

# Geodiversity, Geoheritage and Geoconservation: A Global Perspective

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## ABSTRACT

In recent decades, the growing awareness and necessity of dealing with geodiversity and geoheritage has drawn the attention of the global geoscientific community to conserving and safeguarding it. As a result, the global initiatives, reinforced by the efforts of the regional and local geological communities, have led to a paradigm shift in how geodiversity (diverse geological elements) and geoheritage (geological heritage) are perceived. The efforts and actions of some nations in conserving geodiversity and geoheritage have been exemplary, while others are still in a nascent stage and a few still need to awaken. The concepts of geodiversity, geoparks, geoheritage, and geoconservation are the fruits of the efforts of many global and regional organizations. The collective efforts of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Union for Conservation of Nature (IUCN), Global Geoparks Network (GGN), and the International Union of Geological Sciences (IUGS) have brought the attention of the global geoscientific community, policymakers and governments of almost all nations to ponder the issues of geodiversity and geoheritage. These globally recognised organisations have been at the forefront and their initiatives have permitted the conservation of some significant geological heritage and have demonstrated that they can pave a new path for more sustainable development. These organisations have worked in tandem for the past few decades and have been successful in identifying and designating some of the outstanding and geologically significant sites/geosites as ‘Natural World Heritage Sites’, ‘UNESCO Global Geoparks’. The novel ideas and statutes defining global designation criteria and protocols by these organisations are there to enthuse and encourage earth scientists, policymakers, the public, and governments of all nations to frame their own national and local statutes for the identification and conservation of outstanding national geoheritage and to further integrate them with the international organisations for global designations.

## INTRODUCTION

The Earth is a unique and beautiful example of biodiversity and geodiversity. The geological history of the Earth reveals a lot about how this planet has changed over the last 4.6 billion years in terms of biodiversity, geodiversity, the environment, continents, seas, and landforms, among other things. However, in this consumerism-driven global economy, geodiversity and biodiversity have suffered a huge

damage. The world has lost, and continues to lose, glaciers, forests, rivers, landforms, and lifeforms, resulting in a rapid loss of biodiversity and geodiversity. It becomes imperative to hold on and protect our Earth’s heritage (both biological and geological), as this natural heritage holds the key to our sustainable existence. Humans need to employ their supposed wisdom as “Homo Sapiens” to preserve geological heritage to be able to understand the present Earth and protect its future. The conscious efforts of international organisations such as the United Nations Educational, Scientific, and Cultural Organization; the International Union for Conservation of Nature; the Global Geoparks Network; and the International Union of Geological Sciences have given a global perspective to the most vital geological components of the earth that need immediate consideration.

## GEODIVERSITY, GEOHERITAGE, UNESCO GLOBAL GEOPARKS, IUGS GEOLOGICAL HERITAGE SITES, IUGS HERITAGE STONES, AND GEOCONSERVATION: TERMINOLOGY AND CONCEPTS

It is crucial to understand terms like “geodiversity,” “geoheritage,” “UNESCO Global Geoparks,” “IUGS Geological Heritage Sites,” and “IUGS Heritage Stones,” which are sometimes used interchangeably and cause a lot of misunderstanding. The term “geodiversity,” pertaining to abiotic, non-living elements of the landscape, was coined almost three decades ago and, in essence, is the equivalent of biodiversity, a term which is commonly used for biotic diversity on the earth (Sharples, 1993; Wiedenbein, 1993; Gray, 2018; Gray, 2019; Gordon et al., 2021). It is now an internationally recognised term which includes a wide range of geological materials (rocks, minerals, fossils, sediments, and soils) and geomorphological features (landforms), as well as the natural processes that shape and transform them ([https://www.iucn.org/sites/dev/files/progeo\\_leaflet\\_en\\_2017.pdf](https://www.iucn.org/sites/dev/files/progeo_leaflet_en_2017.pdf); Gray, 2013, 2018, 2019; Crofts et al., 2020; Gordon et al., 2021). However, the term ‘geodiversity’ has had its share of fame and criticism in its usage (Gray, 2008, 2013; Reynard and Brilha, 2018 and references cited therein). Geodiversity can also be described as a value-neutral term comparable to biodiversity and describes natural abiotic phenomenon and processes which led to the creation of natural geological sites and materials on Earth (Brilha, 2018). Geoheritage refers to the geological heritage of great value/significance that is valued by humans for its science, education, aesthetics, cultural and economic aspects ([https://www.iucn.org/sites/dev/files/progeo\\_leaflet\\_en\\_2017.pdf](https://www.iucn.org/sites/dev/files/progeo_leaflet_en_2017.pdf); Sharples, 1993; Gray, 2019; Gordon et al., 2021 and references cited therein). Geoheritage can also be defined

as a value-laden term and is valued for its scientific, educational, cultural, and aesthetic aspects (Brilha, 2018; Gray, 2019 and references cited therein). It can be a geosite or geological heritage site (the point or area of interest), or lithic materials (geocollections, stone and rocks used in monuments, quarries). These sites and materials merit selection for global designation and geoconservation.

