

Sustainable Development and Natural Resources

EurGeol Garth Earls
Director, GSNI

*Tellus Conference, W5
17th October 2007*

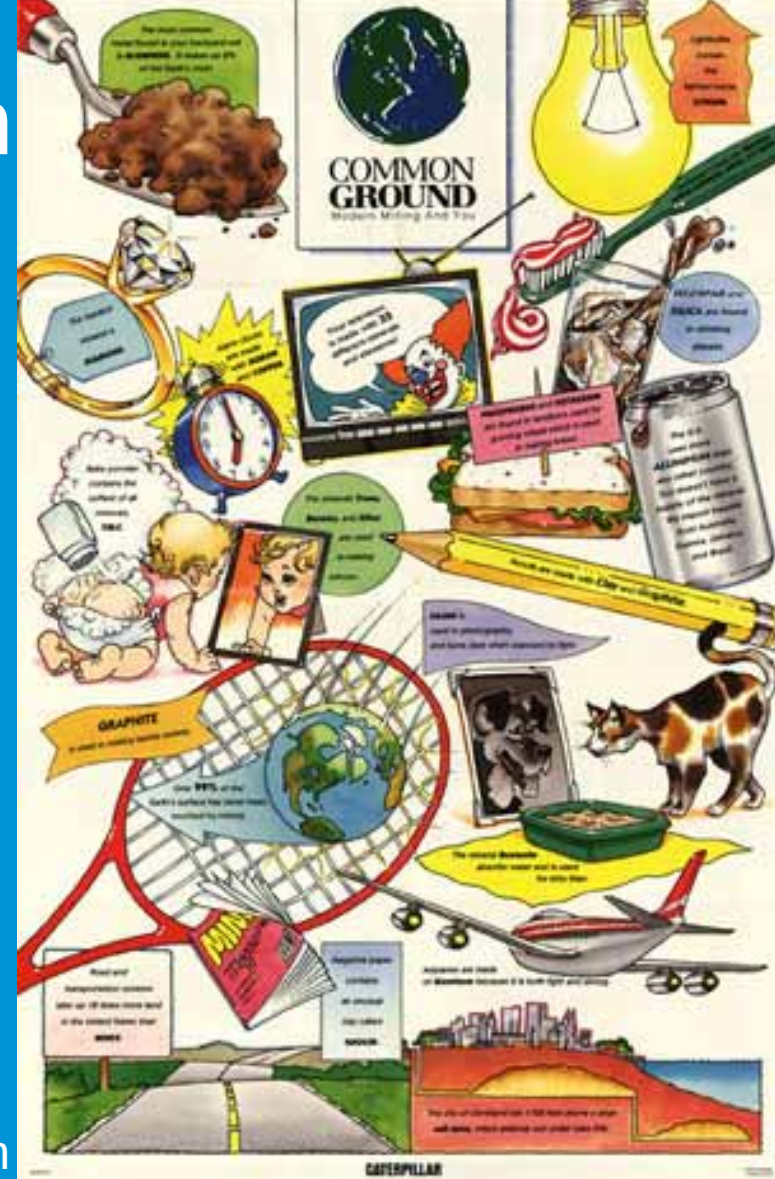
Revegetation of mineral sand dunes

© Rio Tinto

Structure of Presentation

- What are Natural Resources?
- Perceptions and Reality
- Natural Resources and the Sustainable Development Paradigm
- Examples of SD and Natural Resources
- The Tellus Surveys – knowledge based decision making
- Conclusions

Some text and images courtesy of David Groves, Jeremy Richards and Mike Petterson



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What are Natural Resources?

Natural resources can be thought of in five overlapping ways. Each of these reflect values that we associate with them

1. Raw materials – **minerals, hydrocarbons** and biomass
2. Flow resources – **geothermal**, wind, tidal and solar energy
3. Environmental - **water, soil** and air
4. Space is required to produce or sustain all the above
5. Biological - species and genetic information



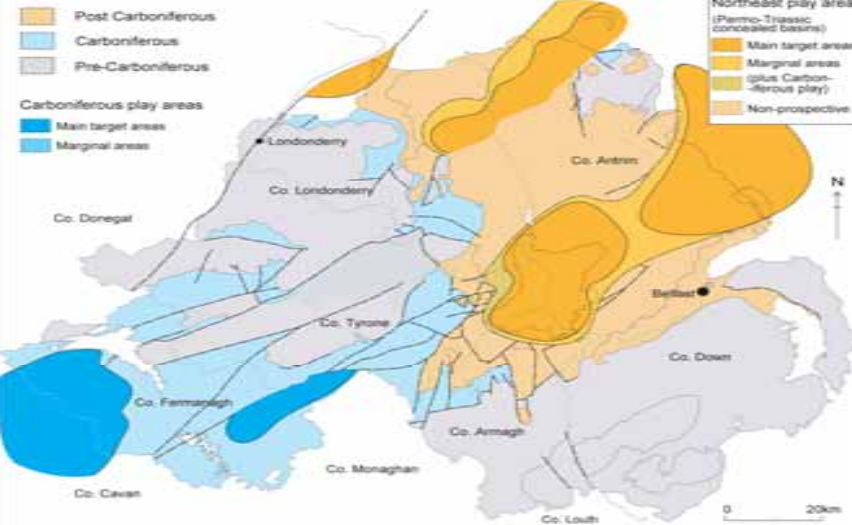
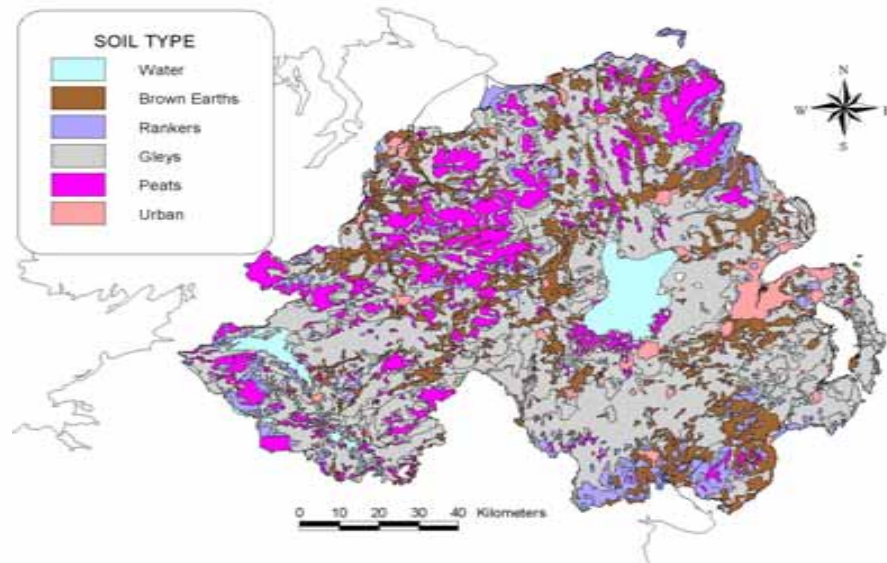
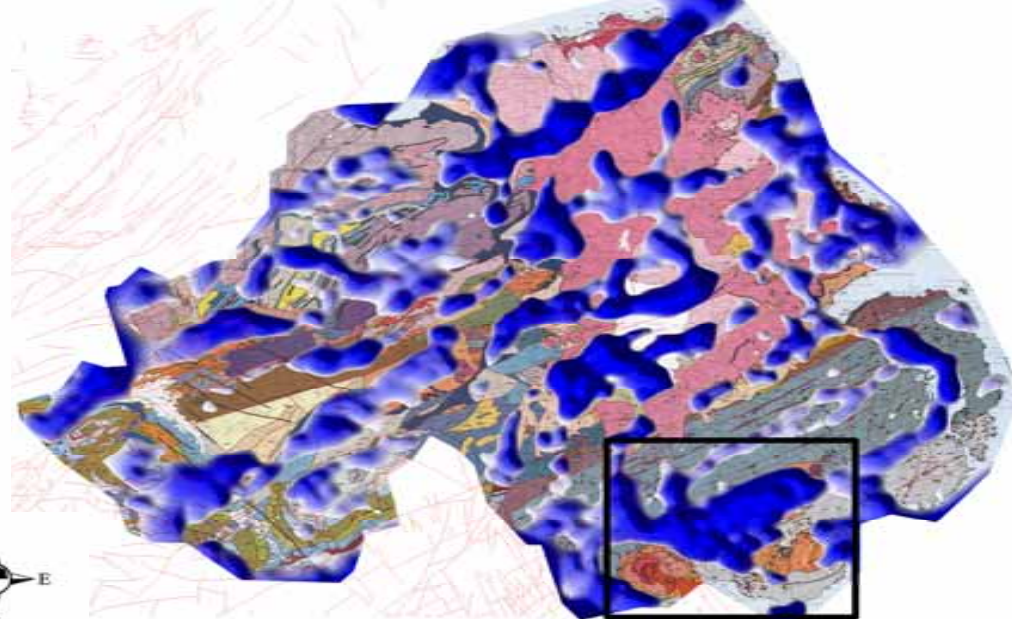
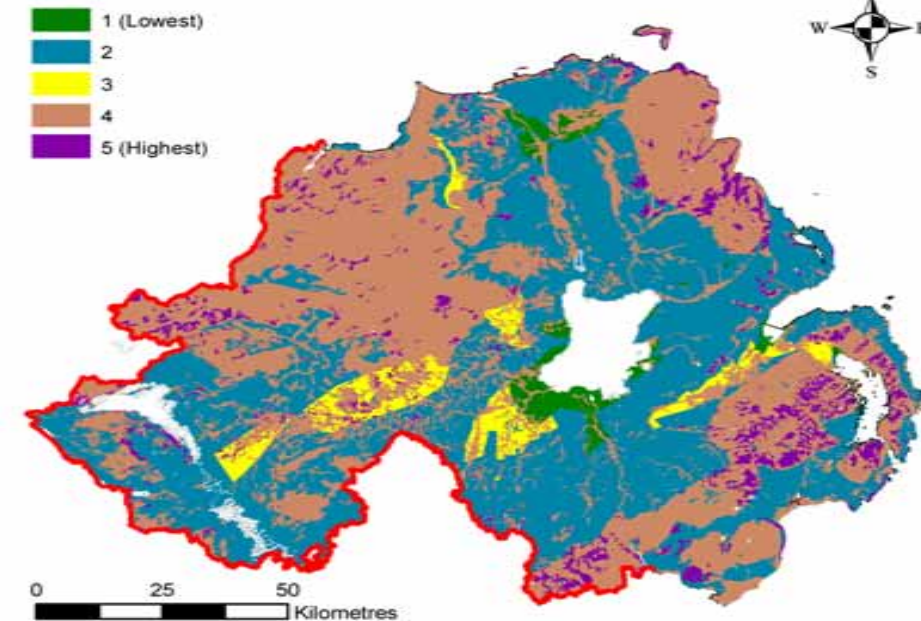


Figure 22.1: Petroleum exploration areas.



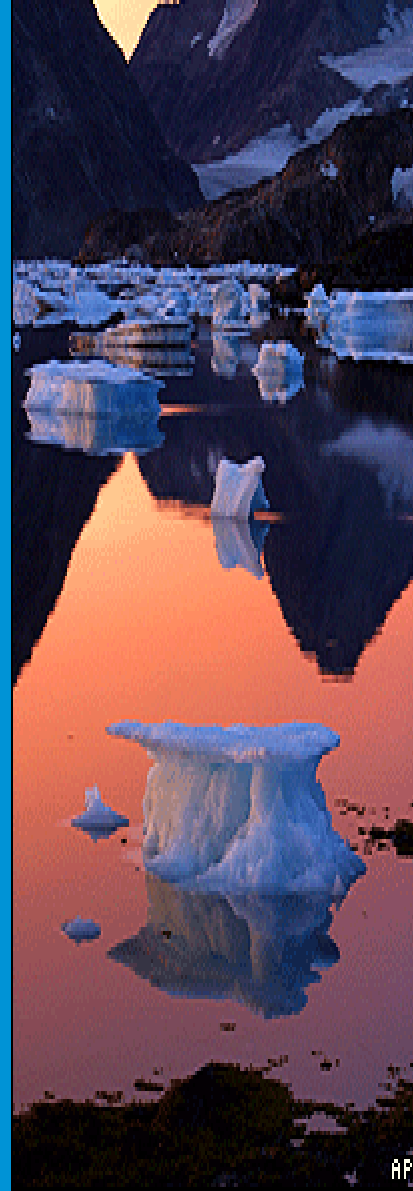


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Sustainable Development

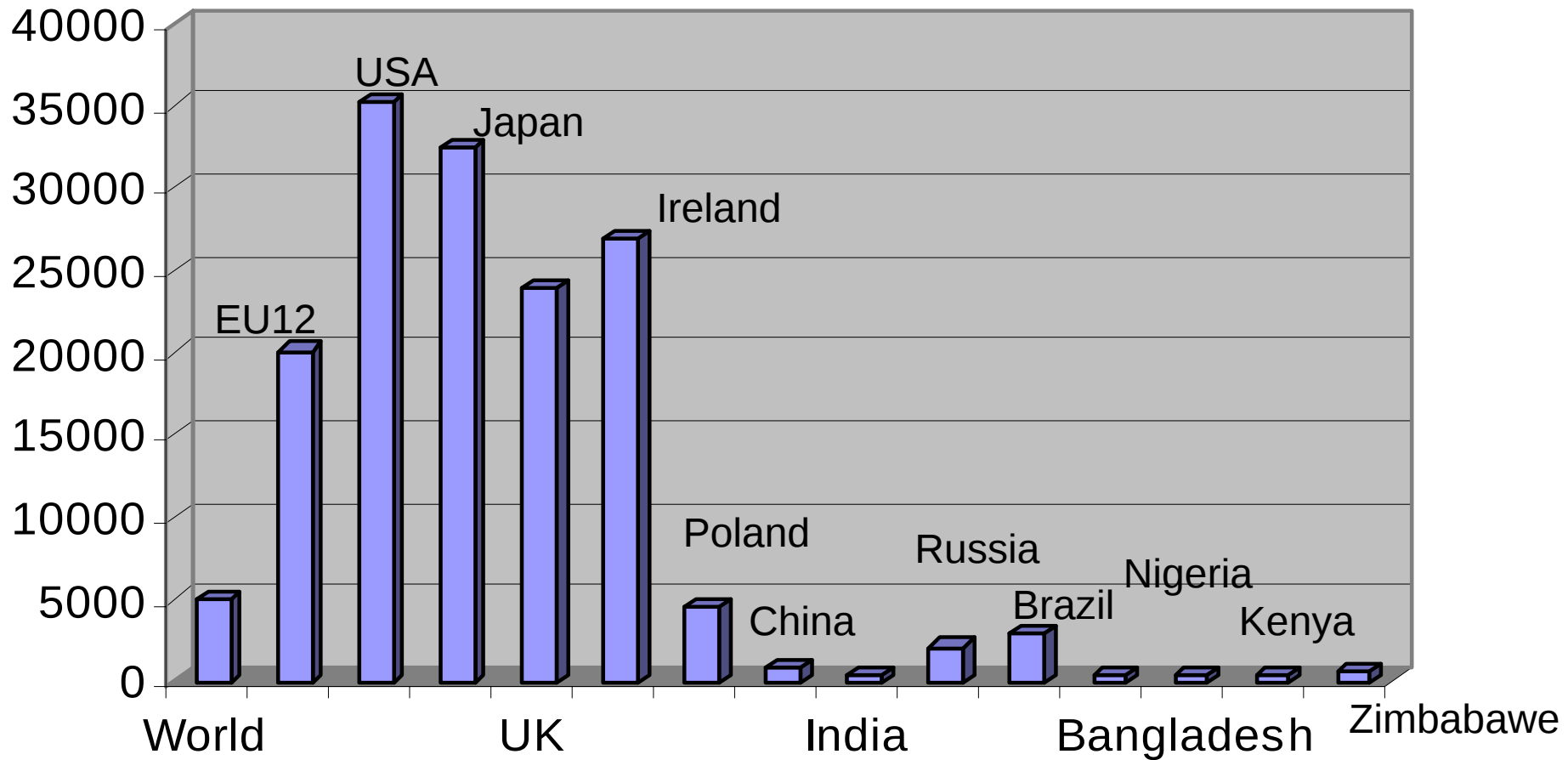
1. Has arisen because of population increase and land and many resources are finite
2. It is about getting a balance between development, government, society and environment by trying to equitably share development benefits
3. It is also about doing more with less, developing in a less consumer-intensive manner and reducing waste streams
4. *But.....there is a lot of rhetoric and hiding behind language rather than finding real solutions*



