Geodiversity:
a key basis for geoconservation, geoparks and geotourism

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Aims

- To argue that we can look at the diversity of abiotic nature (geodiversity) in a similar way that we look at the diversity of living nature (biodiversity);
- To outline the values of, and threats to, geodiversity and demonstrate the need for geoconservation;
- To show that geodiversity is a key basis for geoconservation, geoparks, geotourism, etc.

Structure

1. What is Geodiversity?
2. Values & Threats = Conservation Need;
3. Geodiversity & Geoconservation;
4. Geodiversity & Geoparks;
5. Geodiversity, Geotourism & Public Recreation

1. What is Geodiversity

Queen Mary, University of London

Planet Earth represented as a smooth, steel sphere

= no geodiversity


Parc de la Vilette, Paris

Capelinhos, Faial, Azores

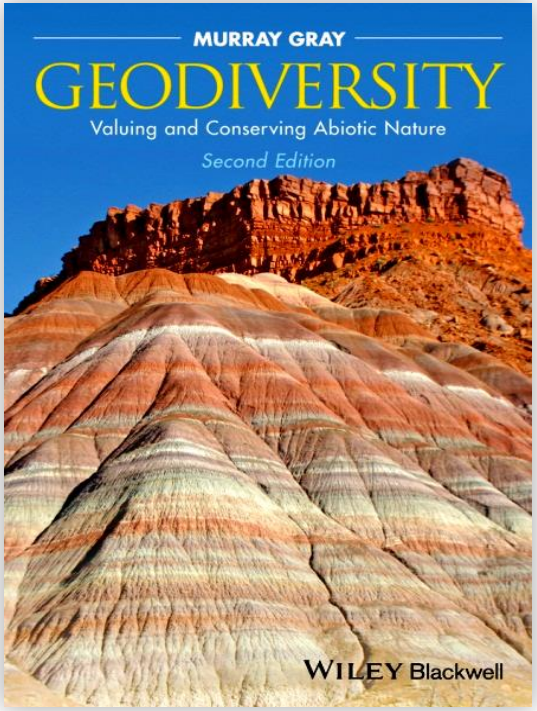
Fortunately, the world is not a perfect sphere composed of a single rock type. It is highly diverse in terms of its:

- geological materials,
- topographic variation, and
- physical processes

Geodiversity…

- Biodiversity (biological diversity) is the variety of living nature;
- Geodiversity (geological & geomorphological diversity) is the variety of non-living nature;
- “Geodiversity: the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landforms topography, physical processes), soil and hydrological features”.

(Gray, 2013)



Geodiversity

- c.5000 named minerals;
- hundreds of named rock types;
- millions of fossil species;
- 19,000 named soil types in USA; 800 in UK;
- huge diversity of processes - fluvial, coastal, glacial, slope, aeolian, hydrological, volcanic, etc.
- huge variation in topography and physical landscape character

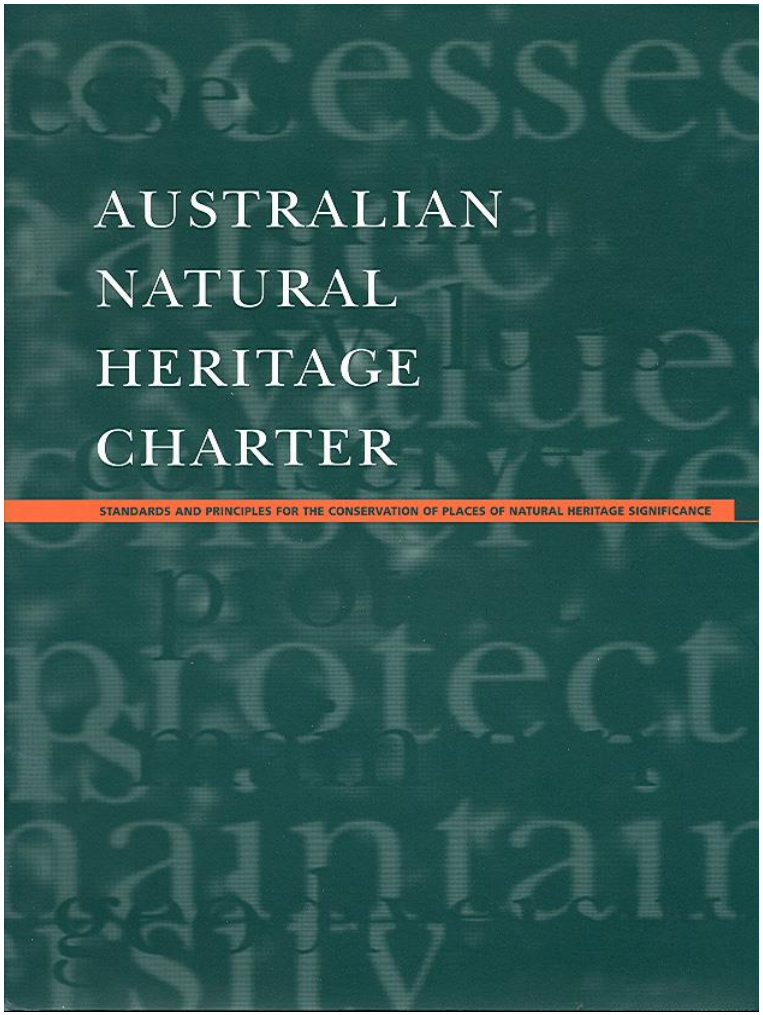
History of Geodiversity

- Dr Kevin Kiernan (Tasmanian Forestry Commission now Univ of Tasmania) in the 1980s was using the terms “landform diversity”, “geomorphic diversity”, and drawing parallels with biological concepts in using the terms “landform species” and “landform communities”;
- E.g. “The diversity among landforms is just as valid a target as the diversity of life when developing nature conservation programs…” (Kiernan, 1991)

History of Geodiversity

- Convention on Biodiversity (1992) made it almost unavoidable that geoscientists would start using the word "geodiversity".
- First use appears to be by F.W. Wiedenbein (April 1993) and Chris Sharples (October 1993), also then working for the Tasmanian Forestry Commission: "Geoconservation aims at conserving the diversity of earth features and systems ('Geodiversity')….."

Australian Natural Heritage Charter



- The ANHC, first published in 1996, gives equal status to biodiversity and geodiversity

- Article 5:

  "Conservation is based on respect for biodiversity and geodiversity. It should involve least possible physical intervention to ecological processes, evolutionary processes and earth processes"

International Growth of Geodiversity


Nieto, L. M. Geodiversidad: propuesta de una definición integradora. *Boletín Geológico y Minero*, Vol. 112, Núm. 2, pp. 3-12, 2001
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Geodiversidad:
propuesta de una definición integradora

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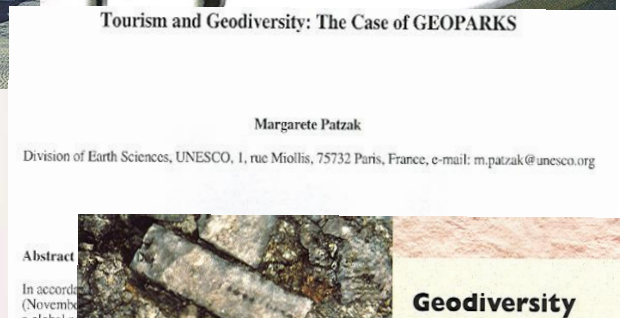
Quarries In Devon
GEODIVERSITY
AUDIT OF ACTIVE AGGREGATE QUARRIES

Geodiversity Update
Issue 3 Summer 2001
The Scottish dimension
Welcome to the 21st century!

