

Geodiversity: redundant term or influential concept

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Origins & Criticisms

- The early development of the geodiversity concept took place in the 1990s in **Tasmania** (Kevin Kiernan, Chris Sharples, Mike Pemberton, Grant Dixon, Ian Houshold, Rolan Eberhard);
- However, most of the published criticism of the term derives from workers in **mainland Australia** (Bernie Joyce, E Stock, Cliff Ollier, Margaret Brocx, Vic Semeniuk);
- In a 2007 paper, Brocx & Semeniuk argued that “**the term geodiversity... should be applied only to region-specific or site-specific features. It should not be used to mean ‘diversity of all things geological’** because the term geology is broad enough in scope and scale...to carry that implication”.
- This was repeated in a recent paper (2019) in which they stated that “**use of the term geodiversity to refer to the ‘whole of Geology’ is a redundant use of the term** and is self-evidentiary.”



Brocx, M. & Semeniuk, V. (2019)

The ‘8Gs’ – a blueprint for geoheritage, geoconservation, geo-education and geotourism. *Aus J Earth Sci.*, 66, 803-821.

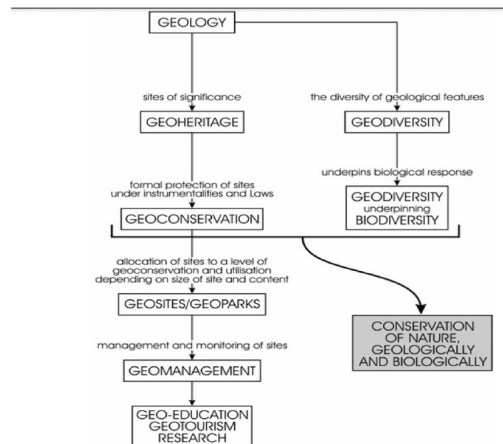


Figure 7. Conceptual diagram showing the sequential interrelationship between Geology, Geoheritage, Geoconservation, Geosites/Geoparks, Geomanagement, Geo-education and Geotourism. Geodiversity is brought in as a separate adjunct as a framework for understanding and managing the biodiversity of a region or locality.



Gray, M. & Gordon, J.E. (2020)

Geodiversity and the ‘8Gs’: a response to Brocx & Semeniuk (2019)
Aus J Earth Sci, 67, 437-444.

In response, John Gordon and I have argued that Geodiversity:

- should not be a “separate adjunct” but instead “deserves to have an absolutely central position” in the relationship between the ‘Gs’;
- does more than underpin biodiversity, important though that is;
- is a global concept, as well as being regional and local.

“The important point is that focusing on the diversity of geology, geomorphology, pedology and hydrology leads to **new insights, new avenues of research and new results**, and this is precisely what the last 25 years of geodiversity research have done, and hopefully will continue to do” (p. 443).

But what are these new insights, research avenues and results?



“New insights, new avenues of research, new results”?

Geodiversity-related topic	Description	Additional insights
1 Celebrating	Celebrating abiotic diversity has never been part of geoscience discourse	Exogeodiversity
2 Measuring	Measurement of geodiversity/geodiversity hotspots	
3 Geosystem services	Goods & services related to geodiversity, equivalent to 'ecosystem services'	Geology as part of 'natural capital'
4 Biodiversity	Geodiversity as the foundation for biodiversity	Conserving Nature's Stage' (CNS) and 'Small Natural Features' (SNFs)
5 Geomaterials	Use of diverse geomaterials in buildings, pavements, transport, household appliances, mobile phones, etc.	Other sources of geomaterials, e.g. deep ocean, other planets/moons/asteroids
6 Geotourism	Peoples' desire to visit different geological/ geomorphological locations	
7 Geoheritage	Geoheritage as part of geodiversity	Exogeoheritage
8 Geoconservation	Geodiversity as the backbone of geoconservation site selection; Geoconservation aims and methods	Georesource conservation/circular economy; Geodiversity, policy and land-use planning; Exogeconservation
9 Geoparks	Use of geodiversity to promote geoparks	
10 Sustainability	Geodiversity and UN Sustainable Development Goals (SDGs); Essential Geodiversity Variables (EGVs)	



1. Celebrating Geodiversity

Queen Mary University of London

Planet Earth represented as a smooth, steel sphere
= no geodiversity



Capelinhos, Azores Global 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.

