be developed.
Time-resolved fluorescence spectroscopy can provide a more robust and informative method for the analysis of crude petroleum oils. Most time-resolved studies to date have utilised the Time Domain based Time Correlated Single Photon Counting (TCSPC) technique. In contrast to TCSPC, measurement in the frequency domain (FD) offers a simpler methodology (no de-convolution) and rapid analysis. FD techniques involve exciting the sample with intensity modulated light at a specific frequency. The fluorescence emission responds at the same modulation frequency and because of the time lag between absorption and emission, the emission is delayed in time relative to the modulated excitation. Another characteristic is that the fluorescence emission signal becomes demodulated relative to the frequency of modulation. Fluorescence lifetimes can then be calculated from the measurement of the differences in the phase and modulation of the excitation and emission light. In this work, we have used an upright confocal Fluorescence Lifetime Imaging Microscope (Alba system from ISS, Champaign, Illinois) with a modulated 405nm violet diode laser providing the excitation light. A frequency synthesiser provides frequencies in the 1 to 300 MHz range in conjunction with an RF amplifier for modulation of the light detector gain.

We have measured the phase and demodulation ratios for 32 bulk crude oils at four different band-passes of wavelength (426-477 nm, 480-520 nm, 542-582 nm, and 600-650 nm), which covers most of the steady state emission spectrum for the oils measured. The 32 oils tested have a wide range of oil maturities and are sourced from diverse geographical locations and rock types. From the phase and demodulation data, various data fitting algorithms are used to determine the fluorescence lifetimes of the oils. In this work we show how the various fitting models compare with TCSPC measurements. The general trend is that fluorescence lifetimes are shorter for heavy (less mature) oils and longer for lighter (more mature) oils. Lifetimes also tend to increase with increasing wavelength band-pass, with lifetimes being shorter in the 426-477 nm bandpass than the 600-650 nm bandpass. To uncover more meaningful trends from this complex data set, chemometric methods (principle components analysis (PCA) and partial least squares (PLS) regression) are employed to correlate the lifetime data to the gross chemical composition of the oils.
Alongside the development of a crude oil model, we have also obtained lifetime data for individual Hydrocarbon Bearing Fluid Inclusions (HCFI). Comparing HCFI data with the data from the crude oils enables a qualitative assessment of the maturity of the oil present. However, the exact composition of the enclosed oil is of vital importance in evaluating reservoir filling histories and oil migration direction – presently, estimates of oil composition without a priori information are used as inputs to geological models. Our goal is to develop a robust, quantitative model based on our crude oil data that will enable the quantitative, non-destructive, analysis of oil composition within HCFI.

Behaviour of fully ponded turbidity currents in confined basins: an experimental study

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Confined areas of low topography on the deep sea floor can be filled by contained turbidites. Flow ponding can result in unusually thick sandstones with distinctive structures that onlap surrounding slopes. Despite being widely recognized, the dynamics of confined turbidity flows and the suspension clouds they create is still poorly known. Key issues are what controls the wide variety of deposit structures observed in confined basins, and the nature of lateral and vertical textural trends within ponded sandstones.
A series of experiments using scaled steady turbidity flows were run in a specially designed tank allowing partial and full ponding. Ultrasonic transducers were employed for non-intrusive 3D measurement of the flow velocity. Sampling of the suspension allowed the calculation of temporal and spatial variation in concentration. Sampling of the deposit and SEM photography were used to map lateral and vertical grain size distributions.

Velocity and concentration data reveal the pattern of growth, the internal circulation and a system of internal waves within a sustained suspension cloud reflecting initial rebound, multiple reflections and the end of the flow input. The results can help explain the complex vertically tiered structure of ponded turbidites and lateral changes as the surrounding onlap slopes are approached.

