Geodiversity, Geoheritage & Geoconservation for Society

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Aims & Structure

As geologists (and geomorphologists) we have not been good at explaining to society (i.e. the public) the value of our subjects;

So Structure/Aims are:

1. What is Geodiversity;
2. Geodiversity for Society – using an ecosystem services approach to describe a way of showing the public and decision-makers that we literally couldn't live without the planet's geodiversity;
3. Geoheritage and Geoconservation for Society - arguing that the public has an interest in ensuring that the planet's geoheritage is conserved for future generations;
4. Conclusions

1. What is Geodiversity

Queen Mary University of London

Planet Earth represented as a smooth, steel sphere

= no geodiversity

Capelinhos, Azores Geopark, Portugal

Fortunately, the world is not a perfect sphere composed of a single rock type.

It's highly diverse in terms of its:

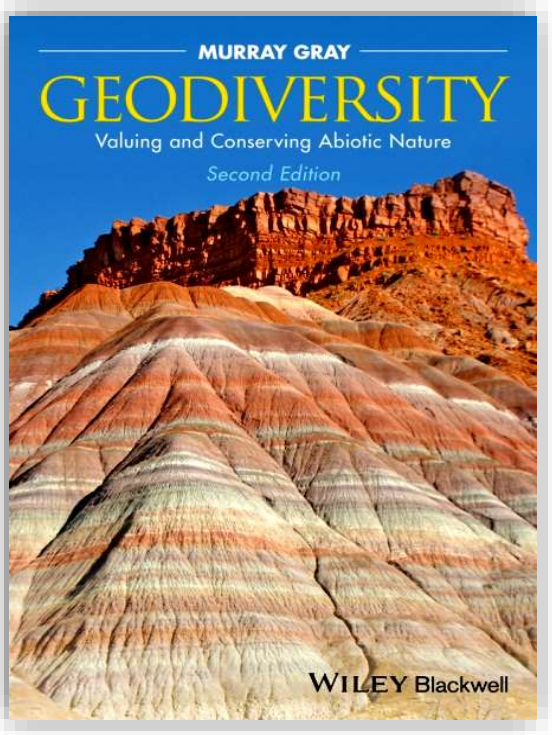
- geological materials,
- topographic variation, and
- physical processes.

Understanding, valuing and celebrating the planet's geodiversity can enrich our lives.

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

2. Geodiversity for Society: an ecosystem services approach

- Ecosystem services are nature's goods and services that benefit society;
- This is now the major way in which decision-makers around the world assess the value of nature;
- The Millennium Ecosystem Assessment (MEA, 2005) classified these goods & services as:
  - Regulating services
  - Supporting services
  - Provisioning services
  - Cultural services
- For example, Provisioning services included in the MEA are as follows:

Provisioning services

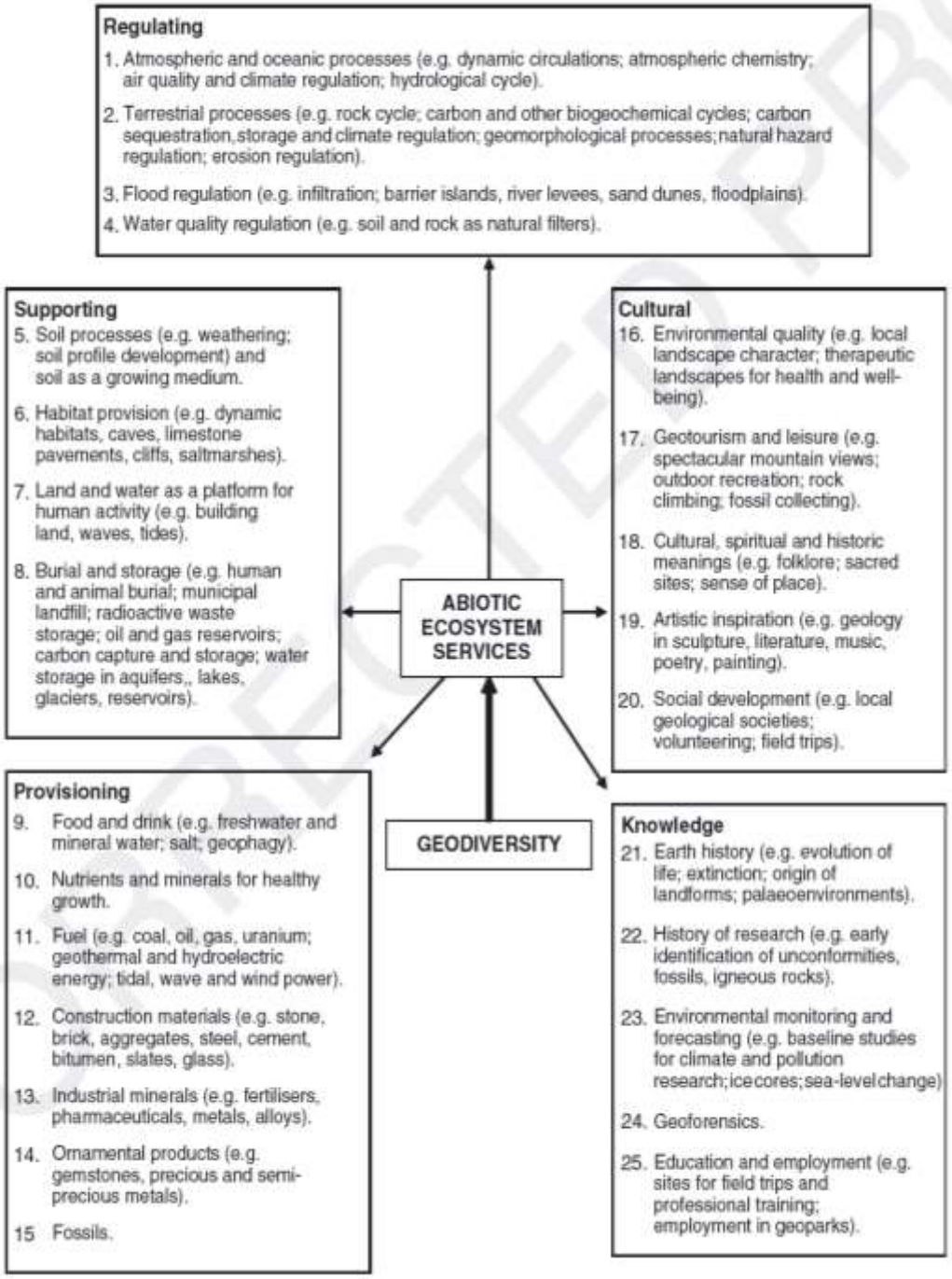
- Food - plants, animals
- Fibre - wood, wool, cotton, etc.
- Fuel - wood, etc.
- Genetic resources;
- Biochemicals & pharmaceuticals;
- Ornamental resources - shells, flowers;
- Fresh water.

