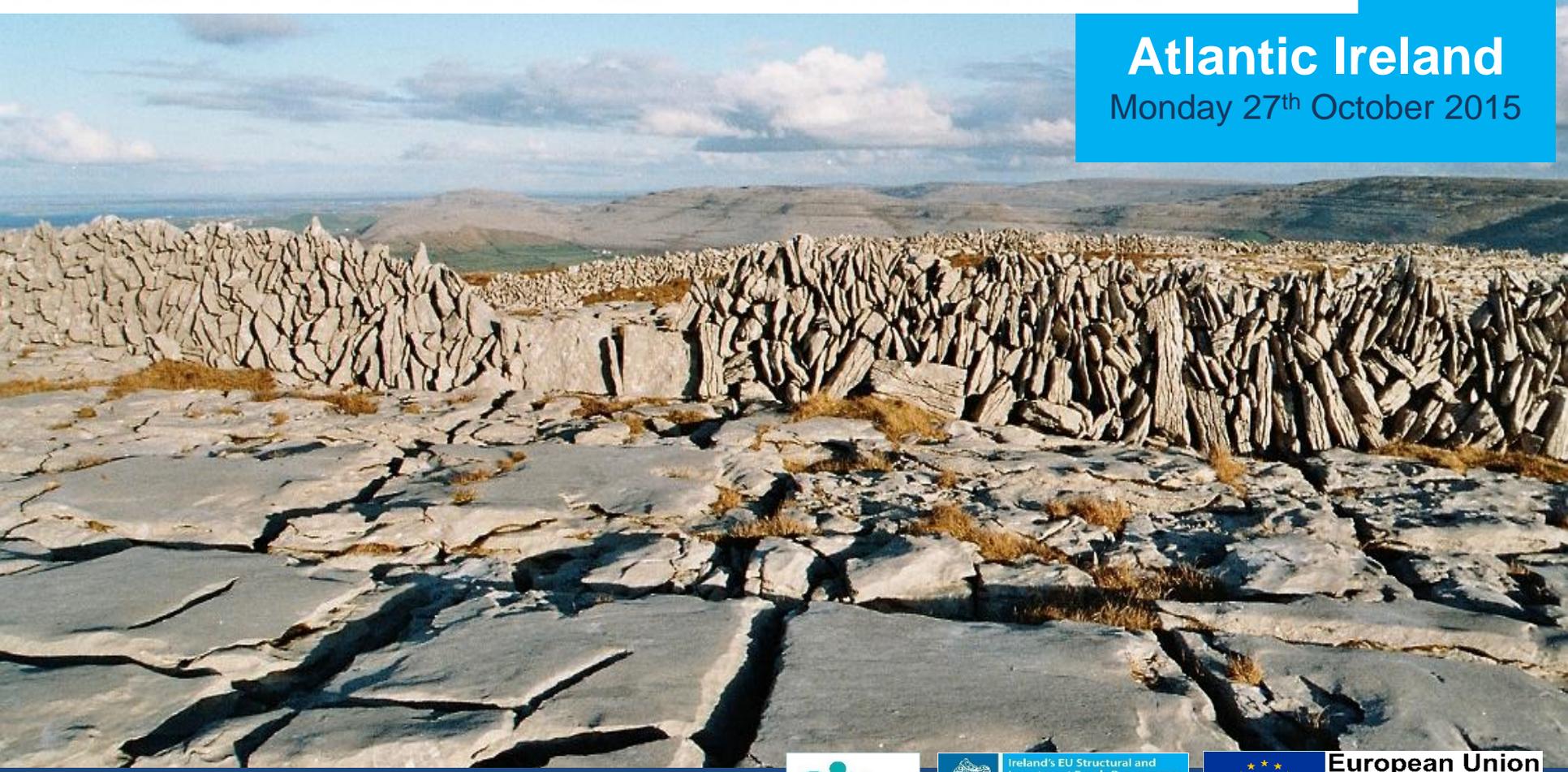


icRAG

IRISH CENTRE FOR
RESEARCH IN APPLIED
GEOSCIENCES

Atlantic Ireland
Monday 27th October 2015



Ireland's EU Structural and
Investment Funds Programmes
2014 - 2020
Co-funded by the Irish Government
and the European Union



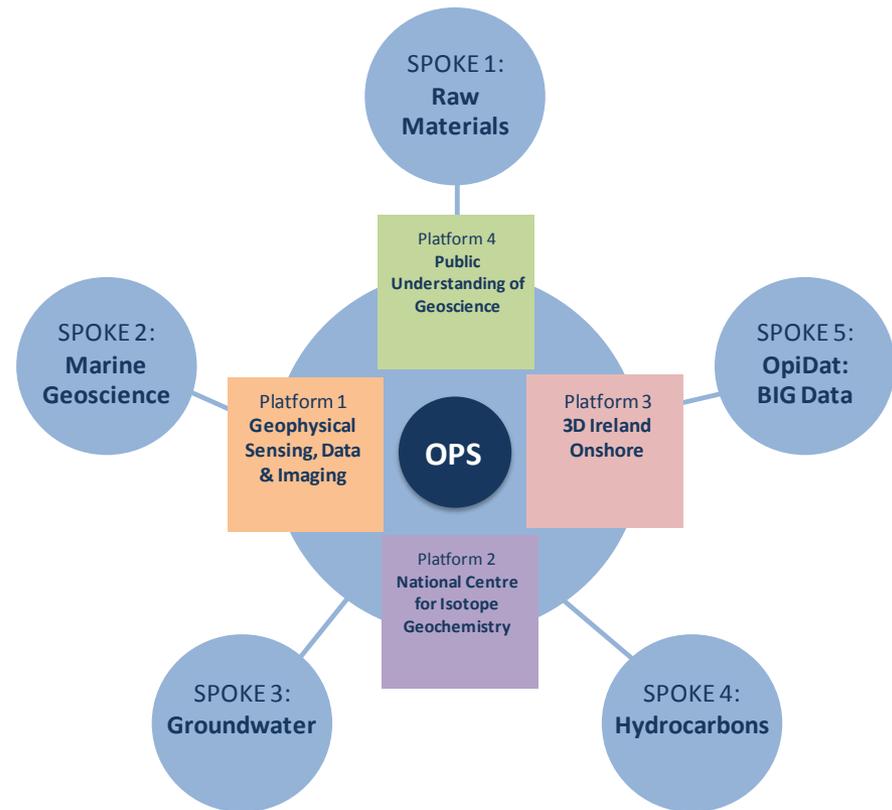
European Union
European Regional
Development Fund

AIMS:

- Help unlock our natural resources.
- Contribute to securing supply of energy and safe water.
- Educate and improve understanding of geosciences.

How do we de-risk exploration for resources?

- Better descriptions of the geology.
- Improved understanding and models of the geology and related processes.
- Innovative techniques for predicting the location and nature of resources.
- Improved methods for optimising the production of resources.



53 Industry sponsors and 5 Government Organisations

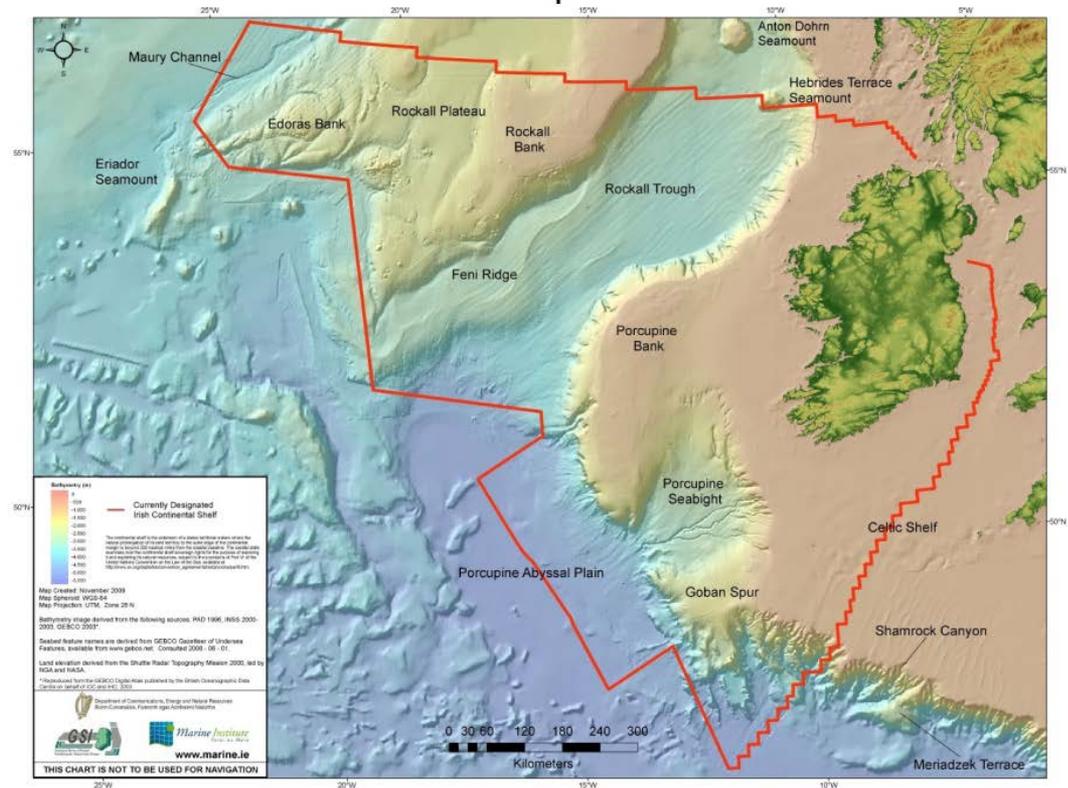


Unlock Ireland's natural resources

In 2006 the geoscience sector employed 1.4% of total employment, but added 3% of GNP (€4.6 billion) to the economy.

Geosciences, Gaining Ground, DCENR (2007)

The Real Map of Ireland





Unlock our natural resources

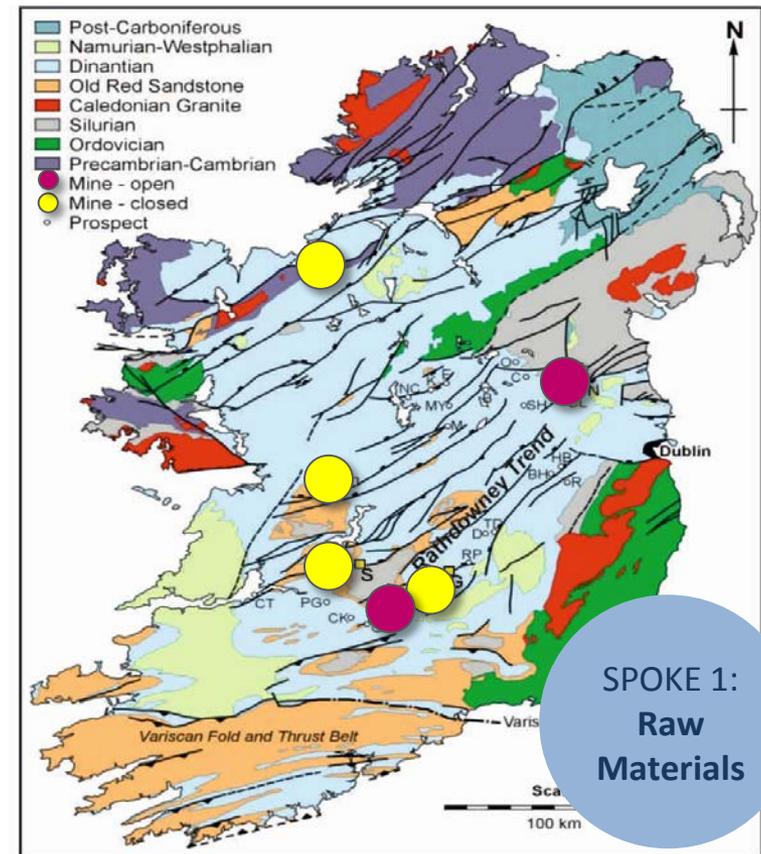
iCRAG will help industry discover new mineral deposits – only two remaining mines in Ireland

The availability of raw materials is a critical requirement for many industries in Europe.

Ireland is the largest producer of Zn in Europe and has significant ECE potential, which underpin the future world energy sector (€1 bn/yr market).