To give a better understanding, the definitions of geodiversity, geoheritage, UNESCO Global Geopark, IUGS Geological Heritage Site, IUGS Heritage Stone, and geoconservation from reliable sources are listed below:

*“Geodiversity is the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landforms, topography, physical processes), soil and hydrological features. It includes their assemblages, structures, systems and contributions to landscapes” (Source: Gray, 2013)*

*“Geodiversity refers to the variety of the geological and physical elements of nature, such as minerals, rocks, soils, fossils and landforms, and active geological and geomorphological processes. Together with biodiversity, geodiversity constitutes the natural diversity of planet Earth” (Source: <https://www.iucn.org/theme/world-heritage/our-work/global-world-heritage-projects/geodiversity-world-heritage-and-iucn>).*

*“The term ‘geodiversity’ encompasses all aspects of the natural non-living materials and processes that formed our planet and continue to shape both its interior and surface today. This broad definition not only includes geological materials (such as modern sediments, rocks, minerals, meteorites and fossils), the processes that formed them (including by rivers and volcanic activity) and the landforms created by such processes (for example cliffs and glacier-cut valleys), it also includes Earth materials removed from a natural to a cultural context, for instance to museums or used as building stones or in jewelry” (Source: [https://geoheritage-iugs.mnhn.fr/media/pays/terms\\_of\\_reference\\_of\\_commission\\_on\\_geoheritage\\_final.pdf](https://geoheritage-iugs.mnhn.fr/media/pays/terms_of_reference_of_commission_on_geoheritage_final.pdf))*

*“Geodiversity is the variety of nature elements, such as minerals, rocks, fossils, landforms and their landscapes, soils, and active geological/geomorphological processes. Together with biodiversity, geodiversity constitutes the natural diversity of planet Earth. Geodiversity underpins biodiversity and provides society with benefits based on regulating, supporting, provisioning, and cultural services” (Source: [https://www.iucn.org/sites/dev/files/progeo\\_leaflet\\_en\\_2017.pdf](https://www.iucn.org/sites/dev/files/progeo_leaflet_en_2017.pdf)).*

*“Geoheritage is the abbreviated version of the term geological heritage. It is part of the natural heritage of a certain area constituted by geodiversity elements with particular geological value and hence worthy of safeguard for the benefit of present and future generations. Geoheritage can include both in situ elements (geosites) or ex situ elements (collections of geological specimens) with paleontological, geomorphological, mineralogical, petrological or stratigraphical significance, among others” (Source: [https://www.iucn.org/sites/dev/files/progeo\\_leaflet\\_en\\_2017.pdf](https://www.iucn.org/sites/dev/files/progeo_leaflet_en_2017.pdf)).*

*“UNESCO Global Geoparks are single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development’ (Source: <https://en.unesco.org/global-geoparks>)*

*“An IUGS Geological Heritage Site is a key place with geological elements and/or processes of scientific international relevance, used as a reference, and/or with a substantial contribution to*

*the development of geological sciences through history” (Source: Definition from IUGS Geological Heritage Sites document via Per. Comm. with Asier Hilario, Chair-International Commission on Geoheritage).*

*“An IUGS Heritage Stone (HS) is an IUGS designated natural stone that has been used in significant architecture and monuments, recognized as integral aspects of human culture” (Source: Definition given in IUGS Subcommittee on Heritage Stones documents).*

*“Geoconservation includes set of actions aimed at informing the management of geological sites comprising inventory and assessment, conservation, statutory protection, interpretation, and monitoring of sites” ([https://www.iucn.org/sites/dev/files/progeo\\_leaflet\\_en\\_2017.pdf](https://www.iucn.org/sites/dev/files/progeo_leaflet_en_2017.pdf)).*

## **UNESCO, THE IUCN, THE GNN, AND THE IUGS: GEO-HERITAGE IDENTIFICATION AND DESIGNATION**

In geoheritage identification and designation, UNESCO, the IUCN, the GNN, and the IUGS all play an important role. The UNESCO Global Geopark designation benefits outstanding sites and landscapes all over the world that contain significant geological, natural, cultural, and intangible heritage, hence supporting sustainable development goals (<https://www.visitgeoparks.org/what-are-geopark>). UNESCO has now a clear role in supporting Global Geoparks through a link introduced in 2001 and consolidated as UNESCO Global Geoparks in 2015 (<https://en.unesco.org/global-geoparks>; <https://www.visitgeoparks.org/what-are-geopark>). The UNESCO supports the 195 Member States’ to establish Global Geoparks around the globe in close association with Global Geopark Network. Regional and National Geopark Committees form the essential components of the Global Geopark Network (refer to Sections 4.4 and 4.5 in the Operational Guidelines for UNESCO Global Geoparks from the link [http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IGGP\\_UGG\\_Statutes\\_Guidelines\\_EN.pdf](http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IGGP_UGG_Statutes_Guidelines_EN.pdf)). The most important fundamental aspect of a UNESCO Global Geopark is that it should be based on sustainable development and involve local communities in a bottom-up approach. UNESCO’s flagship geoscience programme, the International Geoscience and Geoparks Programme (IGGP), works in cooperation with the International Union of Geological Sciences and the Global Geoparks Network, leading to the formal designation of a fundamental building block of geoparks that includes geosites and landscapes with internationally significant geoscientific value. A UNESCO Global Geopark must contain internationally significant geosites and landscapes evaluated by the experts from IUGS-ICG. The requirements listed in the Operational Guidelines must be met in order for an application to be considered for UNESCO Global Geopark designation. (Table 1). At the end of April 2022, 177 Global Geoparks representing 46 countries had been ratified, with China taking the lead with 44 UGGps (<https://unesdoc.unesco.org/ark:/48223/pf0000377255>; <https://en.unesco.org/global-geoparks/list>).