Current ecosystem services approach

- Is biologically dominated;
- No mention of geological resources -
  - mineral fuels,
  - building materials,
  - metals,
  - industrial minerals,
  - gemstones,
  - fossils, etc.
- But also deficiencies in other services;

Geodiversity & Ecosystem Services

- Because of the deficiencies, I've used the MEA classification of ecosystem services to show the goods and services related to geodiversity;
- 5th category of "Knowledge Services" added, part of "Cultural Services" in the MEA classification,because of the importance of geodiversity in providing evidence for the history of Planet Earth and the evolution of life.
- About 25 abiotic ecosystem services have been identified, all the result of the planet's geodiversity.


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).
ABIOTIC ECOSYSTEM SERVICES
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).
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.
GEODIVERSITY
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).

Abiotic Ecosystem Services

Regulating services

1. Atmospheric & oceanic processes;
2. Terrestrial processes;
3. Flood regulation;
4. Water quality regulation;

Supporting Services

5. Soil processes;
6. Habitat provision;
7. Platforms for human activity;
8. Burial and storage;

Provisioning services

9. Food & drink;
10. Nutrients & minerals;
11. Energy sources;
12. Construction materials;
13. Metals & industrial minerals;
14. Ornamental products;
15. Fossils;

Cultural services

16. Environmental quality;
17. Geotourism and leisure;
18. Cultural, spiritual and historic meanings;
19. Artistic inspiration;
20. Social development;

Knowledge services

21. Earth history;
22. History of research;
23. Environmental monitoring/forecasting;
24. Geoforensics;
25. Education & employment.

Case studies/examples

- Case studies and examples now follow;
- Some are taken from Geoparks, others are from National Parks, World Heritage Sites, etc;
- These are simply examples. If you want to use this system to explain the value of geology to your own residents or visitors you could include whichever goods and services are appropriate.

12. Construction materials


Clay roof tiles
Plastic gutters
Metal handle & lock
Plaster walls
Stone window surrounds
Plastic window frames
Glass windows
Stone block paving

Towns & Cities

Building stones, NHM, Vienna, Austria

Baugesteine de

Tonschiefer aus:
Slate *from:*
Le Mans, Sarthe (Frankreich | FRA),
Caernarfonshire (Großbritannien | GBR)

Kalksandstein aus:
Calcareous sandstone *from:*
Winden am See & St. Margarethen,
Burgenland (Österreich | AUT), Občina Br
[„Mokritzer Stein"] (Slowenien | SVN), Vi
Varaždinska županija (Kroatien | HRV)

Kalksandstein aus:
Calcareous sandstone *from:*
Občina Brežice [„Mokritzer Stein"]
(Slowenien | SVN)

Kalkstein aus:
Limestone *from:*
Merlera, Istra (Kroatien | HRV)

Kalksandstein aus:
Calcareous sandstone *from:*
Občina Brežice [„Mokritzer Stein"]
(Slowenien | SVN), Vinica, Varaždinska županija
(Kroatien | HRV), Březová nad Svitavou
(Tschechien | CZE), Wagna (Aflenz an der
Sulm), Steiermark (Österreich | AUT),
Breitenbrunn, Burgenland (Österreich |
AUT), Bruck an der Leitha & Eggenburg,
Niederösterreich (Österreich | AUT)

Building stones used for the facade of the NHM

Kalksandstein, Kalkstein, Marmor aus:
Calcareous sandstone, Limestone, Marble *from:*
Občina Brežice [„Mokritzer Stein"] (Slowenien | SVN),
Breitenbrunn, Burgenland (Österreich | AUT),
Marčana, Istra (Kroatien | HRV),
Carrara, Toscana (Italien | ITA)

Kalksandstein aus:
Calcareous sandstone *from:*
Breitenbrunn, Burgenland (Österreich | AUT)

Kalkstein (rot) aus:
Limestone (red) *from:*
Trento (Italien | ITA),
sowie roter Kalk unbekannter Herkunft
(as well as red limestone of
unknown origin)

Kalkstein (gelb) aus:
Limestone (yellow) *from:*
Trento (Italien | ITA)

Kalksandstein aus:
Calcareous sandstone *from:*
Zogelsdorf, Niederösterreich (Österreich | AUT)

Kalkstein, Kalksandstein aus:
Limestone, Calcareous sandstone *from:*
Oslip, Burgenland (Österreich | AUT)

Kalkstein, Kalksandstein aus:
Limestone, Calcareous sandstone *from:*
Oslip, Burgenland (Österreich | AUT),
Wöllersdorf, Niederösterreich (Österreich | AUT)

Kalksandstein aus:
Calcareous sandstone *from:*
Atzgersdorf, Wien (Österreich | AUT)
(verwendet für das Fundament; in der Skizze
nicht sichtbar | *used for the foundations;*
not shown on the graphic)

13. Metals & industrial minerals

- Smartphones contain half the non-radioactive elements in the Periodic Table.
- These include several Rare Earth Elements such as indium, tantalum and neodymium.
- By definition, these are rare, difficult to recycle and could become scarce.