GEODIVERSITET I NORDISK NATURVÅRD

THE GEORGE WRIGHT FORUM
Geodiversity &
Geoconservation


Tourism and Geodiversity: The Case of GEOPARKS

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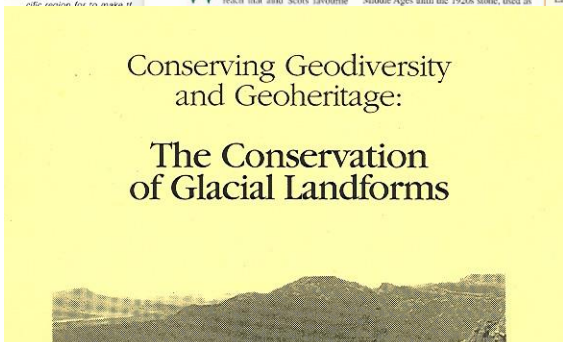
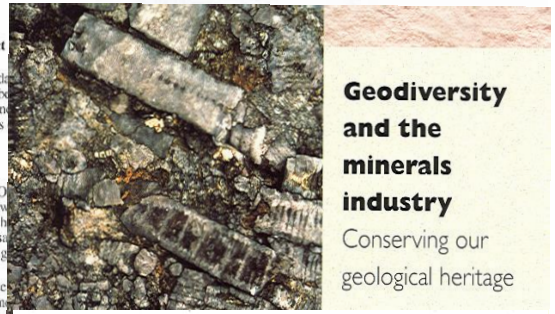

Conserving Geodiversity and Geoheritage:
The Conservation of Glacial Landforms


Geodiversity and the minerals industry
Conserving our geological heritage


Publicações da Associação Portuguesa de Geomorfólogos, Vol. 3, APGeom, 2006, pp. 161-165

Geodiversidade e geoturismo na bacia do Tejo português – uma abordagem preliminar

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Resumo: Na parte portuguesa da Bacia do Tejo associa-se, a paisagens de grande beleza e magnificência, uma enorme diversidade de locais de interesse científico e didáctico, nomeadamente, estações arqueológicas de grande importância, quer a nível europeu, quer mesmo a nível mundial, vestígios de ocupação de povos que nela se implantaram desde a pré-história, monumentos barrocos e góticos de indiscutível interesse patrimonial, para além de outros aspectos históricos já mais recentes, muitos deles relacionados com as cheias do rio e que levaram, por exemplo, ao estabelecimento de uma arquitectura especial nas aldeias ribeirinhas. Essa associação tão diversificada de Património Natural com Património Cultural, fazem da Bacia do Tejo e, em particular, da sua planície aluvial, uma área de grande valor em termos de Geodiversidade, que a tornam candidata a uma futura planificação com vista ao estabelecimento de projectos de Geoturismo a breve prazo e, mais tarde, de um Parque Nacional.

Palavras-chave: Geodiversidade; Património; Geoturismo; Bacia do Tejo.

Abstract: The Portuguese Tagus Basin is associated to landscapes of great beauty and magnificence, a huge diversity of places with scientific and educational appeal namely, archaeological sites of great importance, both at European and worldwide ranks, relics of the local settlers' living habits since pre-historic times, baroque and gothic monuments of undoubtable heritage interest, as well as other more recent historic aspects, many of

「ジオダイバーシティ：日本における
その保全と研究の必要性」の特集号によせて

Preface: Geodiversity: Necessity of Its Conservation and Research in Japan

渡辺　悌二
Teiji WATANABE
(北海道大学　大学院地球環境科学研究院)


scottish wildlife trust
policy
Policy
March 2002

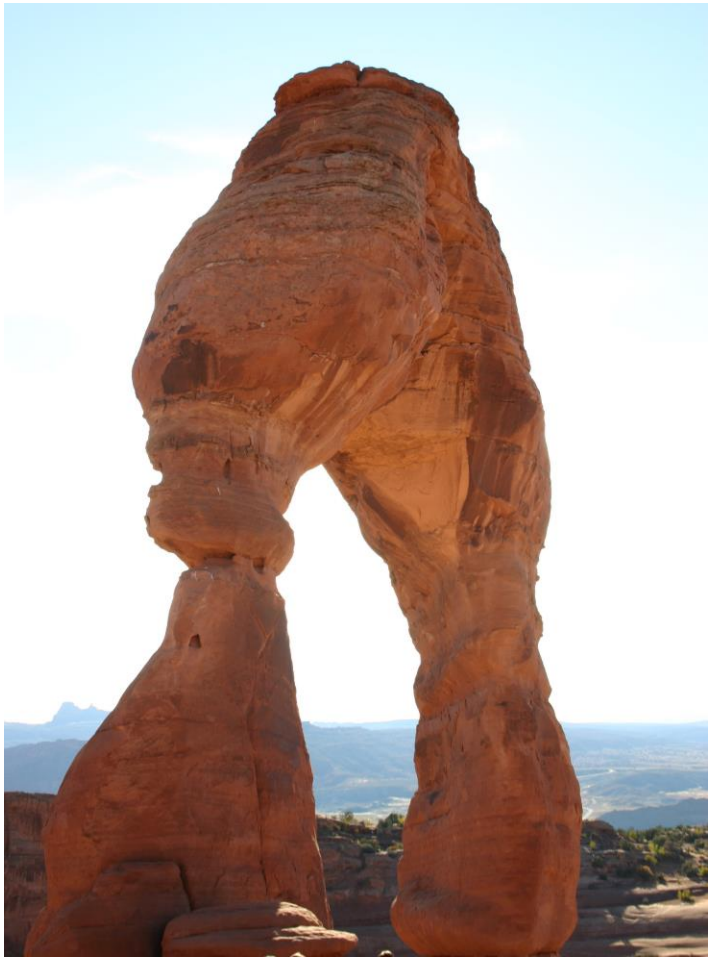
Geodiversity

Policy Summary

The Scottish Wildlife Trust (SWT) will promote the conservation of Geodiversity through its work on its reserves and its support for the Regionally Important Geological and Geomorphological Sites system (RIGS).

Main causes of Geodiversity?