Geoscientists have a long history of describing and explaining this variety but, in general, celebrating it has never been part of geoscience discourse.
Yet, understanding, valuing and celebrating the planet's geodiversity and its uses can enrich our lives.



The first IGD

- We should celebrate geodiversity every day but particularly on International Geodiversity Day starting on:
6th October 2022.
- Why 6th October?
 - We wanted a spring or autumn date so as to allow field activities in both hemispheres.
 - October was the month when a publication first used the term 'geodiversity' (Chris Sharples, Tasmania, October 1993).
 - 6th October was the first date in the month free of other international days.

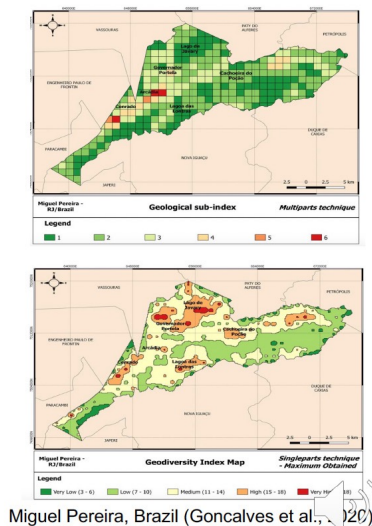


www.geodiversityday.org



2. Measuring Geodiversity

- A major spin-off of the geodiversity concept has been its measurement (cf. biodiversity measurement);
- Several groups are involved in developing methodologies, but most are based on existing maps of geology, topography, soils, hydrology, etc. or remote sensing images;
- The method generally involves placing a grid over an area and counting the number of types/features within each grid square.
- Finally, the geodiversity map is produced by combining the individual counts.



Measuring Geodiversity

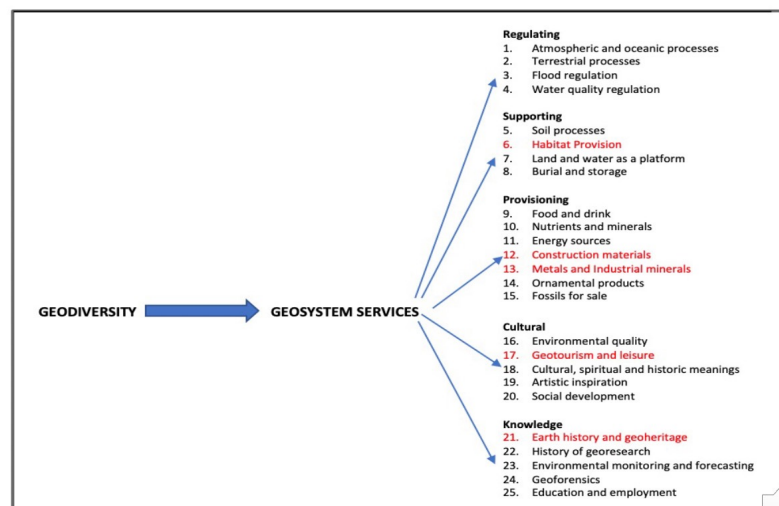
I have 3 concerns here:

- 1. It **undermines the full richness of geodiversity**, one of its most important characteristics, and which I've just encouraged everyone to celebrate. What's being measured is not total geodiversity since small scale features/subtle differences will be missed using small-scale maps and remote sensing images. So **what's being measured is the antithesis of true geodiversity**.
- 2. **Measurement ought to have a clear purpose** such as analyzing changes over time, relating geodiversity to biodiversity, or developing land management and planning, and **this is not always obvious from the studies**.
- 3. **This type of work shouldn't be used for geoconservation purposes** (i.e. for conserving areas of richest geodiversity) because important geosites can occur in areas of low geodiversity, and areas of high geodiversity may have no important geosites.