*The combined direct, indirect and induced impact of mining-related expenditures was ca **€810 million** in 2012.*

Indecon Rpt, 2013





Unlock our natural resources

iCRAG will help increase success rate of groundwater exploration – for communities and industry

Water-hungry industry sectors such as agri-business and high tech, demand a secure and safe supply of water.

*An increasing amount (**18% and rising**) of water comes from subsurface groundwater, whilst surface water sources are more vulnerable to drought and pollution.*

Security of supply of clean water to the public is critical and requires better understanding of hydrogeology and groundwater systems.



Glanbia plant, Co. Kilkenny requires water equivalent of a 30,000 people town – all provided by subsurface groundwater

SPOKE 3:
Groundwater



Unlock our natural resources

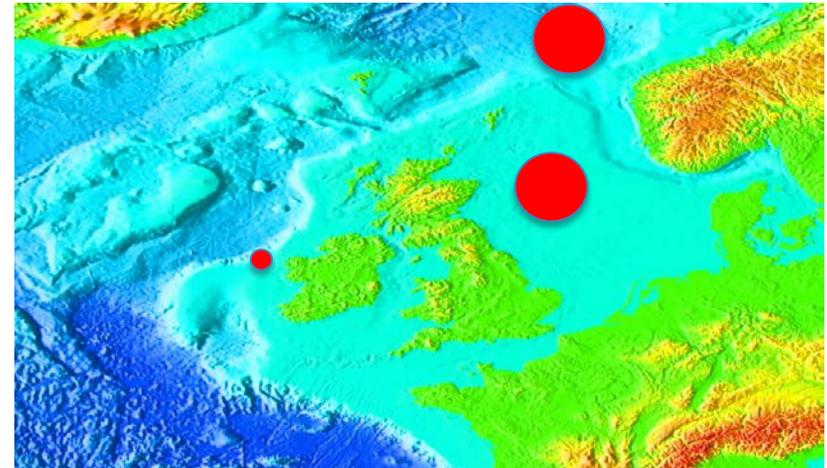
iCRAG will help increase the success rate of hydrocarbon exploration in offshore NW Europe

NW Europe has great hydrocarbon potential – with the oil sectors of Britain and Norway the biggest investors in their economy.

Ireland's success rate is lower.

If iCRAG research provides a marginal improvement in exploration success it will have a major economic impact.

*Five commercial oil/gas discoveries would yield **€22 billion** in corporation and PPRT tax over the life of the fields, and would produce over **12,000 jobs**.*



The probability of wells making a commercial discovery:

UK – 17%

Norway – 14%

Ireland – 3%

SPOKE 4:
Hydrocarbons

PWC report, May 2013



Education and training for geoscientists & Improved geosciences information to decision makers and the general public.

Public perception and understanding can be a major challenge to geoscience sector projects – support and information is important.

Ireland imports 95% of its fossil fuels, with 15% of our electricity generated from coal mainly from Columbia and Poland.

*Shell's Corrib gas discovery project is 10 years behind schedule because of public acceptance issues: since 2006 it has led to **€1 billion** spend with 300 Irish companies and more than **1000 people** employed.*



WITH iCRAG

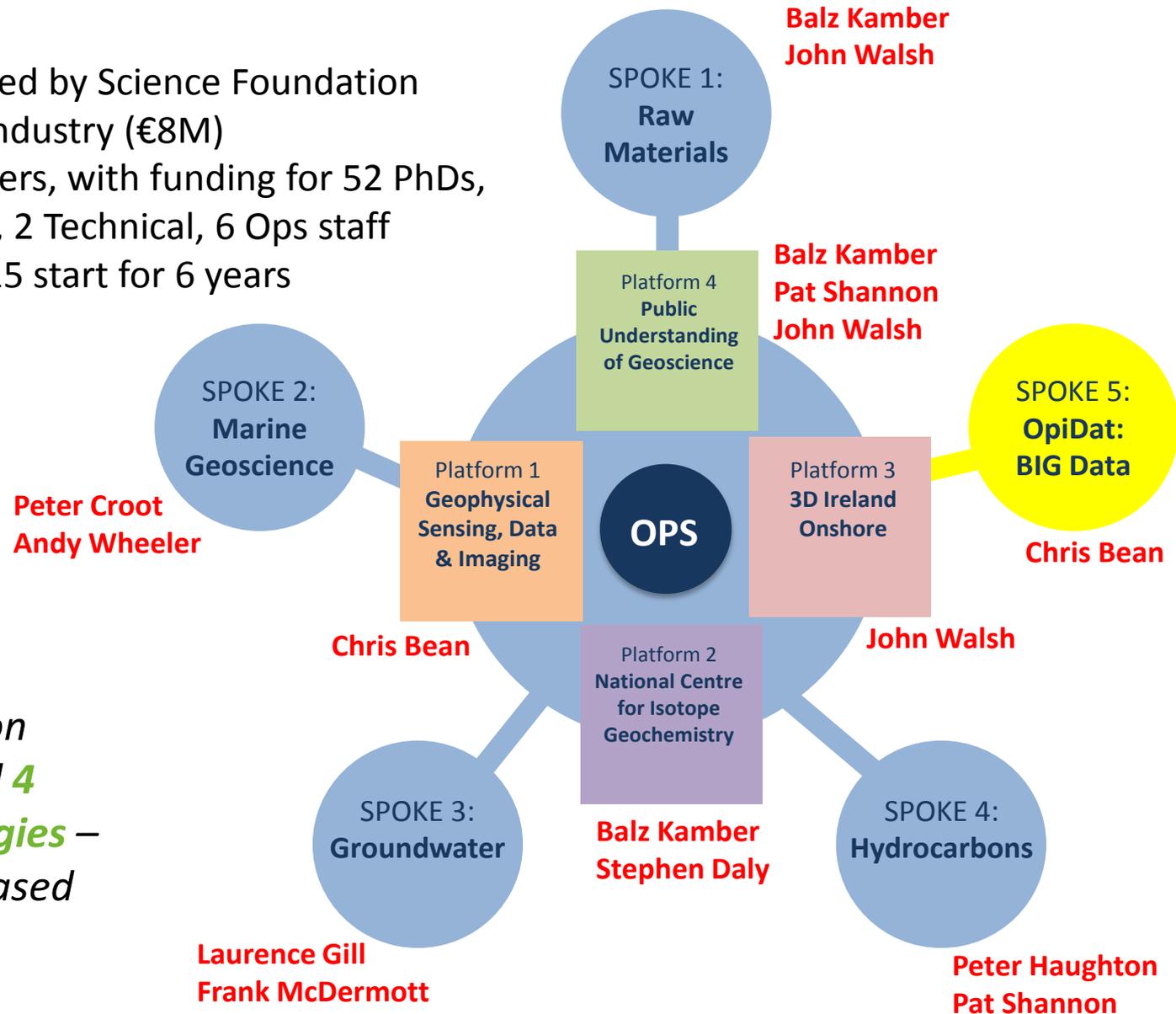
- Critical mass for Irish Geosciences.
- International leader in broad range of Applied Geosciences.
- Increased EU and industry funding.
- Sustainable Centre of Excellence.
- The portal for industry.
- Secure maximum benefit for Ireland from confronting the key economic and societal challenges of the Geosciences.



Funding: Jointly funded by Science Foundation Ireland (€18M) and industry (€8M)

People: 150 researchers, with funding for 52 PhDs, 8 MSc, 41 Post-Docs, 2 Technical, 6 Ops staff

Term: 1st January 2015 start for 6 years



5 spokes linked to different application areas, built around 4 enabling technologies – and equipment – based Platform projects.

PETROLEUM INDUSTRY



PIPCO, an alliance of 17 companies, including majors.

MINERAL INDUSTRY



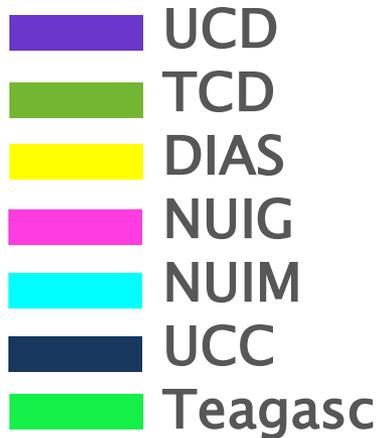
GROUNDWATER INDUSTRY



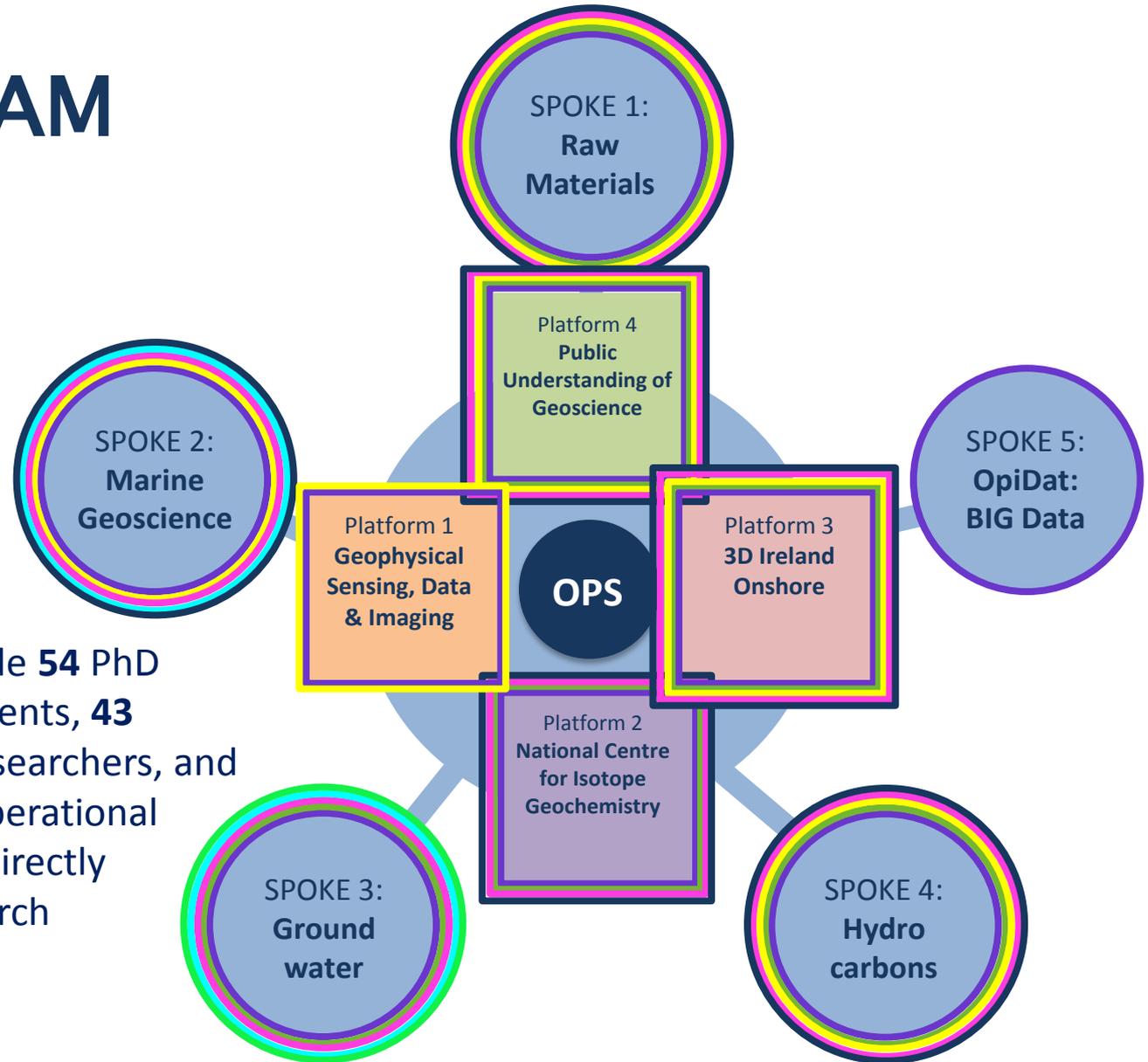
GOVERNMENT ORGANISATIONS



iCRAG TEAM



The centre will include **54** PhD students, **8** MSc students, **43** Postdoctoral level researchers, and **6** members of the Operational Management team directly supporting the research programme team.



iCRAG's AMBITION

To achieve international excellence in applied geoscience research in full range of application areas – requires scale and a multi-disciplinary approach.