In 2004, the Global Geoparks Network was instituted in partnership with UNESCO by the European and Chinese Geopark networks at UNESCO headquarters in Paris ([http://globalgeoparksnetwork.org/?page\\_id=5](http://globalgeoparksnetwork.org/?page_id=5); <http://globalgeoparksnetwork.org/>). The Global Geopark Network officially became an international association of the Global Geoparks and Global Geoparks professionals in the year 2014 (<http://globalgeoparksnetwork.org/>). It is currently a non-governmental organization (NGO) grouping all UNESCO Geoparks in the world (<https://www.visitgeoparks.org/>). The Global Geopark Network’s mission is to conserve and manage important earth heritage, landscapes and geological formations. Global Geoparks advocate sustainable development through geotourism and education ([http://globalgeoparksnetwork.org/?page\\_id=202](http://globalgeoparksnetwork.org/?page_id=202)). They encourage the

**Table 1.** List of criteria for designation of UNESCO Global Geoparks (Source: [http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IGGP\\_UGG\\_Statutes\\_Guidelines\\_EN.pdf](http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IGGP_UGG_Statutes_Guidelines_EN.pdf); <https://en.unesco.org/global-geoparks/how-to-become-geopark>).

S. No.	Criteria no.	Description
1.	(i)	UNESCO Global Geoparks must be single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education, research and sustainable development. A UNESCO Global Geopark must have a clearly defined border, be of adequate size to fulfil its functions and contain geological heritage of international significance as independently verified by scientific professionals.
2.	(ii)	UNESCO Global Geoparks should use that heritage, in connection with all other aspects of that area's natural and cultural heritage, to promote awareness of key issues facing society in the context of the dynamic planet we all live on, including but not limited to increasing knowledge and understanding of: geoprocesses; geohazards; climate change; the need for the sustainable use of Earth's natural resources; the evolution of life and the empowerment of indigenous peoples.
3.	(iii)	UNESCO Global Geoparks should be areas with a management body having legal existence recognized under national legislation. The management bodies should be appropriately equipped to adequately address the area of the UNESCO Global Geopark in its entirety.
4.	(iv)	In the case where an applying area overlaps with another UNESCO designated site, such as a World Heritage Site or Biosphere Reserve, the request must be clearly justified and evidence must be provided for how UNESCO Global Geopark status will add value by being both independently branded and in synergy with the other designations.
5.	(v)	UNESCO Global Geoparks should actively involve local communities and indigenous peoples as key stakeholders in the Geopark. In partnership with local communities, a co-management plan needs to be drafted and implemented that provides for the social and economic needs of local populations, protects the landscape in which they live and conserves their cultural identity. It is recommended that all relevant local and regional actors and authorities be represented in the management of a UNESCO Global Geopark. Local and indigenous knowledge, practice and management systems should be included, alongside science, in the planning and management of the area.
6.	(vi)	UNESCO Global Geoparks are encouraged to share their experience and advice and to undertake joint projects within the GGN. Membership of GGN is obligatory.
7.	(vii)	A UNESCO Global Geopark must respect local and national laws relating to the protection of geological heritage. The defining geological heritage sites within a UNESCO Global Geopark must be legally protected in advance of any application. At the same time, a UNESCO Global Geopark should be used as leverage for promoting the protection of geological heritage locally and nationally. The management body must not participate directly in the sale of geological objects such as fossils, minerals, polished rocks and ornamental rocks of the type normally found in so-called "rockshops" within the UNESCO Global Geopark (regardless of their origin) and should actively discourage unsustainable trade in geological materials as a whole. Where clearly justified as a responsible activity and as part of delivering the most effective and sustainable means of site management, it may permit sustainable collecting of geological materials for scientific and educational purposes from naturally renewable sites within the UNESCO Global Geopark. Trade of geological materials based on such a system may be tolerated in exceptional circumstances, provided it is clearly and publicly explained, justified and monitored as the best option for the Global Geopark in relation to local circumstances. Such circumstances will be subject to approval by the UNESCO Global Geoparks Council on a case by case basis.

creation of regional networks to streamline the process of identification of Global Geoparks, and their geoheritage sites reflecting local conditions. They promote networking and collaboration amongst the regional and national geopark committees to facilitate recognition and preservation of geoparks, aiming at the regional sustainable development (<http://globalgeoparksnetwork.org/wp-content/uploads/2017/03/SPOT-GGN.mp4>). Currently, the Global Geopark Network works in close association with its regional counterparts such as the European Geoparks Network (EGN), Asia Pacific Geoparks Network (APGN), African UNESCO Global Geoparks Network (AUGGN), Latin American and Caribbean Geoparks Network (GeoLAC), Canadian Geoparks Network (CGN) and individual and honorary members (<https://www.visitgeoparks.org/geopark-our-network>; [http://globalgeoparksnetwork.org/?page\\_id=5](http://globalgeoparksnetwork.org/?page_id=5)).