3. Geodiversity & Geosystem Services

- "Ecosystem services" (ES) 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;
- But the current approach is very biocentric, even though ecosystems are defined as including both biotic and abiotic nature.
- Because of this, I've identified about 25 abiotic services, that can be termed "geosystem services", **all of which result from the planet's geodiversity**.

Geosystem Services



Source: Chakraborty, A. & Gray, M. (2020) *J. Nature Conservation*, 56, 125862.

4. Geodiversity & Biodiversity



West Coast NP, S. Africa



Intertidal zone, Algarve, Portugal

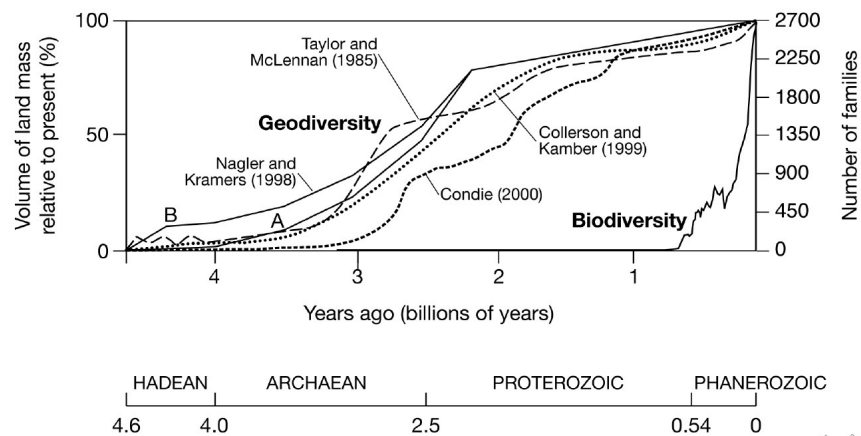


4. Geodiversity & Biodiversity

- Several cross-disciplinary research groups are now studying the links between geodiversity and biodiversity;
- Specifically, the focus on geodiversity has led to the "Conserving Nature's Stage" (CNS) approach.
- This uses the metaphor of geology/geomorphology as the stage while wildlife are the actors "that strut and fret" upon it;
- And Shakespeare has told us, "All the world's a stage" (*As You Like It*, Act II, Scene VII)
- It's now recognised that one of the best ways of conserving biodiversity is to conserve geodiversity.
- This is particularly relevant in times of climate/environmental change, allowing wildlife to migrate to suitable physical habitats, which therefore need to be conserved.



Evolution of Biodiversity and Geodiversity



Source: Chakraborty, A. & Gray, M. (2020) *J. Nature Conservation*, 56, 125862.