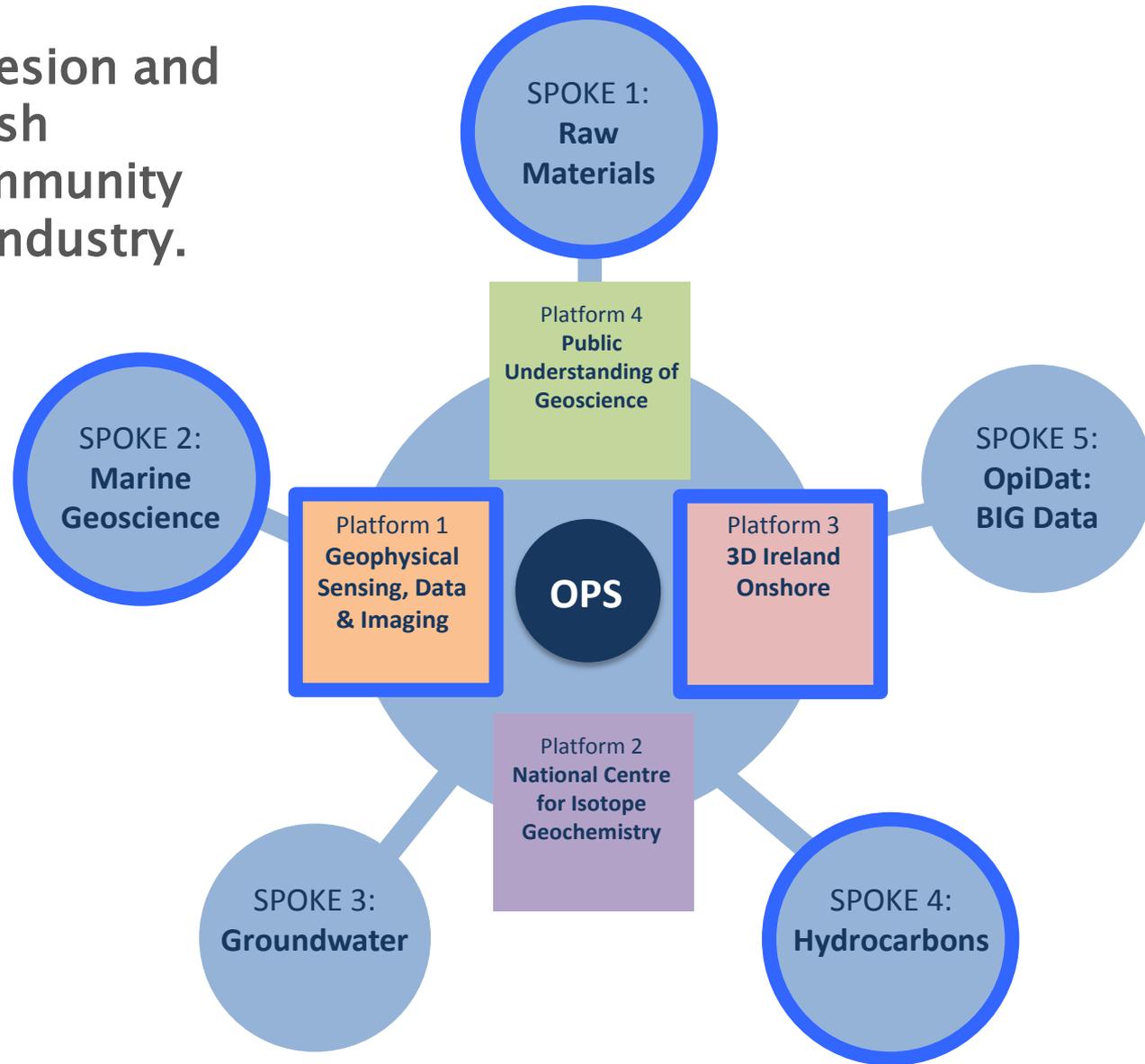


State-of-the-art methods, sometimes borrowed from one discipline or industry, combined with technical insights, potentially arising from another.



To provide cohesion and scale for the Irish Geoscience community and portal for industry.

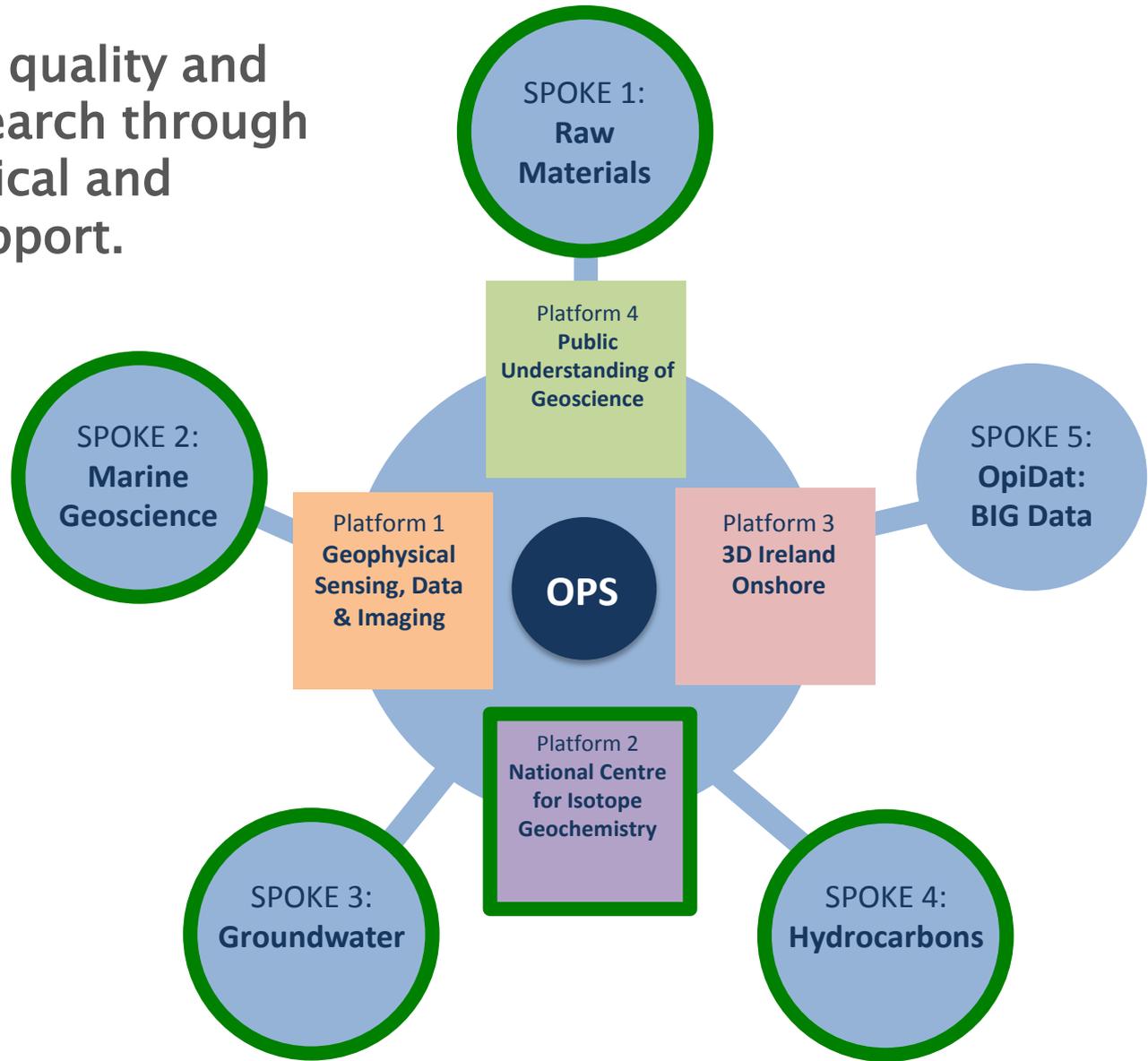
SEISMIC DATA





To improve the quality and quantity of research through targeted Technical and Operational Support.

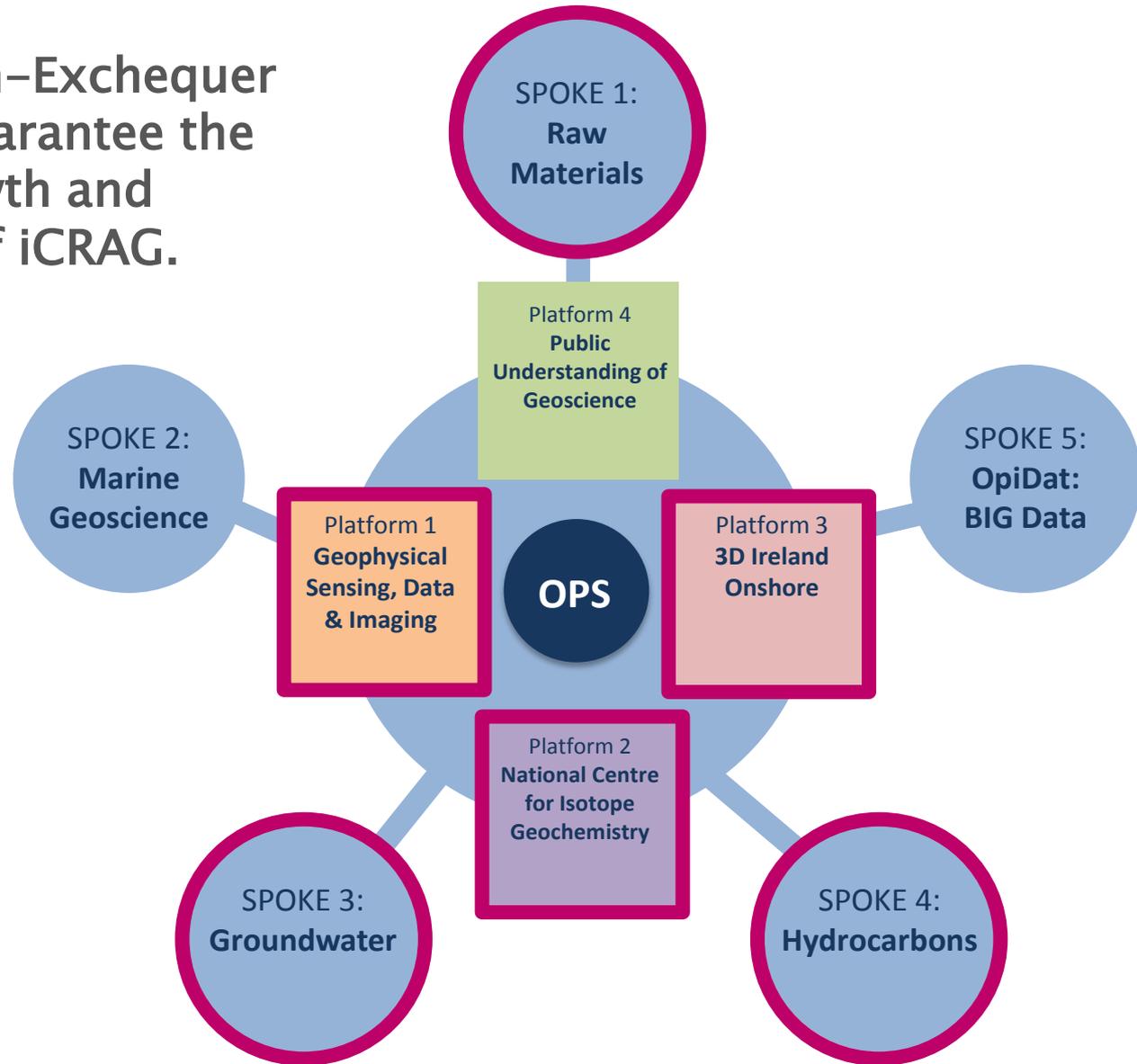
GEOCHEMISTRY





To increase non-Exchequer funding and guarantee the long-term growth and sustainability of iCRAG.

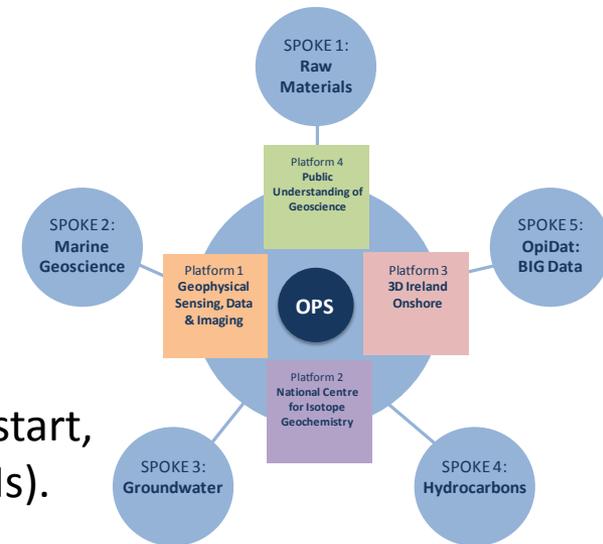
FLUID FLOW



iCRAG 2015

8 TACs (one for each Spoke/Platform)
Comprising up to 9 external experts: industry,
government and academia. Plus spoke leaders.