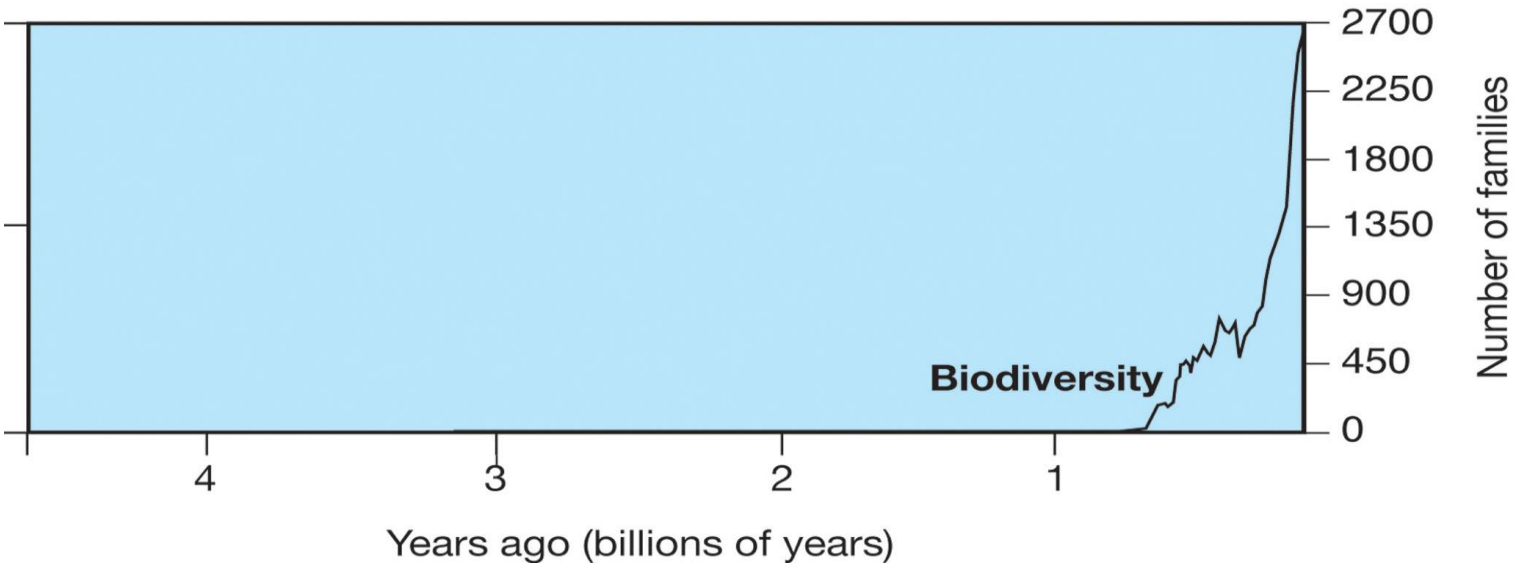
- Plate tectonics;
- Climatic variation
  (spatial and temporal)
  and related surface
  processes;
- Evolution of life.



Delicate Arch,
Arches National Park, Utah, USA

Evolution of Biodiversity

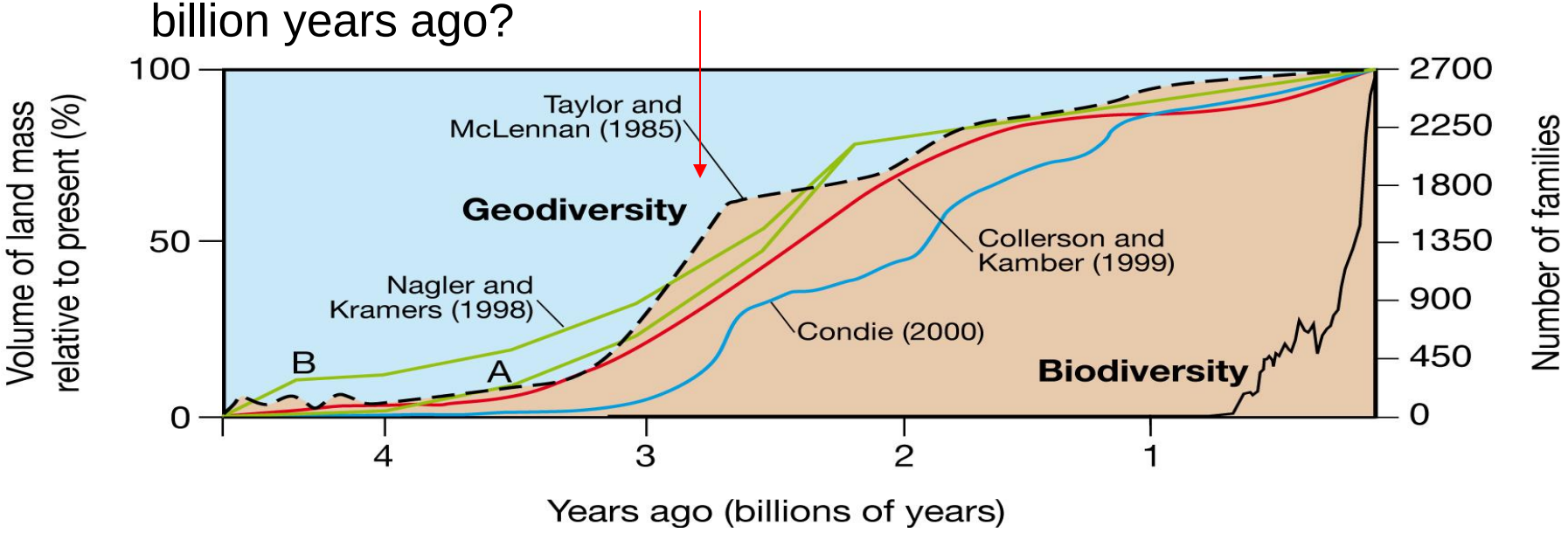
- Biodiversity was limited through most of geological time, then rapidly expanded in the Palaeozoic, but with several significant extinction events.



- How has geodiversity changed through time?

Evolution of Geodiversity?

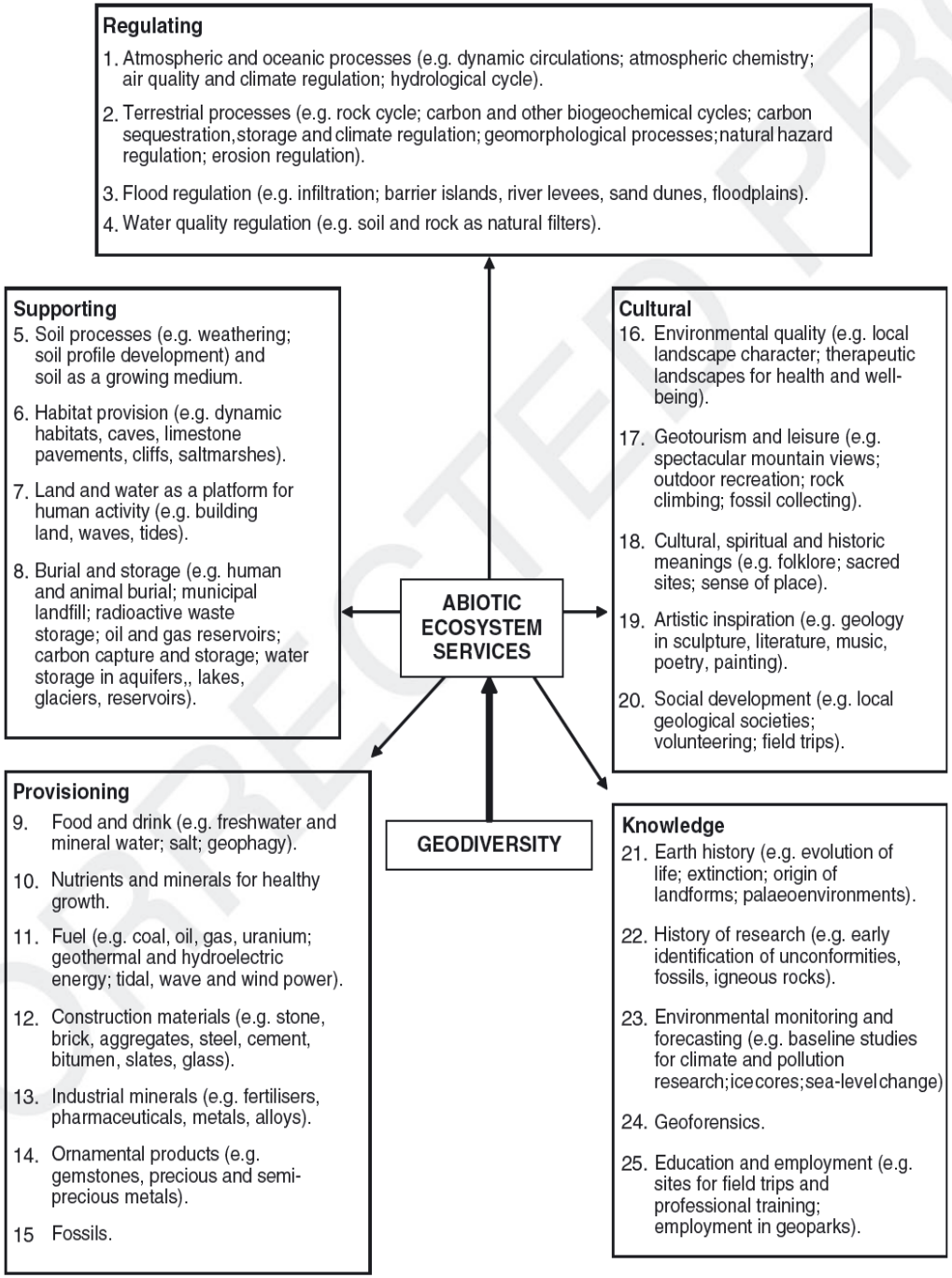
- Suggested S-curve with most rapid development coinciding with expansion of the continental crust and related development of terrestrial processes, land forms and materials, starting c.3 billion years ago?