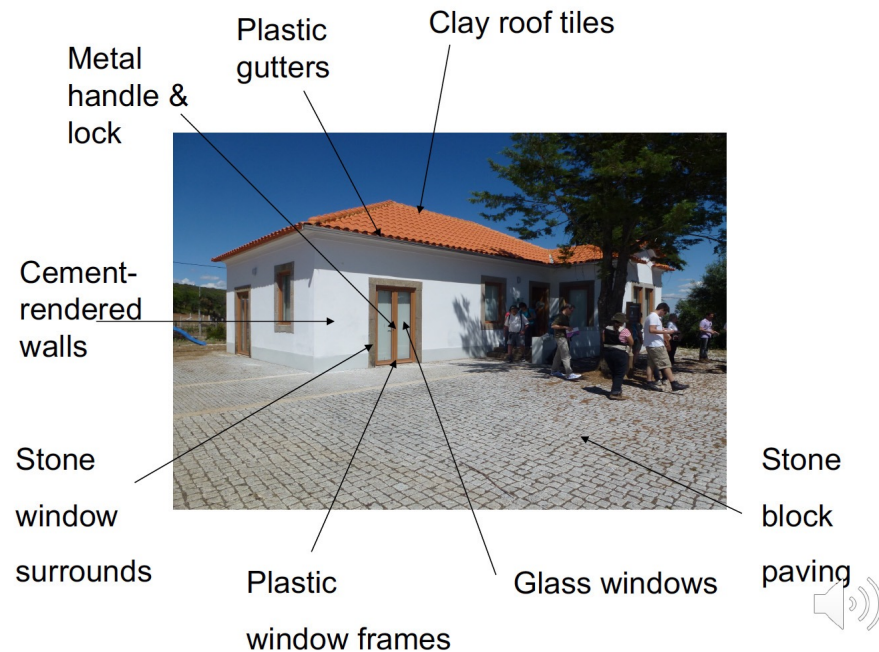


5. Geodiversity of Geomaterials



Copacabana, Rio de Janeiro, Brazil



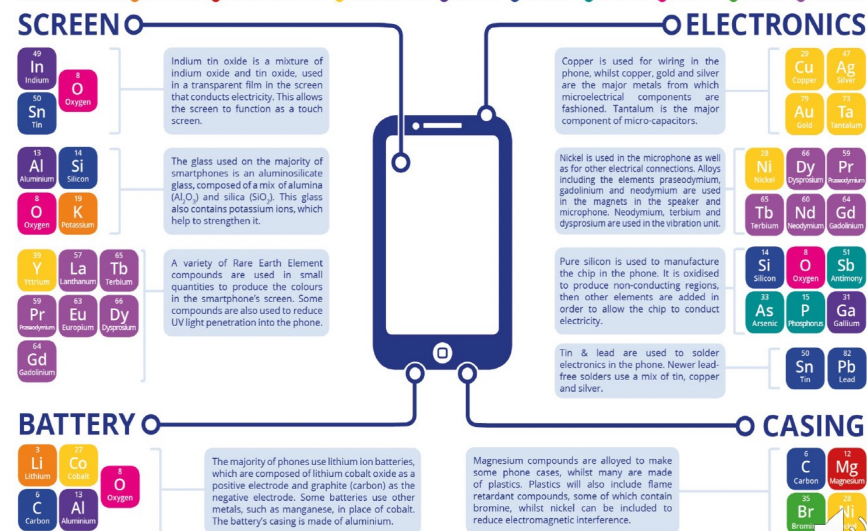


- Smartphones contain over 80% of the non-radioactive elements in the Periodic Table.
- These include several Rare Earth Elements such as indium (essential for screen scrolling) tantalum and neodymium.
- By definition, these are rare, difficult to recycle and could become scarce.
- Also, some are in countries where future supply may not be secure.
- As a result, attention is turning to exploration of other sources, e.g. deep sea or other celestial bodies.



ELEMENTS OF A SMARTPHONE

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



6. Geodiversity, Geotourism & Leisure

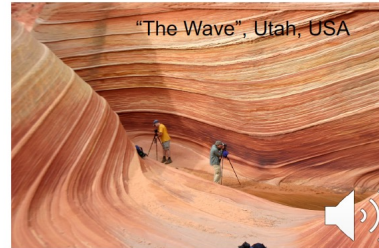
- “Madame, we do not go there as to paradise. We go to see something different from that we are accustomed to”.

(James Boswell, companion to Dr Samuel Johnson, to his wife (1773), quoted by Hose (2008))

- Tourism is about visiting different places;
- **Geotourism** is about visiting different geological/geomorphological places, and **is therefore based on geodiversity**.