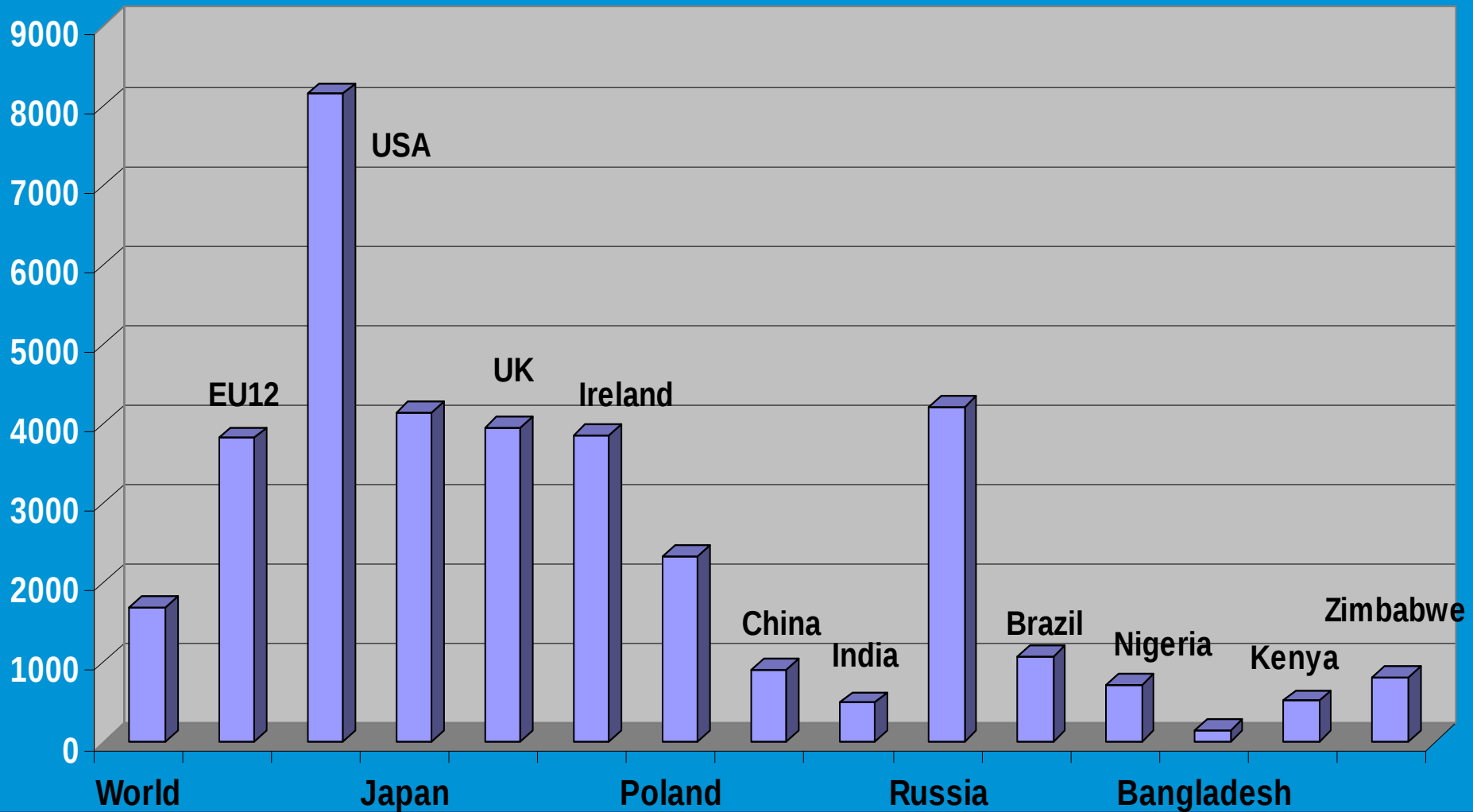
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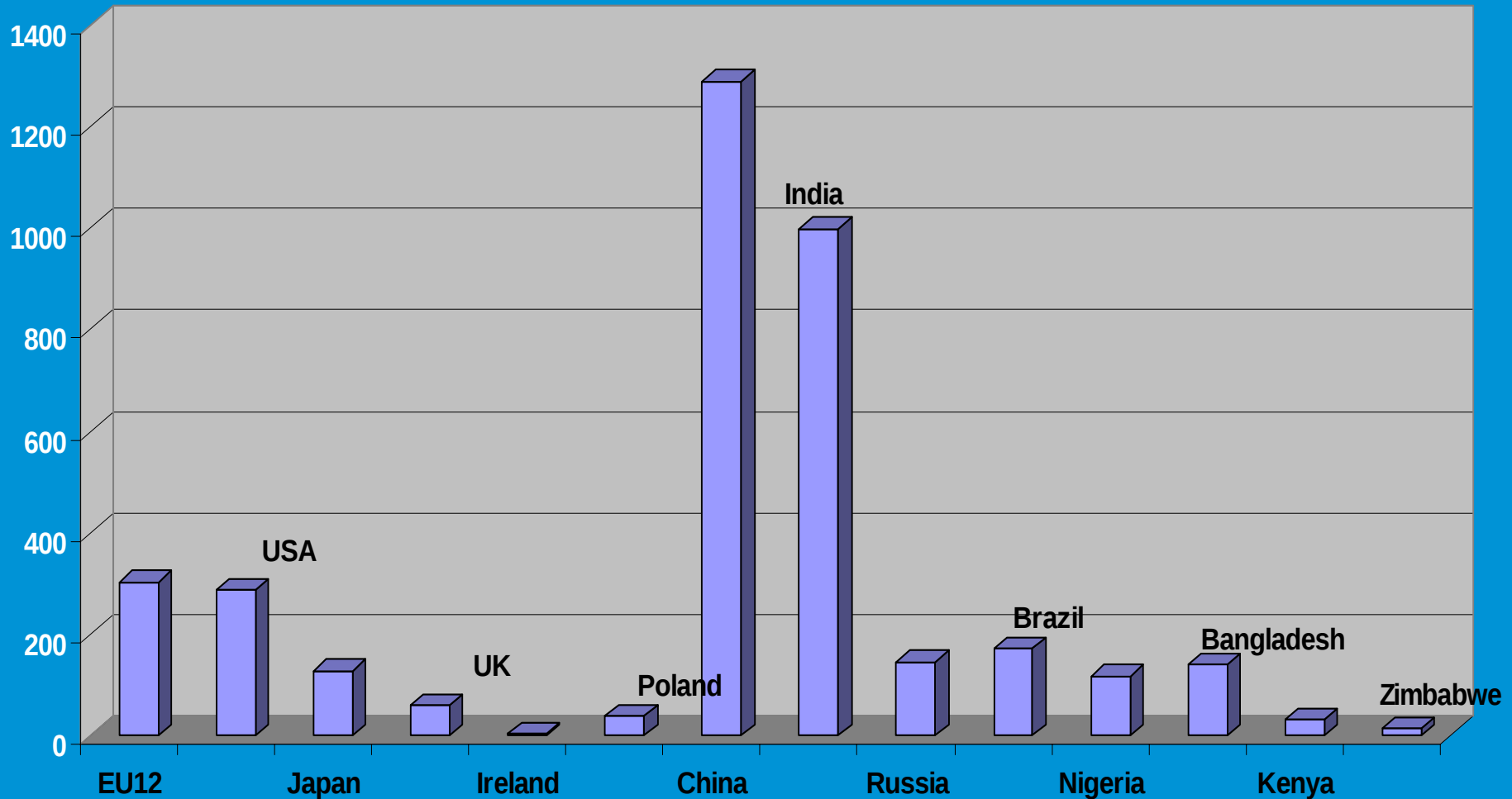
GDP/Head (US\$)



Energy Consumption/Head (Kg Oil Equivalent)



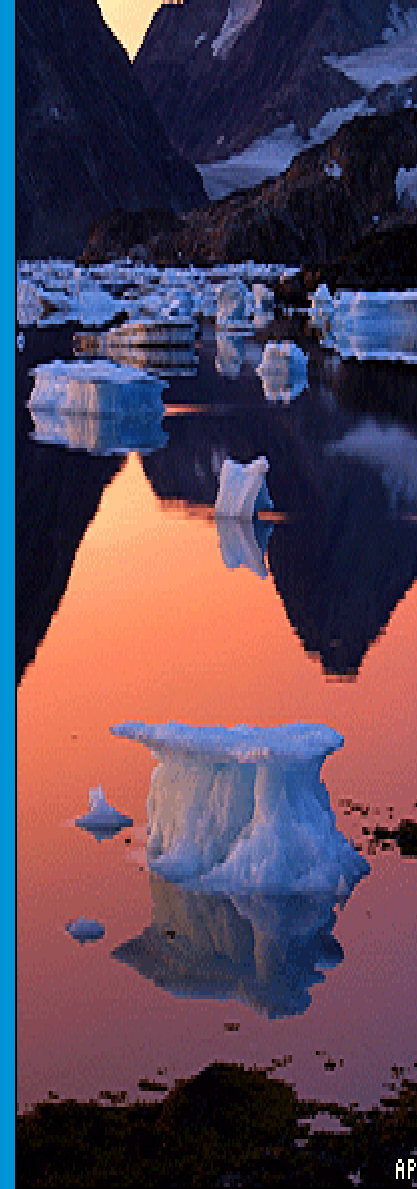
World Population - 6.14 billion



Sustainable Development

Some home truths

1. Evolution is development; all species are designed to develop and flourish, usually at the expense of other species. But growth is normally self-limiting - unsustainable populations will die back or become extinct
2. No development and no life-form has zero impact on the environment, but the environment on this planet has an extensive ability to absorb change



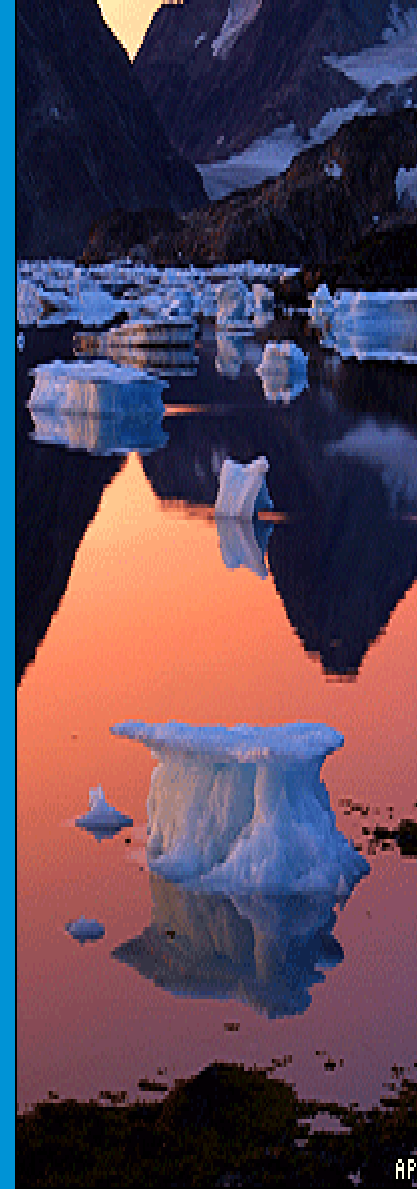
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Sustainable Development

home truths cont...

3. The human population is projected to grow 50% by 2050 (from ~6 bn to ~9 bn). Is this sustainable? Why is no-one seriously addressing *this* question?
4. Newly mined materials will be essential to support this growing population. It is estimated that 5x the amount of metal mined in the world to date must be mined in the next 50 years to satisfy this growth
5. 5% of the world's population consumes 30% of the world's mineral wealth



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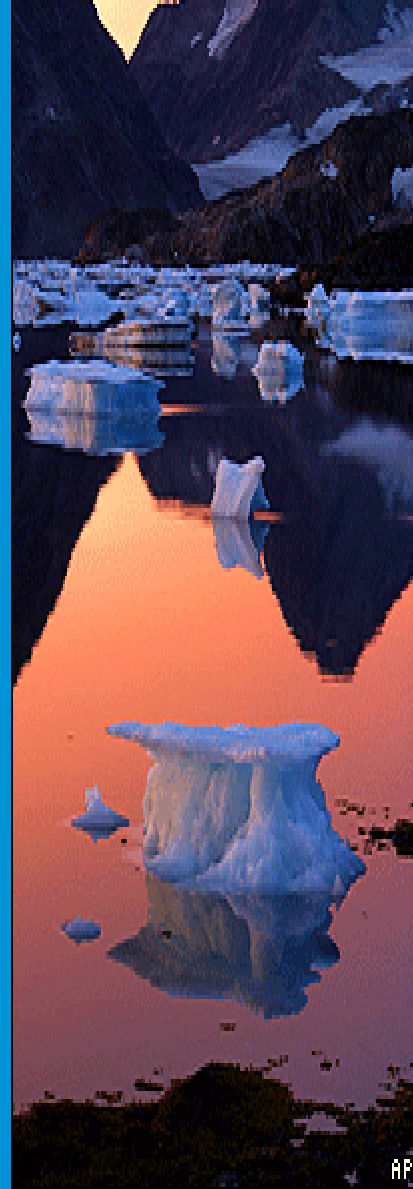
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Sustainable Development

home truths cont...

6. Laudable objectives of reducing poverty imply significant increases in raw materials usage to build infrastructure and meet new consumer demand in developing countries.
7. Per capita consumption rates in the developing world are growing fast, and would be huge if they matched US rates.
8. Recycling cannot satisfy this demand when population and per capita consumption are growing.

Thus, we have no option but to continue mining



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Living requires materials

If you cannot grow it

You have to extract it



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The Guardian

Protesters dig in to save landscape from quarry: 'It'll cost millions to get us out'



Paradigms

I want a new house

I want

Canadian Pro Mining Awareness Slogan



BAN MINING.....



LET THE BAN
FREEZE IN THE DARK!



newhere else for zinc

I want

I don't want gas exploration,
wind farms or power
stations near me



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Sustainable Development

What does it mean in the context of the minerals industry?

- Development must not exhaust the natural environment's ability to absorb change.
- A sustainably developed mine will leave no post-closure liabilities.
- Ideally, development will leave a net positive environmental legacy (e.g., parks, wetlands, fertile farmland, enhanced biodiversity, removal of natural contaminants).
- Development must not sterilize resources for future generations (e.g., by high-grading, careless infrastructure development and urban planning).



Sustainable Development

What does it mean in the context of the minerals industry?

- Development must leave a net positive, equitable, social legacy.
- Development must create net wealth that accrues to *all* genuine stakeholders. Stakeholders who are impacted by development or whose resources are being exploited must be properly compensated.
- Creative compensation packages that include training and investment should be implemented to ensure that sustainable societies are left after mining is complete



Sustainable Development Models and Opportunities within the Minerals Industry

Extraction Techniques

- 4% of world's energy consumption used to crush and grind rocks and minerals. Up to 7% if smelting included
- Improve efficiency and recovery
- Develop new mineral processing techniques
- Develop safer processing methods and reagents

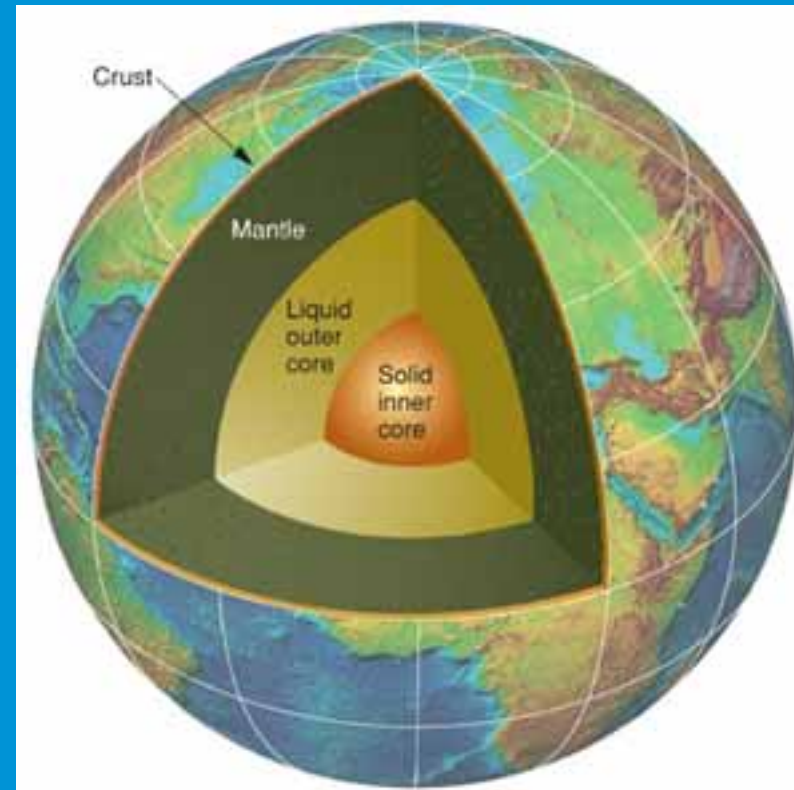


Sustainable Development Models - Opportunities in the Minerals Industry

Environmental Control and Management

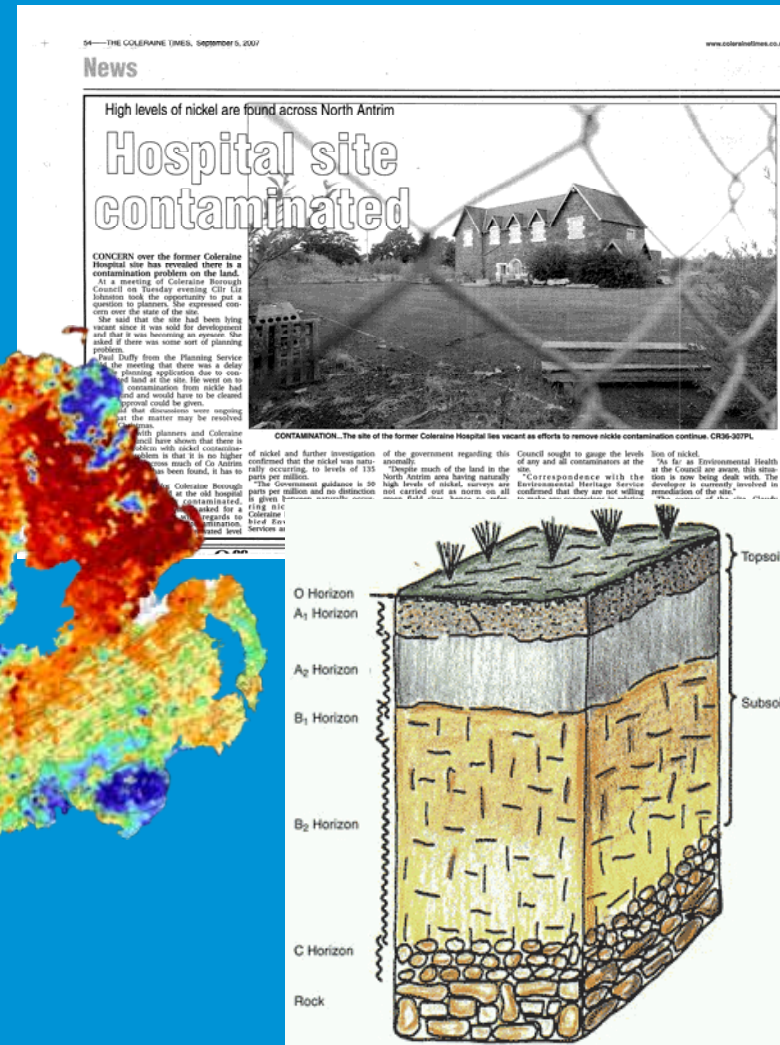
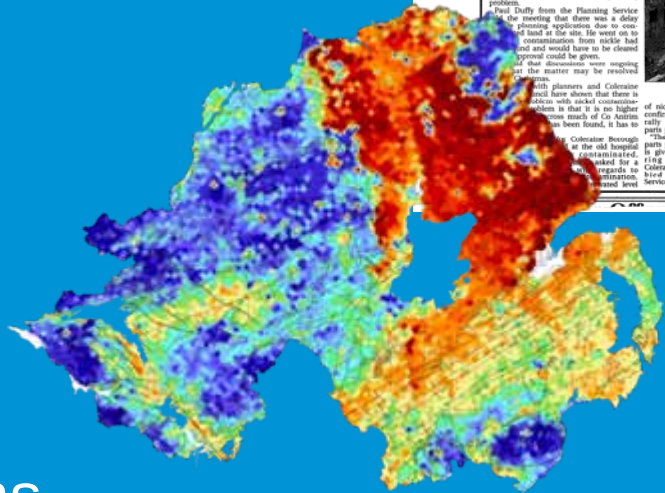
- * Probably < 0.1% of world's land surface disturbed by mineral extraction — point source disturbance, and very small compared with forestry and farming
- Upside potential: improvement of water quality, habitat
- Increased biodiversity potential in reclaimed lands

*e.g. British Columbia, Canada:
~0.1% of land area disturbed by mining, compared with 51.5% designated as productive forest, >4% harvested since 1981 (Mining Assoc. B.C., 2001; B.C. Ministry of Forests, 2000)



Geoscientists and Sustainable Development

- Geoscientists have much to offer in the field of sustainable development, because we have expert knowledge of many of the natural processes that give rise to environmental problems



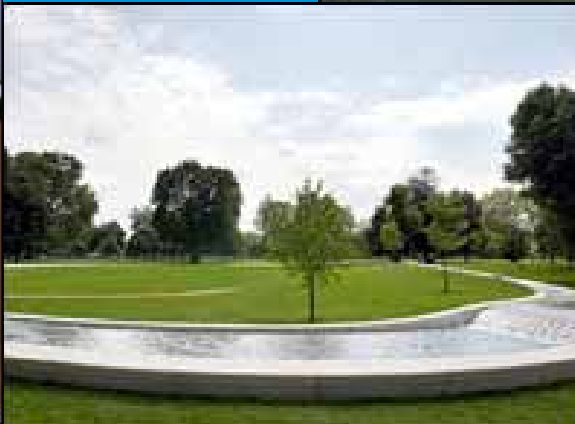
Minerals and Sustainable Development in Northern Ireland



McConnell and Sons of Kilkeel

“The head of a County Down firm which constructed a new memorial to the armed forces in Staffordshire has spoken of his pride at its completion.”