- No significant reverses in the continuous increase in geodiversity?

2. Values & Threats

- Geodiversity creates huge benefits for society;
- In fact, we couldn’t live without it;
- At least 25 values (goods and services) of geodiversity can be recognised using a modified version of the Millennium Ecosystem Assessment (MEA, 2005) classification scheme.


Regulating
1. Atmospheric and oceanic processes (e.g. dynamic circulations; atmospheric chemistry; air quality and climate regulation; hydrological cycle).
2. Terrestrial processes (e.g. rock cycle; carbon and other biogeochemical cycles; carbon sequestration, storage and climate regulation; geomorphological processes; natural hazard regulation; erosion regulation).
3. Flood regulation (e.g. infiltration; barrier islands, river levees, sand dunes, floodplains).
4. Water quality regulation (e.g. soil and rock as natural filters).
Supporting
5. Soil processes (e.g. weathering; soil profile development) and soil as a growing medium.
6. Habitat provision (e.g. dynamic habitats, caves, limestone pavements, cliffs, saltmarshes).
7. Land and water as a platform for human activity (e.g. building land, waves, tides).
8. Burial and storage (e.g. human and animal burial; municipal landfill; radioactive waste storage; oil and gas reservoirs; carbon capture and storage; water storage in aquifers,, lakes, glaciers, reservoirs).
Cultural
16. Environmental quality (e.g. local landscape character; therapeutic landscapes for health and well-being).
17. Geotourism and leisure (e.g. spectacular mountain views; outdoor recreation; rock climbing; fossil collecting).
18. Cultural, spiritual and historic meanings (e.g. folklore; sacred sites; sense of place).
19. Artistic inspiration (e.g. geology in sculpture, literature, music, poetry, painting).
20. Social development (e.g. local geological societies; volunteering; field trips).
ABIOTIC ECOSYSTEM SERVICES
GEODIVERSITY
Provisioning
9. Food and drink (e.g. freshwater and mineral water; salt; geophagy).
10. Nutrients and minerals for healthy growth.
11. Fuel (e.g. coal, oil, gas, uranium; geothermal and hydroelectric energy; tidal, wave and wind power).
12. Construction materials (e.g. stone, brick, aggregates, steel, cement, bitumen, slates, glass).
13. Industrial minerals (e.g. fertilisers, pharmaceuticals, metals, alloys).
14. Ornamental products (e.g. gemstones, precious and semi-precious metals).
15 Fossils.
Knowledge
21. Earth history (e.g. evolution of life; extinction; origin of landforms; palaeoenvironments).
22. History of research (e.g. early identification of unconformities, fossils, igneous rocks).
23. Environmental monitoring and forecasting (e.g. baseline studies for climate and pollution research; ice cores; sea-level change)
24. Geoforensics.
25. Education and employment (e.g. sites for field trips and professional training; employment in geoparks).

Regulating Services

- Atmospheric & oceanic processes - dynamic circulations; atmospheric chemistry; hydrological cycle;
- Terrestrial processes - rock cycle; carbon cycle; geomorphological processes;
- Flood control - infiltration; barrier islands; levées; sand dunes;
- Water quantity & quality - storage in aquifers; lakes; reservoirs, glaciers; soil & rock as natural filters.

Supporting Services

- Soil processes - weathering; soil profile development; soil as a growing medium;
- Habitat provision - caves, cliffs, ponds, limestone pavements, saltmarshes, etc;
  NB The gannet *Sula bassana* is named from the Bass Rock
- Land as a platform - building land; airports; sporting activities;
- Burial & storage - human/animal burial; municipal landfill; radioactive waste storage; oil & gas reservoirs; carbon capture & storage (CCS)

Provisioning Services

- Food & drink - mineral water; whisky & beer; salt; geophagy;
- Nutrients & minerals for healthy growth;
- Fuels - coal; oil; gas; uranium; geothermal; hydroelectric; wave & wind;
- Construction materials - stone; steel; sand & gravel; cement; concrete; bitumen; glass;
- Industrial minerals - fertilizers; metals; alloys; pharmaceuticals;
- Ornamental products - gemstones; precious and semi-precious metals;
- Fossils.

Cultural Services

- Environmental quality - local landscape character; therapeutic landscapes;
- Geotourism & leisure - mountain & coastal views; potholing; rock climbing; fossil collecting;
- Cultural, spiritual & historic meanings - folklore; sacred sites; sense of place;
- Artistic inspiration - geology in sculpture, literature, music; poetry; painting;
- Social development - local geological societies; group field trips.

Knowledge Services

- Earth history - evolution of life; origin of landforms; palaeoenvironments;
- Understanding physical processes;
- Geoforensics;
- History of research - unconformities; igneous rocks;

- Environmental monitoring - glacier retreat; sea-level change; acidification;
- Education & employment - field sites; professional training; geoparks.

Generic Threats to Geodiversity

- Complete loss of site/geological extinction;
- Partial loss/physical damage/resource depletion;
- Fragmentation of interest;
- Loss of visibility or intervisibility;
- Loss of access;
- Interruption of natural processes;
- Off-site impacts;
- Pollution;
- Visual impacts

Specific threats

- Mineral extraction - loss of natural landforms
- Landfill - loss of visibility
- Land development - loss of materials, landforms, visibility, fragmentation of interest;
- River/coastal/natural hazard management - interruption of processes, loss of landforms & visibility
- Forestry - loss of visibility
- Agriculture - partial loss/physical damage, pollution
- Recreation - partial loss/physical damage
- Over-collecting - loss of minerals and fossils
- Ignorance - the biggest threat of all?

Pico, Azores, Portugal

3. Geodiversity & Geoconservation

The Conservation Equation:

Value + Threat = Conservation Need

Situation with World Heritage Sites

- Up until recently World Heritage Sites have been proposed by countries and accepted by UNESCO if they met the criterion of “outstanding universal value”,

  i.e. UNESCO adopted a reactive role;
- In the last decade, IUCN/UNESCO have become more proactive and analytical;
- For example, a study by Dingwall *et al.* (2005) looked to see if the geological column is represented in the World Heritage list….and discovered a significant gap at the Silurian.