Characterization of Quaternary sediments using geophysical techniques in the Tullamore region of Co. Offaly

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Several types of glacial and postglacial geomorphological features, which occur in the Irish Midlands have been analysed and characterized using Electrical Resistivity (ER) and Ground Penetrating Radar (GPR) geophysical techniques. Lithological changes in the Quaternary sediments can be inferred from ER data. Time-lapse resistivity imaging survey has been carried out on a monthly basis during 2006 along four different lines. Variations in the transfer and absorption of water through the sediments have allowed the detection of more subtle changes in the nature of the glacial sediments. In addition, the changes in resistivity on a monthly basis have been found to be considerable. Moreover, GPR has been used to classify and characterize the sedimentological and deformational structures within esker ridges, frontal moraines, glaciolacustrine sub-aqueous fans, lacustrine plains and glaciodeltaic sediments. GPR surveys carried out on exposures that occur in gravel pits, using different antenna frequencies, have facilitated the interpretation of the data gathered on areas where exposure was not available. Internal sedimentary and deformation structures within Quaternary sediments such as foresets and bottomsets within glaciodeltaic sediments, channel features and faulting within sub-aqueous fan and morainic sediments and the presence of boulders within esker ridges have been identified. Furthermore, water table and lithological boundaries have been detected using these techniques.

Constraints on crustal structure in SW-Ireland from shear-wave refraction and density data

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VARNET-96 was an international, multidisciplinary project, designed to examine the 'Variscan Front' in southwest Ireland. The seismic experiment consisted of two lines running approximately SSE-NNW. Along line A eight in-line shots were recorded over a length of ca 200 km. Line B is ca 140 km long and recorded 13 in-line shots. Results from ray-tracing and travel-time inversion of refracted and reflected S-waves indicate a multi-layer crust that can be sub-divided into a sedimentary layer, an upper crust, a middle crust, a lower crust, and the uppermost mantle. The sedimentary and upper crustal layers show strong vertical and lateral velocity variations along the profiles. Throughout the middle crust velocities increase, and reach maximum values of up to 4.1 km/s in the lower crust. The central part of the lower crust along line B shows a strong anomaly. This area was modelled as a low velocity region with values of Vs=3.90 km/s. The P- and S-wave crustal velocities define variations in Poisson's ratio, giving better constraints on the likely petrological composition of the crust. This is further constrained by density variations derived from the P- and S-wave velocities that are correlated with changes in Bouguer gravity anomaly across southwest Ireland.

Vesta comes of age: an appraisal of basaltic meteorite chronology and petrogenesis

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Most basaltic meteorites probably come from asteroid 4 Vesta. Isotopic dates from basaltic meteorites pose a problem. The oldest known solar system objects are clasts in chondritic meteorites called calcium-aluminium-rich inclusions (CAIs). These formed 4567.11±0.16 Myr ago. Basaltic meteorites have yielded precise Pb-Pb ages of only 700 kyr to 1 Myr younger than CAIs. The same basaltic meteorites have yielded consistent ages of 3 to 4 Myr younger than CAIs based on all other isotopic systems (26Al-26Mg, 53Mn-53Cr, 182Hf-182W). A new 2-stage model may explain the age discrepancy. Large, first-generation planetesimals formed quickly at the beginning and suffered high-energy collisional encounters in < 1 Myr after CAIs. Condensates from the resulting vapour plumes retained U (refractory) but were depleted in Pb (volatile). The condensates accreted at 1 to 1.5 Myr into second-generation bodies. Thermal modelling shows that these bodies would have been heated by radioactive 26Al decay and melted to make basalt at 3-4 Myr. Almost all Pb and U in these bodies would have fractionated into the basalt (both are highly incompatible). Hence, the basalt would inherit the old Pb-Pb age of the original condensates. The model also explains the depletion of volatile elements in basaltic meteorites.

Electrical resistivity surveying of the Cloyne Cave system and surrounding area.

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In 1986 when Higgs and Beese discovered the presence of a non-marine lacustrine clay deposit of Lower to Mid Jurassic age it has since been postulated that the palaeokarst surfaces on the Waulsortian Limestone Formation were well established by this stage. There has been extensive electrical resistivity surveying carried out over a large area of land to the East and South of the village of Cloyne investigating the now concealed palaeokarst surfaces. It can be clearly seen in the reproduced sections that there is double-tiered cave system present under the surrounding environs of Cloyne. It has also been shown that there are large buried valleys striking in an approximately northeast to southwest direction, these valleys are up to 50m deep and over 70m in width in places. Along the edge of the interface between bedrock and the buried valleys a second lower cave system can be observed, weathered pinnacles of limestone can also be observed. Surveying was also carried out within the cave system and this has shown that there is on average 2m of clay present in the upper cave system with large voids present underneath. These voids demonstrate a network of caves corresponding to the upper cave system.