BBC News, Friday 12 October 2007



Indigenous Resources – International Reputation

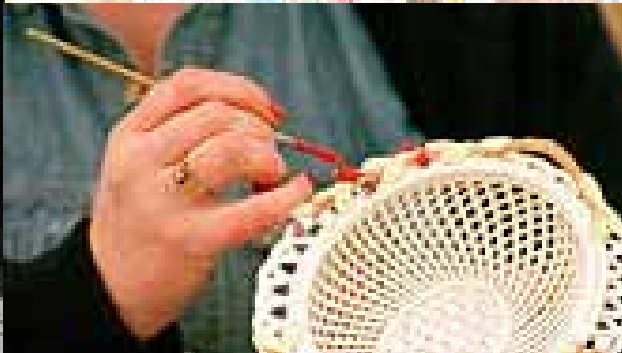


J. C. Bloomfield

J. C. Bloomfield

Lord James

© Fermanagh County Museum



© Harrison Photography



Erin – Belleek Pottery



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Post Closure Uses



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**Historic Landmarks
reflect Local Stone**



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Albert Memorial – Newry Granite Pedestal and some Columns



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Mining and Quarrying – a transient land use



**Curraghinalt Gold Mine,
Co. Tyrone, 1988**



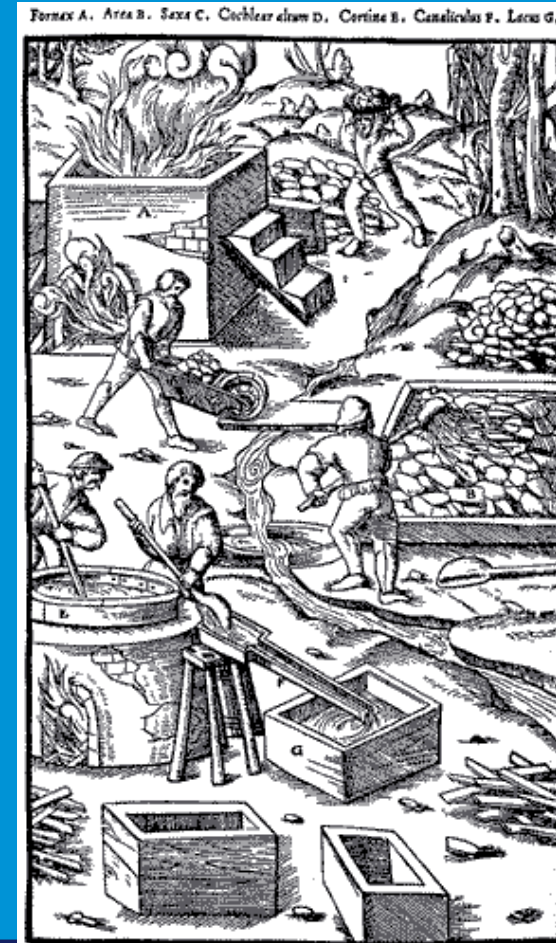
**Curraghinalt Gold Mine,
Co. Tyrone, 2004**

Sustainable Development Models and Opportunities within the Minerals Industry

Mineral Exploration

- Improve discovery rate through application of innovative exploration methods
- Develop predictive exploration models
- Identify new resource types
- Demonstrate responsible community engagement and environmental awareness from the outset
- Knowledge based decision making

De re Metallica, 1556





Ireland – Operating Mines

Carrickfergus - salt

Cavanacaw – Au

Tara – Zn Pb

Galmoy – Zn Pb

Lisheen – Zn Pb



Galantas Gold

Cavanacaw Deposit

43-101 compliant

	Tonnes	g/t Au
Proven Reserve	181,480	7.36
Probable Reserve	185,830	7.68
Indicated Resource	1,183,680	7.02

4.3m @ 7.87 g/t Au including
1m @ 27.42g/t Au



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Tournigan Gold



Curraghinalt Deposit

43-101 compliant inferred resource
527,700 tonnes grading 15.45 g/t Au; 6.0 g/t Au cutoff

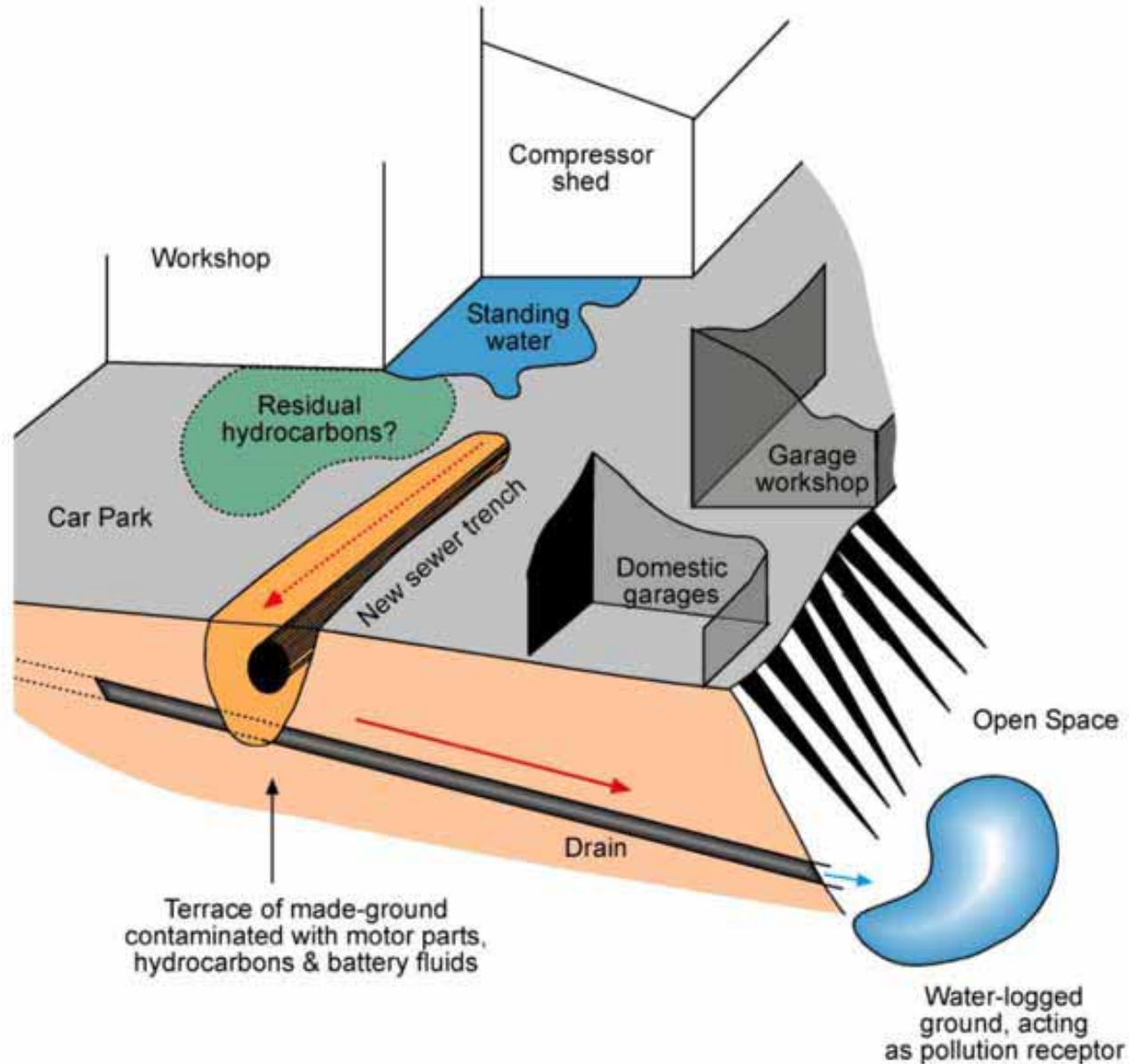


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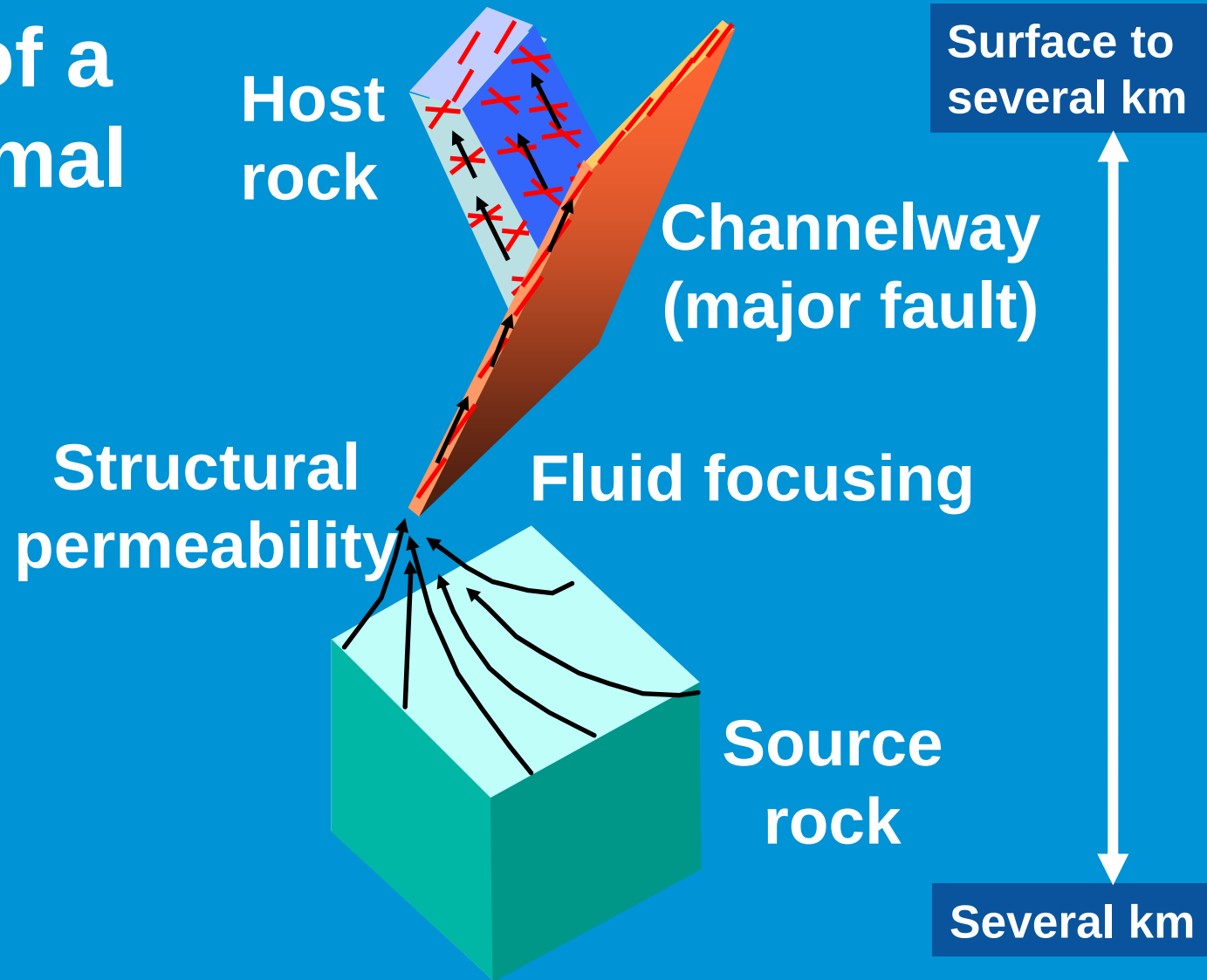
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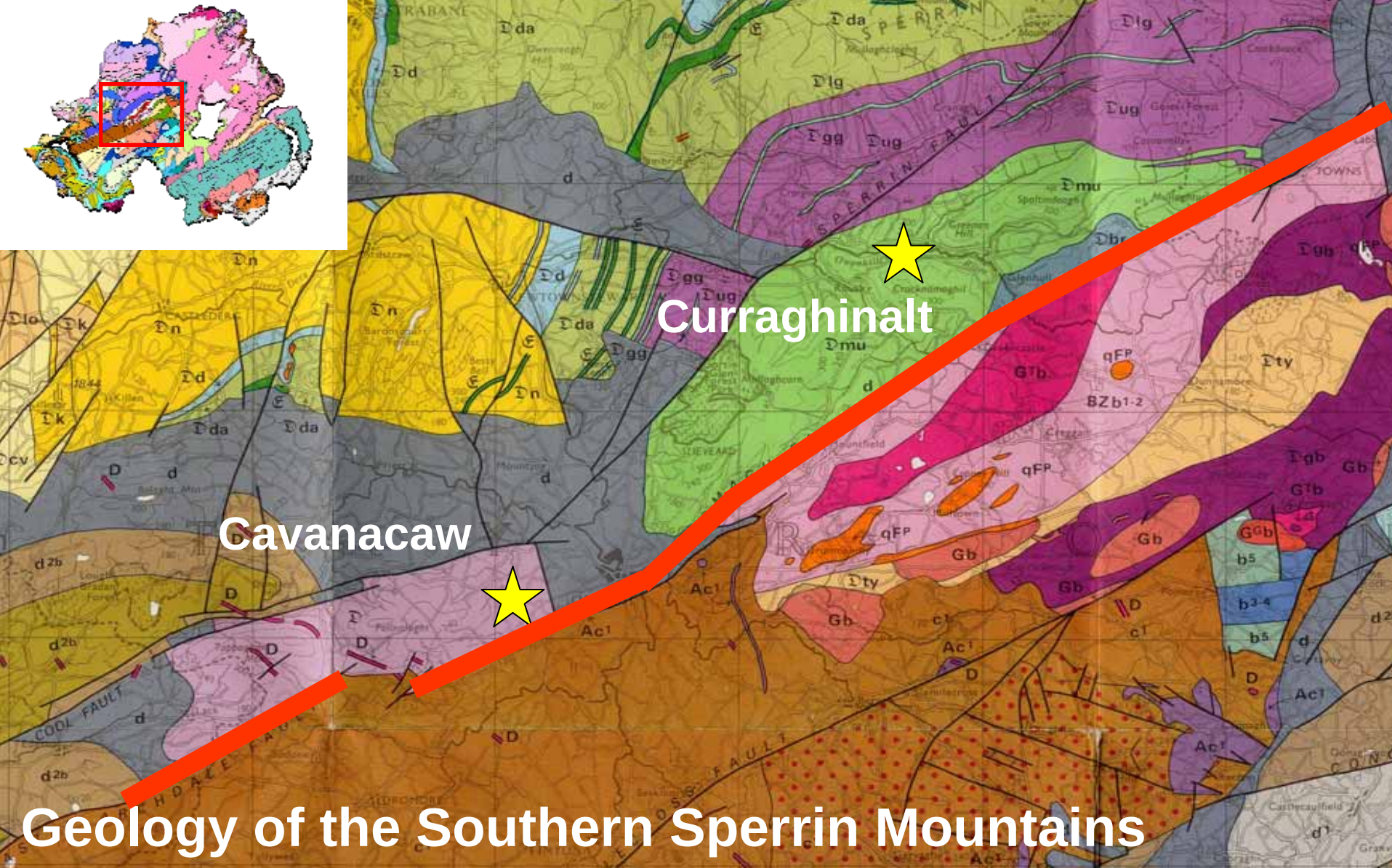
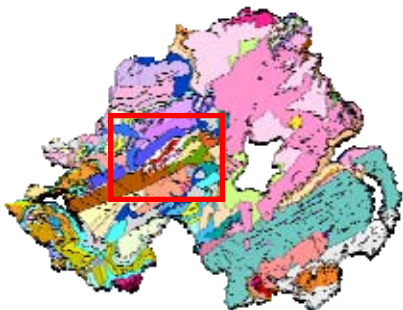
How to Form a Mineral Deposit