Geological System	Biological Event	World Heritage Site
Quaternary	Humans appear Ice Age	Naracoote (Australia) 170k years
Pliocene		
Miocene		Riversleigh (Australia) 15/25m years
Oligocene		
Eocene		Messel Pit (Germany) 47myears
Palaeocene	First primates	
Cretaceous	Extinction of dinosaurs Origin of flowering plants	Dinosaur Provincial Park (Canada) 75m years
Jurassic	Age of dinosaurs First birds	Jurassic Coast (UK)
Triassic	First mammals/dinosaurs	Jurassic Coast (UK) Monte San Georgio (Switzerland)
Permian		Grand Canyon (USA)
Carboniferous	First reptiles	Mammoth Cave (USA)
Devonian	First amphibians/forests	Miguasha (Canada) 300m years
Silurian	First land plants	
Ordovician	First fish/coral	Gros Morne (Canada) 500m years
Cambrian	First trilobites	Burgess Shale (Canada) 520m years
Precambrian	First algae/bacteria	

Source: Dingwall et al., 2005

Devonian WHS:
Miguasha, Quebec, Canada

Temporal Geodiversity

- IUCN/UNESCO are therefore looking to make the World Heritage List representative of the geological column, i.e. looking to ensure that temporal geodiversity is represented;
- But there is an easy and cheap way in which they could do this at a stroke.

GSSPs 1

- This is by adopting the emerging network of Global Stratotype Sections and Points (GSSPs);
- Since 1977 the International Commission on Stratigraphy (ICS), a Commission of the International Union of Geological Sciences (IUGS), has been working to establish a network of just over 100 GSSPs;
- About 64% have been ratified so far;
- The network establishes all the sites where the boundaries between series, systems and stages in the geological column are defined;

Ratified GSSPs (March 2014)

China	10	Malta	1
UK	9	Egypt	1
		Greenland	1
Italy	9	Tunisia	1
USA	7	Portugal	1
France	6	Austria	1
Spain	4	Kazakhstan	1
Czech Rep.	3	Germany	1
Morocco	2	Uzbekistan	1
Sweden	2	Australia	1
Canada	2		

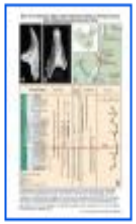
Total = 64

GSSPs 2

- The network is the fundamental basis for the geological timescale and history of the Earth;
- Given this importance and the decades of effort by the geological community to reach agreement on the best sites, it follows that they ought to be conserved from loss or damage;
- The intention of establishing the network is to select key sites that will exist into the future as key reference points.

GSSPs 3

- Some sites do have legislative protection including 9 sites in the UK designated as Sites of Special Scientific Interest;
- In Newfoundland, Canada, the Cambrian/ Ordovician boundary at Green Point lies within Gros Morne National Park and is therefore protected by Parks Canada legislation and management plans.

Dapingian Stage	470 ± 1.4	Huanghuachang Section, NE of Yichang city, Hubei Province, S. China	30.8605°N 110.3740°E	10.57 m above base of the Dawan Formation	Conodont FAD of *Baltoniodus triangularis*		Ratified 2007	Episodes 28/2, p. 105 - 117, 2005; Episodes 32/2, p. 96-113, 2009
Lower Ordovician Series								
Floian Stage	477.7 ± 1.4	Diabasbrottet, Hunneberg, Sweden	58.3589°N 12.5024°E	in the lower Tøyen Shale, 2.1m above the top of the Cambrian	Graptolite FAD *Tetragraptus approximatus*		Ratified 2002	Episodes 27/4, p. 265-272, 2004
Tremadocian Stage	485.4 ± 1.9	Green Point Section, western Newfoundland	49.6829°N 57.9653°W	at the 101.8m level, within Bed 23, in the measured section	Conodont FAD *lapetognathus fluctivagus*		Ratified 2000	Episodes 24/1, p. 19 - 28, 2001
Cambrian System								
Furongian Series								
Stage 10	489.5	candidate section is Duibian (Zhejiang province, China)			*Trilobite FAD of* Lotagnostus americanus. *An internal substage division might be FAD of* Codylodus adesei *conodont*			
				108.12m above the				

The Global Cambrian-Ordovician Boundary, Green Point, Newfoundland, Canada

GSSPs 4

- Yet for most of the sites there is no legislative protection in the countries involved;
- In my view, this important network of sites deserves international recognition by UNESCO and legislative protection in all the countries concerned.

A thematic approach?

- According to Dingwall et al. (2005), UNESCO is also looking at establishing a list of 13 geothemes to help in assessing future applications and identifying possible gaps:

- Tectonic & structural features	3
- Volcanoes/volcanic features	13
- Mountain systems	11
- Stratigraphic sites	2
- Fossil sites	11
- Fluvial & lacustrine systems & landscapes	10
- Caves & karst	7
- Coastal development	8
- Reefs, atolls & oceanic island	1
- Glaciers & ice caps	6
- Ice Ages	7
- Arid & Semi-arid landforms & landscapes	4
- Meteorite impact	1

- Therefore IUCN/UNESCO are trying to ensure that temporal and thematic aspects of geological diversity are represented on the World Heritage List.

WH Caves & Karst

- A thematic study of WH Cave & Karst sites was published by the IUCN (Williams, 2008);
- It concluded poor representation of such sites in S America, Africa, Australasia, Asia and Middle East;
- And in arid, semi-arid and periglacial areas, and on evaporite rocks;
- It recommended that countries with poor representation of such sites be encouraged to apply for WH status;
- i.e. the WH List should be more spatially representative of cave and karst geodiversity.

WH Volcanoes 1

- Wood (2009) reviewed all volcanic World Heritage Sites inscribed up to the end of 2008 as well as those on all Tentative Lists.
- He found that 57 inscribed properties contained some volcanic geology, with 27 of these containing at least one active volcano,
- while 40 volcanic properties were included in the Tentative Lists, 25 with one or more active volcanoes.
- Wood concluded that while the World Heritage List appears to possess good overall representation of volcanic features, deeper analysis revealed “some gaps that might be filled by future nominations”. These included:

WH Volcanoes 2

- some important features of basaltic volcanism, such as fissure volcanoes, sub-glacial volcanoes;
- volcanic edifices and continental flood basalts;
- some features of more silicic volcanism, including calderas and large ash or pumice flows (ignimbrites);
- some of the world's most iconic volcanoes, e.g. Mt Etna, Italy; Thera (Santorini), Greece; Mt Fuji, Japan (included on the List in 2013); Paracutin, Mexico; Mt St Helens and Crater Lake, USA; Laki, Iceland; Mt Pelée, Matinique, and Tambora, Indonesia.

- Thus again, here, we see an attempt to ensure that the global geodiversity of volcanic features is included on the World Heritage List.

Geodiversity & National Geoconservation Systems

- Although the word “geodiversity” was first used only in 1990s, the principles behind it’s application to nature conservation have a longer history;
- For example, the Report of the UK Wild Life Conservation Special Committee (Huxley, 1947) contains the following quote:

UK Wild Life Conservation Special Committee

- “Great Britain presents in a small area an extremely wide range of geological phenomena…..the supply of a steady flow of trained geologists for industrial work at home and overseas, require that there shall be available in this country a sufficient number of representative areas for geological study”

- “range of geological phenomena” = geodiversity
- “representative areas” = areas representative of the country’s geodiversity.