ELEMENTS OF A SMARTPHONE

ELEMENTS COLOUR KEY: ALKALI METAL · ALKALINE EARTH METAL · TRANSITION METAL · GROUP 13 · GROUP 14 · GROUP 15 · GROUP 16 · HALOGEN · LANTHANIDE

SCREEN

49 In Indium
8 O Oxygen
50 Sn Tin

Indium tin oxide is a mixture of indium oxide and tin oxide, used in a transparent film in the screen that conducts electricity. This allows the screen to function as a touch screen.

13 Al Aluminium
14 Si Silicon
8 O Oxygen
19 K Potassium

The glass used on the majority of smartphones is an aluminosilicate glass, composed of a mix of alumina (Al_2O_3) and silica (SiO_2). This glass also contains potassium ions, which help to strengthen it.

39 Y Yttrium
57 La Lanthanum
65 Tb Terbium
59 Pr Praseodymium
63 Eu Europium
66 Dy Dysprosium
64 Gd Gadolinium

A variety of Rare Earth Element compounds are used in small quantities to produce the colours in the smartphone's screen. Some compounds are also used to reduce UV light penetration into the phone.

ELECTRONICS

29 Cu Copper
47 Ag Silver
79 Au Gold
73 Ta Tantalum

Copper is used for wiring in the phone, whilst copper, gold and silver are the major metals from which microelectrical components are fashioned. Tantalum is the major component of micro-capacitors.

28 Ni Nickel
66 Dy Dysprosium
59 Pr Praseodymium
65 Tb Terbium
60 Nd Neodymium
64 Gd Gadolinium

Nickel is used in the microphone as well as for other electrical connections. Alloys including the elements praseodymium, gadolinium and neodymium are used in the magnets in the speaker and microphone. Neodymium, terbium and dysprosium are used in the vibration unit.

14 Si Silicon
8 O Oxygen
51 Sb Antimony
33 As Arsenic
15 P Phosphorus
31 Ga Gallium

Pure silicon is used to manufacture the chip in the phone. It is oxidised to produce non-conducting regions, then other elements are added in order to allow the chip to conduct electricity.

50 Sn Tin
82 Pb Lead

Tin & lead are used to solder electronics in the phone. Newer lead-free solders use a mix of tin, copper and silver.

BATTERY

3 Li Lithium
27 Co Cobalt
8 O Oxygen
6 C Carbon
13 Al Aluminium

The majority of phones use lithium ion batteries, which are composed of lithium cobalt oxide as a positive electrode and graphite (carbon) as the negative electrode. Some batteries use other metals, such as manganese, in place of cobalt. The battery's casing is made of aluminium.

CASING

Magnesium compounds are alloyed to make some phone cases, whilst many are made of plastics. Plastics will also include flame retardant compounds, some of which contain bromine, whilst nickel can be included to reduce electromagnetic interference.

6 C Carbon
12 Mg Magnesium
35 Br Bromine
28 Ni Nickel

14. Ornamental products
(gemstones, precious metals)

9. Food and Drink

Wine character is often partly related to parent material and soil.

Greywacke – a Sauvignon Blanc from New Zealand
Flint – a Bacchus from England

8. Burial & Storage

18. Cultural, spiritual & historic meanings

Mt Fuji, Japan
(Photo: Abhik Chakraborty)