- Source
- Pathway
- Receptor



Anatomy of a Hydrothermal System





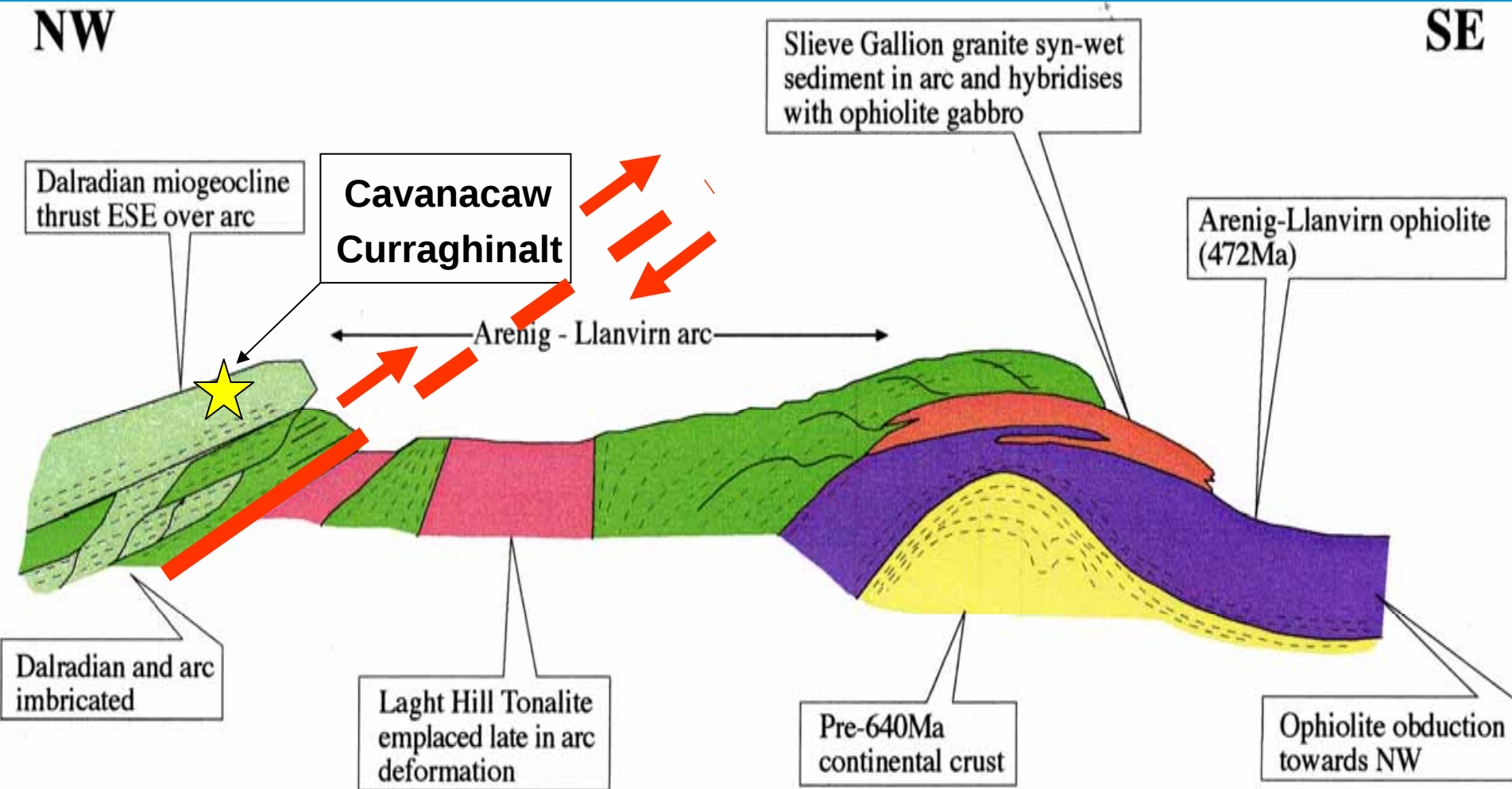
Geology of the Southern Sperrin Mountains



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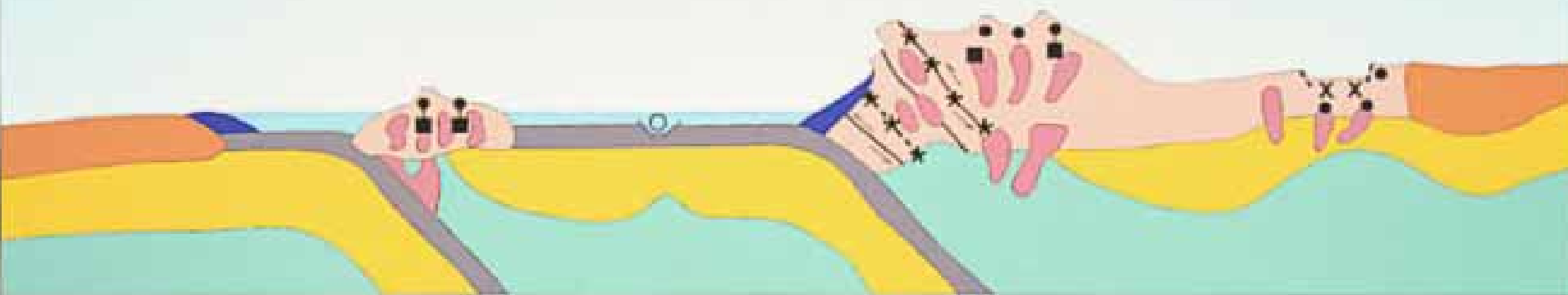
Schematic cross section of Dalradian- Tyrone Igneous Complex relationships



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CONTINENT	OCEANIC ARC	BACK ARC	ACCRETED TERRANES	CONTINENTAL ARC	BACK-ARC CRATON MARGIN
	• Epithermal Au-Ag ■ Porphyry Cu-Au ($\pm$skarns)	○ VHMS Cu-Au	★ Orogenic Au	• Epithermal Au ■ Porphyry Cu-Au-Mo ($\pm$skarns)	• Intrusion-related Au - x Carlin-style Au



Accretionary wedge

Granitoids

Asthenosphere

Continental crust

Oceanic crust

Extensional fault

Older craton

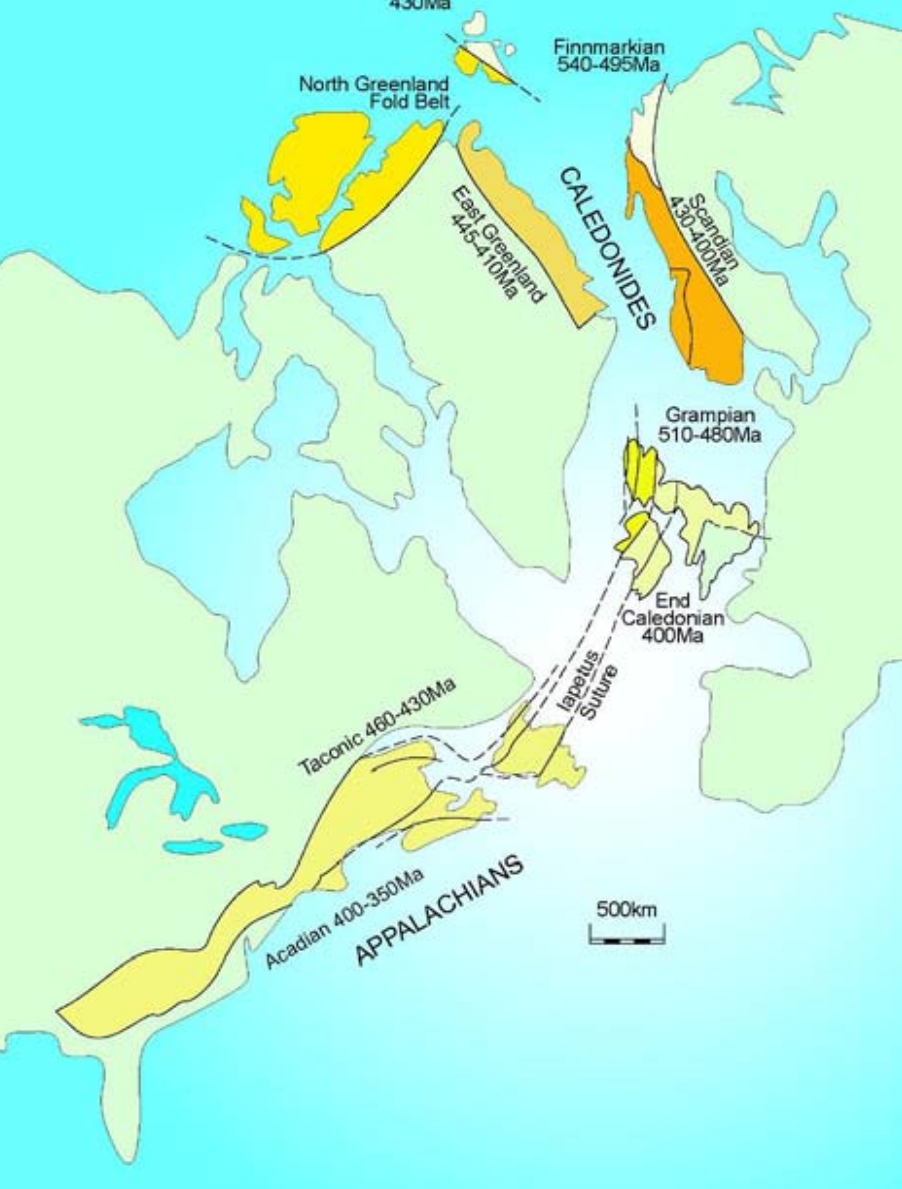
Subcrustal lithosphere

Compressional fault/thrust

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Ordovician Arc

New Brunswick -
Newfoundland -
Co. Tyrone

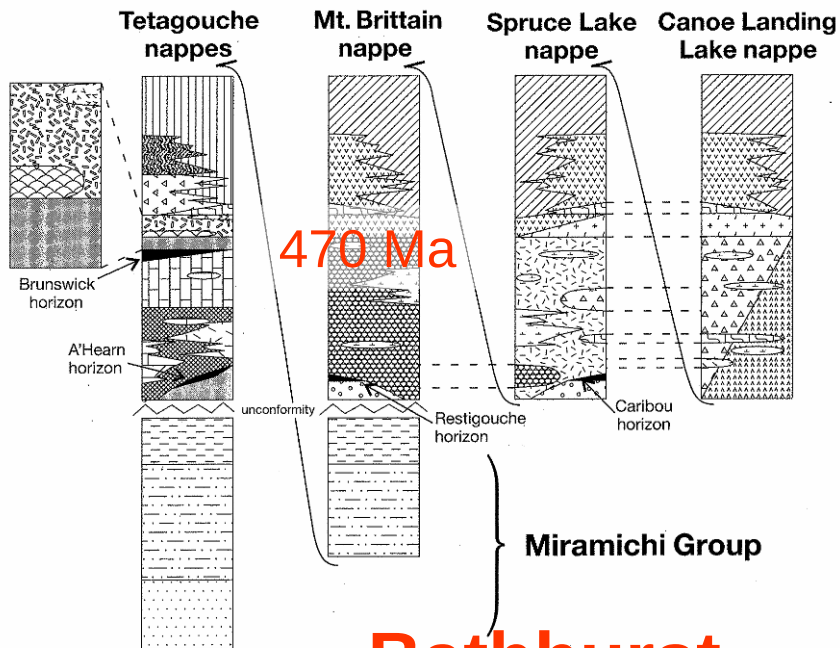


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Tetagouche Group

California Lake Group



Caradoc	Burrellian	ORDOVICIAN
	456 Ma	
	Aurelucian	
	459 Ma	
	Llandeillan	
Llanvirn	461 Ma	
	Abereiddian	
	465 Ma	
Arenig	Fennian	
	471 Ma	
	Whittandian	
	475 Ma	
	Moridunian	
	480 Ma	
Tremadoc	Migneitian	
	Cressagian	

Tetagouche Group

Little River Formation

- Black shale, siltstone and chert
- Beresford alkali basalt
- Brunswick Mines alkali basalt
- Red shale

Flat Landing Brook Formation

- Forty Mile Brook basalt
- Moody Brook basalt
- Fragmental rhyolite
- Massive rhyolite
- clastic sedimentary rocks

Nepisiguit Falls Formation

- Massive sulphide
- Little Falls member
- Grand Falls member
- Lucky Lake member
- clastic sedimentary rocks
- Massive sulphide
- Vallée Lourdes member

Miramichi Group

- Patrick Brook Formation
- Knights Brook Formation
- Chain of Rocks Formation

California Lake Group

Boucher Brook Formation

- Black shale, siltstone and chert
- Camel Back alkali basalt
- Red shale

Spruce Lake Formation

- Feldspar porphyries
- Shellalah Hill member
- clastic sedimentary rocks
- Massive sulphide
- Charlotte Brook member

Canoe Landing Lake Formation

- Orvan Brook tholeiites
- Nine Mile tholeiites
- Canoe Landing Lake alkali basalt
- Red shale
- clastic sedimentary rocks

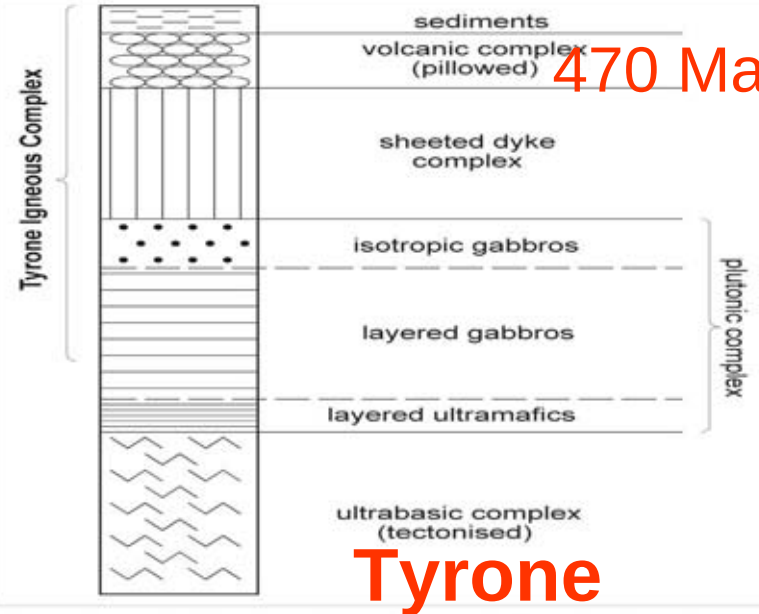


Figure 3.2: Idealised section of an ophiolite showing the extent of the Tyrone Igneous Complex.

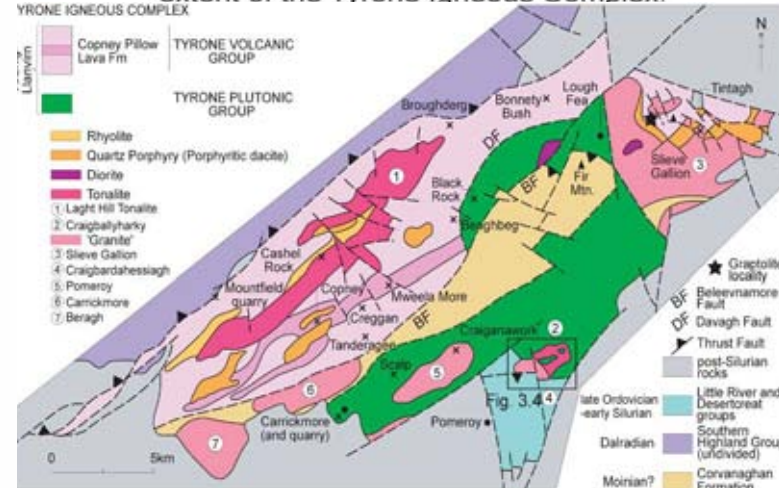


Figure 3.1: Geological map of the Tyrone Inlier including the Central Inlier (Corvanagh Formation) and Tyrone Igneous Complex.