SSSI network in the UK

- One of the criteria used to select geoconservation sites in the UK is:

  "Sites that are representative of an Earth science feature, event or process that is fundamental to Britain's Earth history" (Ellis et al., 1996).

- i.e. again there is a sense here of intending to establish a network of sites that represents Britain's geodiversity.

Situation in Ireland

- Some countries have tried to reassess their geoconservation aims, and usually this is done on the basis of geodiversity;
- For example, the Irish Geological Heritage programme has identified 16 geological themes, e.g. Precambrian; coastal geomorphology;
- “Each theme is intended to provide a national network of Natural Heritage Area sites and will include all components of the theme’s scientific interest” (Parkes & Morris, 2001).
- i.e., the system is intended to establish a representative selection of Ireland’s geodiversity

Situation in the USA

- National Parks - new units must not represent a feature already adequately represented in the system.

  By implication there is a sense here that the aim is to have representatives of the range of the country's natural and cultural heritage (including geodiversity).

- NNLs - must be "one of the best examples of a type of biotic community or geologic feature".

  i.e in the USA there is an attempt to conserve different types of geologic features, i.e. geodiversity

Situation in New Zealand

- “The overriding objective of earth science conservation in New Zealand should be to ensure the survival of the best representative examples of the broad diversity of geological features, landforms, soil sites and active physical processes.”

(Kenny & Hayward, 1993)

Geodiverity & Geoconservation

- So Geodiversity provides a key basis for selecting geoconservation sites at both the international and national levels…..

…and is also the basis for developing geoconservation management aims…

Element of Geodiversity	Rare or Common	Management aims
Rocks & Minerals	Rare	Maintain integrity of outcrop and subcrop. Remove samples for curation.
	Common	Maintain exposure and encourage responsible collecting. Encourage sustainable use. Value historical and modern uses of geomaterials.
Fossils	Rare	Wherever possible, preserve *in situ.* Otherwise remove for curation.
	Common	Encourage responsible collecting and curation.
Topography/Land form		Maintain integrity of topography/land form. Encourage authentic contouring in restoration work and new landscaping schemes.
Landscape		Maintain contribution of natural land form, rock outcrops and active processes to landscape. Encourage geomorphologically authentic design in restoration work and new landscaping schemes.
Processes		Maintain dynamics and integrity of operation. Encourage restoration of process and form using geomorphologically authentic design principles.
Soil		Maintain soil quality, quantity and function.

…and geoconservation methods

Point

Diffuse

		Element of Geodiversity						
Geoconservation Method	Sub-Method	Rocks	Minerals	Fossils	Landforms	Landscapes	Processes	Soils
Site Management	Secrecy	x	x	xx	x			
	Signage	x	x	x	x		x	
	Physical Barriers	x	x	xx	xx		xx	
	Reburial			xx				
	Site Clearance	xx	x	xx				
Curation			x	xx				
Licensing		x	x	xx	x			
Supervision	Static/Mobile Rangers			x	x			
	Remote				x			
	Local Residents			x				
Benevolent Ownership		xx	xx	xx	xx	xx	xx	xx
Restoration					xx	xx	xx	
Legislation	Nature Conservation (Statutory Sites)	xx	xx	xx	xx	xx	xx	xx
	Planning	xx	xx	xx	xx	xx	xx	xx
	Environmental				x	xx	xx	xx
Policy	Non-Statutory Sites (eg WHS, Geoparks, Local Sites)	xx	xx	xx	xx	xx	xx	x
	Management Plans	xx	xx	xx	xx	xx	xx	xx
	Policies/Position Statements	xx	xx	xx	xx	xx	xx	xx
	Codes of Conduct	x	xx	xx	x			
Education	Visitor Centres & Museums	xx	xx	xx	xx	xx	xx	x
	Publications	xx	xx	xx	xx	xx	xx	xx
	Panels	xx	xx	xx	xx	xx	xx	x
	Activities & Clubs	xx	xx	xx	x			
	TV Programmes	xx	x	xx	x		xX	
	Training & CPD	xx	xx	xx	x		x	
	Other							

4. Geodiversity & Geoparks

- Geoparks have 3 aims:
  - conservation of geoheritage;
  - geological education for the wider public;
  - sustainable socio-economic development mainly through geotourism.

Arouca Geopark, Portugal

Geodiversity and Geoparks

- A survey of the European Geoparks website (www.europeangeoparks.org) reveals that, as a network, they demonstrate the great geodiversity of European geology;
- Some geoparks are mainly based around a single type of geological feature e.g. Lesvos Petrified Forest Geopark, Greece or Vulkaneifel Geopark, Germany;

- But “The concentration and variety of maar-craters give the Vulkaneifel an outstanding position among the worldwide volcanic regions”.

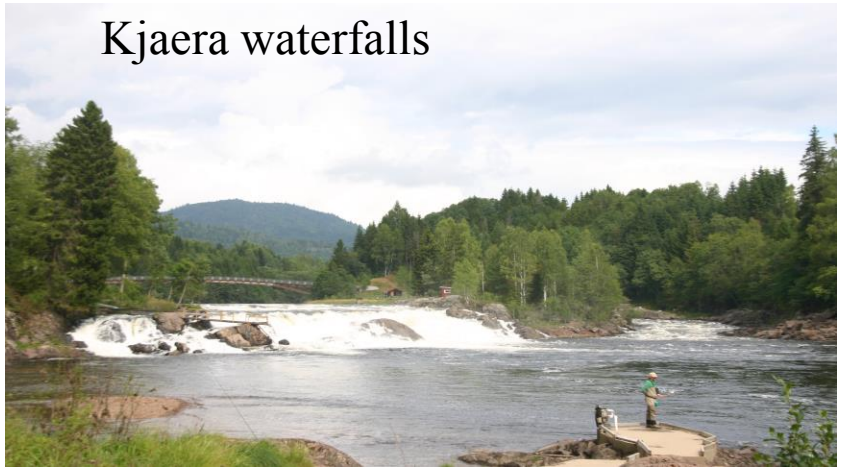
- Several Geoparks try to attract visitors by promoting their geodiversity;
- Gea Norvegica Geopark, Norway is the clearest example.

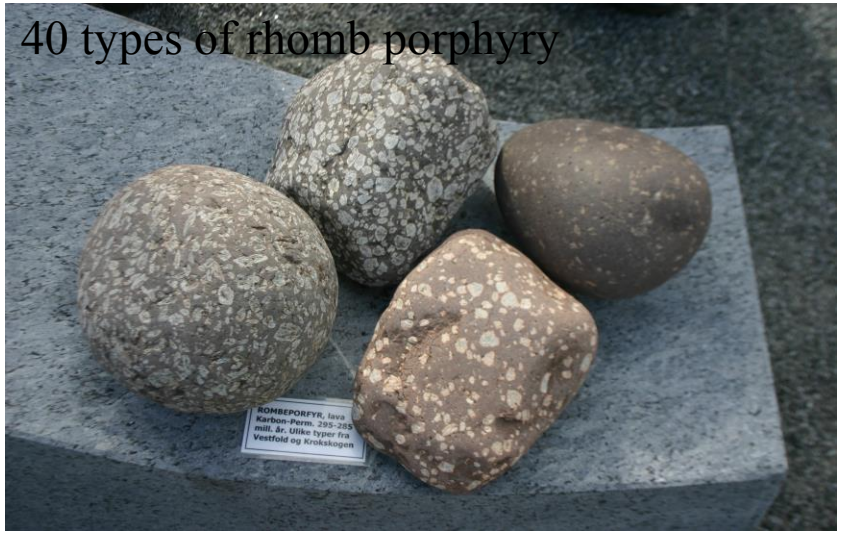
- “Unique for the Gea Norvegica Geopark is the extreme geodiversity present. During the very long time-span of geological evolution, a great variety of rock types and geological deposits formed through a wealth of processes in widely different geological environments…. Textbook examples can be found in almost any field of geology”