- ➔ **Technical Advisory Committees (x8): December 2014**
- ➔ **Project descriptions (x 54): 7th January 2015**
- ➔ **TAC meetings: February 2015**
- ➔ **Project decisions: March 2015**



Of the 54 projects, linked to 54 people, earmarked for 2015 start,
35 Investigators of 46 associated with 2015 projects (25 as PIs).

44 positions proceed to recruitment (24 Post-Docs, 17 PhD, 1MSc, 2 Technical staff).
Remaining positions – (18 Post-Docs, 35 PhDs, 7 MSc).

Spoke 4: *Hydrocarbons*

Leaders:

Peter Haughton (UCD)

Pat Shannon (UCD)

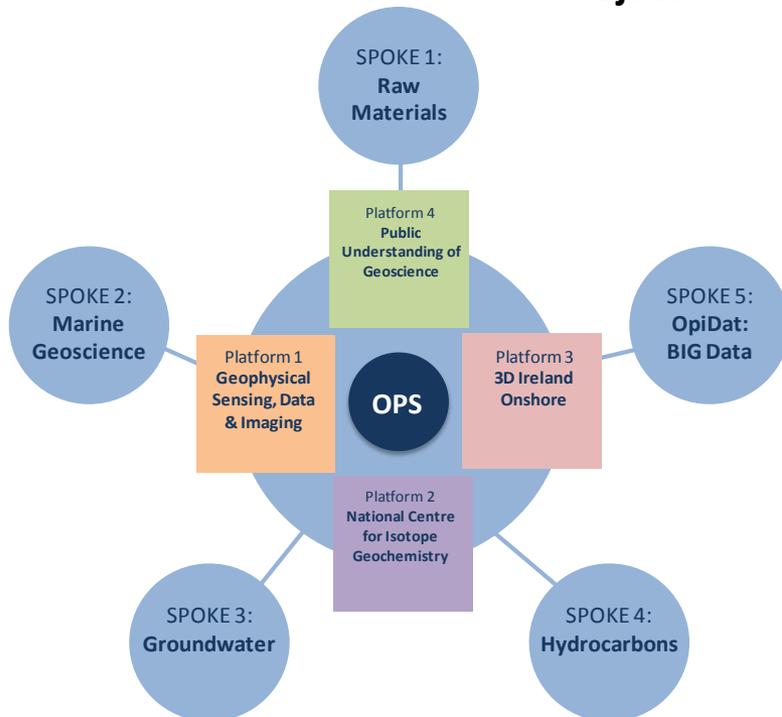
Project: TP4.1: Sediment tracking

Project: TP4.2: Basin evolution and petroleum systems

Project: TP4.3: Reservoir modelling and software development

Project: TP4.4: Unconventional hydrocarbons

Project: TP4.5: Global subsurface training centre



Links with:

- ➔ Raw Materials – Fractured reservoirs
- ➔ Groundwater – Fracture-related flow
- ➔ Marine – sea bed/environment

Hydrocarbons Spoke (TP4)

TP4.1

Sediment tracking

- new provenance tracers
- modern sand dispersal and mixing
- sediment volumes/partitioning
- recycling
- impact on RQ

TP4.2

Basin evolution/petroleum systems

- early rift architecture/young rifts
- fault characterisation and structural evolution
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- hyperextended basins and their fills
- stratigraphy at the continental-oceanic transition
- thermal history/migration modelling

TP4.3

Modelling and imaging

- hierarchical depositional modelling
- well and seismic conditioning
- software development
- reservoir monitoring using OBC/OBS

TP4.4

Unconventionals

- gas hydrates

TP4.5

Training and outreach

- development of Clare training resource
- public engagement

Hydrocarbon spoke projects – 12 ratified for 2015 start

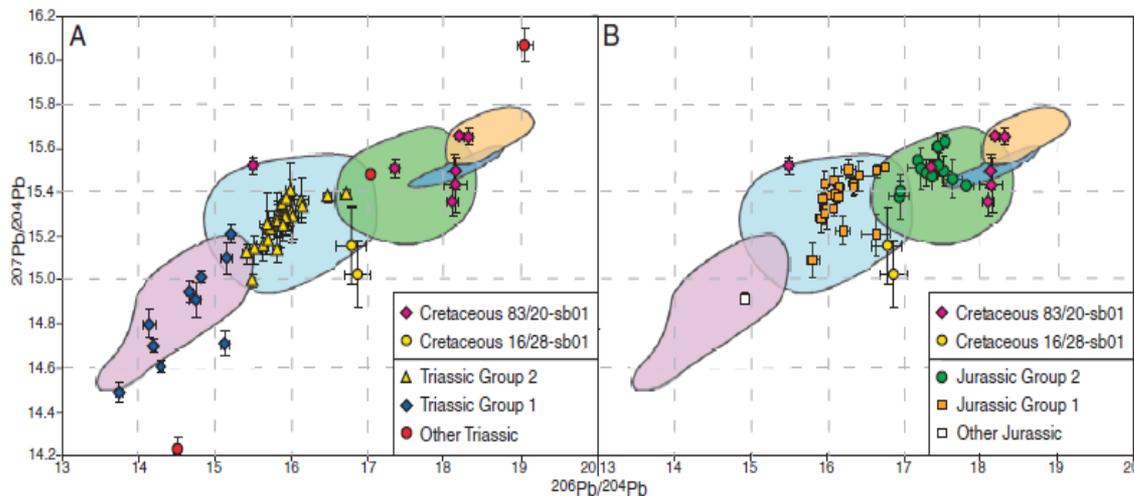
TP	PI	Co-PI(s)	Project title	PhD/PD	Yrs
4.1	Shane Tyrrell (NUIG)	Haughton; Chew; Daly; Shannon; Meere	Development of novel sediment tracers: validation and application of conventional and new provenance proxies	PD	4
4.1	Shane Tyrrell (NUIG)	Haughton; Chew; Daly; Shannon; Meere	Development of novel sediment tracers: investigating the primary controls on reservoir sandstone quality	PhD	4
4.2	Peter Haughton (UCD)	Shannon; O'Reilly; Welford	Crustal and sedimentary architecture of hyperextended basins	PD	4
4.2	Conrad Childs (UCD)	Walsh; Shannon	The kinematics of fault systems in offshore Ireland – implications for fault related trapping and leakage	PD	4
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4.2	Peter Haughton (UCD)	Shannon; Childs	Characterisation of deep-water stratigraphic traps developed across the syn-rift to post-rift transition in Atlantic-margin basins	PhD	4
4.2	Conrad Childs (UCD)	Walsh; Shannon	Structural and kinematic analysis of the Celtic Sea basins - exploring links between evolution and traps	PhD	4
4.3	Tom Manzocchi (UCD)	Haughton; Childs; Walsh; Jackson	Hierarchical compression-based reservoir modelling conditioned to seismic and well data	PhD	4
4.3	Tom Manzocchi (UCD)	Haughton; Childs	Hierarchical sedimentary characterisation and modelling of submarine channels	PhD	4
4.4	Michael Max (UCD)		Commercialization of Natural Gas Hydrate: geological attributes, environmental factors, and new exploration and production technology	PD	3
4.5	Peter Haughton (UCD)	Shannon; Pulham; Davies	Development of Clare Subsurface Training Centre and securing the long-term future of Clare-based applied geoscience training	PD	3

Hydrocarbons Spoke (TP4)

TP4.1

Sediment tracking

- new provenance tracers
- modern sand dispersal and mixing
- sediment volumes/partitioning
- recycling
- impact on RQ



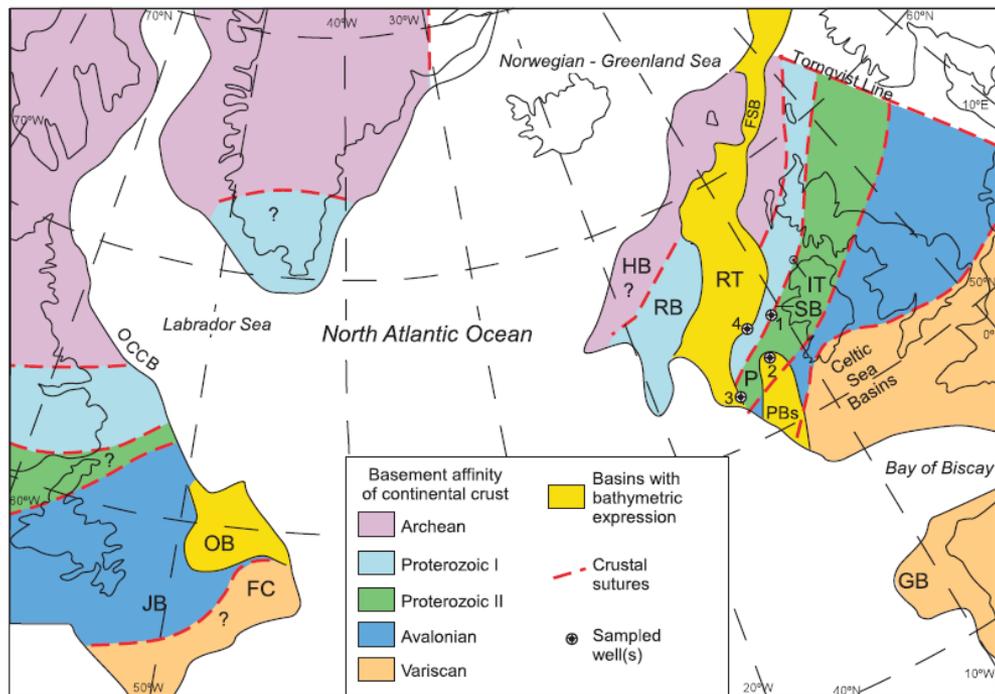
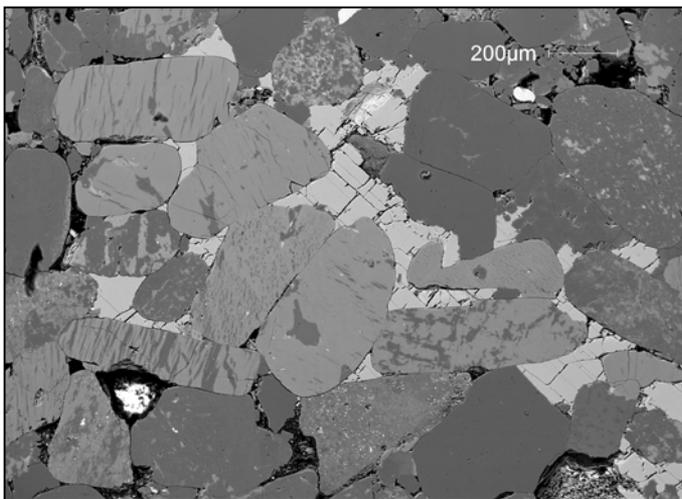
Tyrrell, S., Houghton, P. & Daly, J.S. 2007. Drainage reorganization during breakup of Pangea revealed by in-situ isotopic analysis of detrital K-feldspar. *Geology*, 35, 971-974.

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Hydrocarbons Spoke (TP4)

**TP4.1
Sediment tracking**

- new provenance tracers
- modern sand dispersal and mixing
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Develop sediment tracking techniques and associated predictive tools for reservoir sandstone distribution and quality.