Golden Temple, Kyoto, Japan

Ryoakan Temple Garden, Kyoto, Japan

Sense of Place

19. Artistic Inspiration-
sculptures in stone

St John, New Brunswick, Canada

Sculptures in Metal

Fossils as Art

6. Habitat provision

West Coast NP, South Africa

Algarve, Portugal

17. Geotourism & Leisure

Hopewell Rocks, New Brunswick, Canada

16. Environmental quality

2. Terrestrial processes

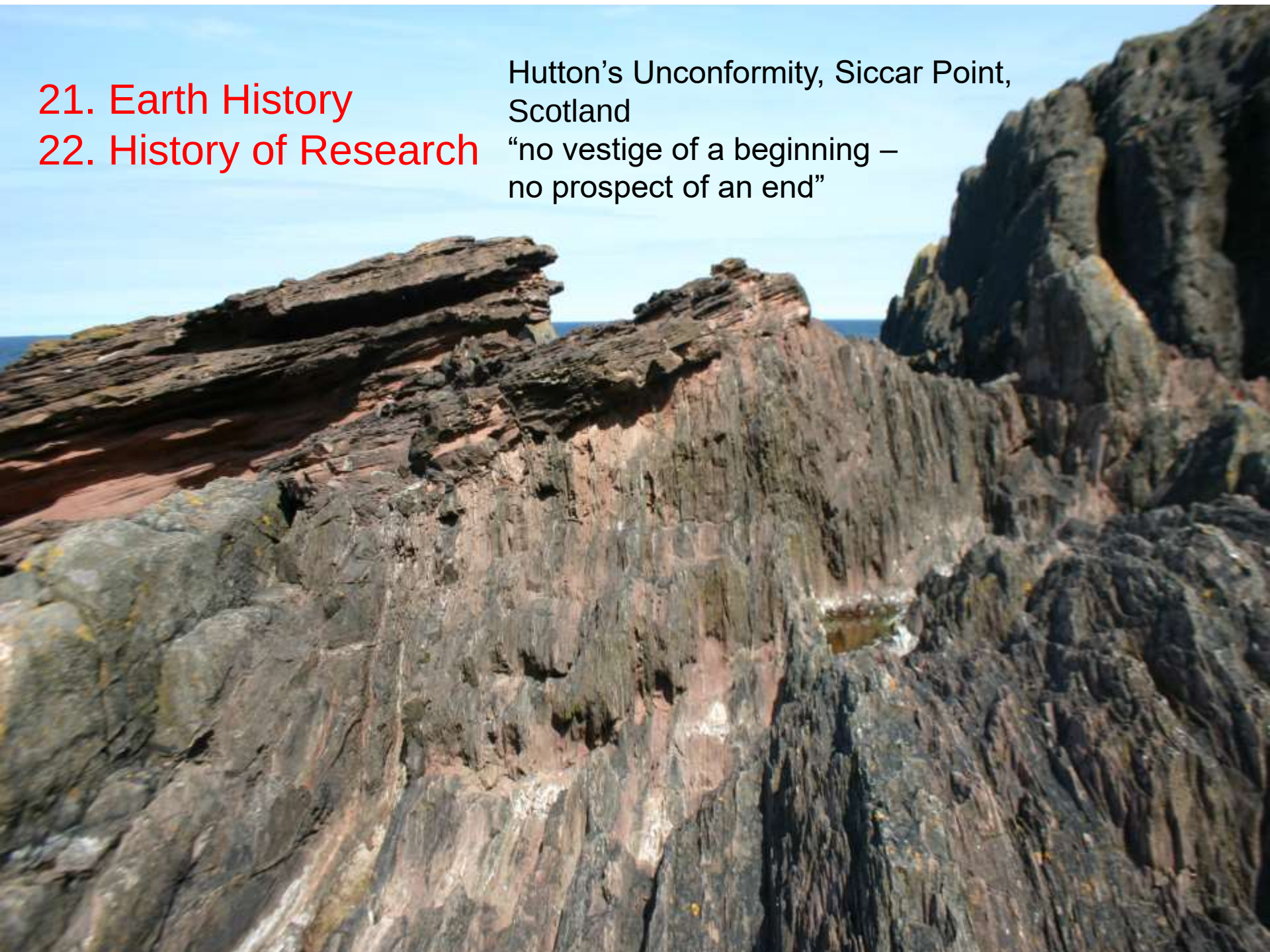
North Pennines Global Geopark, England

5. Soil as a growing medium:

Olive grove, Terras de Cavaleiros Global Geopark, Portugal

Historic (18) stone olive press, Naturtejo Global Geopark, Portugal

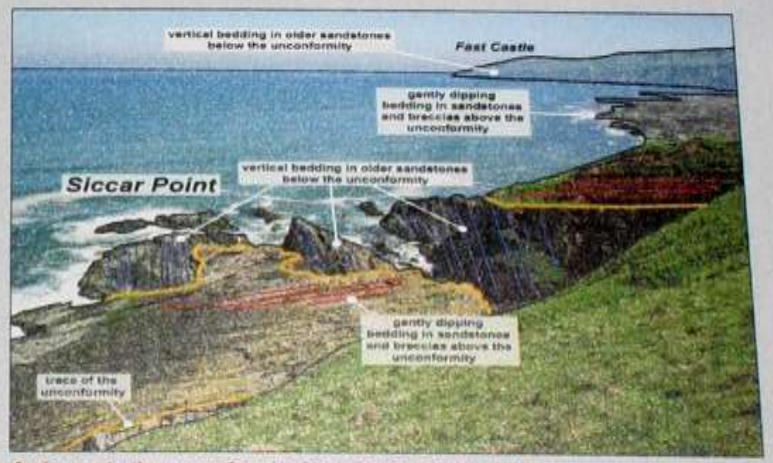
21. Earth History
22. History of Research



Hutton's Unconformity, Siccar Point, Scotland
"no vestige of a beginning – no prospect of an end"

SICCAR POINT

James Hutton (1726 – 1797) known as the founding father of geology was a man of genius. Whilst farming nearby, he indulged in his passion for geology. The rocks here at Siccar Point were the defining proof for his revolutionary Theory of the Earth. Most people at this time thought the world no older than a few thousand years. Hutton realised that earth processes are cyclical and that geological time is virtually unlimited. What we see today is very much how he would have seen it over 200 years ago (but a moment in geological time!).



A view onto the unconformity from the top of the slope.

SAFETY WARNING

The slope down to the unconformity is steep and dangerous. Please proceed with care at your own risk along the field boundary to your right. You do not need to go down to the shore to observe what these photographs illustrate.

A close-up of the unconformity from the shore

The yellow lines mark the time gap between the underlying vertical rock-layers (greyish in colour and called 'Greywackes') and the overlying gently dipping rock-layers (reddish in colour and called 'Old Red Sandstone and Conglomerates'). The gap represents 55 million years.

During this time the underlying rocks formed from layers of sediment deposited on the floor of an ancient ocean, had been folded, uplifted and eroded. This produced an uneven land surface onto which the overlying rocks were then deposited as sand and gravel. The irregular surface between the vertical and the gently dipping rock-layers is known as an unconformity.

To find out more about Hutton AND THE TRAIL take a trip to the James Hutton Exhibition located at the Reiver Country Farm shop in Auchencrow.