“Extreme geodiversity in an old rifted continent”

- “Textbook examples can be found in almost any field of geology”:
  - Deep orogenic environments
  - Rift environments
  - Ductile deformation: folds and mylonites
  - Faults and fractures
  - Sediments of highly different origins
  - Glacial deposits and glacial features
  - Volcanics, plutons, dykes, sills, laccoliths, pegmatites
  - Metamorphic rocks in orogens and contact aureoles
  - Metasomatic rocks and hydrothermal vein deposits
  - Weathering and soils
  - A wide range of fossils and minerals
  - Many different geological resources (gravel, minerals, rocks, oil)”

Gea-Norvegica Geopark, Norway





Geopark Geodiversity

Bergstrasse-Odenwald Geopark, Germany
"Solely in central Europe, the region between Rhine, Main and Neckar exposes not just a great variety of magmatic and sedimentary rocks, but also the tracks of two global tectonic events"

Cabo de Gata-Níjar Geopark, Spain
"its geological diversity derives from the predominance of volcanic substrata and recent coastal deposits…lava flows, volcanic domes, volcanic calderas, columnar joints, fossilized beaches, reef constructions, etc."

Copper Coast Geopark, Ireland
"The Copper Coast is an outdoor geology museum with a geological heritage that reflects the variety of environments under which the area has evolved over the last 460 million years"

Terra Vita Geopark, Germany
"By means of an enormous variety of different sedimentary rocks, which are accessible in natural or artificial openings, this huge area can be investigated, reconstructed and explained to visitors in an accessible way".

N.W. Highlands Geopark, UK
"The Geopark contains some of the most important and diverse geological and geomorphological features in Britain".

Itoigawa Geopark's 24 Geosites

A Geopark Rich in Diversity

Itoigawa Global Geopark encompasses the entirety of the City of Itoigawa. Stretching 45km east to west along the coast and rising from 0 to nearly 3000m in elevation from coast to its highest peaks, the City of Itoigawa is home to rich geological and topographical diversity. From the sparkling jade found along the Itoigawa and Omigawa Coasts, to majestic mountains and volcanoes like Renge and Yakeyama, the Itoigawa

5. Geodiversity, Geotourism & Recreation

- “Madame, we do not go there as to paradise. We go to see something different from that we are accustomed to”.

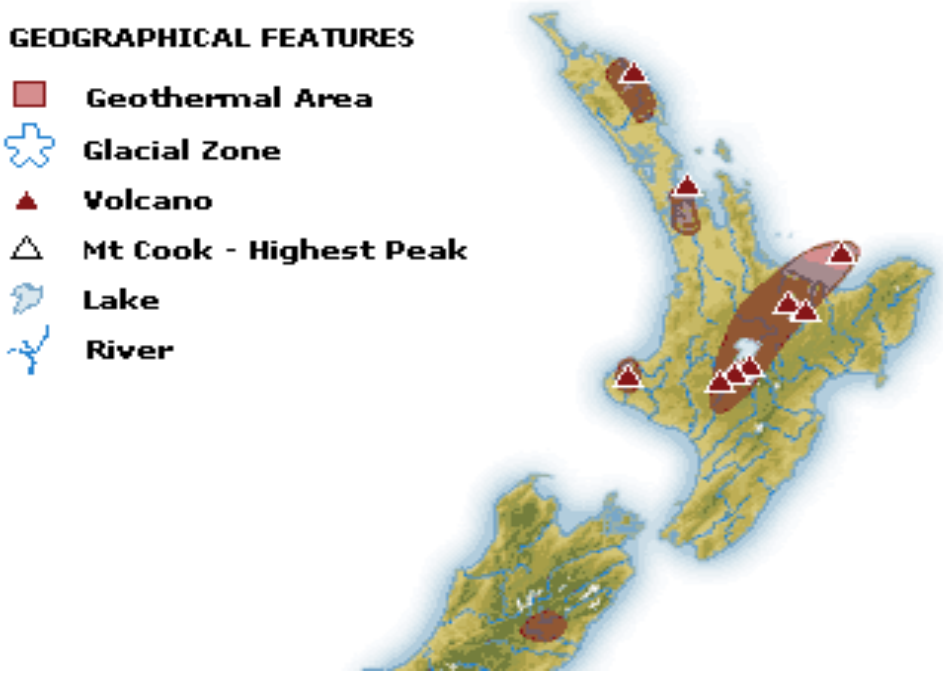
(James Boswell to his wife, 1773)

- So Tourism is based on the diversity of places;
- Geotourism is based on the diversity of geological places;
- Many countries use their geodiversity to promote tourism;

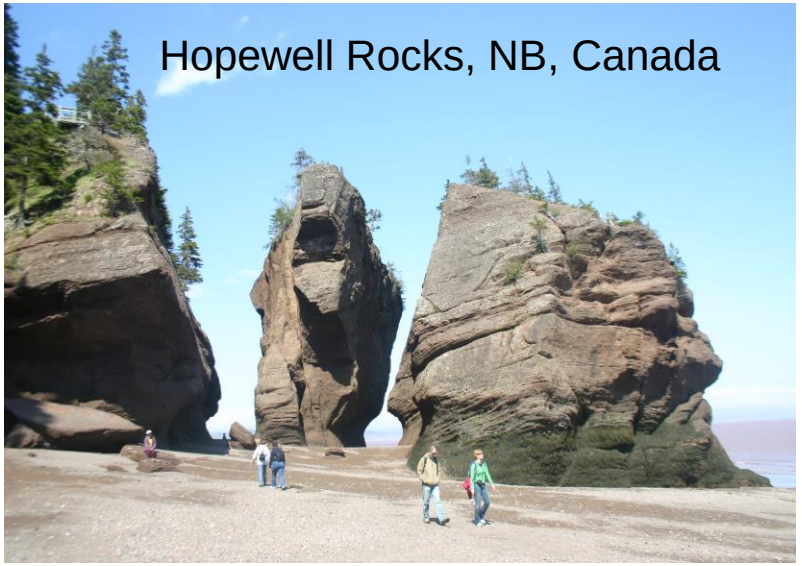
Geography and Geology

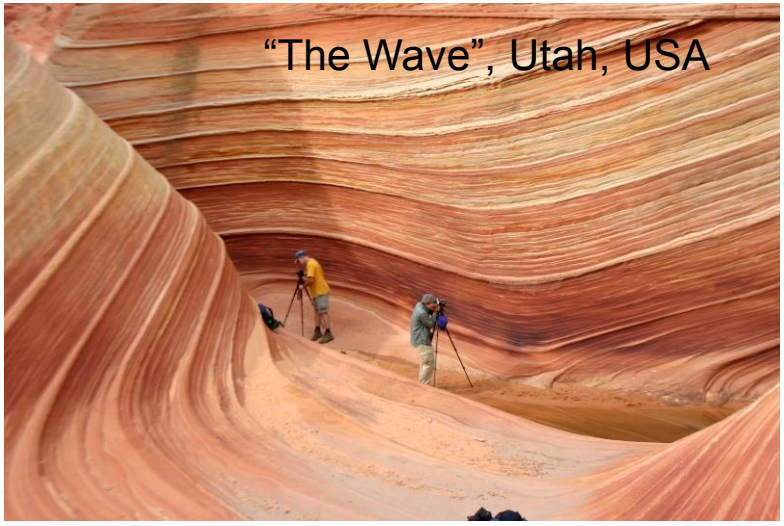
New Zealand's Awesome Landscape

You'll find a variety of awesome landscapes in New Zealand, all within easy reach of each other. Spectacular glaciers, picturesque fiords, rugged mountains, vast plains, rolling hillsides, subtropical forest, volcanic plateau, miles of coastline with gorgeous sandy beaches - it's all here. No wonder New Zealand is becoming so popular as a location for movies such as the Lord of the Rings