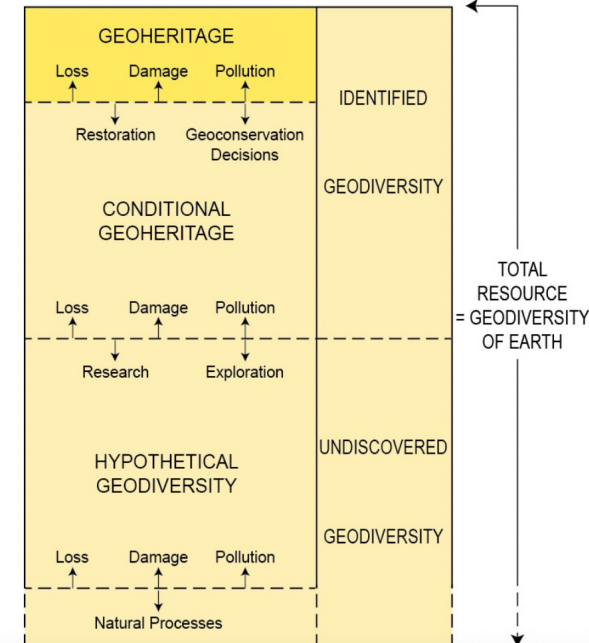
Geodiversity & Geotourism



Geotourism & Geodiversity of the Grand Canyon



Iguaçu Falls, Brazil/Argentina border "The world's best geotourism destination"?



7. Geoheritage

"those parts of the planet's geodiversity that may be specifically identified as having geoconservation significance" (Sharples, 2002)

8. Geodiversity & Geoconservation

The Geoconservation Equation

$$\text{Value} + \text{Threat} = \text{Conservation Need}$$

- 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.



World Heritage Sites

- At the international level, in 1994 UNESCO launched a Global Strategy aimed at making the WH List “representative, balanced and credible”, i.e. IUCN/UNESCO became more proactive and analytical;
- The aim was to identify and attempt to fill major gaps, thematic or spatial, in the List;
- For example, Dingwall et al. (2005) looked to see if the geological column is represented in the WH List and discovered a significant gap at the Silurian.



Geological Period 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) 47m years
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 Giorgio (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



Theme 1: History of planet Earth and the evolution of life

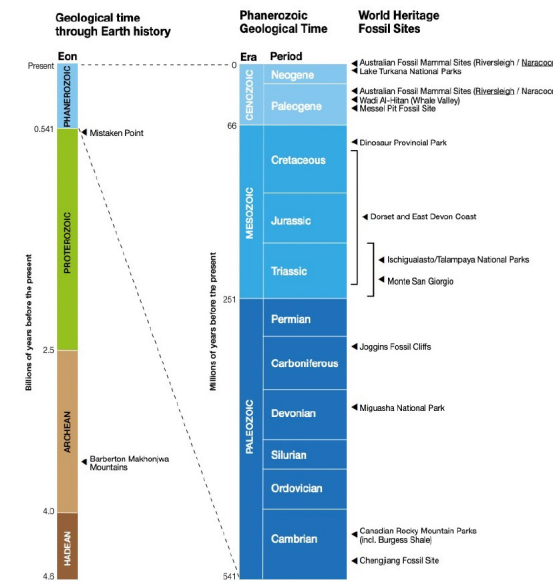


Figure 5: Temporal distribution of UNESCO Fossil Properties (Theme 1). Modified from Thomas and Narbonne, 2015, Fig. 3.4. Formal stratigraphic names and dates are from the International Chronostratigraphic Chart (May 2021)