Soil Geochemistry

Cw

Ct

Au

40 ppb

2 ppb

0

20km



TELLUS



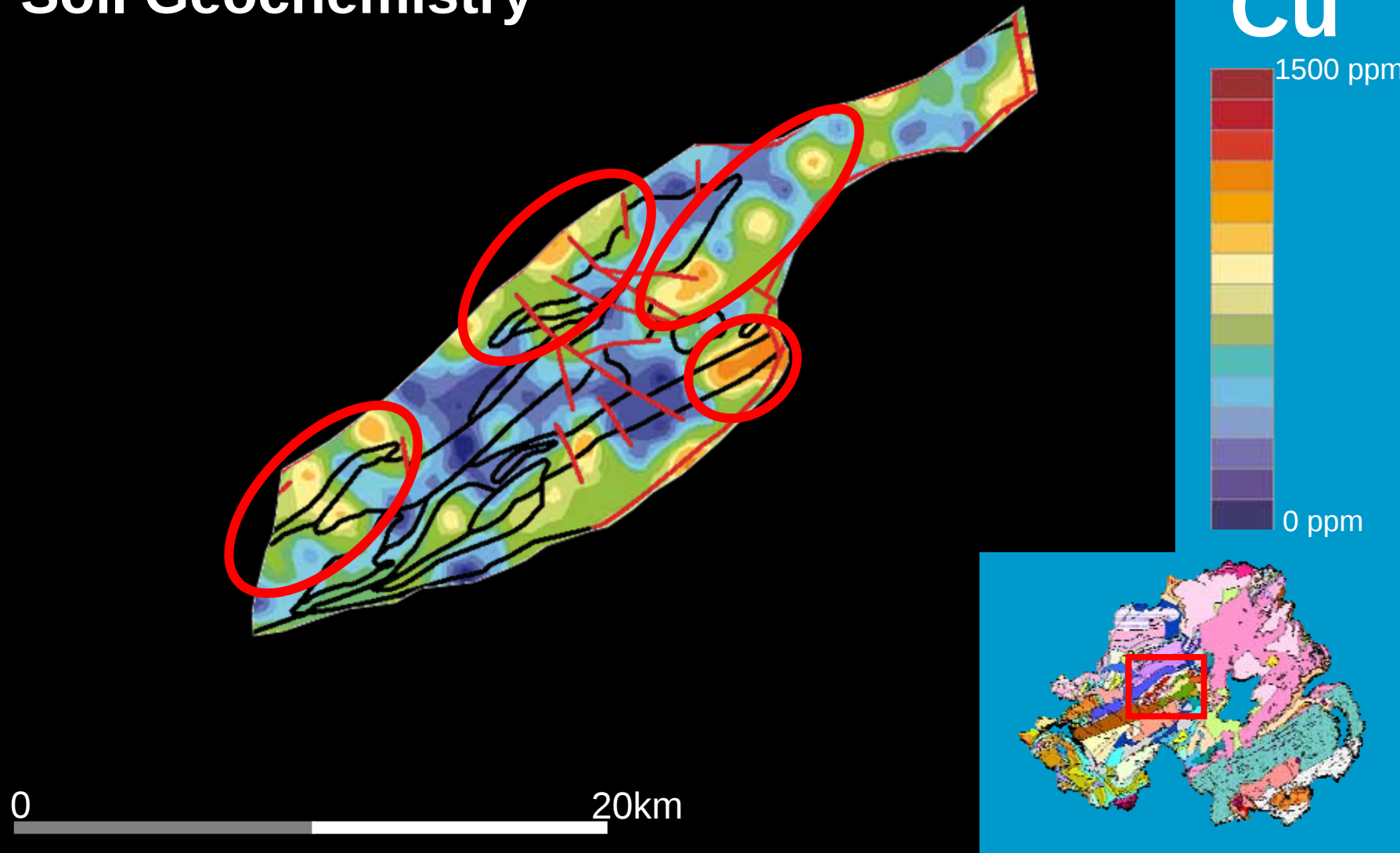
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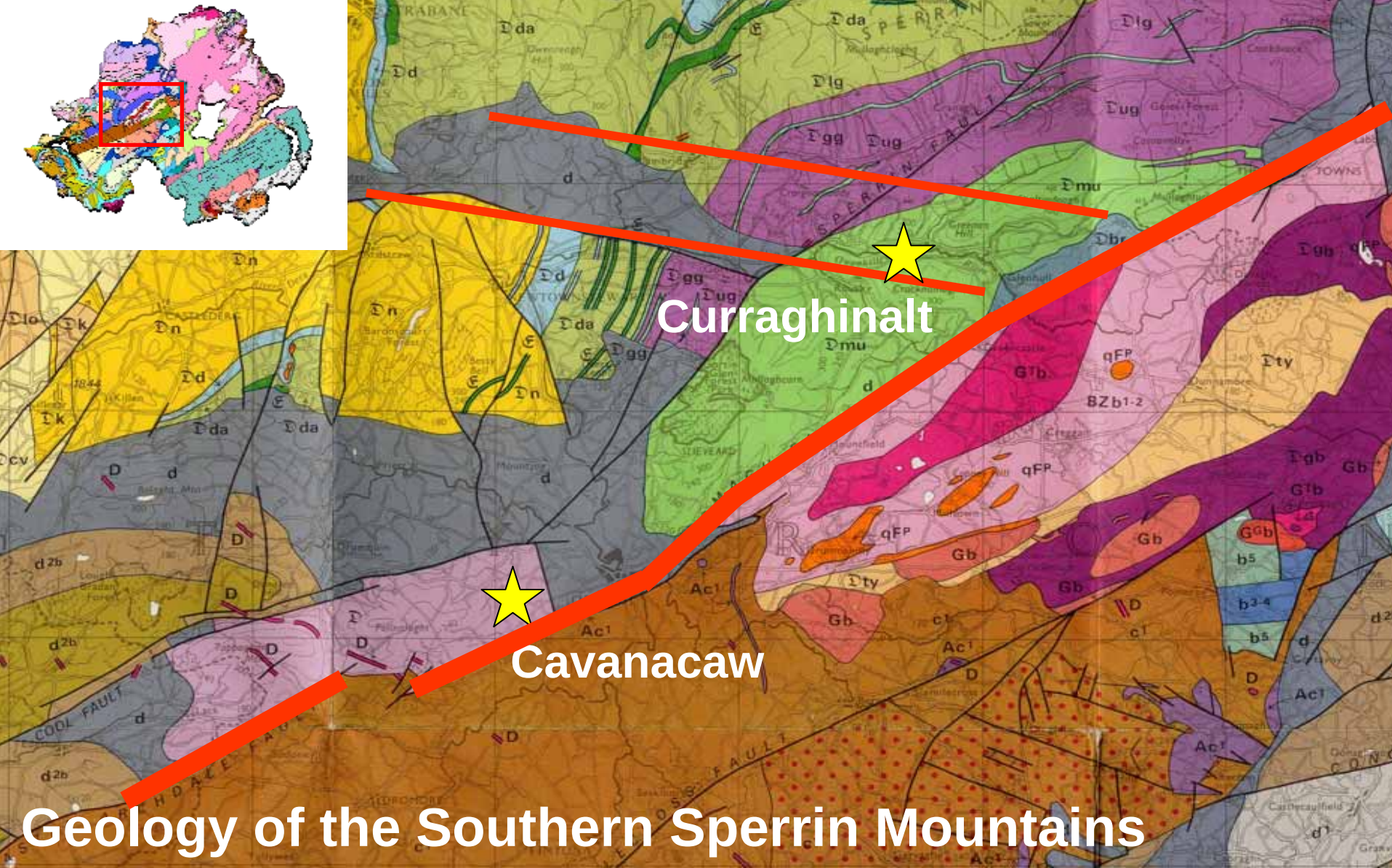
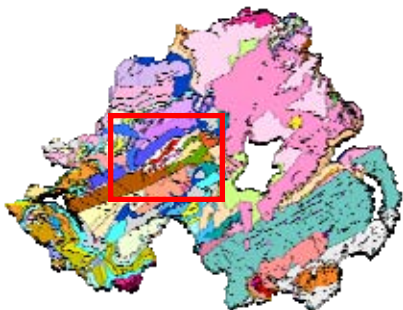
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Soil Geochemistry

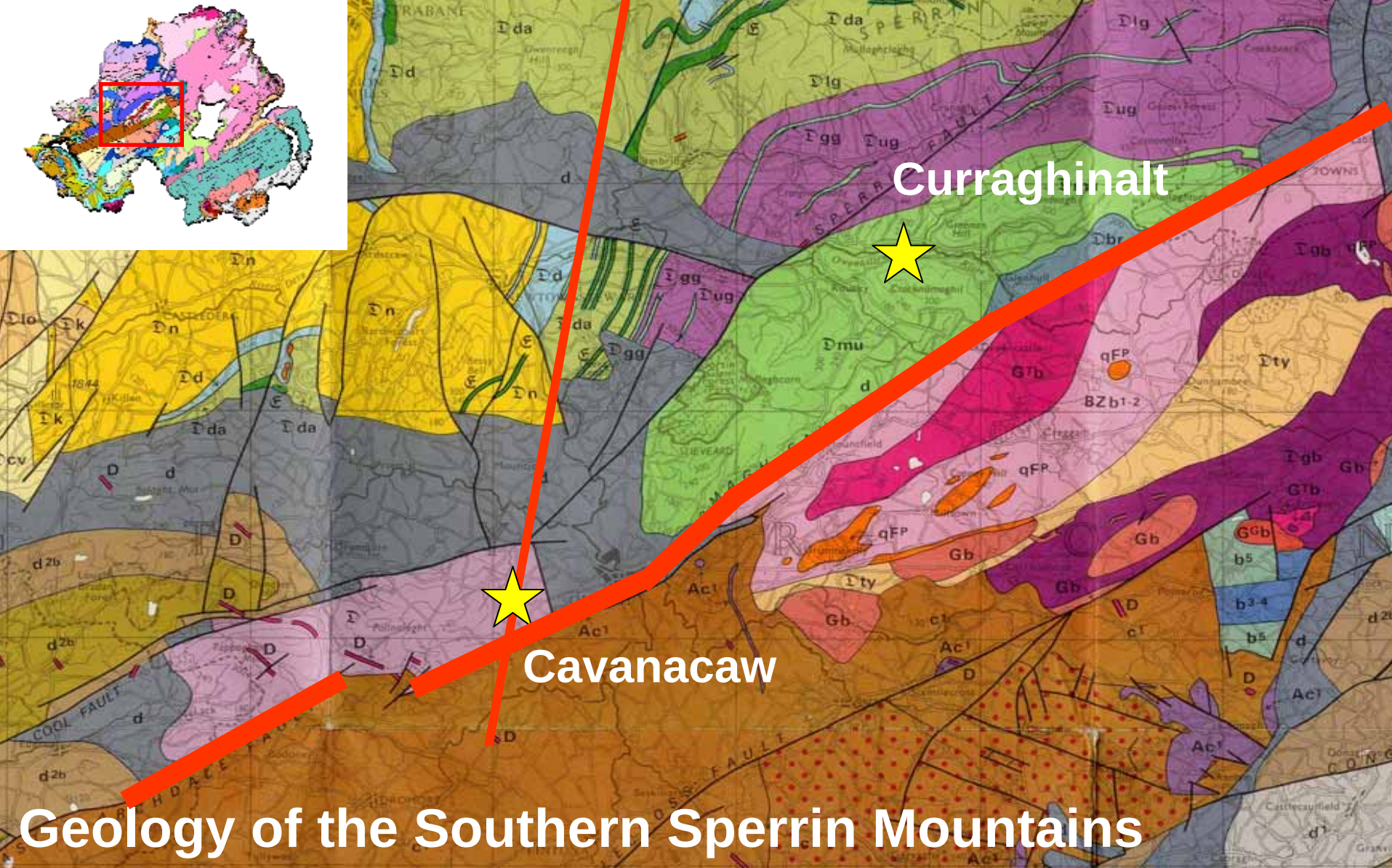
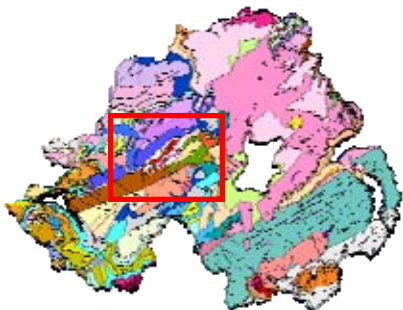


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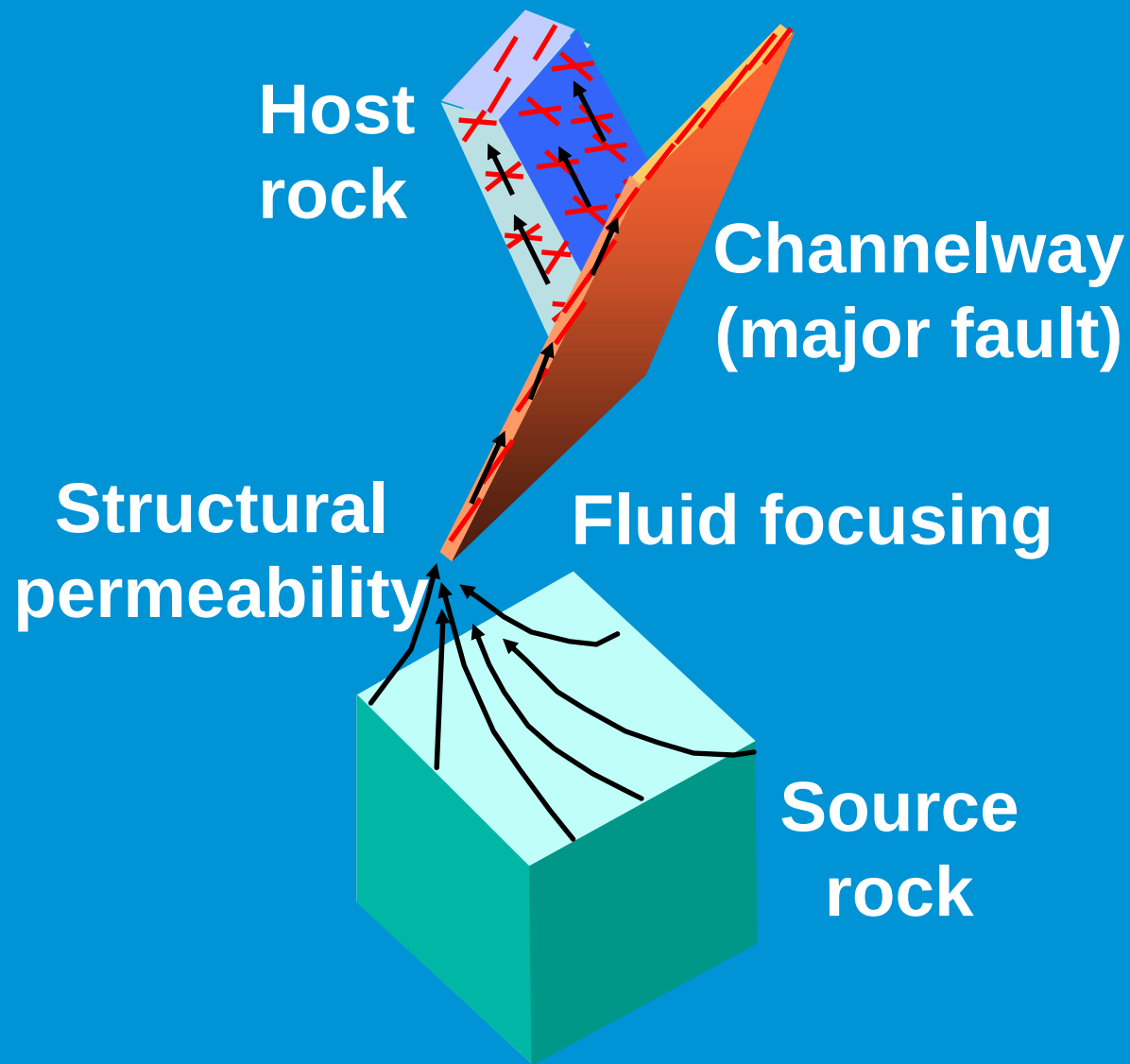
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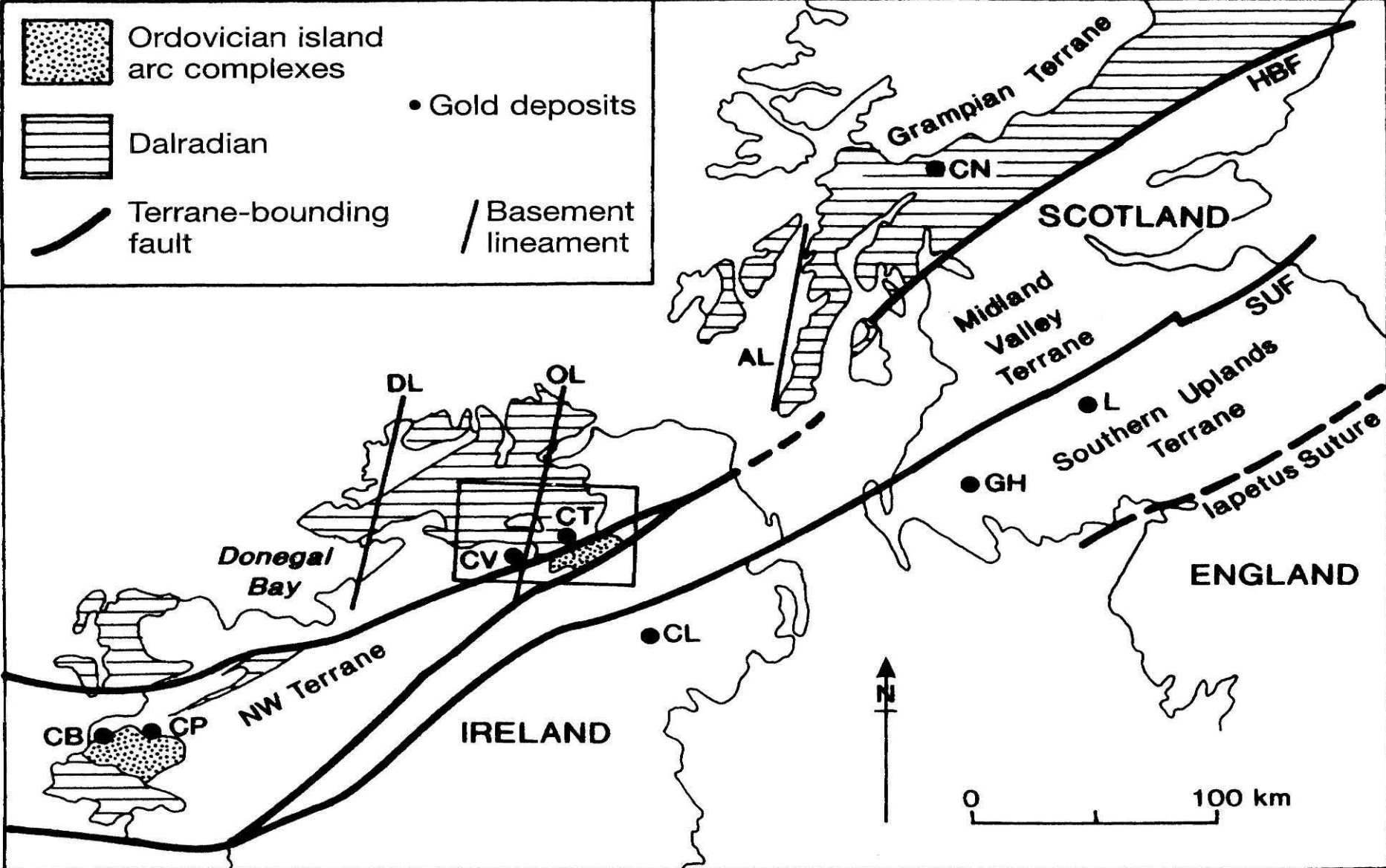