Physical modelling of basement controlled normal faulting in wedge-shaped cover sequences

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We have performed a series of sandbox experiments in order to investigate the impact of a dipping base cover interface on fault growth and geometry. Normal faults developing in the analogue material have fault dips of ca 65°. We varied both the dip of the basement faults and the dip of the base cover interface: the basement faults have dips of 45 and 70° and the base cover interface has dips of 0, 10 and 20° and its strike was always normal to the strike of the pre-cut faults. Using the stereonet it can be easily shown that under boundary conditions where the base cover interface is inclined, strike changes of the faults within the cover are expected, if the fault dip within the cover is not exactly the same as the pre-cut fault dip. This is due to the fact that a continuous fault that

refracts across the interface has to have the same fault/interface intersection lineation. Our simple geometrical predictions of the orientation of cover faults are verified with our sandbox experiments, in which we observed either fault strike changes or systematic stepping of fault segments within wedge-shaped sand covers.

Waterloo Bay, Larne, Northern Ireland: A potential Global Stratotype Section and Point for the base of the Jurassic System.

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Many stratotypes for geological Stage and System boundaries are already designated but that for the base of the Jurassic Period, the best known of all geological periods, has yet to be decided from candidates in southern England, Austria and the Americas. A foreshore section at Waterloo Bay, Larne, on the east coast of Northern Ireland, exposes an almost uninterrupted succession from the upper part of the Mercia Mudstone Group (Triassic, Norian) through to the lower part of the Lias Group (Jurassic, Sinemurian). Not previously studied in detail, it is now clear that the Triassic-Jurassic boundary section here is superior in many respects to that at St. Audrie's Bay, SW Britain, long cited as one of the candidate GSSPs.

The boundary succession (base Lilstock Formation to top Planorbis Subzone) at Larne is significantly thicker and deposition demonstrably more continuous than anywhere else in NW Europe. Sedimentary cycles are clearly developed and provide significant potential for global correlation, an important aspect of any proposed GSSP. A rich fauna of ammonites, bivalves, gastropods, echinoids, crinoids, trace-fossils and occasional vertebrates are present. Within the Planorbis Subzone (basal Lias Group) clearly definable biohorizons can be recognised for the ammonites *Psiloceras erugatum*, *Neophyllites imitans*, *N. antecedens*, *Psiloceras planorbis/sampsoni* and *P.plicatulum*. The site would make an ideal stratotype for the first three of these, for which no surface stratotypes currently exist.

Discovery of new rugose corals from Lower Carboniferous Waulsortian mud-mounds

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Examination of Waulsortian mud-mounds on Howth peninsula, Co. Dublin has led to the discovery of clusters of small solitary and colonial rugose corals, some of which are new taxa. Three different genera of rugose corals have been identified: *Amplexocarinia*, a fasciculophyllid and an axophyllid. The last named genus has a complex axial structure, lonsdaleoid dissepiments and a weakly fasciculate colonial growth. The fasciculophyllid shows evidence of budding. The corals occur in two small pockets associated with abundant ostracods, bryozoans, crinoids, goniatites and rare tabulate corals (*Syringopora*). Corals are normally very rare in Waulsortian mud-mounds with only occasional records of *Amplexus*. The exposures at Sutton have never yielded corals before and most of the section is dolomitised. The upper Tournaisian mud-mound facies with stromatactid cavities and general absence of calcareous algae are usually interpreted as having formed in deep-water low-energy environments. However, it is suggested that the corals at Sutton may have flourished in the upper part or flanks of mud-mounds, acting as pioneers, some of whose descendants in the early Viséan occupied shallower water shelf facies. The coral assemblage at Sutton is compared with coral faunas from Carboniferous mud-mounds in the Craven Basin in northern England.