UNESCO has ten World Heritage Site designation criteria (Table 2; <https://whc.unesco.org/en/guidelines/>; Mc Keever and Narbonne, 2021; <https://portals.iucn.org/library/sites/library/files/documents/2021-025-En.pdf>). The first six criteria are for cultural site designation and the last four criteria are for natural site designation. The IUCN provides official advice to UNESCO for the evaluation and designation of World Heritage Natural Sites. IUCN focuses on diverse themes (<https://www.iucn.org/theme>), related to the conservation and protection of the natural world with strategies for sustainable development involving local communities/indigenous inhabitants (<https://www.iucn.org/about>). IUCN comprises member organizations

and experts from both government and civil society. The criterion (viii) of the Table 2 for UNESCO Natural World Heritage Site designation is based on the geological themes proposed by the International Union for Conservation of Nature in 2005 and 2021 (Table 3; <https://portals.iucn.org/library/sites/library/files/documents/Rep-2005-009.pdf>, <https://portals.iucn.org/library/sites/library/files/documents/2021-025-En.pdf>). The IUCN report "*Geological World Heritage: A Global Framework*" published in 2005 defined thirteen (13) geological and geomorphological topics that have been fully reviewed and re-framed in 2021, particularly in light of the recently established UNESCO Global Geoparks label (Dingwall et al., 2005; <https://portals.iucn.org/library/sites/library/files/documents/Rep-2005-009.pdf>; Mc Keever and Narbonne, 2021; <https://portals.iucn.org/library/sites/library/files/documents/2021-025-En.pdf>). This latest 2021 IUCN report entitled "*Geological World Heritage: A revised global framework for the application of criterion (viii) of the World Heritage Convention*" (Mc Keever and Narbonne, 2021; <https://portals.iucn.org/library/sites/library/files/documents/2021-025-En.pdf>) emphasizes that significant geological elements which are instrumental in understanding the Earth need recognition at a global level, and that there are still missing features or underrepresented elements on the World Heritage list. The report also observes a lopsided global scenario in terms of the designation of World Heritage sites exhibiting significant geological heritage. There are sites in Africa, Arab states, and Latin America, and countries in such areas are way behind in getting their

**Table 2.** List of criteria outlining Outstanding Universal Value (OUV) for selection of a site to be designated as a World Heritage Site (Source: <https://whc.unesco.org/en/criteria/>).

S. no.	Criteria no.	Description	A few Examples of the World Heritage Sites designated based on the criteria
1.	(i)	To represent a masterpiece of human creative genius;	Taj Mahal, India; <a href="http://whc.unesco.org/en/list/252">http://whc.unesco.org/en/list/252</a> Angkor, Cambodia; <a href="http://whc.unesco.org/en/list/668">http://whc.unesco.org/en/list/668</a>
2.	(ii)	To exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design;	Angkor, Cambodia; <a href="http://whc.unesco.org/en/list/668">http://whc.unesco.org/en/list/668</a> Historic Centre of Prague, Czech Republic; <a href="http://whc.unesco.org/en/list/616">http://whc.unesco.org/en/list/616</a>
3.	(iii)	To bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared	Angkor, Cambodia; <a href="http://whc.unesco.org/en/list/668">http://whc.unesco.org/en/list/668</a>
4.	(iv)	To be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history	Angkor, Cambodia; <a href="http://whc.unesco.org/en/list/668">http://whc.unesco.org/en/list/668</a> Historic District of Old Québec, Canada; <a href="http://whc.unesco.org/en/list/300">http://whc.unesco.org/en/list/300</a>
5.	(v)	To be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change	Landscape of Grand Pré, Canada; <a href="http://whc.unesco.org/en/list/1404">http://whc.unesco.org/en/list/1404</a>
6.	(vi)	To be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. (The Committee considers that this criterion should preferably be used in conjunction with other criteria)	Landscape of Grand Pré, Canada; <a href="http://whc.unesco.org/en/list/1404">http://whc.unesco.org/en/list/1404</a>
7.	(vii)	To contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance	Great Barrier Reef, Australia; <a href="http://whc.unesco.org/en/list/154">http://whc.unesco.org/en/list/154</a> China Danxia; <a href="http://whc.unesco.org/en/list/1335">http://whc.unesco.org/en/list/1335</a>
8.	(viii)	To be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features	Great Barrier Reef, Australia; <a href="http://whc.unesco.org/en/list/154">http://whc.unesco.org/en/list/154</a> Chengjiang Fossil Site, China; <a href="http://whc.unesco.org/en/list/1388">http://whc.unesco.org/en/list/1388</a> China Danxia; <a href="http://whc.unesco.org/en/list/1335">http://whc.unesco.org/en/list/1335</a>
9.	(ix)	To be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals	Great Barrier Reef, Australia; <a href="http://whc.unesco.org/en/list/154">http://whc.unesco.org/en/list/154</a>
10.	(x)	To contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation	Great Barrier Reef, Australia; <a href="http://whc.unesco.org/en/list/154">http://whc.unesco.org/en/list/154</a>