Receptor

Pathway

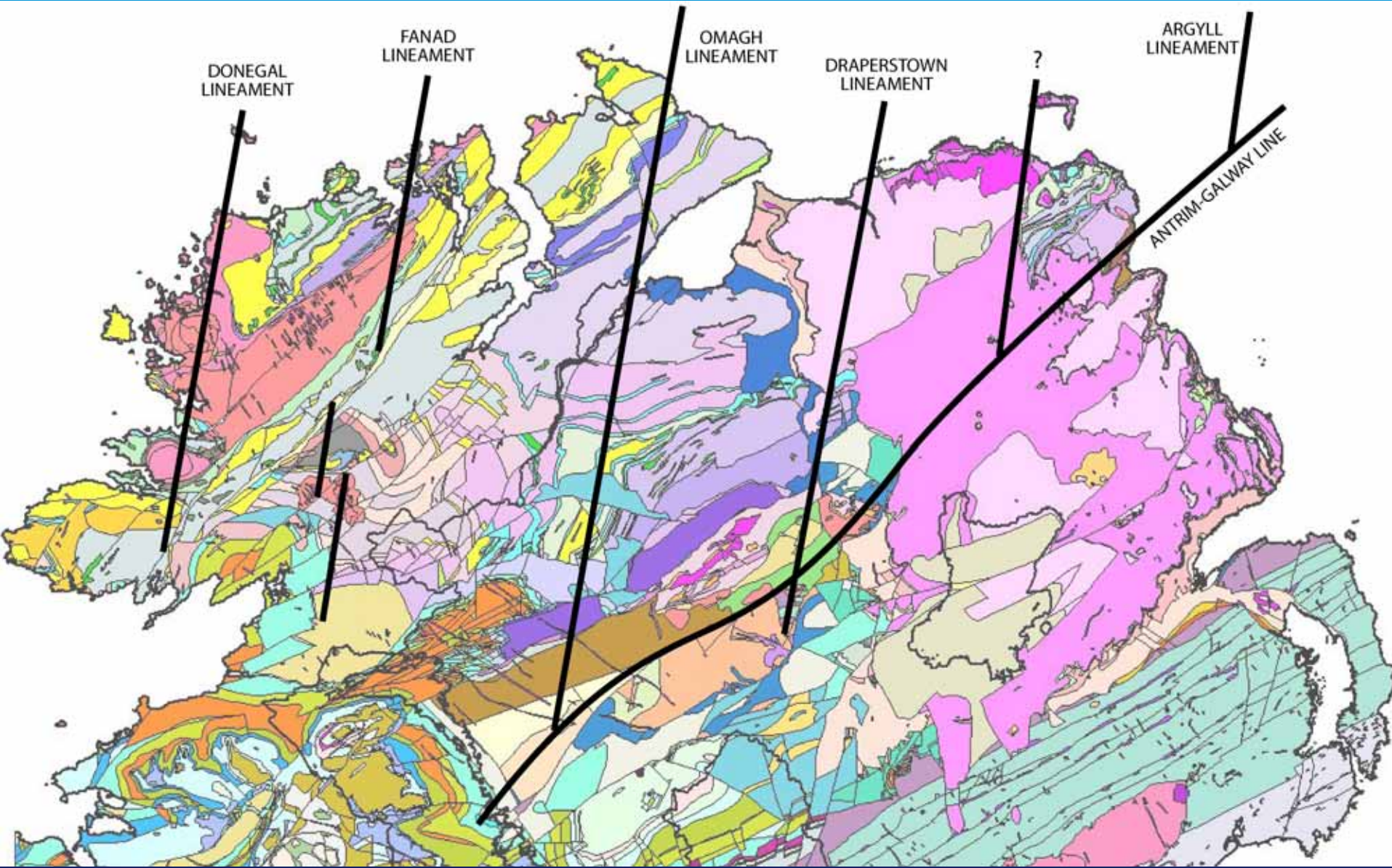
Source





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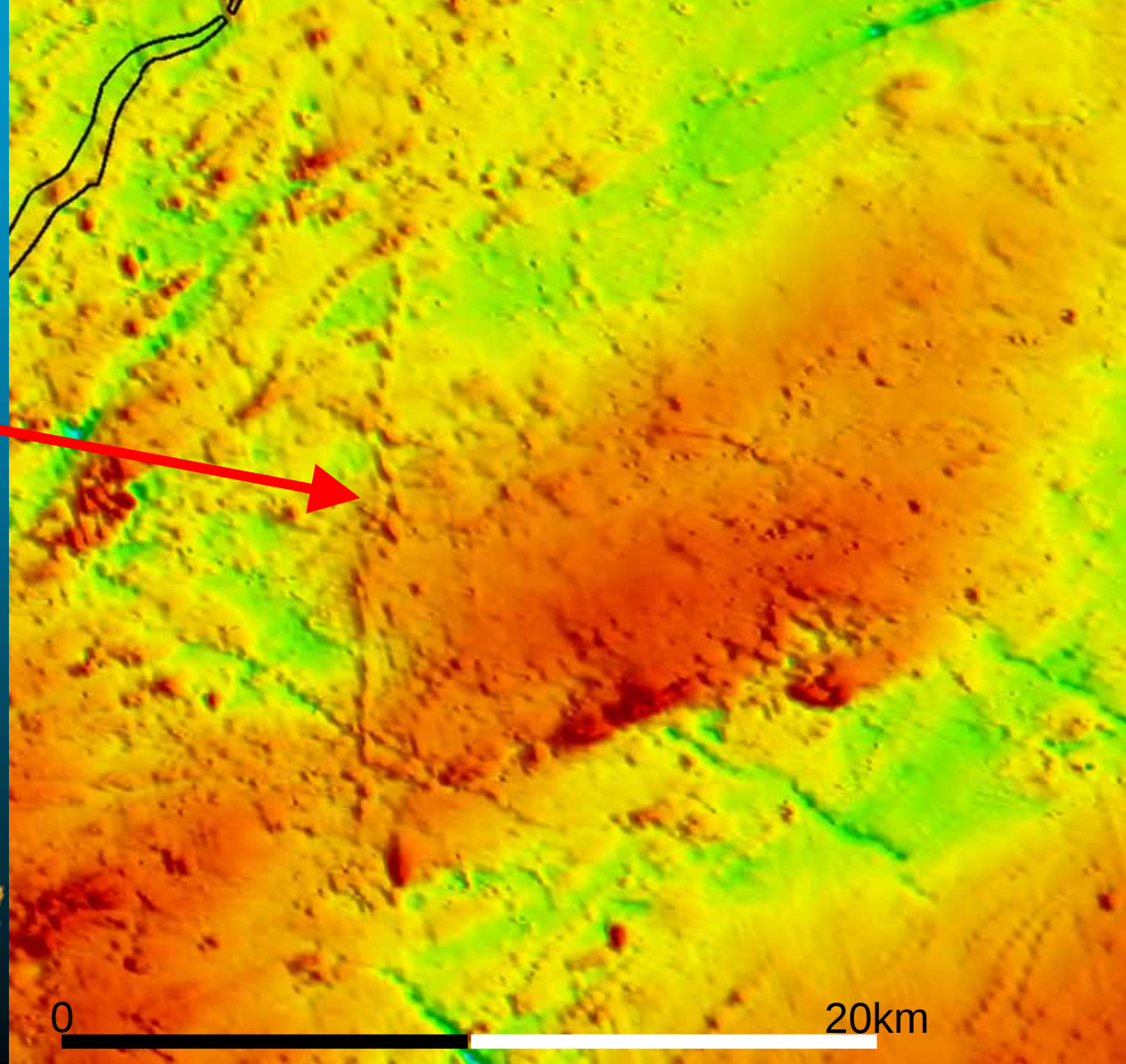
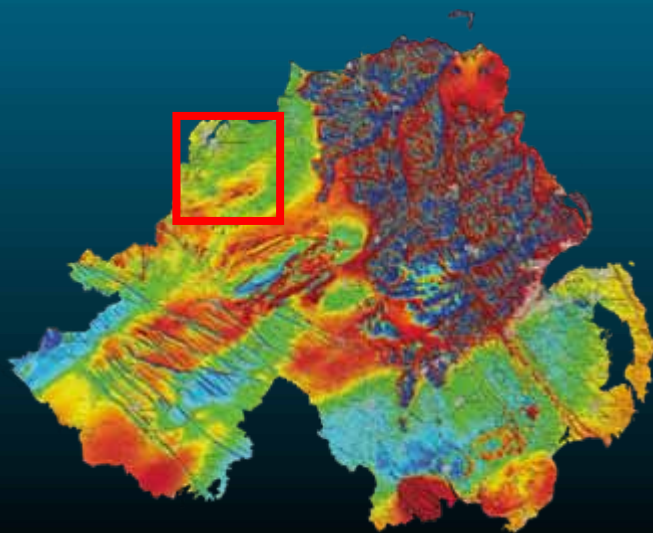
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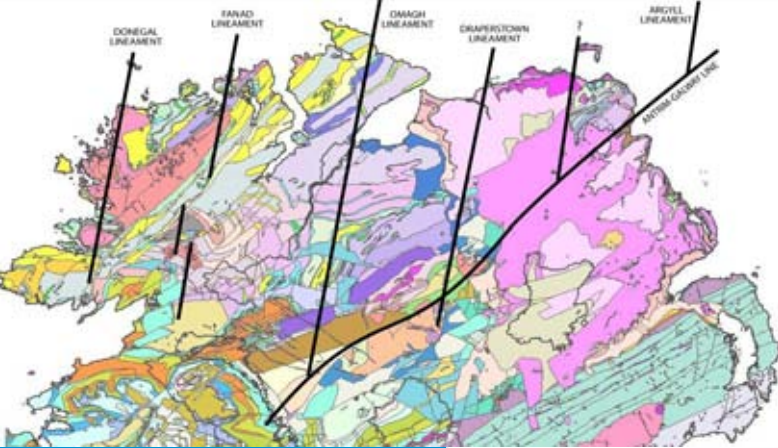


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Omagh Lineament





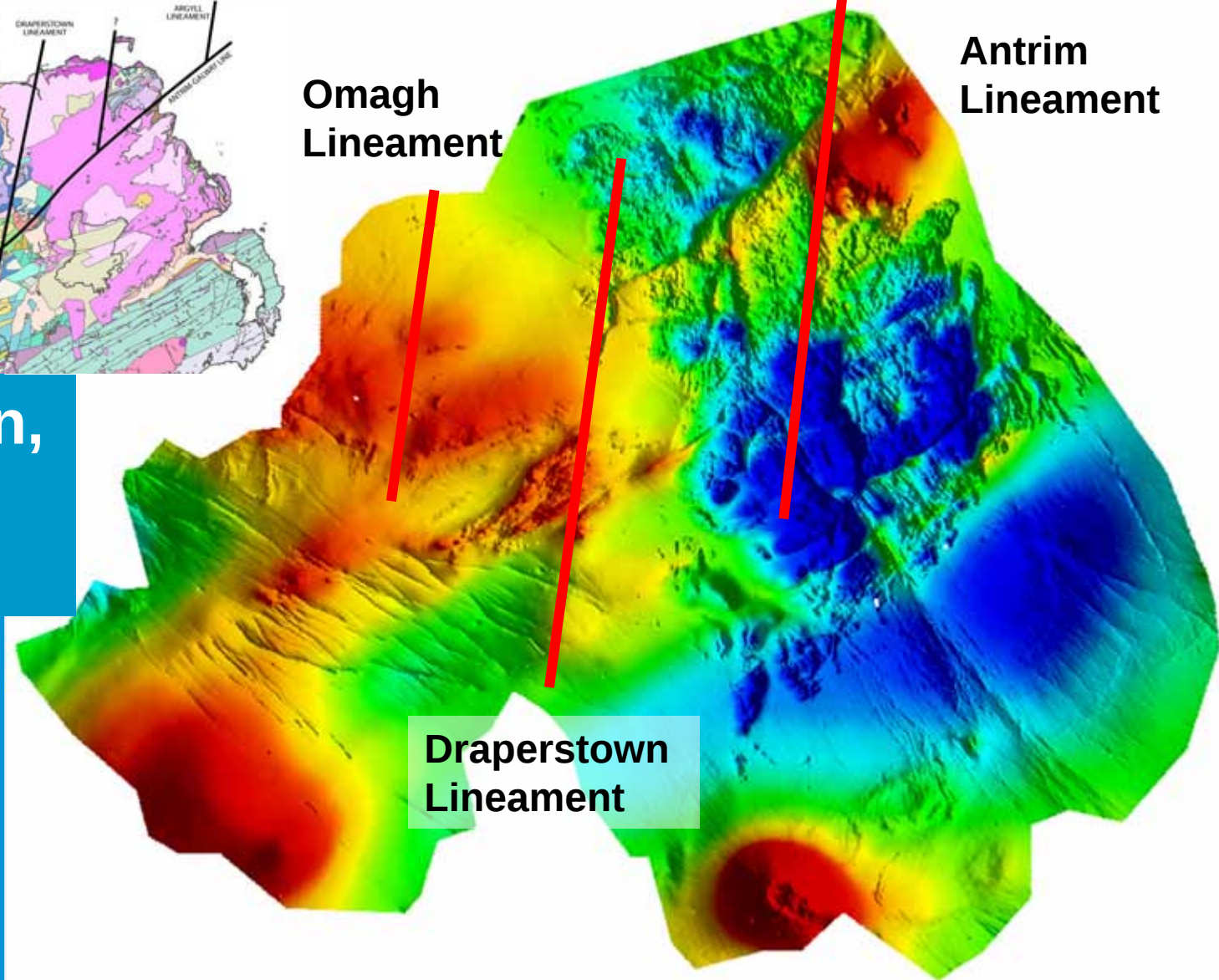
Omagh
Lineament

Antrim
Lineament

Draperstown,
Antrim
Lineaments

0 20km

Pseudogravity



Draperstown
Lineament

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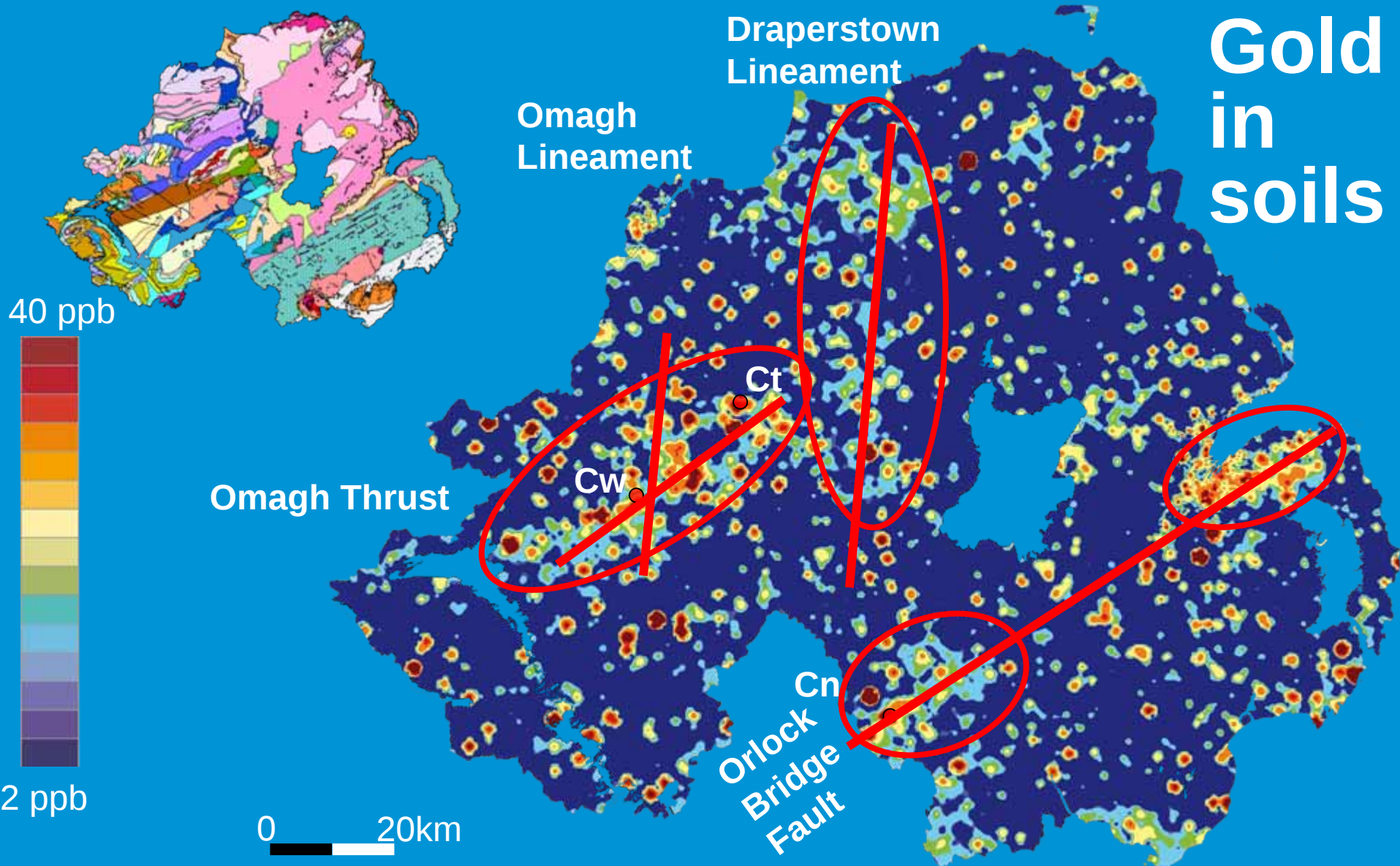
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Gold in soils