Re and Os isotopic systematics in organic-rich shales from the Clare Basin, Ireland – preliminary results

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187Re-187Os dating of organic-rich shales is a relatively new method for dating sedimentation, and has been shown to yield accurate and precise age constraints. To test the applicability of this geochronometer on black shales that have experienced elevated palaeotemperatures (> 350 °C) through burial, six samples from a single bed of organic-rich shale (Bilinguites bilinguis marine band, R2b1) from the thermally overmature Carboniferous Clare Basin were analysed. The samples have unusually high total Re and total Os contents, 72-228 ppb and 0.47-1.32 ppb, respectively. The samples have extremely high Re/Os ratio (1200 to 2400) and a highly radiogenic 187Os/188Os compositions (6.4 to 12.5). These data (n=6) yield a preliminary Re-Os isochron age of 313 ± 23 Ma (MSWD = 20, 2 ˙ with an initial 187Os/188Os ratio of 0.68 ± 0.62. The precision of the results (± 7%, 2 ˙ is lower than recently-published results (often <± 1%, 2 ˙ from other organic-rich shale samples, using the same analytical protocols. The samples are unaltered, so the lack of precise correlation is chiefly a function of scatter in the data, and secondly a lack of samples with low Re/Os ratios. Additional samples with lower Re/Os ratios would improve the regression.

Other marine bands in the Clare Basin will be dated for further assessment of the method potential at elevated palaeotemperatures.

Regional evolution of Permo-Triassic basins along the NW European Atlantic Margin

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The Permo-Triassic basins of the Northern Atlantic region developed in a complex geological setting. Seismic reflection data and well data from the Irish, the West of Shetland and the Norwegian offshore were interpreted and were used to gain further insights into their development. The basins generally show a range of structural and stratigraphic geometries from the Variscan orogenic region northwards into the Norwegian sector. On the flanks of the Rockall Basin interpreted Permo-Triassic strata typically exhibit a tabular geometry on E-W sections and a constant thickness. Seismic packages record rare examples of stratal wedges in N-S and SE-NW directions, which are interpreted as low-magnitude syn-rift deposits. However, in comparison to the Jurassic, the Permo-Triassic strata represent minor rift phases. Interestingly Permo-Triassic salt is probably present in the Rockall basins in the form of salt pillow structures and salt walls, an interpretation that is supported by a ductile character of the seismic reflectors and abundant detachment faulting. The geometries of the Permo-Triassic strata and their distribution over broad areas suggest wide extension of continental crust during basin formation.

Deposits of thermohaline currents on slopes west of Ireland - implications for climate change

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The Quaternary in Northern Europe was marked by climatic fluctuations occurring with variable periodicity. On larger scales there were glacial and interglacial periods (~40-100 ka), whereas at shorter time-scales, stadial/interstadial variations occurred at ~5-10 ka. The latter are less well understood, but may coincide with perturbations in thermohaline currents in the North Atlantic. In this study, a suite of gravity cores from the stable western slope of the Porcupine Bank (offshore west Ireland) are being investigated. Detailed logging of cores on traverses from high to low on the slope at a depth

of ~500 to ~1500 m and subsequent correlation are helping to constrain the nature of these near-surface slope deposits in 3D. The sedimentological framework will be combined with geochemical analysis and dating techniques in order to elucidate climatic and oceanic signals. Furthermore, changes in the water column stratification impinging on the Porcupine Bank will also be reconstructed. These results will inform a study of cores taken from north of the main area, where the slope has been subject to instability, with the aim of better constraining the timing of slope failures. A micropalaeontological study (specifically foraminifera) is being undertaken in parallel with the gravity core sedimentology. Combined, both studies will create a better picture of oceanic and climatic variations west of Ireland during the Late Quaternary.