significant geological sites designated (<https://www.iucn.org/news/world-heritage/202107/new-iucn-report-assesses-potential-more-geological-world-heritage>). The 2021 report encourages the State Parties/Member states to recognize the outstanding geological heritage and propose them for evaluation to get the status of Natural World Heritage Site. The 2021 IUCN report lists eleven (11) geological and geomorphological themes for recognition and designation of geologically important Natural World Heritage sites, which fit well into the geological criterion (viii) (Table 2 and 3; <https://portals.iucn.org/library/sites/library/files/documents/2021-025-En.pdf>). To date, 1154 properties have been listed as UNESCO World Heritage Sites, which include 897 cultural sites, 218 natural sites, and 39 mixed sites (<http://whc.unesco.org/en/list/>). Only 93 of 1154 World Heritage Sites have fulfilled criteria (viii) enumerating the geological significance of these sites (<https://www.iucn.org/news/world-heritage/202107/new-iucn-report-assesses-potential-more-geological-world-heritage>).

The 2021 IUCN report also suggests how the UNESCO World Heritage and UNESCO Global Geopark designations can complement each other (Mc Keever and Narbonne, 2021; <https://portals.iucn.org/library/sites/library/files/documents/2021-025-En.pdf>). Consider the example of China Danxia, which is a UNESCO World Heritage Natural Site, based on criterion (vii) and (viii) (Table 2; <https://whc.unesco.org/>

[en/list/1335](http://whc.unesco.org/en/list/1335)). Since 2015, China Danxia, has also been classified as a UNESCO Global Geopark (<https://en.unesco.org/global-geoparks/danxiashan>). It is imperative to mention that criteria for evaluating 'Outstanding Universal Value' for a proposed heritage site have to be met and not all heritage sites can make it to the World Heritage List (Table 2; <https://whc.unesco.org/en/criteria/>). Similarly, only internationally significant geological sites can form the basis of the UNESCO Global Geoparks designation (<https://en.unesco.org/global-geoparks/how-to-become-geopark>). In fact, a site having 'Outstanding Universal Value' or high geoscientific value can become UNESCO World Heritage or Global Geopark if all requirements for protection, management, sustainable development and community inclusion are also met.

Stones have played a significant role as recorders of our cultural evolution, and as a result, they should be recognised as an important criterion for the nomination of stone-built Cultural World Heritage Sites. Hence, it is proposed that the stone characteristics and quarry details of the stones used in stone-built UNESCO Cultural World Heritage Sites be included in the criteria for designation of World Heritage Sites listed in Table 2, as this will add to the value of education, which is one of UNESCO's main goals. The new criteria for stone, its quarries, and details on the origin and nature of the stones can be included in the UNESCO list of criteria for Cultural World Heritage

**Table 3.** List of eleven geological themes for designation of the World Heritage Properties (Source: Mc Keveer and Narbonee, 2021; <https://portals.iucn.org/library/sites/library/files/documents/2021-025-En.pdf>).