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Hydrocarbons Spoke (TP4)

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Basin evolution/petroleum systems

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Modelling and imaging

- hierarchical depositional modelling
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- software development
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TP4.4

Unconventionals

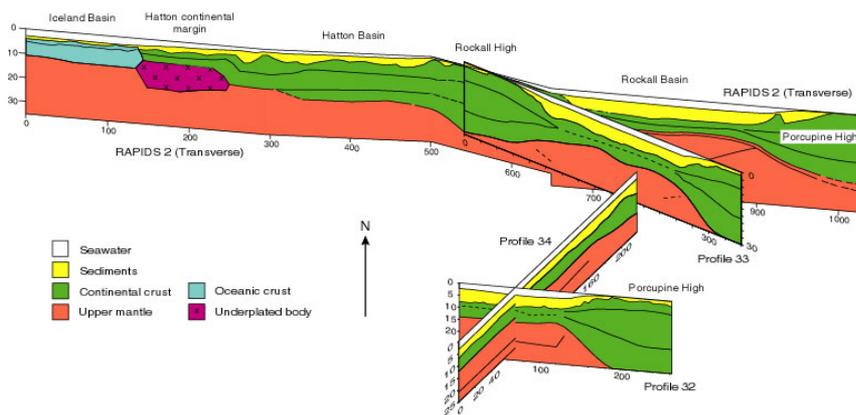
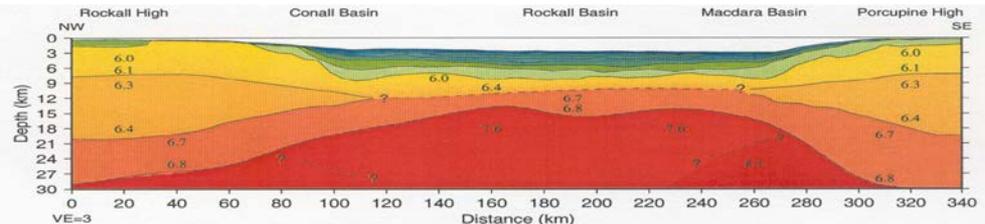
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Training and outreach

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Hydrocarbons Spoke (TP4)

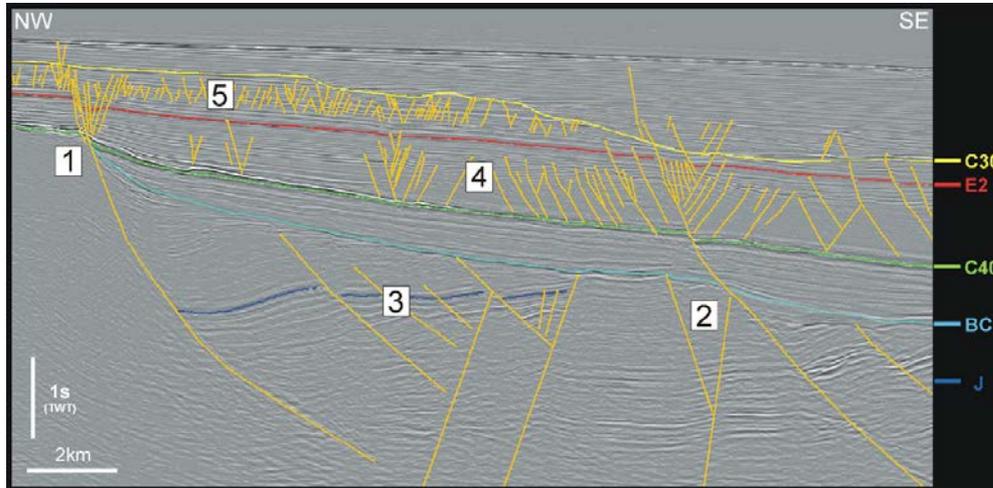


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Hydrocarbons Spoke (TP4)

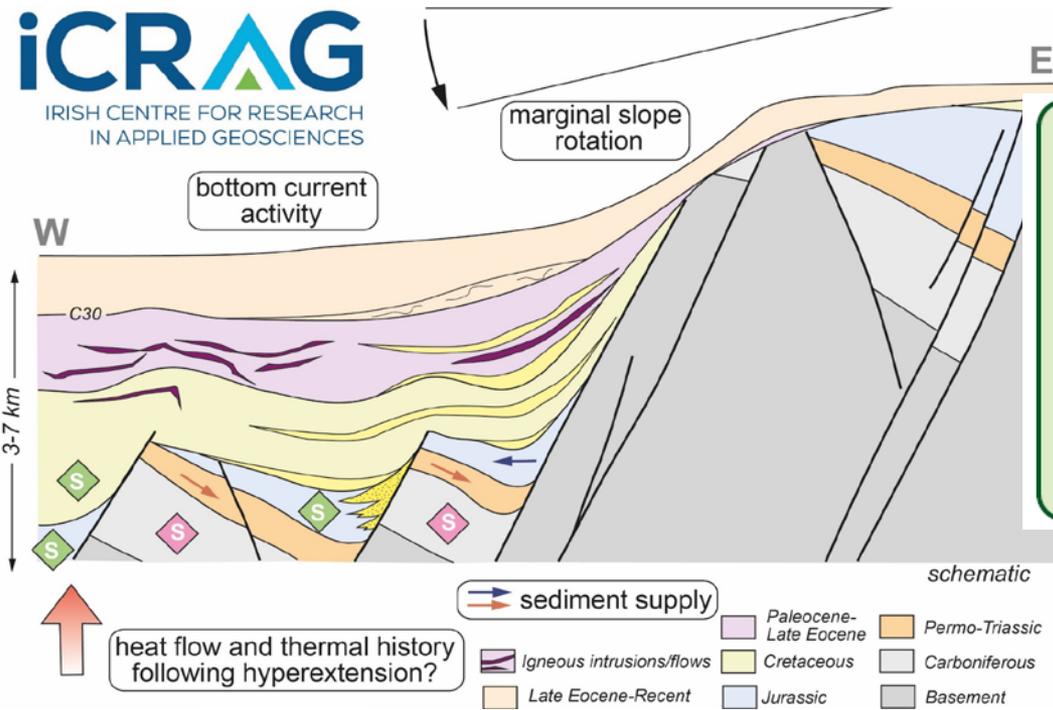


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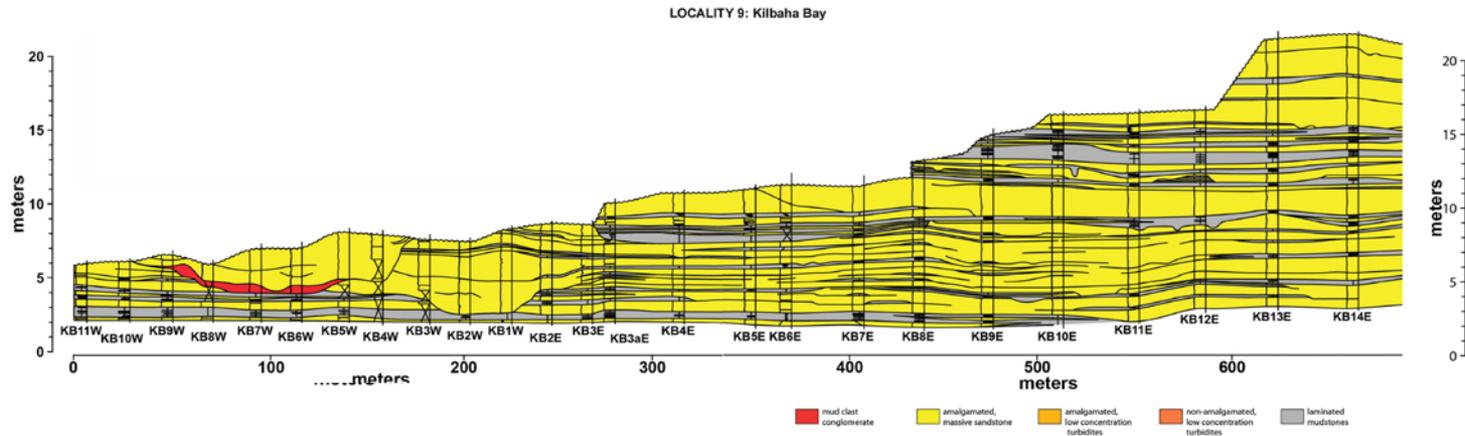
- gas hydrates

TP4.5

Training and outreach

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Hydrocarbons Spoke (TP4)



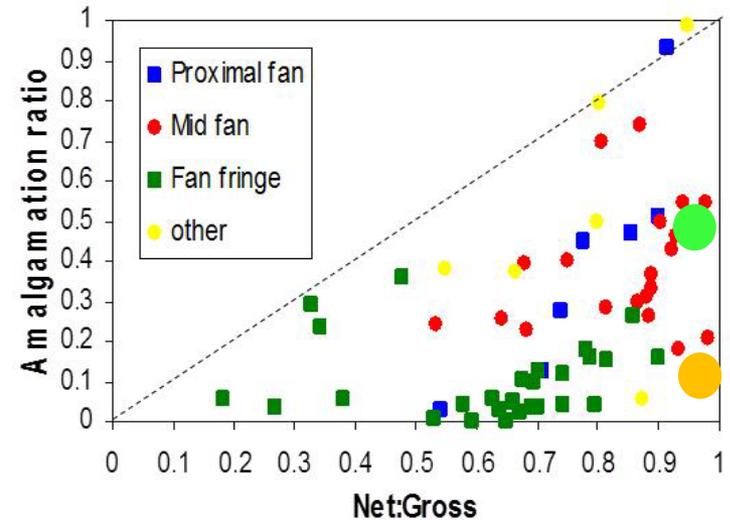
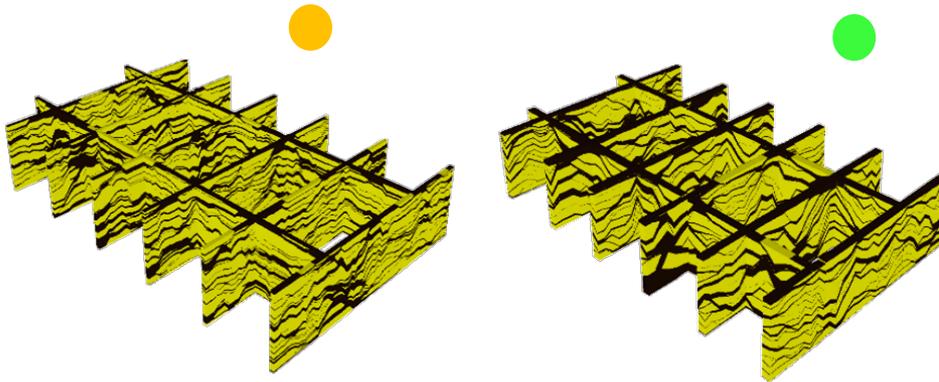
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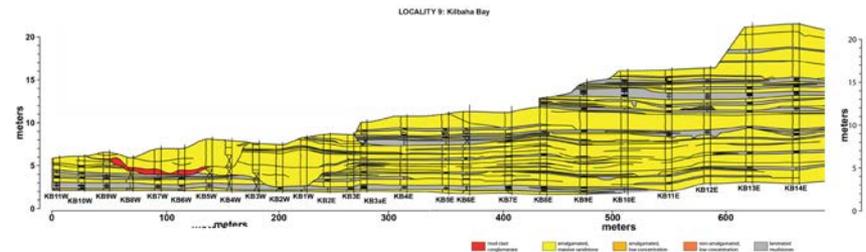
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Hydrocarbons Spoke (TP4)



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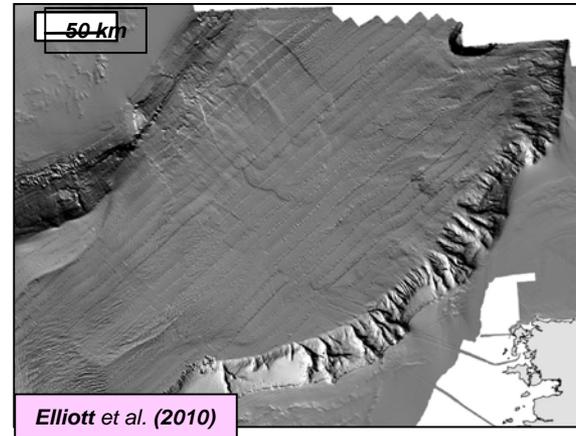
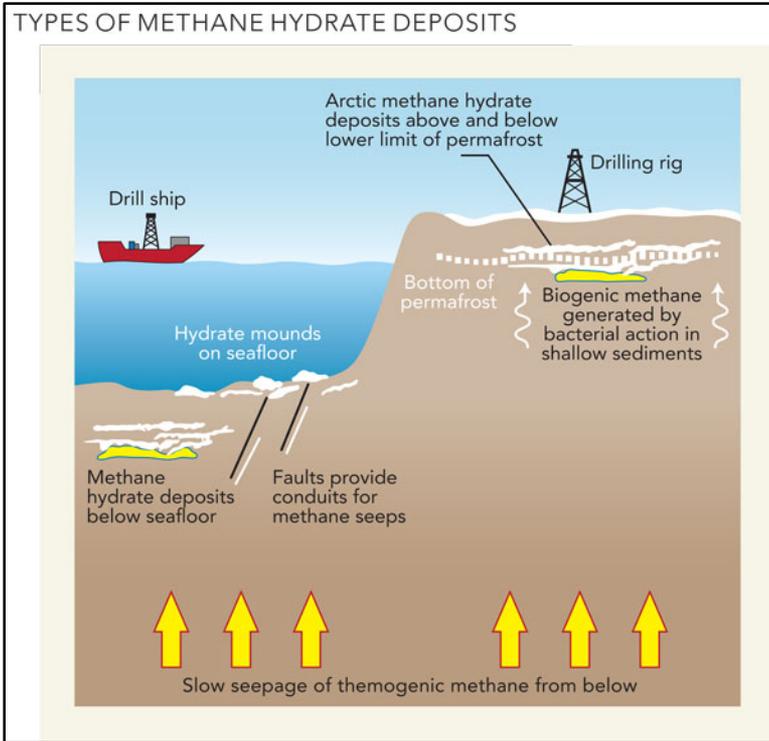
- gas hydrates