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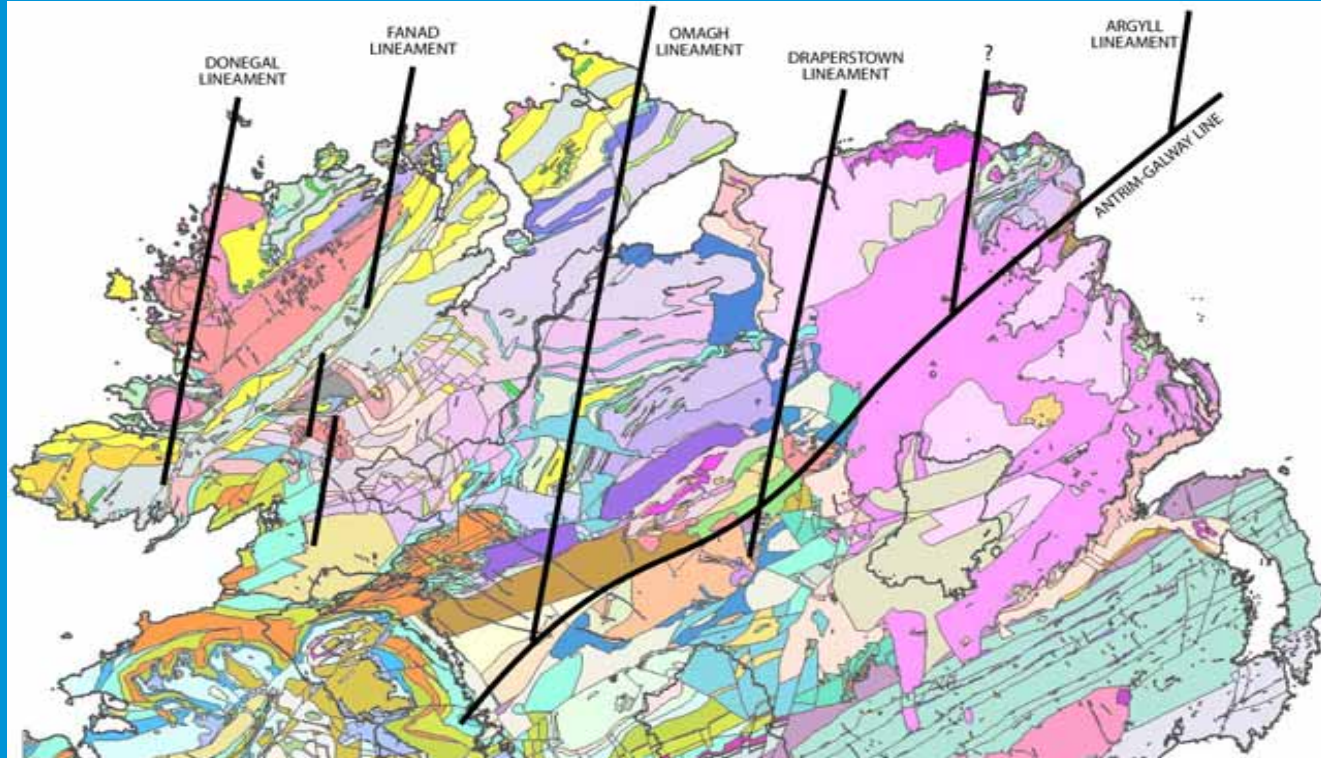


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The Omagh Lineament and the Draperstown lineament focus Ordovician-Silurian and Carboniferous fluids

The last movement on the Omagh lineament was c. synchronous with the emplacement of the Irish Zn-Pb deposits

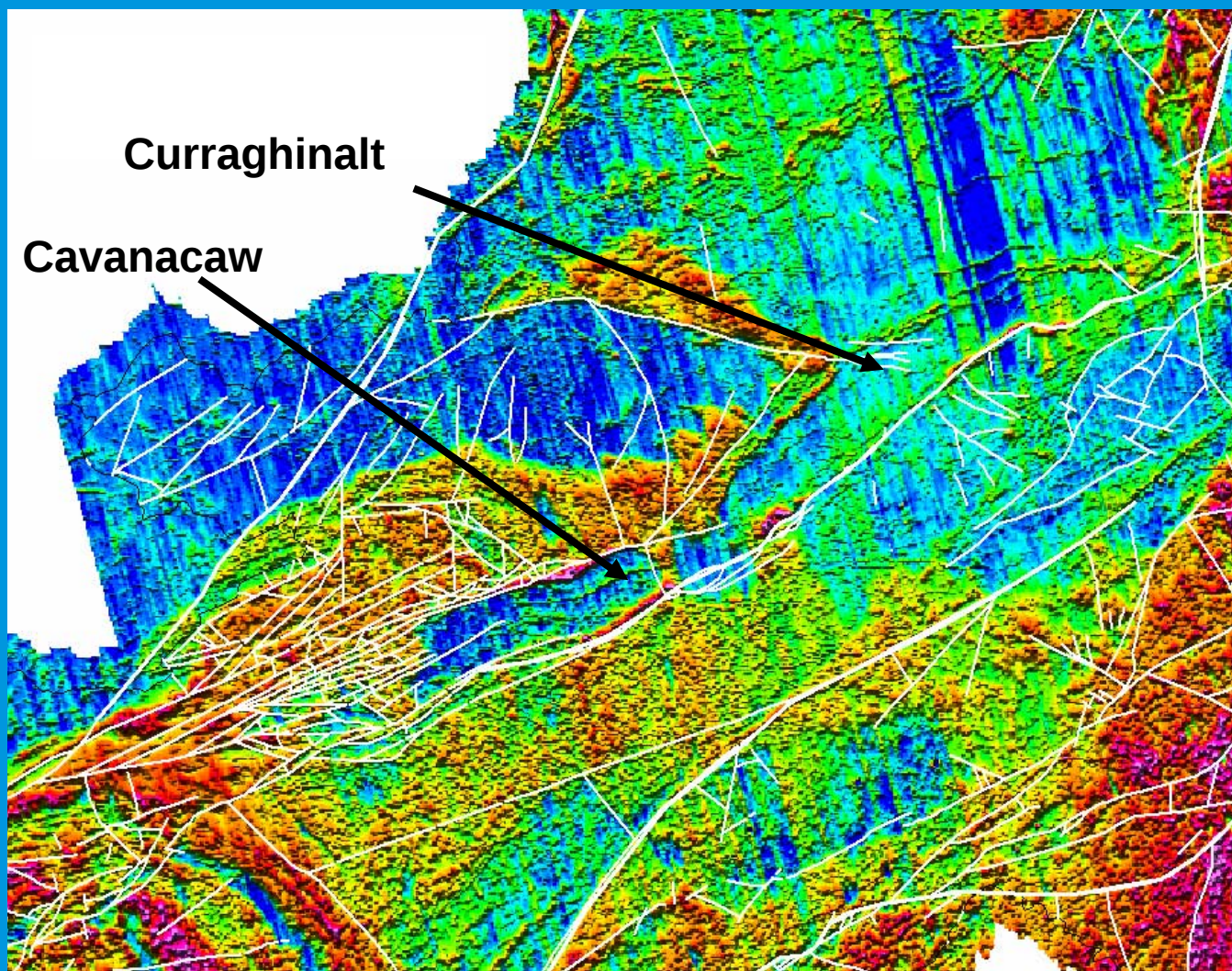
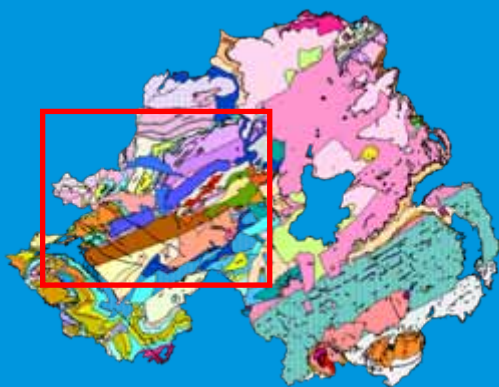
Receptor – Host Rock



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Tyrone and Fermanagh EM



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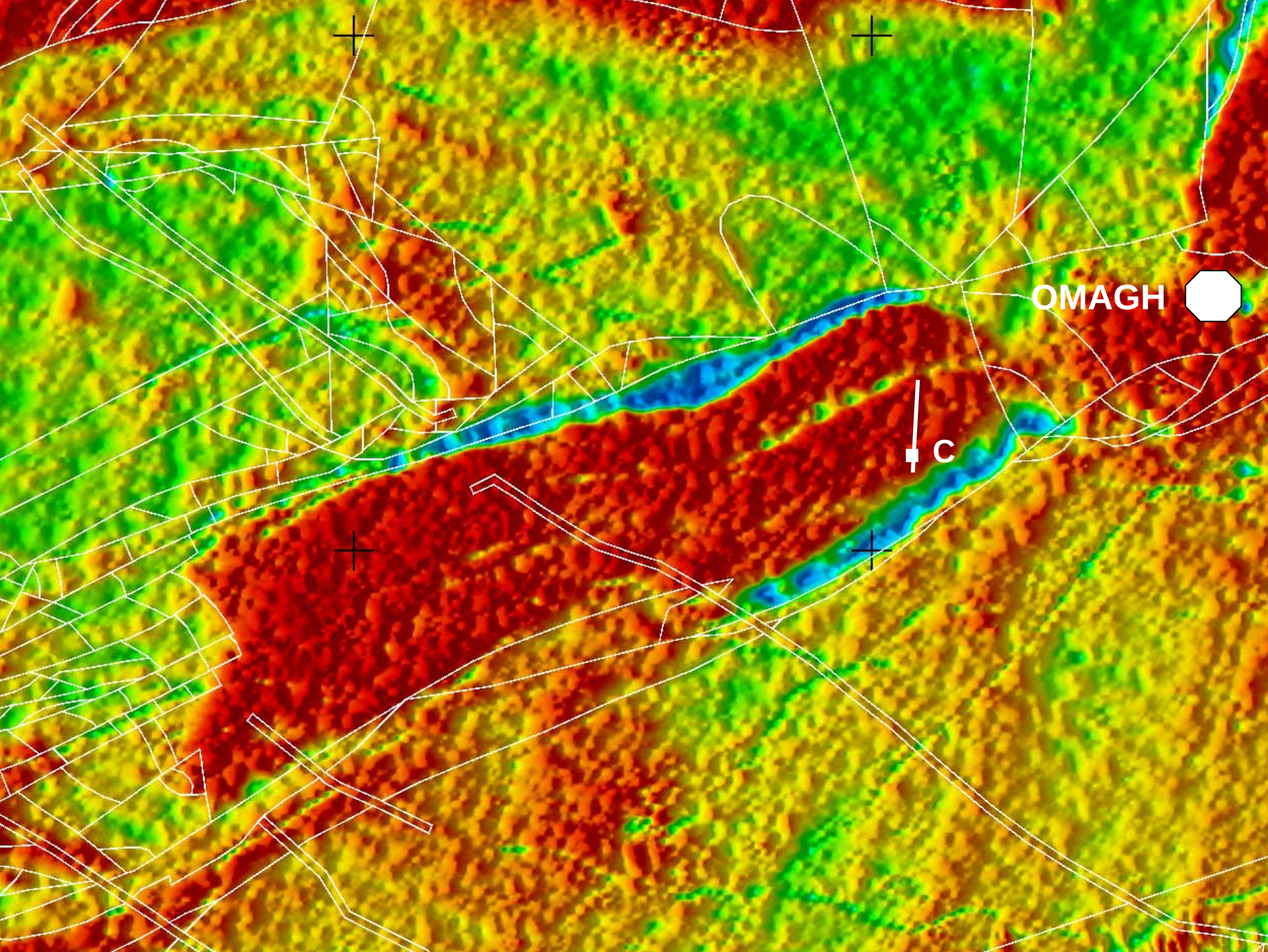


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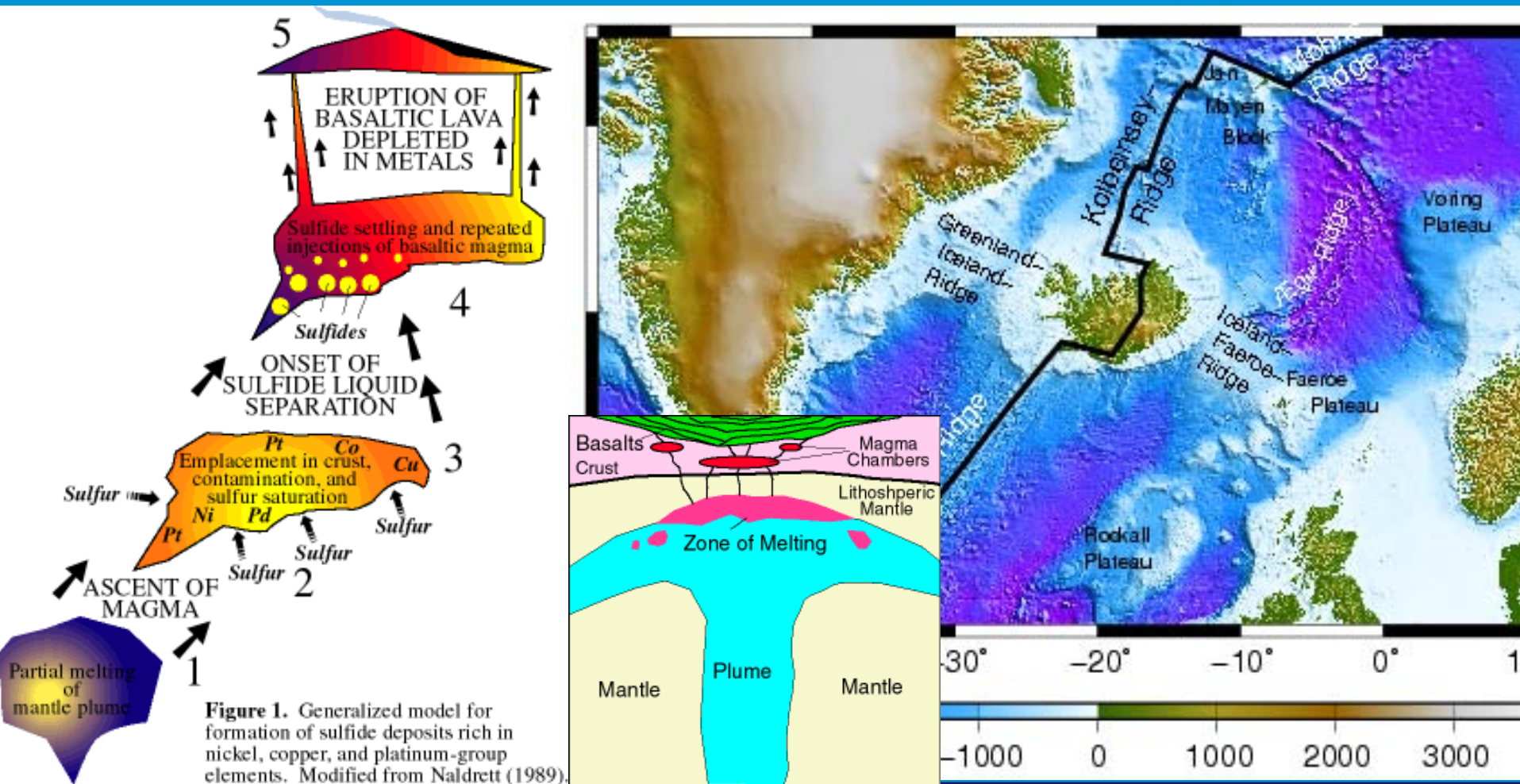
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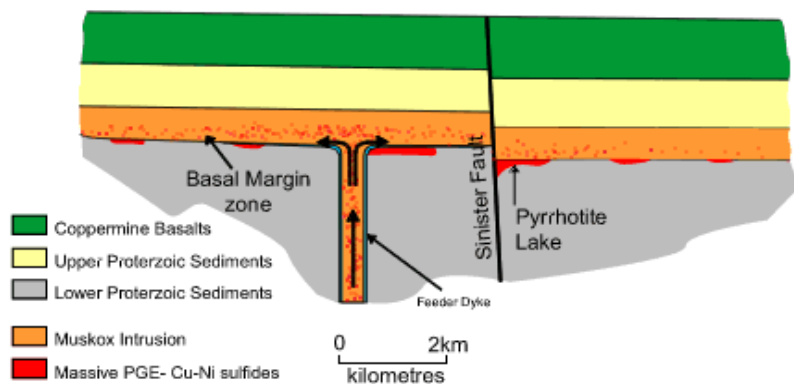
OMAGH

C

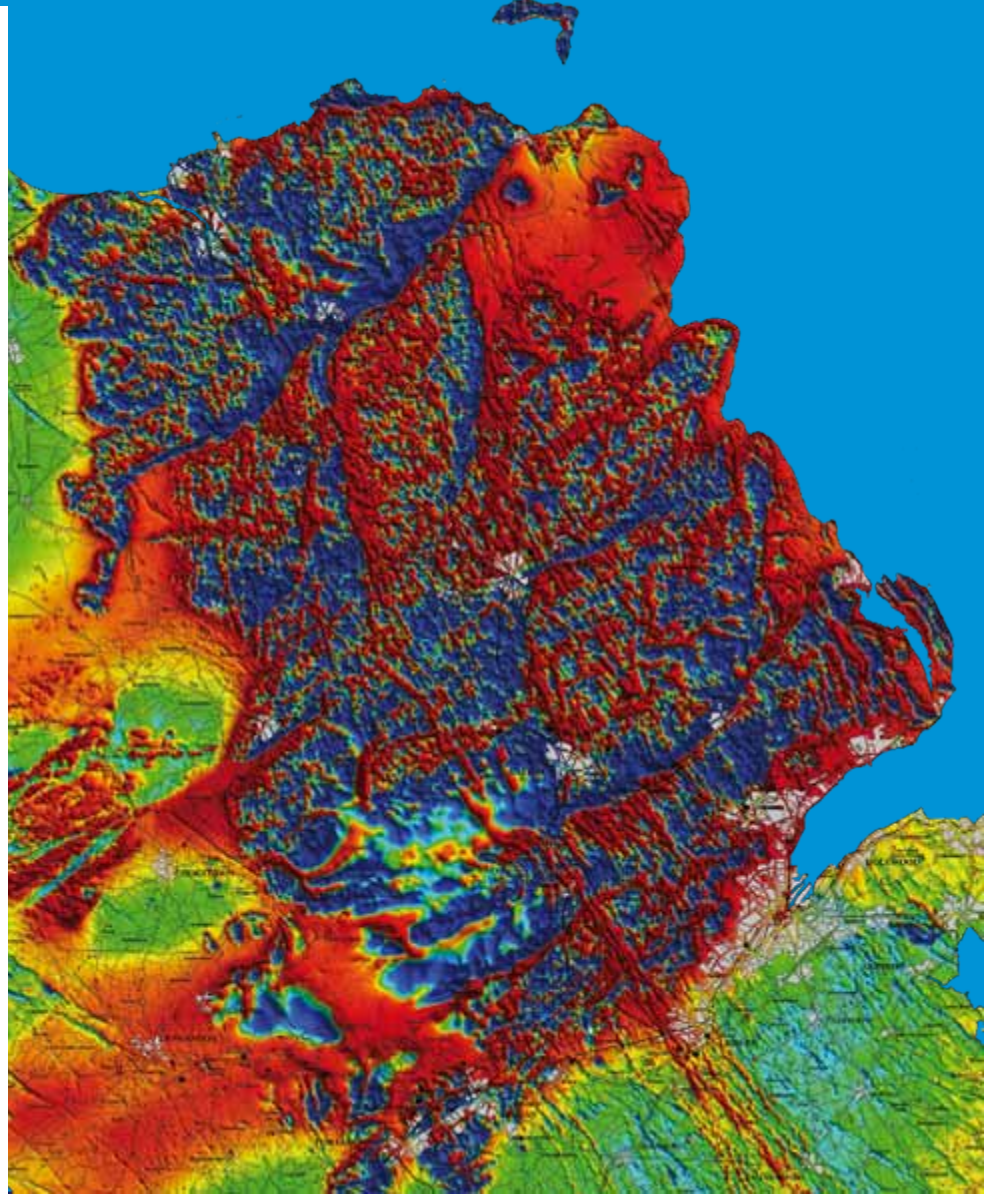
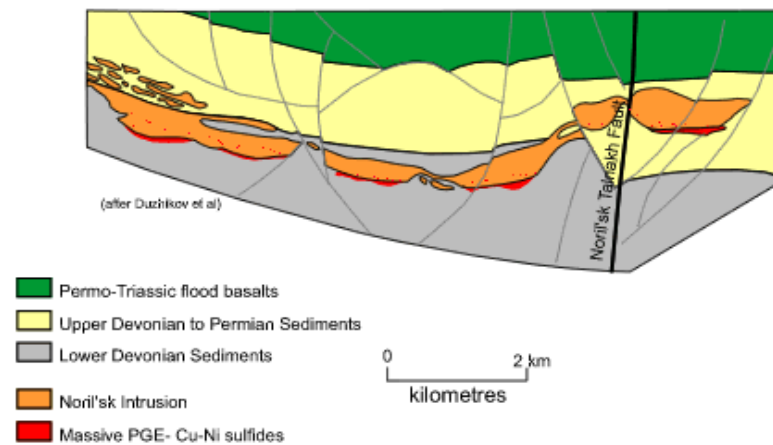
Applications of the Tellus data to other minerals - Nickel