This project was initiated by BFRS and implemented in partnership with farmers on whose land this trail occurs and with public and private funding. www.bfrs.org

3. Geoheritage & Geoconservation for Society

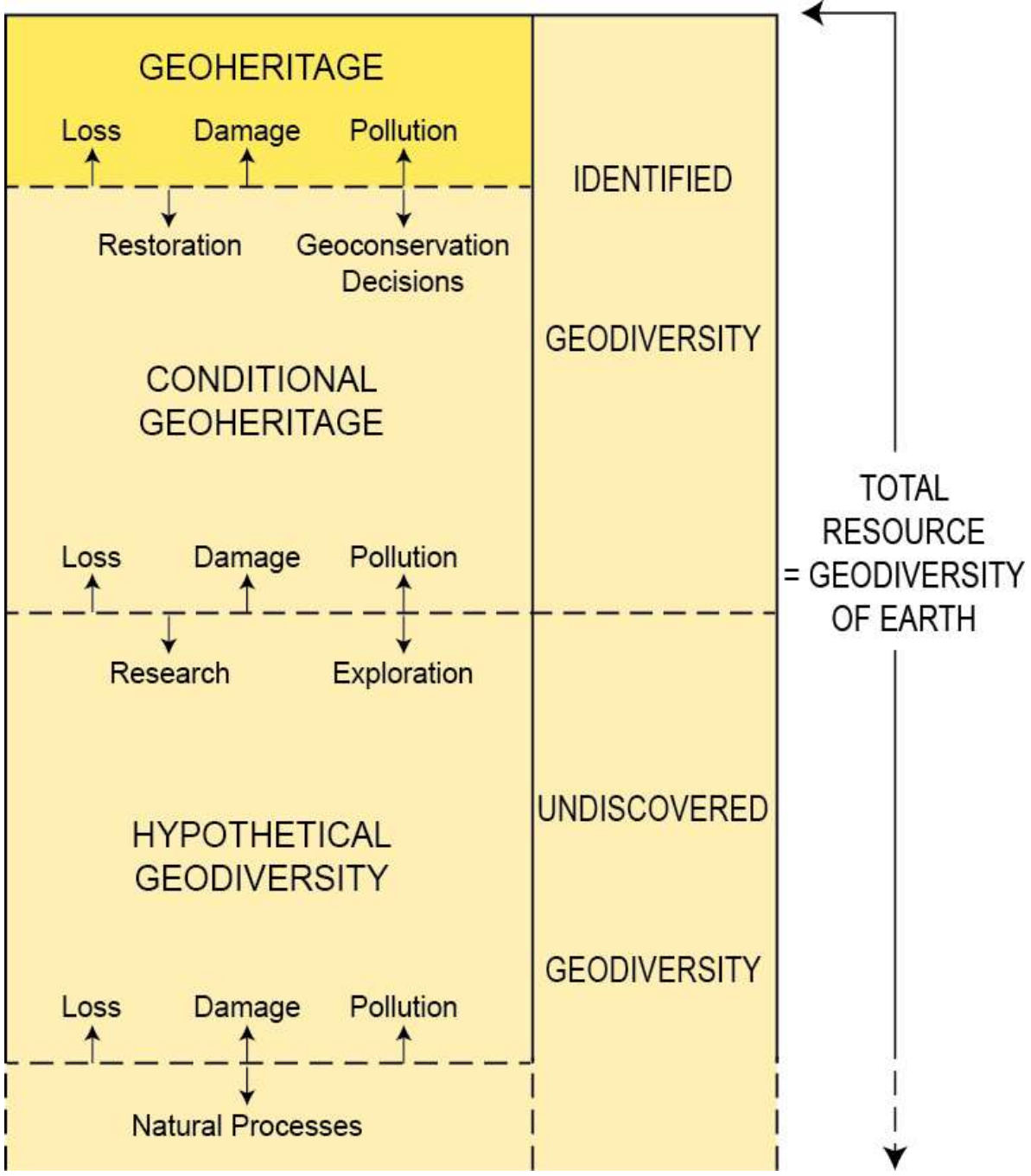
The Geoconservation Equation

Value + Threat = Conservation Need

- As we've seen, geodiversity creates many values;
- But it can also be threatened by human actions, e.g. engineering projects;
- Therefore, geoconservation is essential in order to protect geosites, natural landscapes and physical processes.
- But does society agree?

Geoheritage & Geoconservation

- **Geoheritage** – “those parts of the planet’s geodiversity that may be specifically identified as having geoconservation significance” (Sharples, 2002)
- **Geoconservation** - “action taken with the intent of conserving and enhancing geological and geomorphological features, processes, sites and specimens” (Burek & Prosser, 2008)


GEOHERITAGE
Loss
Damage
Pollution
Restoration
Geoconservation
Decisions
CONDITIONAL
GEOHERITAGE
Loss
Damage
Pollution
Research
Exploration
HYPOTHETICAL
GEODIVERSITY
Loss
Damage
Pollution
Natural Processes
IDENTIFIED
GEODIVERSITY
UNDISCOVERED
GEODIVERSITY
TOTAL
RESOURCE
= GEODIVERSITY
OF EARTH