TP4.5

Training and outreach

- development of Clare training resource
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Hydrocarbons Spoke (TP4)



TP4.4
Unconventionals
 - gas hydrates

TP	PI	Co-PI(s)	Project title	PhD/PD	Yrs
4.4	Michael Max (UCD)		Commercialization of Natural Gas Hydrate: geological attributes, environmental factors, and new exploration and production technology	PD	3

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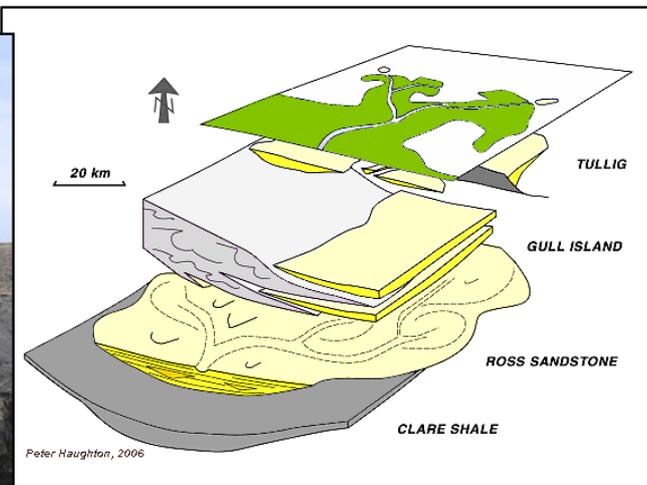
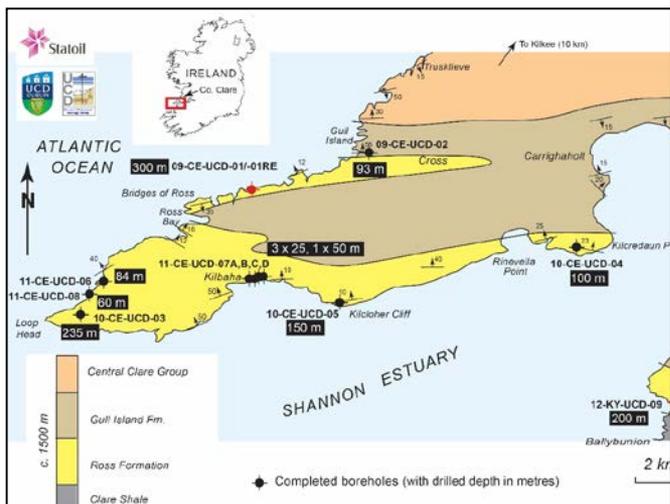
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Hydrocarbons Spoke (TP4)

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TP4.5
Training and outreach
 - development of Clare training resource
 - public engagement

Spoke 2: *Marine Geoscience*

Leaders:
Peter Croot (NUIG)
Andy Wheeler (UCC)

Project TP2.1: Marine acoustics

Develop novel and emerging techniques for imaging near sea floor structure using the ocean's background acoustic noise, removing the need to shoot seismic, and resulting in environmental advantages and cost benefits.

Project TP2.2: Enhancing knowledge & understanding of Ireland's seabed

Strategic evaluations of Ireland's seabed pertinent to industry's needs and to evaluate seabed geohazards, including landslides, which could negatively impact sea bed installations and pipelines.

Project: TP2.3: Marine remote sensing applications

New remote sensing tools for industry to aid in the economic development of Ireland's offshore regions and provide baselines for assessing GES, with development of a suite of decision making software tools customized to Ireland's offshore regions for industry and policy makers.



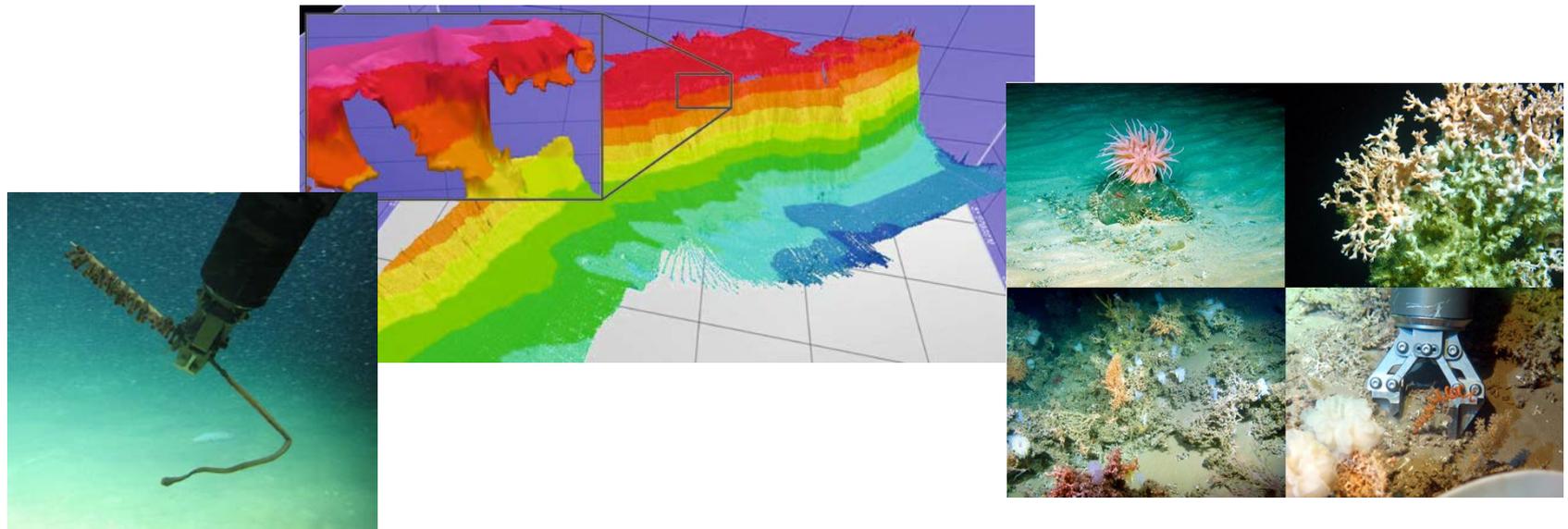
Links with:

- ➔ Hydrocarbons – seabed/environment
- ➔ Raw Materials – sea bed aggregates
- ➔ Geophysics, Geochemistry & 3D Model

Spoke 2: *Marine Geoscience*

Leaders:
Peter Croot (NUIG)
Andy Wheeler (UCC)

TP	PI	Co-PI(s)	Project title	PhD /PD	Yrs
TP 2.1	Chris Bean	M. White	Novel applications of broad band near sea floor pressure/acoustic monitoring for time lapse remote sensing of sea-bed processes	PD	2
TP 2.2	Andy Wheeler	X. Monteys; S. McCarron; J. Scourse	Quaternary Seismostratigraphies of Irish Shelf Seas (QuSISS)	PD	2
TP 2.2	Andy Wheeler	A. Georgiopoulou; Q. Crowley	Coral Carbonate Mound Archives for Submarine Canyon Exchange Processes (CoMA_CoP)	PhD	4
TP 2.3	Peter Croot	N/A	Influence of natural biogeochemical controls on primary productivity on the optical properties of surface seawater	PD	3
TP 2.3	Peter Croot	N/A	Application of CDOM optical properties for tracing natural and manmade surface slicks.	PhD	4
TP 2.3	Tim McCarthy	N/A	Marine Observation Platform & Slick Feature Mapping	PD	2



Spoke 1: *Raw Materials*

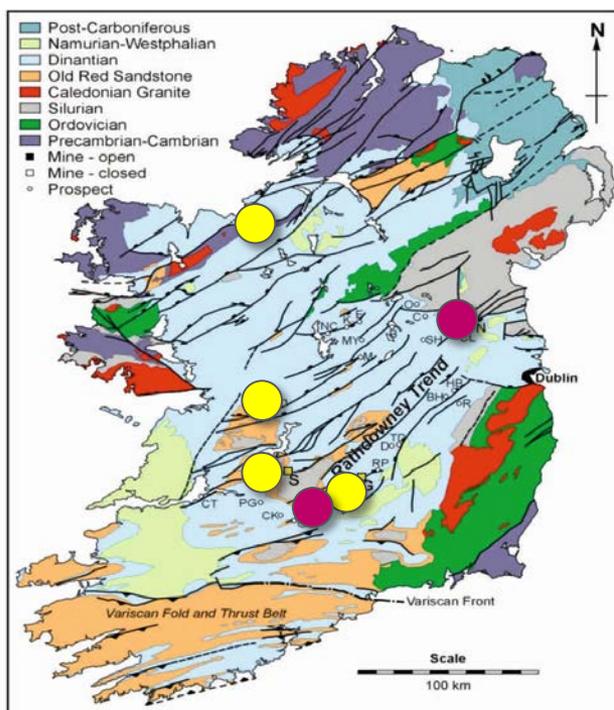
Leaders:

Balz Kamber (TCD)

John Walsh (UCD)

Some of our Raw Materials research have potential implications for hydrocarbon-related studies.

- More than 50% of the world's hydrocarbon reservoirs are in limestones.
- A major component of iCRAG's raw materials research concentrates on the world class Zn-Pb Irish Orefield, in which mineral deposits are entirely hosted by limestones.
- This spoke therefore provides an excellent basis for examining fluid flow within limestones, with a variety of potential implications for hydrocarbon studies including:
 - (i) Fault/fracture controlled fluid flow.
 - (ii) Regional dolomitisation
 - (iii) Fault/fracture geometries within limestones.