Theme No.	Name of the theme	Brief Description of the individual theme is given here (for details on each theme please refer to the IUCN report 2021 and references cited therein. The report can be downloaded from the link: <a href="https://portals.iucn.org/library/sites/library/files/documents/2021-025-En.pdf">https://portals.iucn.org/library/sites/library/files/documents/2021-025-En.pdf</a> )	A few Examples of the World Heritage Properties designated based on individual theme which fulfils criteria (viii) pertaining to geological heritage of OUV given in Table 1. For complete list of World Heritage Properties based on each theme please refer to the link: <a href="https://portals.iucn.org/library/sites/library/files/documents/2021-025-En.pdf">https://portals.iucn.org/library/sites/library/files/documents/2021-025-En.pdf</a>
1.	History of planet Earth and the evolution of life	This theme documents major events in Earth history and the fossil record of life	Dinosaur Provincial Park, Canada; Shark Bay, Western Australia, Australia
2.	Tectonic systems	This theme includes the 'Tectonic and structural features' and the 'Mountain systems'. The theme includes mountain ranges, convergent plate boundaries (subduction zones), divergent plate boundaries (ocean ridges), sliding plate boundaries (transform zones), continental rift valleys and cratonic shields.	Volcanic systems have been kept out of this theme and have been included as a separate theme. Gondwana Rainforests of Australia, Australia; Three Parallel Rivers of Yunnan Protected Areas, China.
3.	Erosional systems	The theme 'Erosional systems' include "significant on-going geological in fact, geomorphological processes in the development of landforms" and these processes may produce "significant geomorphological or physiographical features."	Grand Canyon National Park, United States of America; The Dolomites, Italy
4.	Volcanic systems	Volcanoes are true wonders of the planet; they are central to the formation, evolution and sustenance of biological systems; they form some of our deepest and most significant cultural attachments to the land; and they attract large numbers of visitors for their aesthetic appeal.	Yellowstone National Park, United States of America; Tongariro National Park, New Zealand
5.	River, lake and delta systems	The theme covers fluvial, lacustrine and deltaic landscapes and their associated features and the processes which formed them. Waterfalls are also included under this theme.	The erosional features are covered primarily by Theme 3 given above. In terms of deltas, this theme only covers the special cases of inland and inverted deltas, while coastal deltas are covered within Theme 7. There is also some overlap with Theme 9, as many important fluvial, lacustrine and deltaic processes and landforms occur in glacial landscapes. Nahanni National Park, Canada; Willandra Lakes Region, Australia
6.	Cave and karst systems	The theme covers systems developed predominantly by the process of dissolution of soluble rocks. This mainly involves carbonate rocks (limestone, dolomite, marble) and evaporate rocks (gypsum, salt). In these terrains drainage disappears in enclosed depressions, rivers sink underground, and caves are signature landforms. Some sandstone landscapes are also included because these rocks can become relatively soluble under subtropical and tropical conditions.	Mammoth Cave National Park, United States of America; South China Karst, China
7.	Coastal systems	Coastal systems refer to physical processes and physiographical features present in the coastal zone.	Everglades National Park, United States of America; Gulf of Porto: Calanche of Piana, Gulf of Girolata, Scandola Reserve, France
8.	Marine systems	Marine systems includes seafloor and submarine features, coral islands, reefs and oceanic islands. The theme encompasses "significant on-going geological processes in the development of landforms, or significant geomorphological features" found in the shallow and deep marine areas. Geological features of marine areas including physical, chemical and biological processes, tectonic settings and sedimentary environments including continental shelf and slope, basin floors, abyssal plains, oceanic trenches, submarine ridges are included in this theme.	Great Barrier Reef, Australia
9.	Glacial and periglacial systems	This theme includes geological processes, landscape and geomorphological features developed by past or present glacial and periglacial systems. This includes 17% of the World Heritage Properties inscribed under criterion (viii) for their OUV (primary elements).	Kluane / Wrangell-St. Elias / Glacier Bay / Tatshenshini-Alsek, Canada and United States of America; Tasmanian Wilderness, Australia
10.	Desert and semi-desert systems	The theme covers aeolian processes and landforms, as well as features produced by intermittent runoff and evaporation. Thus, it includes landscape features such as dunes and dune fields of various types and sizes, yardangs, deflation hollows, wadis and playas.	El Pinacate and Gran Desierto de Altar Biosphere Reserve, Mexico; Namib Sand Sea, Namibia
11.	Meteorite impacts	The theme of Meteorite impacts includes features produced by the impacts of meteors, comets, asteroids and other extraterrestrial objects with the Earth, including both physical structures formed by extra-terrestrial impacts, such as impact craters, as well as major effects caused by them, such as mass extinction.	Vredefort Dome, South Africa; Stevns Klint, Denmark

Site designation, as has been done in the case of Natural World Heritage Site designation by incorporating the geological criterion (viii). Many Cultural World Heritage Sites, such as the Taj Mahal of India, Malta's Megalithic Temples, the United Kingdom's Stonehenge, and India's Elephanta Cave Temples, have indeed been carved in stone and reveal a great deal about our past cultures, but there are no specific criteria for these unique stones in the list of criteria for designation of Cultural World Heritage Sites (Table 2). IUGS has led the way in identifying and designating significant stones as IUGS Heritage Stones, which have been used in iconic heritage monuments and reveal our cultural evolution (Kaur et al., 2020a; Kaur et al., 2021a; Kaur, 2022 and references cited therein)

The International Union of Geological Sciences is one of the most important international geological organisation that deals directly with geosciences and geological problems and fosters international cooperation in earth sciences. IUGS propagates ideas, programs, research, awareness, and education towards preserving the Earth's natural environment and resources. The theme 'Geoheritage' fits very well with the goals of the IUGS. IUGS created the International Commission on Geoheritage (ICG) in 2016 at the 35th International Geological Congress held in Cape Town, South Africa (Pereira and Page, 2017; Kaur, 2022 and references cited therein; <https://www.iugs.org/commissions>). The International Commission on Geoheritage has now three subcommissions: (i). Subcommission on Geological Heritage Sites; (ii). Subcommission on Heritage Stones; (iii). Subcommission on Geocollections (Kaur, 2022). The IUGS Commission on Geoheritage has recently revised and reformulated its statutes and Terms of Reference for the designation of IUGS Geological Heritage Sites and Heritage Stones. The website of the Commission on Geoheritage is under construction and will soon be launched as a single website containing information on all three subcommissions. The IUGS designation sets an international benchmark based on the fulfillment of criteria set out in the terms of reference for the IUGS Commission on Geoheritage. In October 2022, the International Commission on Geoheritage will announce the first 100 IUGS Geological Heritage Sites in a big event celebrating the 60 years of IUGS.