		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							

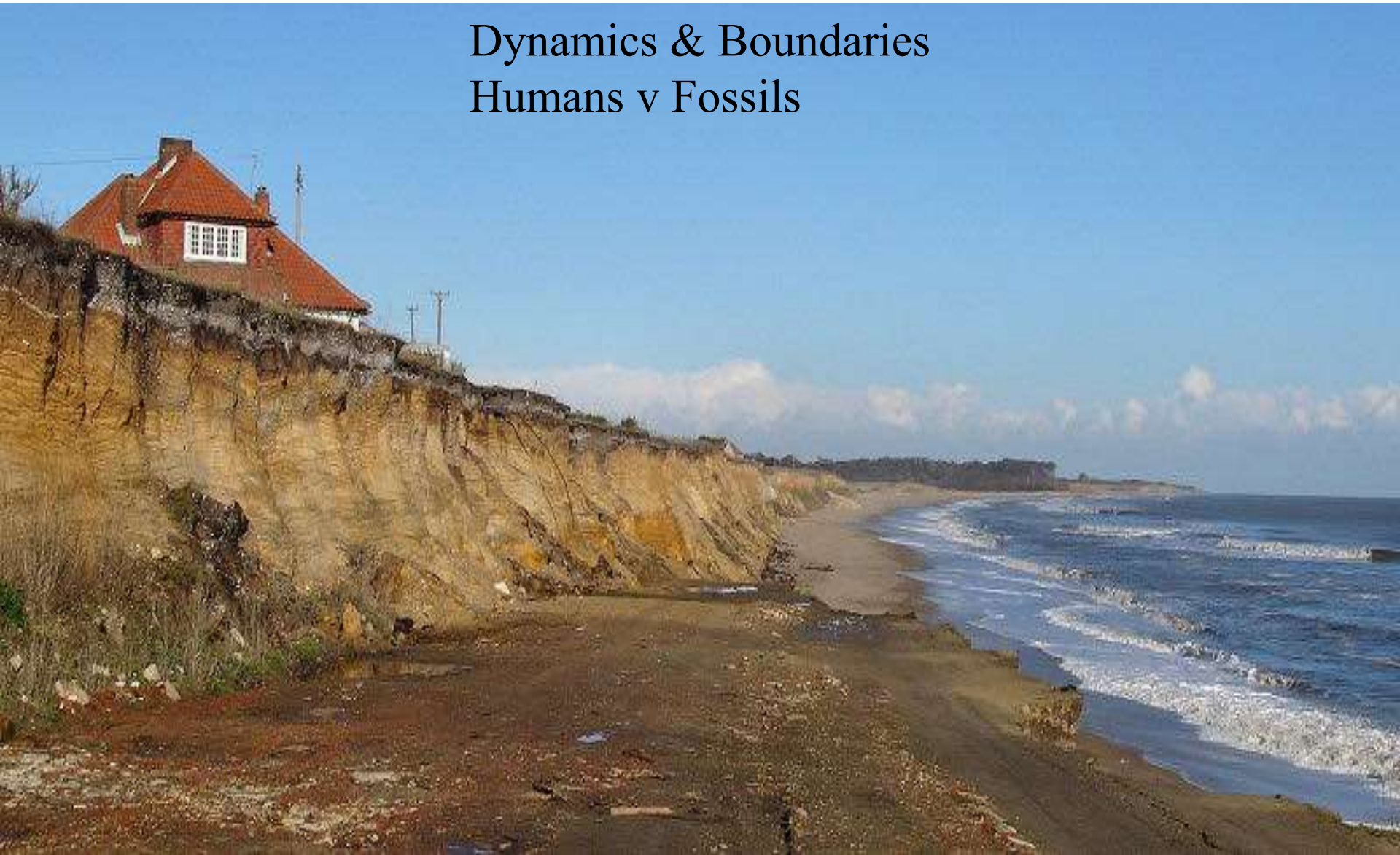
Birling Gap, S. England
Site of Special Scientific Interest (SSSI),

Birling Gap SSSI, S. England

- Residents could not persuade authorities to protect coast;
- Submitted their own planning application for a protective revetment of boulders at the cliff foot.
- Permission refused by local authority as being detrimental to the SSSI and scenic quality;
- Residents appealed and Public Inquiry held in 2000;
- Residents argued that “scientists” were blocking protection of homes;
- English Nature argued that continued erosion of cliffs was important to:
    - maintain beach material supply,
    - retain cliff exposures in Chalk and periglacial stratigraphy
    - conserve coastal scenery.
- Inquiry Inspector agreed - SSSI status held to be important and not just for scientists – “designations reflect the national importance of the site, with such designations being underpinned by legislation and Government and local policies”

This is an important decision that emphasises that geoheritage is important “for society” and that conservation legislation and policy are authourised by the public through decisions made by their elected representatives.

Easton Bavents, E. England



Easton Bavents, E. England

- Residents wanted sea defences built to stop land and houses eroding into the sea;
- Lack of action led to one resident dumping large amounts of waste soil onto the beach in front of the cliffs from 2003-05;
- Should have had planning consent, but local authority refused to take any enforcement action to require a retrospective planning application for the removal of the material.

Easton Bavents coast

Easton Bavents, E. England

- The cliffs themselves are in early Quaternary sediments and were made an SSSI in 1989,
- But since then the cliffline has retreated outside the mapped boundary of the SSSI;
- To prevent further dumping, Natural England redesignated a new boundary including 225m inland (50 year erosion prediction).
- The residents appealed, but all these were dismissed by the English courts.
- Thus the court system in England has supported geoconservation objectives.

Menie House, East Scotland

- In 2006, *Trump International Golf Course Scotland* applied for planning permission for 2 golf courses;
- One was to be a championship course that would take up the southern third of the Foveran SSSI, a coastal sand dune area 14km north of Aberdeen.

Menie House, East Scotland

- The proposals were also to include:
  - A clubhouse, golf academy, driving range, practice ground, ancillary buildings, etc.;
  - A 450-room resort hotel on 8 floors, conference centre and spa;
  - 950 holiday apartments in 4 blocks;
  - 36 golf villas and 500 houses;
  - Accommodation for 400 staff;
  - A new access, gatehouse, roads and car parks

Menie House, East Scotland

- After cconsideration at 2 meetings of Aberdeenshire Council in 2007, the application was “called in” by the Scottish government and a 4-week public inquiry was held in 2008;
- Objectors included Scottish Natural Heritage which was concerned that the active sand sheets and dune system would be affected by excavations and stabilisation measures. They proposed moving the championship course away from the most important part of the SSSI.

Foveran SSSI
Aberdeenshire

Menie House, East Scotland

- Donald Trump himself gave evidence at the public inquiry;
- He stated that if the championship course was moved away from the SSSI, it would no longer be the truly great course he intended since it would not include the spectacular high dune system;
- If he was refused permission he said he would withdraw the project and the area would lose the investment.

Menie House, East Scotland

- The planning inspectors concluded that “much, though not all, of the geomorphological interest in that affected area of the SSSI would be compromised as would its overall integrity….The loss of this dynamism cannot be mitigated against”.
- However, their overall conclusion was that the adverse effects were outweighed by the social and economic benefits that were of national significance.