Proto-Muskox Intrusion



Noril'sk



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Nickel in soils

Antrim
Basalts

Shanmullagh
Formation

Lough
Erne
Dyke

Gala Gp 3-7

Co Down
Dyke
Swarm

0 20km

360 ppm

0.4 ppm

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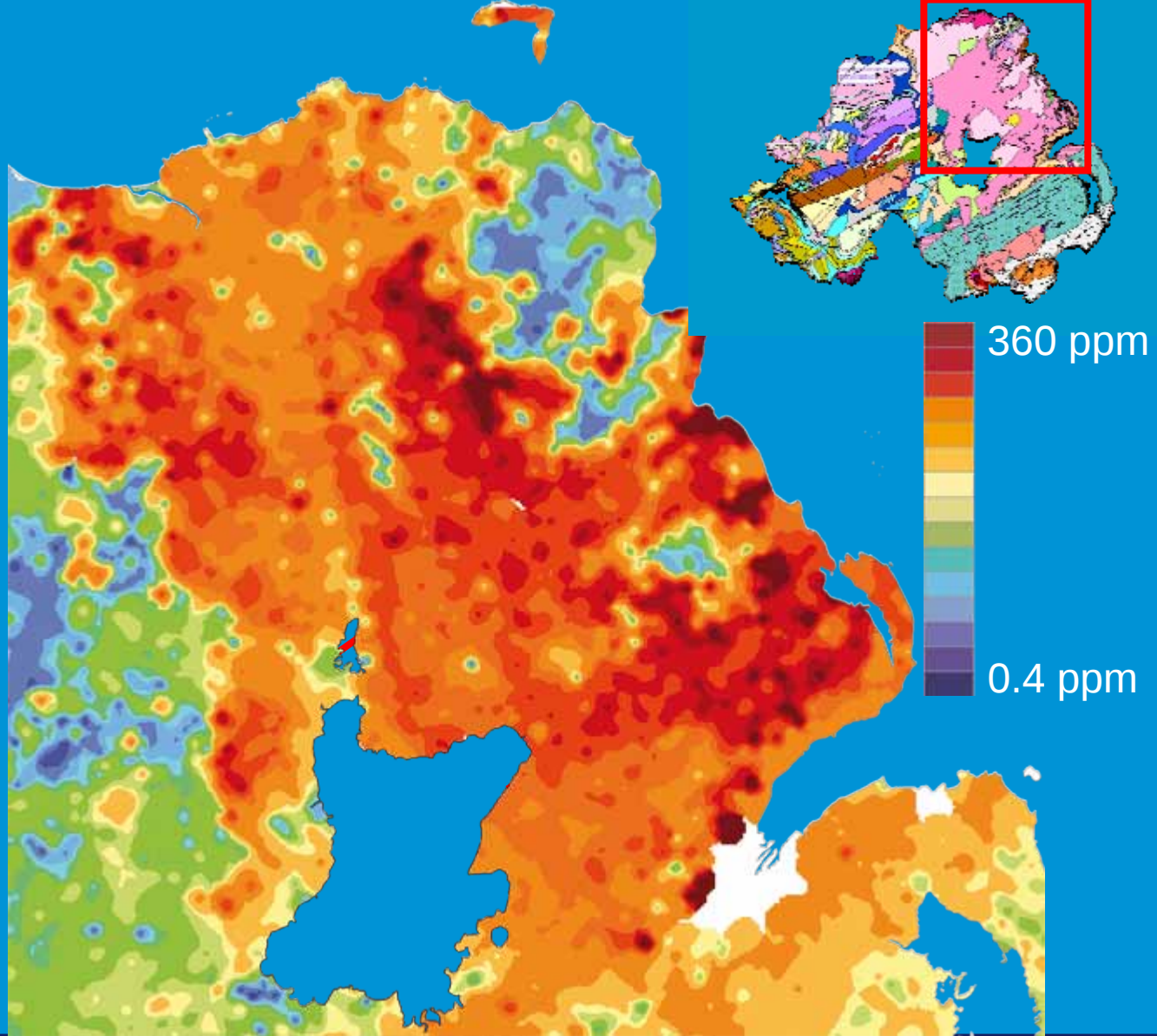
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NE Antrim

Nickel in soils and magnetics

0 20km



TELLUS



Building
Sustainable
Prosperity

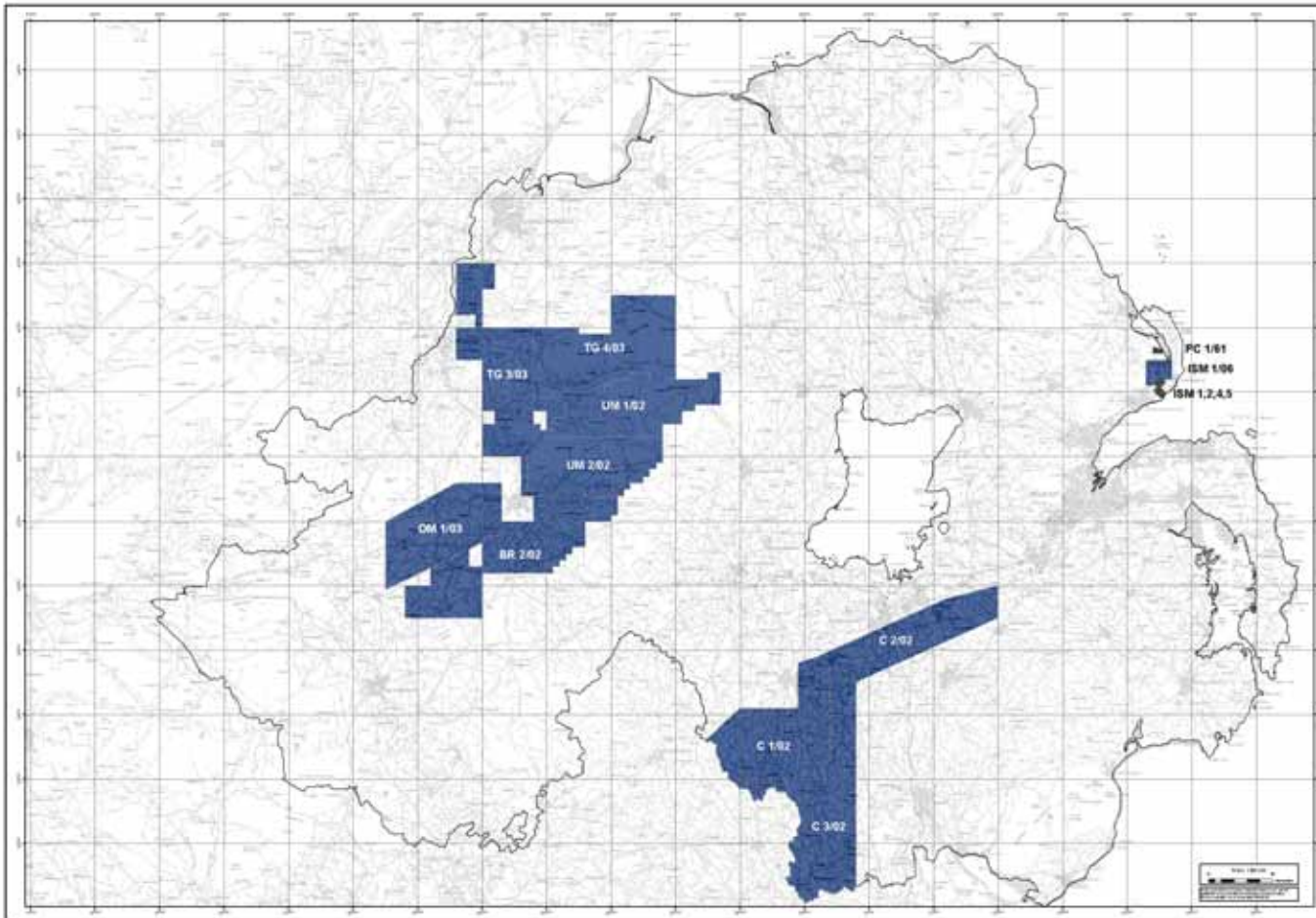


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Licence Map Pre Tellus

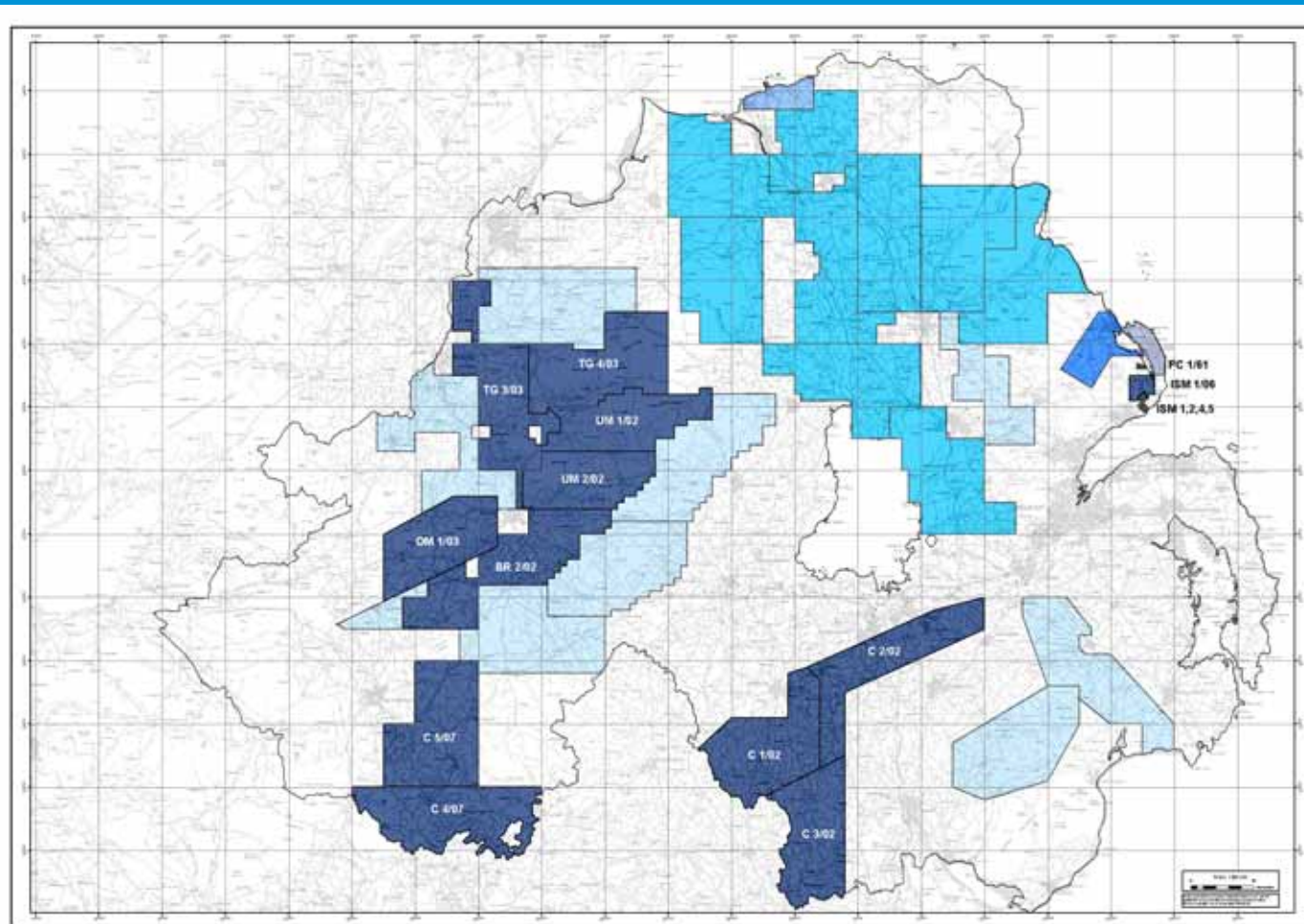
Committed
Mineral
Exploration
expenditure
<£0.5 million



Licence Map Post Tellus

Committed
mineral
exploration
expenditure
£17 million

Over 50% under
licence or
application



Mineral Exploration and Mining – Good or Bad?

- Exploration is essentially non invasive
- Less than 0.1 % of planet Earth is affected by mining
- Extractive industries are a transient land use
- Former mining sites are now World Heritage Sites
- Need to stop thinking in human life cycles
- The Landscape is dynamic – we don't like change
- We need minerals to live



Groups of Indicators

1. Economic Sustainability

- Sustainable economic performance
- Economic impacts of the industry
- Employment impacts of the industry

2. Environmental Sustainability

- Natural resource protection
- Environmental strategy
- Manage local environmental impacts

3. Social Sustainability

- Internal stakeholder relations
- External stakeholder relations



Corporate Citizenship: A New Paradigm

OLD

Polluter pays
Tangential
Regulation and compliance
Crisis–management
'Do no harm'
Public Relations
Description
Regulatory Drivers

NEW

Pollution prevention
Strategic
Rights and responsibilities
Precautionary approaches
'Guarantee positive good'
Social Reporting
Indicators
Financial Drivers

Source: Alyson Warhurst, Warwick University

Conclusions 1

- Unless we deny the development of the human species, the need for newly mined mineral resources will continue.
- Exploitation of such resources should be planned and conducted in such a way that:
 - Net benefits accrue fairly to all stakeholders;
 - The environment is not impacted beyond its capacity to absorb change;
 - Post-closure legacies are negligible or even positive.

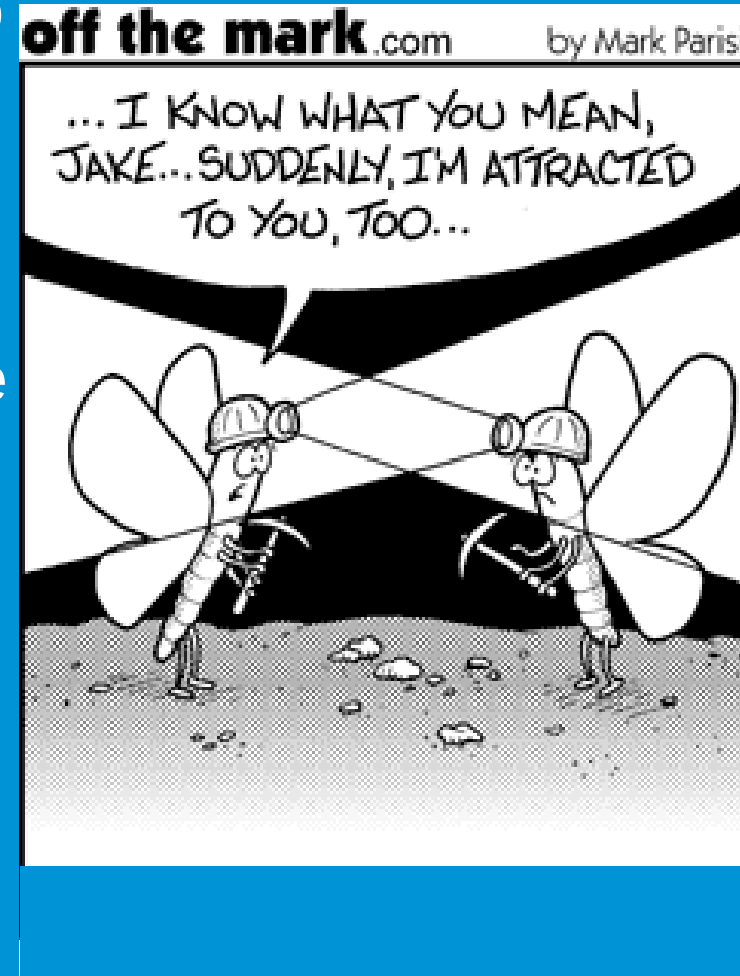


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Conclusions 2

- Geoscientists have a leadership role to play in ensuring sustainable development of natural (and especially mineral) resources
- The breadth of science experience allows geoscientists an almost unique perspective on all aspects of the extractive industry cycle - from exploration through development, to closure and reclamation
- Tellus was designed to help, support and manage development of natural resources in an environmentally responsible manner



Pinatubo - two days in 1991



10 billion tons of magma
20 million tons SO_2
800,000 tons Zn
600,000 tons Cu
550,000 tons Cr
300,000 tons Ni
10,000 tons As
1,000 tons Cd
800 tons Hg



60 volcanoes erupt per day
>3,000 vent fields at mid ocean ridges