Sediment dispersal across the Pangean Supercontinent: insights from provenance analysis of Mesozoic sandstones, offshore western Ireland

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Mesozoic sedimentary basins on the NE Atlantic Margin record a complex history of active tectonism and thermal subsidence prior to and during Pangean break-up. Sandstones of Triassic and Jurassic age, west of Ireland, are prospective for hydrocarbons, though the origin and distribution of potential reservoirs remains poorly understood. Determining the provenance of sedimentary rocks can help to constrain the distribution of reservoir sandstones and the scale/geometry of ancient drainage systems. A technique utilising the Pb isotopic composition of detrital K-feldspar provides a powerful means of tracking individual sand-grains back to their source and overcomes some of the weaknesses inherent in traditional provenance methods. Previously reported Pb data imply that Triassic sandstones from the Slyne Basin (Corrib Gasfield) were sourced from Archaean and Proterozoic rocks in northern Pangea and transported more than 500 km. New Pb analyses of Upper Jurassic fluvial and marine sandstones from the northern Porcupine Basin suggest a small-scale drainage system, flowing southwards from the Porcupine High. Combined with a revised Pb basement domain map of the North Atlantic region, these data imply derivation from two distinct local uplifted Proterozoic massifs. The absence of Archaean grains suggests a significant reorganisation of the drainage since the Triassic.

A new model of fault zone and fault rock thickness variations

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The thicknesses of fault rock and fault zones and the fault normal separations for breached and intact relay zones each show a positive correlation with fault displacement. The correlation for fault rocks is widely interpreted as a growth trend principally controlled by fault rock rheology, with new fault rock generated by wall rock wear or strain hardening of slip surfaces. Analysis of a large compilation of faults with a variety of fault and rock types, supports an alternative model in which faults localise as segmented arrays of irregular fault surfaces, with individual locations along a fault evolving across the thickness-displacement trend due to the progressive destruction of relay zones and fault surface irregularities. The final fault rock thicknesses are therefore strongly influenced by the original fault structure. Our model predicts and is supported by a progressive increase in the ratio of displacement to thickness, or shear strain, from a median value of 0.28 for intact relay zones to a median of 50 for fault rocks. The large scale range on which both fault segmentation and the irregularity of fault surfaces occurs, with the latter resulting from both propagation and from segment linkage, provides the basis for application of this model over a scale range of at least 8 orders of magnitude.

Field Observations on Phonolitic Lavas at Teide Volcano, Tenerife

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The Pico Teide/ Pico Viejo central volcanic complex on Tenerife erupted phonolitic lava several times during the last 10,000yr from perimeter and flank vents. The resulting highly alkaline lava flows show distinct features in cross-section that differ significantly from common Aa-style lava flows. Near the vents, these flows form classic levées and flow channels. However, near the end of the flow these lavas form prominent lobes with aspect ratios higher than that of typical Aa flows. At roadcuts orthogonal to flow direction, lava deposits consist of several roughly concentric sequences of a massive capping layer and brecciated lava underneath. We currently consider two emplacement mechanisms: a) a single flow of continuous lava supply, which develops different cooling regimes due to changes in initial temperature and gas content, and b) consecutive pulses of lava through tubes, which have been either drained and refilled, or supplied by changing effusion rates. These enigmatic features may be due to a unique combination of composition, gas content and viscosity on Tenerife as these features have yet to be documented elsewhere. Further work will be conducted in the field along with complementary analogue

experiments. Constraining rheology and viscosity may help determine a suitable emplacement model.

Completion of the national geochemical and geophysical surveys of Northern Ireland

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The Geological Survey of Northern Ireland has now completed new national geochemical and airborne geophysical surveys over Northern Ireland, under the Tellus Project. These data will be made available in 2007 for geological and environmental research and to promote further mineral exploration. The geochemical surveys have mapped the regional distribution of 60 elements and compounds in soils, stream sediments and stream waters. New anomalies in gold, platinum group elements and base metals have been mapped. More detailed soil sampling in Belfast and Londonderry provides an urban geochemical baseline. The latest geophysical imagery has revealed great detail on regional and local structural features. The new magnetic map sharply outlines the Palaeocene Antrim lavas, characterises the various intrusive complexes and shows the whole of Northern Ireland to be intruded by different classes of Palaeogene dykes to an extent not previously realised. Regional and local lineaments and gross variations in formation electrical conductivity have been mapped by the electromagnetic system; these results will contribute to both mineral exploration and environmental management. The radiometric (gamma-ray) results image lithological variations and provide a new means of estimating radon risk in different areas.

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