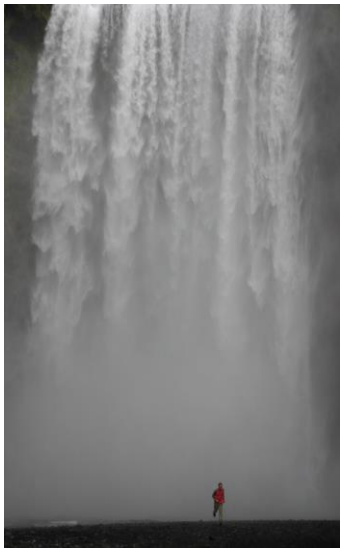


Geodiversity & Geotourism

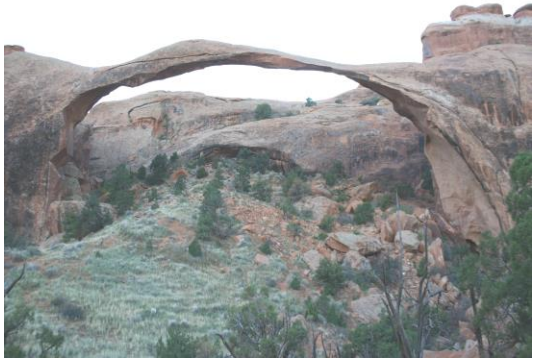


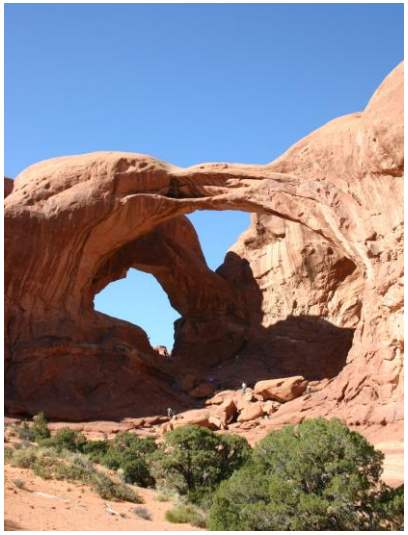


Waterfalls, Iceland



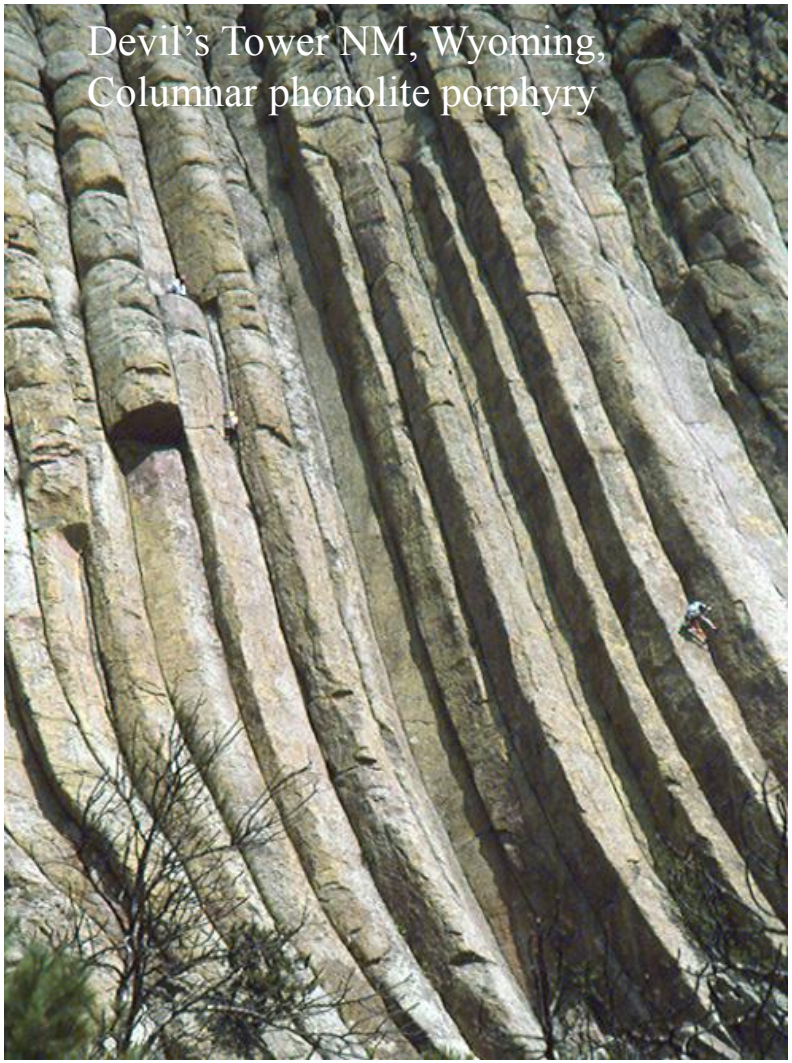
Natural Arches, USA





Geotourism & Geodiversity of the Grand Canyon

Rock climbing & Geodiversity



Skiing & Geodiversity

La Tuile, Italy

N. American classification of Ski Runs

Green Circle Runs, 6-25^{o}

Blue Square Runs, 24-40^{o}

Black Diamond Runs, >40^{o}

Double Black Diamond Runs, Very steep + jumps, etc.

Most ski resorts will attempt to provide a diversity of runs to cater for different abilities and experiences.

Sport & Leisure activities where topographic diversity is valued

- Skiing (downhill & cross-country);
- Snowmobiling;
- Rock climbing (also values rock diversity);
- Hill walking;
- Running (cross-country);
- Motor cycle scrambling;
- Mountain biking;
- Endurance road cycling (e.g. Tour de France);
- Off-road driving;
- Whitewater rafting;
- Whitewater canoeing/kayaking;
- Canyoning;
- Caving/potholing;
- Golf.

However, other sports, e.g. football, need a “level playing field”

Scotland’s “links” golf courses like St Andrews are constructed on Holocene raised beaches whose surfaces have been modified into aeolian sand dunes and stabilised by vegetation.

Conclusions

- Geodiversity is the abiotic equivalent of biodiversity and can be assessed in a similar way;
- The Earth's geodiversity brings a huge range of goods and services of benefit to modern society - we couldn't live without it;
- Geoconservation should be based on geodiversity;

  i.e. the fundamental aim of geoconservation should be to protect the geodiversity of a country, region, geopark etc.;
- Geodiversity is also an important basis for geotourism, geoparks and many leisure activities.

Thank you for listening

Want to read more?

Gray, M. 2013.

Geodiversity: valuing and conserving abiotic nature.

Wiley Blackwell, Chichester

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