Selected raw materials projects with relevance to hydrocarbons

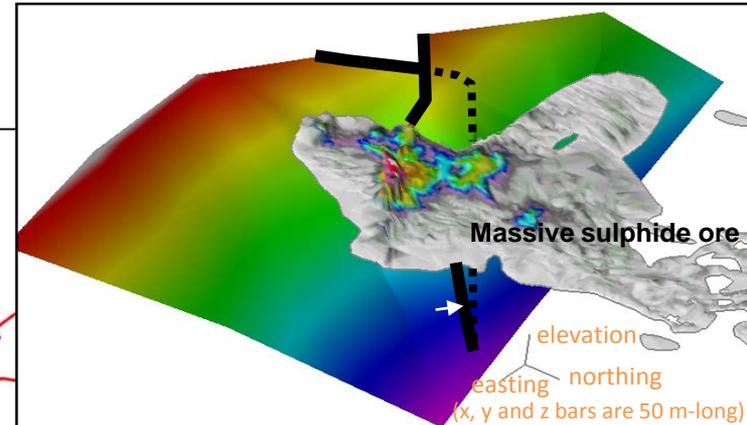
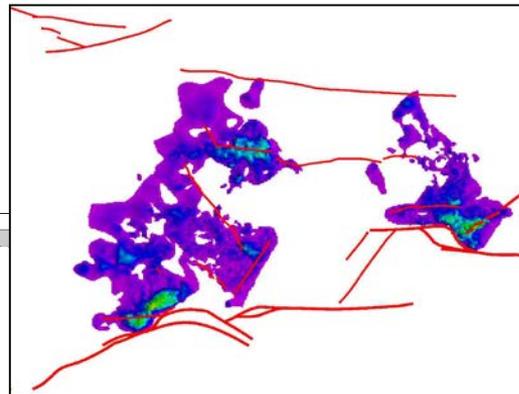
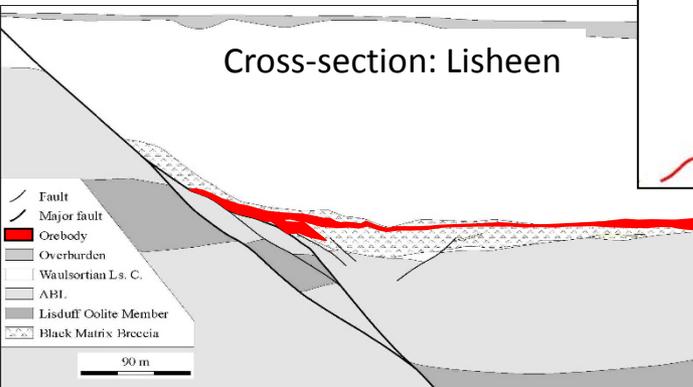
Spoke 1: *Raw Materials*

Leaders:

Balz Kamber (TCD)
John Walsh (UCD)

TP	PI	Co-PI(s)	Project title	PhD/PD	Yr
TP1.1	Sean McClenaghan	B. Kamber	Delineating hydrothermal Zn-Pb signatures along fault structures of the Rathdowney Trend, Southwest Ireland.	PhD	4
TP1.1	John Walsh	C. Childs; T. Manzocchi; A. Soden	Structural evolution of Lower Carboniferous faulting and its links to fluid flow and mineralization	PD	4
TP1.2	Sean McClenaghan	D.Chew	Characterizing orogenic vein systems to promote gold exploration across Irish terranes.	PhD	4
TP1.2	Pat Meere	P. Muech; J. Kinnaird; R. Unitt;	Metallogenesis of Cu deposits hosted in Upper Devonian and in Southern Zn-Pb Orefield	PhD	4

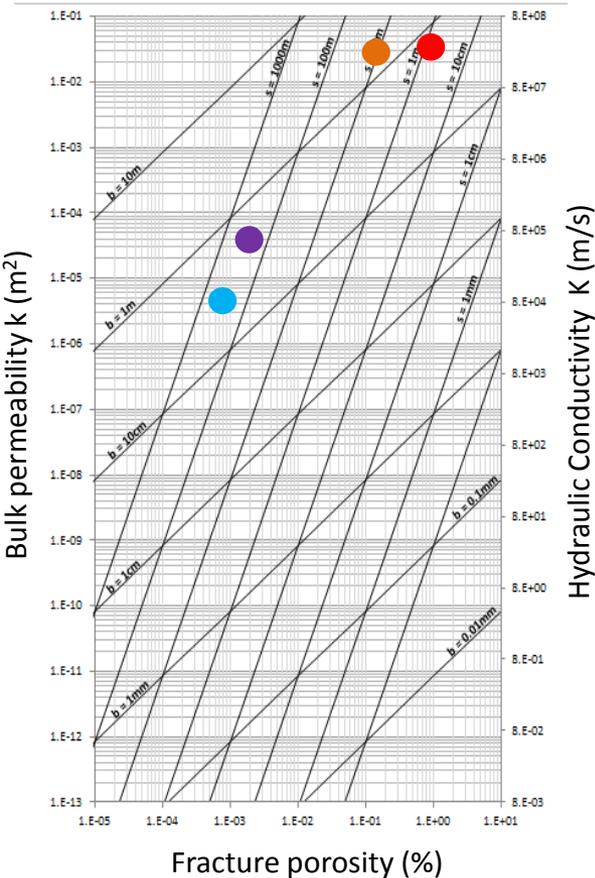
Cross-section: Lisheen



600 m

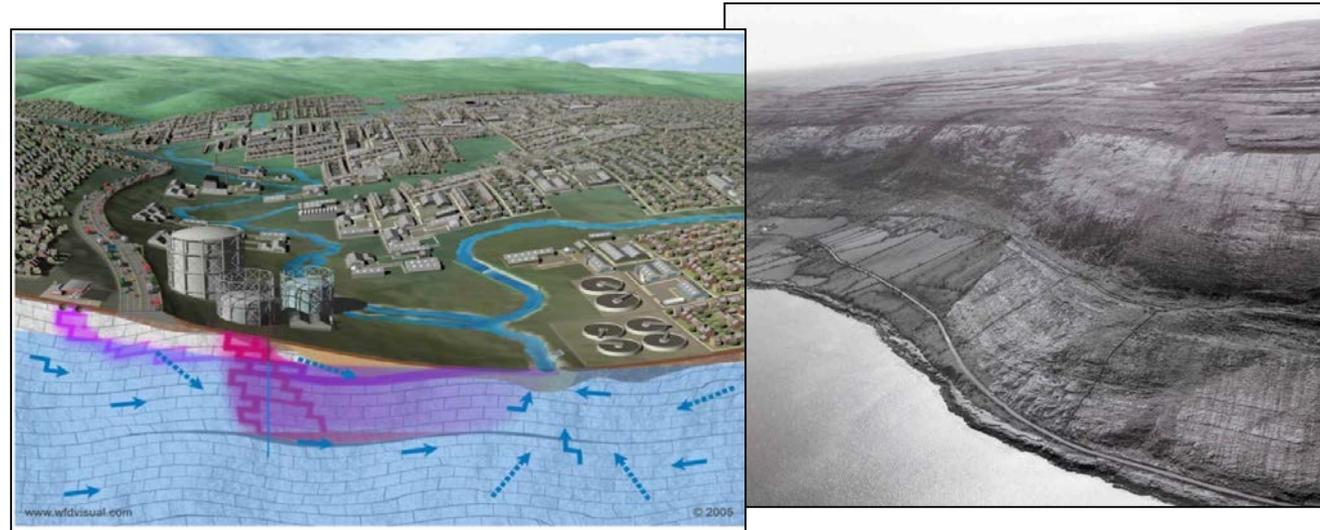
- (i) Fault/fracture controlled fluid flow.
- (ii) Regional dolomitisation
- (iii) Fault/fracture geometries within limestones.

Spoke 3: Groundwater



Selected groundwater projects with relevance to hydrocarbons

TP	PI	Co-PI(s)	Project title	PhD/PD	Yrs
3.1	Laurence Gill	F. McDermott; B. Kamber; A. McNabola; M. Lee; P. Murphy	Prediction of response (and solutions) of lowland karst areas prone to flooding to climate change	PhD	4
3.1	Bruce Missteart	Laurence Gill	Impacts of changing climate on groundwater recharge in low storativity fractured-rock aquifers	PhD	4
3.1	John Walsh	T. Manzocchi; C. Childs	Quantitative assessment of the impact of faults, fractures and related karst networks on groundwater flow	PhD	4



- (i) Quantitative parameterisation of fault/fracture controlled fluid flow within limestones.
- (ii) Development of karst within limestones.
- (iii) Karst-controlled groundwater flow.

Platforms:

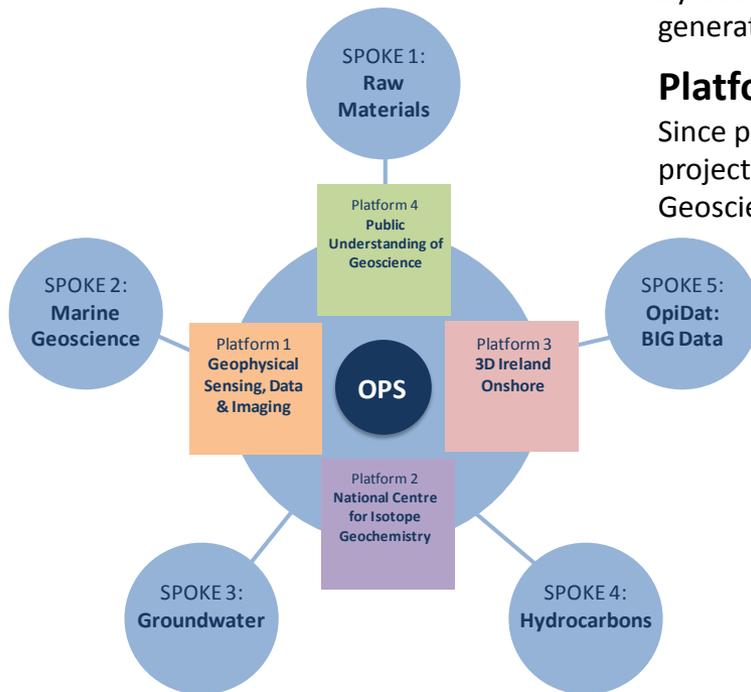
Leaders:

Chris Bean (UCD)

Stephen Daly (UCD)

Balz Kamber (TCD)

John Walsh (UCD)



Platform 1: Geophysical sensing, data and imaging

Provide cohesive physical, technical and knowledge-based sensing, data & imaging infrastructure for iCRAG research. Perform research and provide support on a broad range of geophysical techniques, though specialising in seismic methods in particular.

Platform 2: National Centre for Isotope Geochemistry

Support the geochemical analytical requirements of iCRAG research, and develop methods for efficient disaggregation and petrographic characterisation of rock samples (ores, reservoir sandstones etc.) prior to chemical and isotopic analysis.

Platform 3: 3D Model Ireland

Common datasets are unique national archives for research in different sectors (e.g. groundwater and mineral deposits are in the same rocks). Using archive mineral exploration/production data, together with geological and geophysical data supplemented by Geological Survey of Ireland (GSI) and Exploration and Mining Division (EMD), will generate a 3D Geological Model of the Irish Carboniferous on a broad range of scales.

Platform 4: Public perception and understanding of geosciences

Since public perception and understanding can be a major challenge to geoscience sector projects, this platform will investigate this issue and provide support and information on Geosciences to facilitate decision making by the public and by policy makers.

Links with:

 All spoke research

Platforms:

Leaders:

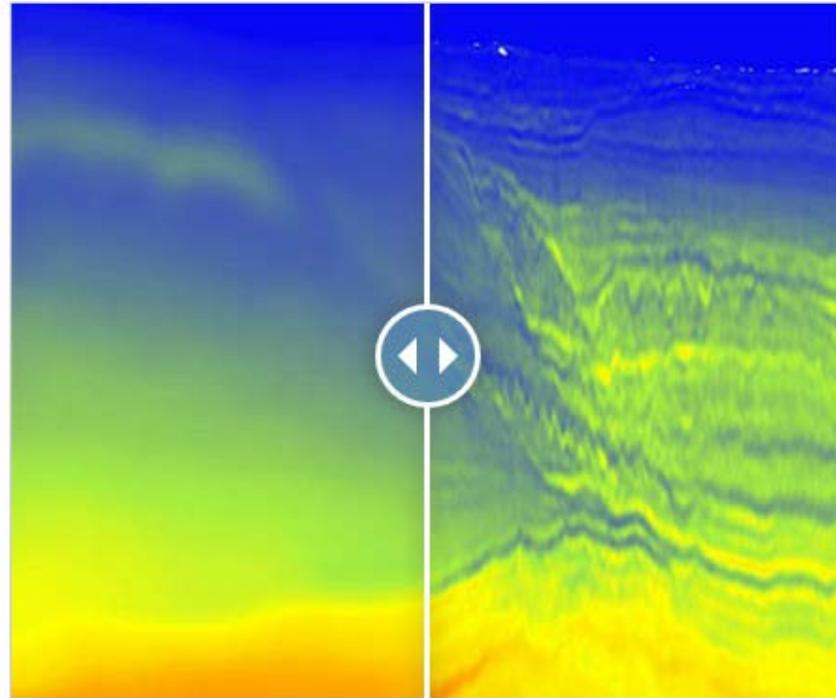
Chris Bean (DIAS)
Stephen Daly (UCD)
Balz Kamber (TCD)
John Walsh (UCD)



Platform 1: Geophysical sensing, data and imaging

Provide cohesive physical, technical and knowledge-based sensing, data & imaging infrastructure for iCRAG research. Perform research and provide support on a broad range of geophysical techniques, though specialising in seismic methods in particular.

FWI enhances resolution in velocity model



In this NW Australia FWI example, the left image shows the velocity field from standard PSDM tomography, while the right image is the output from FWI. This new level of detail has helped the operator improve reservoir positioning and optimize drilling decisions.