The ratification of the International Commission on Geoheritage and the establishment of international standards for the designation of geological heritage sites, heritage stones, and geocollections was much needed by the global Earth Science community, as other organisations such as UNESCO and IUCN deal with a wide range of topics other than geological heritage, geoparks, and geoconservation. While providing its own designations such as IUGS Geological Heritage Sites, Heritage Stones, and Geocollections, the IUGS works in close association with UNESCO on the Global Geoparks programme and UNESCO Natural World Heritage, as well as with other concerned organizations, such as the IUCN. The IUGS can offer much-needed guidance on the identification of UNESCO Global Geoparks and World Heritage Sites of geological significance.

## **GEOCONSERVATION: THE WAY FORWARD**

The Earth is the source of immense geodiversity: natural geological resources and significant geological sites (geosites), and this is valued by humankind as geoheritage. Game-changing rules in the name of economic development at the expense of our geological heritage have already irreversibly damaged some of our most important pristine geological heritage sites and depleted geo-materials. Some of the geoheritage has been lost due to lack of awareness or explicitly in the name of development. The need to conserve geological heritage is as urgent as the need to conserve biodiversity, human history, cultures, and traditions. In fact, conservation and sustainable use start with respecting the geoenvironment. The way forward is through geoconservation, as it lays down rules for the conservation of significant

geological sites and materials. Geoconservation is an emerging and arguably the most important geoscience discipline which deals with the management and upkeep of geological heritage sites and ex-situ geoheritage such as stone monuments, stone quarries and geocollections in museums etc.

Geoheritage sites with considerable significant geological features and fossils and evidence of processes leading to their formation are certainly worthy of conservation, and protecting them protects other aspects of our environment. These conserved geoheritage sites can be used as natural geological exhibitions or museums for scientific studies, educational field trips, field training, cultural activities, and sustainable economic activities via. geotourism. Thus, it becomes important to assess the geological heritage from a multiple heritage perspective. It also becomes extremely important to ensure utmost care in framing guidelines and strategies to preserve and conserve them for the present and future generations (Prosser et al., 2018; Reynard and Brilha, 2018 and references cited therein). The best method to frame any geoconservation standard for regions and countries is to use a participatory approach based on local preferences and needs, with respect to the government, locally involved geoscientists, and locally aware politicians. The participation of local communities, the development of public awareness, and the participation of all actors are equally important in the conservation of geoheritage. On a global level, nations should create strong networks amongst themselves and should follow a participative approach in sharing ideas on geoconservation and success stories of the geoconservation models adopted by them to help each other.

UNESCO, through some of its important programmes (World Heritage, Global Geoparks and International Geoscience Programme), promotes the idea of conservation of geoheritage. Neither of these global designations gives legal protection to the geological heritage. The responsibility of legal protection rests with the countries in which they are located. However, for seeking a UNESCO designation, a clear legal protection plan adopted by the respective country to conserve and protect the property proposed is mandatory (Gray 2019; <https://whc.unesco.org/en/guidelines/>; [http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IGGP\\_UGG\\_Statutes\\_Guidelines\\_EN.pdf](http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IGGP_UGG_Statutes_Guidelines_EN.pdf)). The below excerpts from the operational guidelines for the designation of UNESCO World Heritage Sites and Global Geoparks clearly indicate the significance of conserving our natural and geoheritage sites for local communities and future generations, with the main focus on sustainable development of these:

*'The cultural and natural heritage is among the priceless and irreplaceable assets, not only of each nation but of humanity as a whole. The loss, through deterioration or disappearance, of any of these most prized assets constitutes an impoverishment of the heritage of all the peoples of the world. Parts of that heritage, because of their exceptional qualities, can be considered to be of 'Outstanding Universal Value' and as such worthy of special protection against the dangers which increasingly threaten them'.*

*'Since the adoption of the Convention in 1972, the international community has embraced the concept of "sustainable development". The protection and conservation of the natural and cultural heritage constitute a significant contribution to sustainable development'.*

*'The Convention aims at the identification, protection, conservation, presentation and transmission to future generations of cultural and natural heritage of Outstanding Universal Value'.*

*'The criteria and conditions for the inscription of properties on the World Heritage List have been developed to evaluate the Outstanding Universal Value of properties and to guide States Parties in the protection and management of World Heritage properties'.*

(Source: Para 4, 6, 7, and 8 of The World Heritage Convention in

'The Operational Guidelines for the Implementation of the World Heritage Convention' document dated 10th July 2019; <https://whc.unesco.org/en/guidelines/>)

*'UNESCO Global Geoparks must be single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education, research and sustainable development'*

*'UNESCO Global Geoparks should be areas with a management body having legal existence recognized under national legislation. The management bodies should be appropriately equipped to adequately address the area of the UNESCO Global Geopark in its entirety'*

*'UNESCO Global Geoparks should actively involve local communities and indigenous peoples as key stakeholders in the Geopark. In partnership with local communities, a co-management plan needs to be drafted and implemented that provides for the social and economic needs of local populations, protects the landscape in which they live and conserves their cultural identity. It is recommended that all relevant local and regional actors and authorities be represented in the management of a UNESCO Global Geopark. Local and indigenous knowledge, practice and management systems should be included, alongside science, in the planning and management of the area'*

*'A UNESCO Global Geopark must respect local and national laws relating to the protection of geological heritage. The defining geological heritage sites within a UNESCO Global Geopark must be legally protected in advance of any application. At the same time, a UNESCO Global Geopark should be used as leverage for promoting the protection of geological heritage locally and nationally'*

(Source: criteria (i), (iii), (v), and (vii) of 'The Operational Guidelines for UNESCO Global Geoparks' document; [http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IGGP\\_UGG\\_Statutes\\_Guidelines\\_EN.pdf](http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IGGP_UGG_Statutes_Guidelines_EN.pdf)).