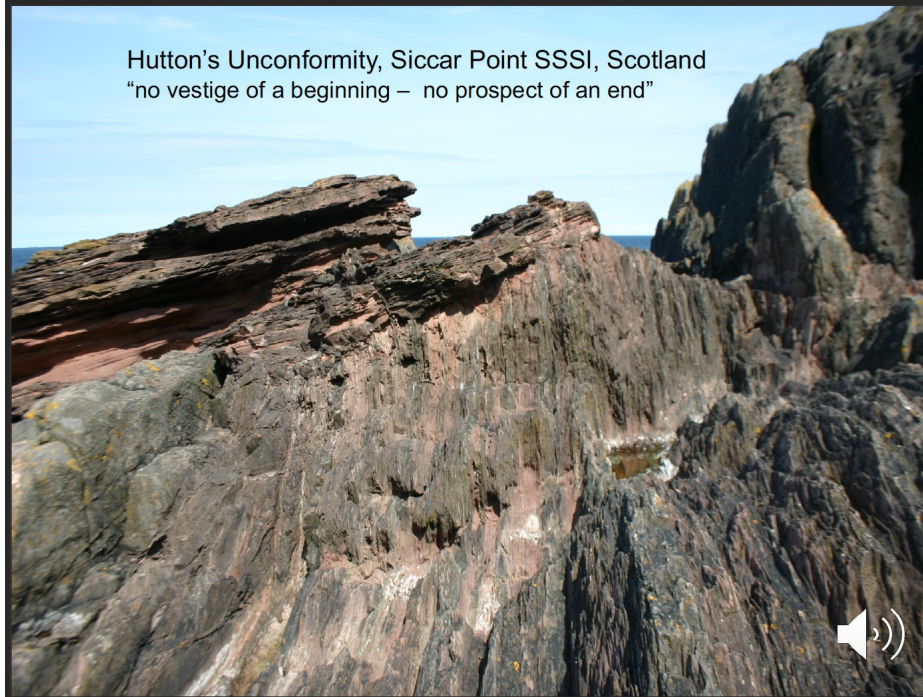
Filling Gaps

- UNESCO/IUCN are also interested in filling thematic gaps, and have commissioned a number of studies aimed at reviewing existing WH sites, those on national Tentative Lists and important sites not on either list:
 - Fossil sites (Wells, 1996);
 - Caves & Karst (Williams, 2008);
 - Volcanoes (Wood, 2009; Casadevall et al., 2019)
 - Desert Landscapes (Goudie & Seely, 2011)
- So in all these studies, there is a sense of trying to ensure that the World Heritage List is **representative** of the **temporal** and **thematic** aspects of the world's **geodiversity**.



National Geoconservation Sites

- Many countries, including UK, Ireland, USA, Spain, New Zealand, select their geoconservation sites to **represent the geodiversity of these countries**.
- In the UK, the main network of conservation sites is the Sites of Special Scientific Interest (SSSI) network;
- One of the 3 ways in which these sites are selected 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).
- So, there is a sense here of intending to establish a network of sites that **represents Britain’s geodiversity**.



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



9. Geodiversity & Geoparks

- A survey of the European Geoparks reveals that, as a network, they demonstrate the great geodiversity of European geology;
- Some geoparks are based on a single type of geological feature e.g. Vulkaneifel Geopark, Germany;
- But even these demonstrate how a single type can demonstrate internal diversity. E.g. “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.





- Is described as having “Extreme Geodiversity in an old rifted continent”
- “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” (Dahlgren, 2006).



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”.

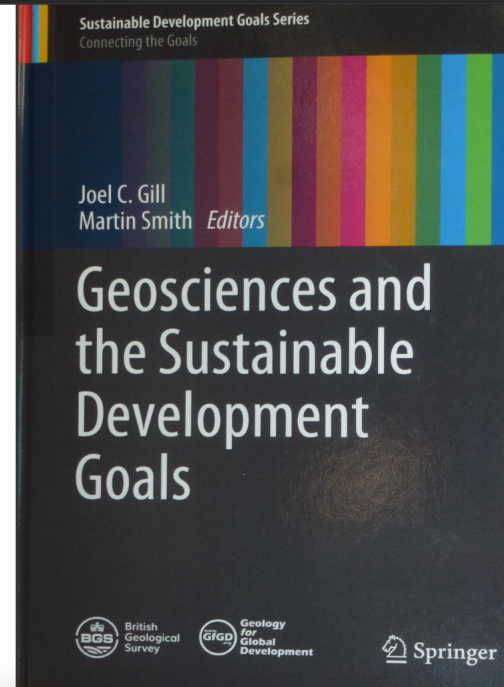
N.W. Highlands Geopark, UK

“The Geopark contains some of the most important and **diverse** geological and geomorphological features in Britain”.