→ All spoke research

Platforms:

Platform 1: Geophysical sensing, data and imaging

Current projects ->
(seeding technological
development)

TP	PI	Co-PI(s)	Project title	PhD/PD	Yrs
Geophysics	Sergei Lebedev		Seismic imaging with massive datasets using sparsifying transformation methods	PD	4
Geophysics	Chris Bean	P. Bromirski; P. Jousset	Development of noise correlation methods in the marine environment,	PD	3
Geophysics	John Walsh	P. Haughton, C.Childs, A. Georgiopoulou, T. Manzacchi, M. Max	Provide IT Support for Platform and Spoke projects involving Seismic interpretation and 3D modelling	IT position	3

Future proposed positions (2xPD & 2xPhD) ->

Use to develop 3D geophysical images using novel technology, likely spatially co-incident with the 3D geological model built in Platform 3 (3D model Ireland)

Why this?

- (i) Developing new imaging methodology (of global significance)
- (ii) Yielding Ireland's first ultra high resolution shallow (top 1km) passive seismic images
- (iii) Compare Geological and Geophysical models directly (rare opportunity)

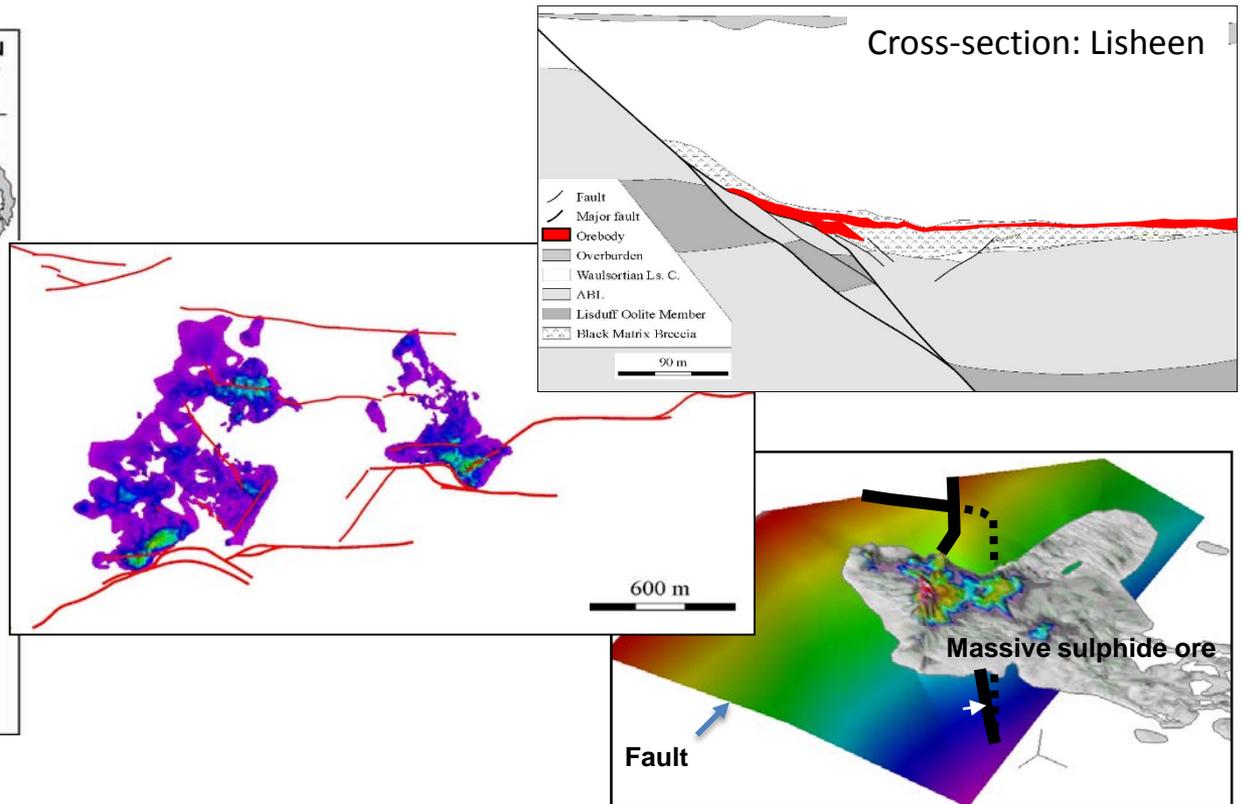
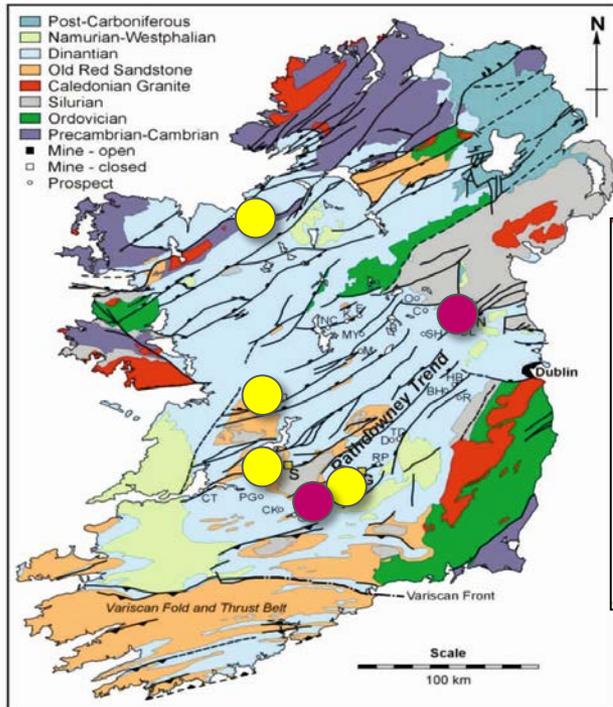
Platform 3: *3D Model*

Leader:
John Walsh (UCD)

Platform 3: 3D Model Ireland

Common datasets are unique national archives for research in different sectors (e.g. groundwater and mineral deposits are in the same rocks). Using archive mineral exploration/production data, together with geological and geophysical data supplemented by Geological Survey of Ireland (GSI) and Exploration and Mining Division (EMD), will generate a 3D Geological Model of the Irish Carboniferous on a broad range of scales.

This platform project investigates the Zn-Pb Orefield of Ireland, which is hosted by Carboniferous limestones. Associated technical results will therefore have some relevance for flow within limestones reservoirs.



Platform: Public Perception/ Understanding

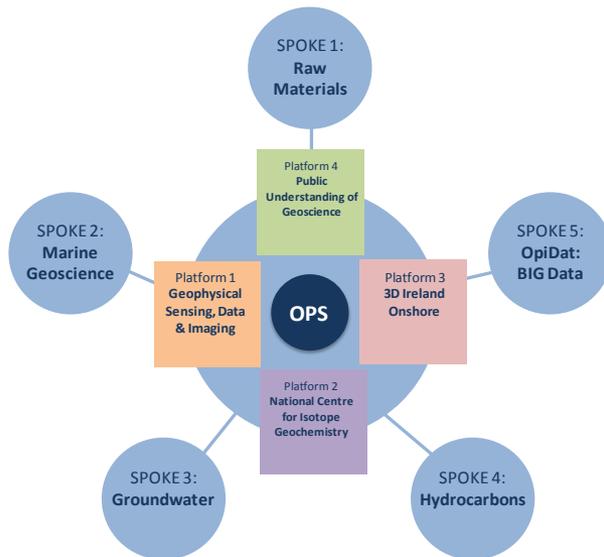
PPU TAC members

Platform 4: Public perception and understanding of geosciences

Since public perception and understanding can be a major challenge to geoscience sector projects, this platform will investigate this issue and provide support and information on Geosciences to facilitate decision making by the public and by policy makers.

TP	PI	Co-PI(s)	Project title	PhD/PD	Yrs
Public Perception/Understanding	TBD	All Co-Pis and FIs	Public perception and understanding of geosciences	Post-Doc	5
Public Perception/Understanding	TBD	All Co-Pis and FIs	Public perception and understanding of geosciences	Post-Doc	5

Together with Fergus McAuliffe (iCRAG Outreach and Education Officer)



- Formation of our TAC for PPU research
- Commissioning of systematic review by GSI
- Review, report and workshop
- Proposals for research

iCRAG 2016



Review Project Descriptions: December 2015



New Projects: Up to 20 new hydrocarbon/marine-related projects – starting in 2016



Industry Events: April and October 2016
Agreed and main sponsor signed.



Industry Reporting: Quarterly short reports and annual technical reports.

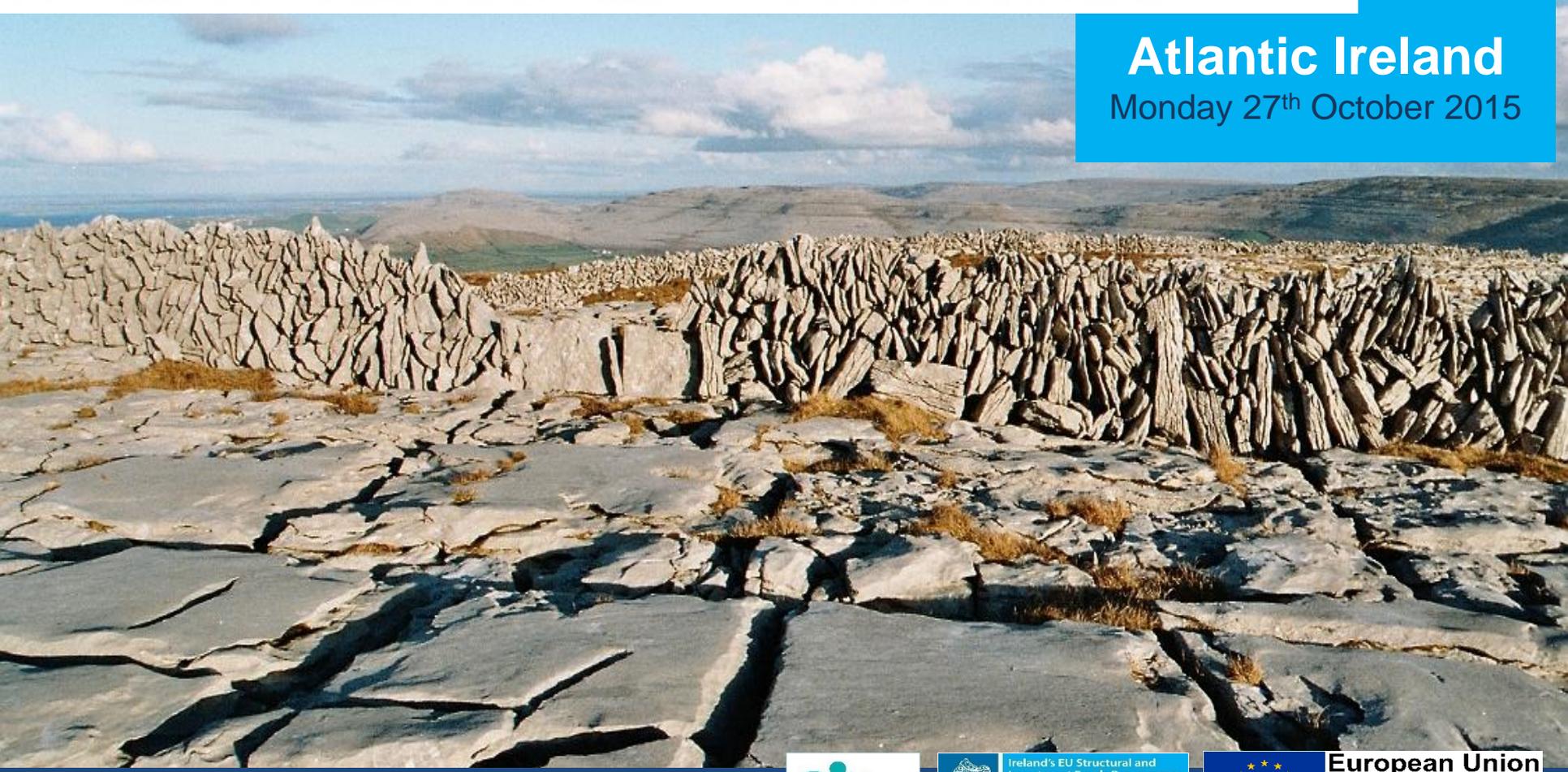


Potential Spoke Additions: Proposal deadline end Q1 2016.

icRAG

IRISH CENTRE FOR
RESEARCH IN APPLIED
GEOSCIENCES

Atlantic Ireland
Monday 27th October 2015



Ireland's EU Structural and
Investment Funds Programmes
2014 - 2020
Co-funded by the Irish Government
and the European Union



European Union
European Regional
Development Fund