Menie House, East Scotland

- The Scottish government ministers agreed and the project was given consent;
- The course is now built, but due to the recession the other buildings have not yet been constructed;
- Jonathan Hughes, Scottish Wildlife Trust's Head of Policy believes that the decision "sends dangerous messages that SSSIs could be up for grabs if you write a big enough cheque".
- So this is a case where the environmental impacts on a geomorphological SSSI were outweighed by the economic and social ones.

SSSIs in Great Britain

The impetus for establishing a network of over 2000 SSSIs in Great Britain was a report from a government *Wild Life Conservation Special Committee* (1947), which contains the following quote:

- "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, requires that there shall be available in this country a sufficient number of representative areas for geological study"

1. This is a further reason for society supporting the conservation of a scientific site network.
2. The network would seek to conserve the country's geodiversity ("range of geological phenomena" = geodiversity; "representative areas" = areas representative of the country's geodiversity).

Land-use Planning in England – National Planning Policy Framework

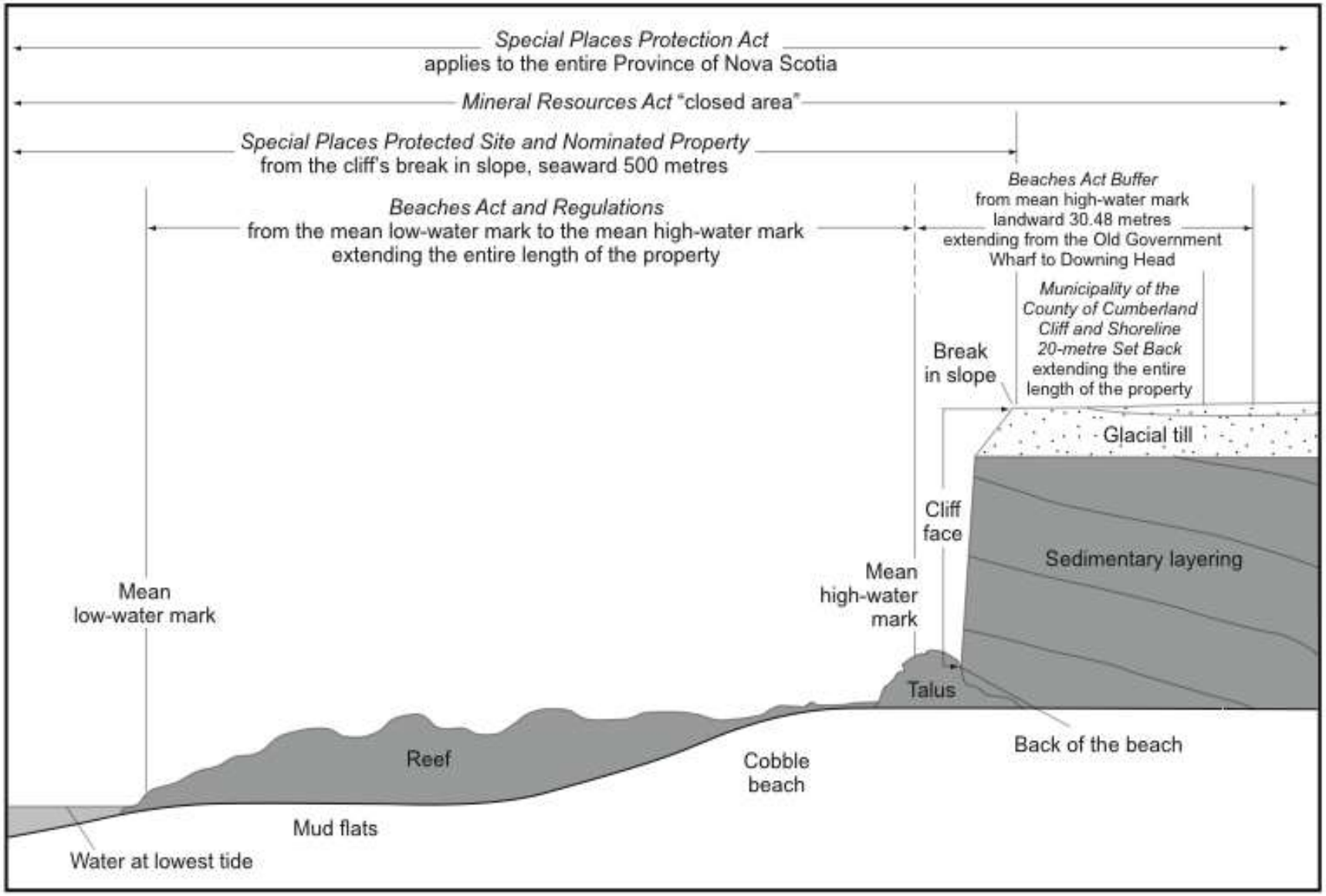
- Launched in 2012, this guidance states government policy on spatial planning, which local authorities are expected to follow. The three areas where geodiversity is considered are:

- Paragraph 109: “protecting and enhancing valued landscapes, geological conservation interests and soils; ...”
- Paragraph 113: “Local planning authorities should set criteria based policies against which proposals for any development on or affecting protected wildlife or geodiversity sites or landscape areas will be judged ... ”
- Paragraph 117: “To minimise impacts on biodiversity and geodiversity, planning policies should: ... aim to prevent harm to geological conservation interests;”

National & Sub-national Geoconservation

- Most European and many other nations do have geoconservation legislation and/or policies, but this is not true everywhere.
- This gives the international geoconservation community one of our most important future projects.