### **The Indian Scenario for UNESCO Global Geoparks and World Heritage Sites and IUGS Designations**

Unequivocally, India is endowed with some of the best geoheritage sites, heritage stones and geocollections of global significance. Sadly, the efforts by the Indian geoscientific community to get a national bill for the protection of geological heritage have been unsuccessful (Ahluwalia, 2006; Banerjee, 2021). In spite of having nationally recognised geosites and geoheritage sites, India lacks UNESCO Global Geoparks. On account of the absence of a legal bill under national legislation, India will not be able to propose its internationally significant geosites for UNESCO Global Geopark designation. It is clearly mentioned in the statutes of UNESCO Global Geoparks that a legal procedure for geoconservation should be in place for putting in a proposal for the designation of Global Geoparks:

*'The aspiring UNESCO Global Geopark must have geological heritage of international value and be managed by a body having legal existence recognized under national legislation that has a comprehensive management plan, covering governance, development, communication, protection, infrastructure, finance, and partnership issues'* (<https://en.unesco.org/global-geoparks/how-to-become-geopark>).

However, India has been able to get the 'IUGS-Global Heritage Stone Resource' label for its iconic Makrana Marble (Garg et al., 2019; Kaur et al., 2020a). Many iconic heritage stones of India, which fulfil the criteria for the IUGS Heritage Stone designation as laid out by the Subcommittee on Heritage Stones, have been documented and shall be proposed for IUGS designation soon (Kaur et al., 2019a, b; Kaur et

al., 2020a, b, c, d; Kaur et al., 2021b; Sreejith et al., 2021; Garg et al., 2021; Sen et al., 2022; Kaur, 2022). The window to propose for the IUGS Geological Heritage Site designation is open now and it is not mandatory to have a national legal bill to apply. The International Commission on Geoheritage evaluates the geological site strictly based on its significant scientific value. The newly upgraded IUGS subcommittee on Heritage Sites could form a platform for the inclusion of a more representative selection of Indian geoheritage on the world stage, and would complement the IUGS Heritage Stone designation from India.

### **CONCLUDING REMARKS**

The abiotic and biotic components of the Earth work in a perfect symbiotic relationship. If this synergetic relationship is disturbed beyond a certain limit, the outcome may be catastrophic. Loss of biodiversity affects geodiversity, and loss of geodiversity degrades biodiversity. International organisations like UNESCO, IUCN, and IUGS emphasize awareness of the biotic and abiotic components of the Earth through designations, education, science, and sustainable development programmes that favour conserving and preserving biodiversity, geodiversity, tangible and intangible cultural elements linked to different civilizations, etc. The abiotic component, which includes geodiversity, encompasses the sum total of discovered and undiscovered geological sites, georesources, and geological processes. Geodiversity, in a nutshell, has given us a better insight into how the face of the earth has transformed/evolved in the last 4.6 billion years. The implications of disturbing and damaging geodiversity can be catastrophic. If we damage our geodiversity, we definitely damage our planet's biodiversity. The damage can be life-threatening for almost all species that depend on the symbiotic relationship with the Earth's geological diversity. However, as a result of natural degradation processes augmented by unmindful rapid industrialization and urbanization, we are losing our non-replenishable geodiversity and our geological heritage at a great speed. Due to the absence of stringent geoconservation laws in some countries, precious geoheritage has been lost.

Many national and international organisations have come together to advocate for the preservation and conservation of geoheritage during the last few decades. Hopefully, with the unified efforts of the global geoscientific community, the governments and people of all nations will realise the relevance of geodiversity and geoheritage and will accept the urgency of safeguarding, sustainably developing, and conserving the geoheritage for current and future generations, supporting the key initiatives of UNESCO, IUCN, GNN and IUGS.

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### **List of acronyms used in the text:**

**GGN** - Global Geoparks Network;  
**GHSR**-Global Heritage Stone Resource;  
**HSCS** -Subcommittee on Geoheritage Sites and Collections;

**HSS**-Subcommission on Heritage Stones;  
**ICG**- International Commission on Geoheritage;  
**IGCP**-International Geoscience Programme;  
**IGGP**- International Geoscience and Geoparks Programme;  
**IUCN**-International Union for Conservation of Nature;  
**OUV**-Outstanding Universal Value;  
**UGGP**-UNESCO Global Geopark;  
**UNESCO**-United Nations Educational, Scientific and Cultural Organization  
**WHS**-World Heritage Sites

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