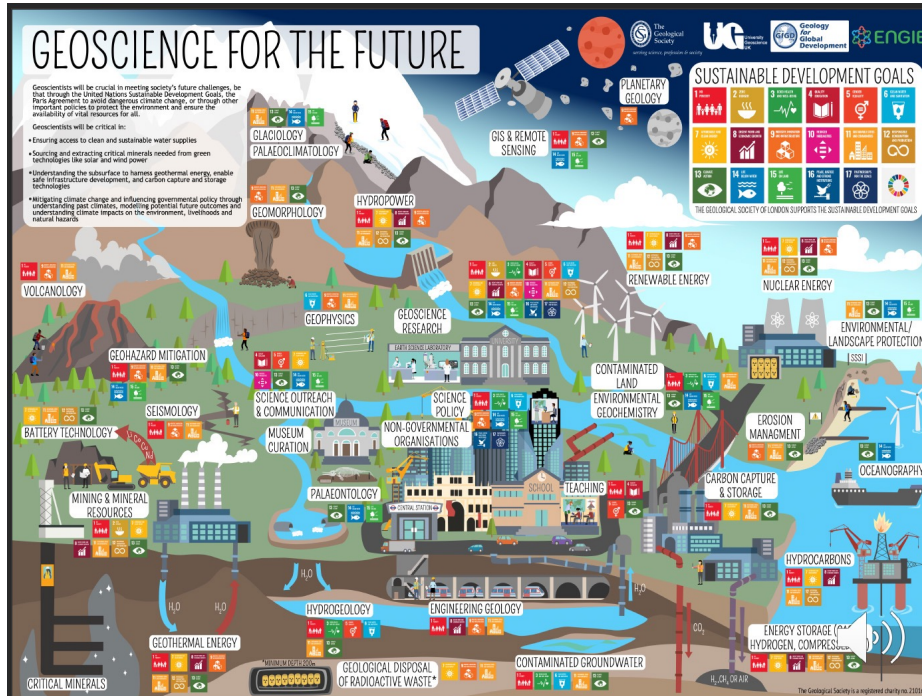
10. Geodiversity & Sustainable Development

In 2015, the United Nations adopted a series of 17 Sustainable Development Goals (SDGs) and 169 individual targets with the aim of achieving these within 15 years, i.e. by 2030.



- **The geosciences were not involved in framing these goals and targets** and yet they need to be closely involved in achieving them as this book demonstrates.
- And it's the geodiversity of the planet that's an important key to achieving them.



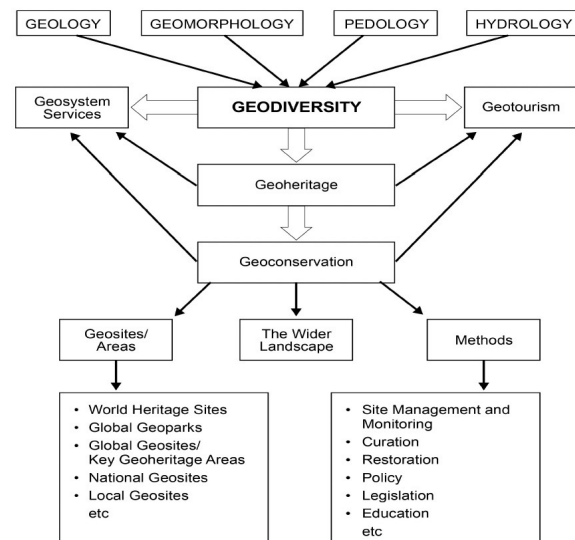


Conclusions

- So, 'geodiversity' has spawned a very wide spectrum of **new insights, new research avenues and new results**;
- Boothroyd & McHenry's (2019) online search found nearly 1000 articles published between 1993 and 2019 that had used the terms 'geodiversity' or 'geological diversity';
- Hopefully, the above brief outlines have demonstrated that geodiversity:
 - is global, as well as regional/local, just as biodiversity is;
 - is more than just related to biodiversity, important though that is.
 - is absolutely central to any relationship between the 'Gs';
 - is therefore, not a "redundant" term but instead is a significant, evolving, multi-faceted, geoscience paradigm.



Geodiversity & the 'Gs'



Source: Gray & Gordon (2020)



Thank you for listening...

...and thanks to everyone who has encouraged and helped me develop these ideas over the last 25 years.

Want to read more?

Gray, M. (2013).

Geodiversity: valuing and conserving abiotic nature.

2nd edition.

Wiley Blackwell, UK

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