Joggins Fossil Cliffs World Heritage Site,
Nova Scotia, Canada.
Protected by local legislation



Joggins WHS, Nova Scotia, Canada


Mt Omuro Natural Monument,
Izu Peninsula (National) Geopark, Japan
4000 year old scoria cone


大室山天然記念物国指定!
Natural Monument Mt. Omuro Designated by the National Government
大室山でわかる 伊豆の大地のひみつ
History of Omuroyama volcano and Izu peninsula
火山がつくった伊東の大地
伊豆半島の生い立ち
伊豆半島ジオパーク
PENINSULA GEOPARK

A - Z
of South African National Parks

YOUR NATURAL HERITAGE

South African
NATIONAL PARKS

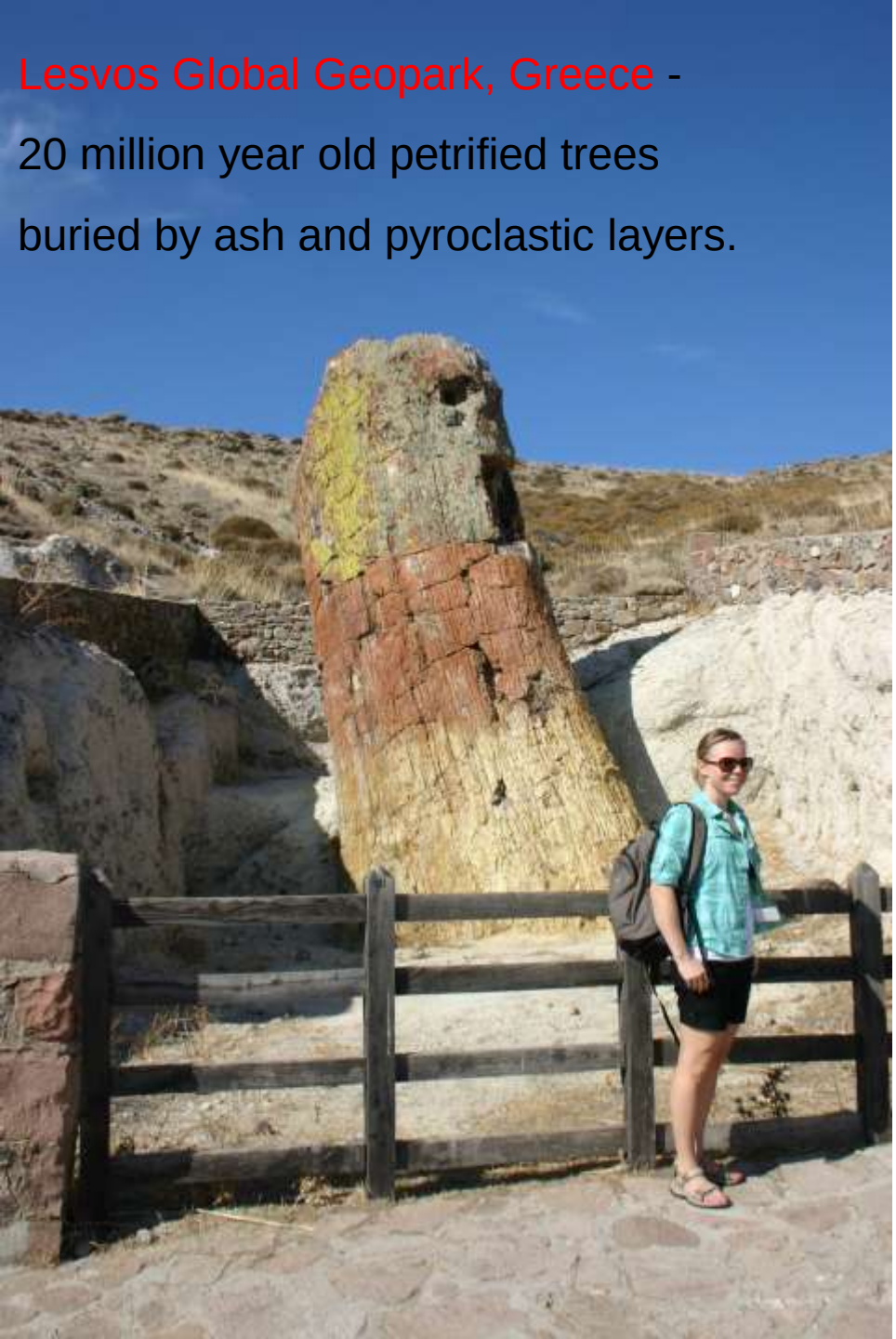
YOUR NATURAL HERITAGE

WEST COAST NATIONAL PARK

Visitor's Map

explore, discover, relax...

West Coast Fossil Park National Heritage Site, South Africa



Global Geopark aims:

- conservation of geoheritage;
- geological education for the public;
- sustainable economic development.

“the aim is to allow local communities to take ownership of their geological and other heritage by protecting it, promoting it and, by doing so, gaining some sustainable economic benefit from it”.

(Gray, 2013)

Langkawi Geopark, Malaysia

World Heritage Sites

- Outstanding Universal Value (OUV);
- Sites should have ”significance that is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity.
- As such the permanent protection of this heritage is of the highest importance to the international community as a whole”.

Operational Guidelines for the Implementation of the World Heritage Convention


River Li, South China Karst World Heritage Site

Geodiversity, Geoheritage & Geoconservation for Society

4. Conclusions

1. Our planet has an incredible and magnificent geodiversity that ought to be understood and celebrated, because, quite simply, our modern society couldn't live without it.

2. Geoconservation of geoheritage is important because it protects the evidence for Earth history, the evolution of life and local palaeoenvironments. Geoconservation is supported and funded by society through:
   - international, national and local legislation and policy passed by elected representatives;
   - public funding;
   - local geoconservation initiatives on the ground, including educational ones.

Thank you for listening

Want to read more?

Gray, M. 2013.

Geodiversity: valuing and conserving abiotic nature.

2nd edition.

Wiley Blackwell, UK

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