ESSAY

GEODIVERSITY – Its Valuation

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There must be very few people on this Earth who will consider our planet boring and static. On the contrary, our world is dynamic, full of thrills, pulsating with eternal conundrums that make life a little complex. We are primarily concerned with the surface of the Earth, which supports rocks in the hills and mountains, sediments in the river valleys, lakes and islands, oceans, volcanoes, and glaciers. Earthquakes and volcanoes often occur to disturb the quietness of the earth system. These dynamic activities modify the appearance of the surface, and that leads to the creation and identification of landforms of various kinds.

The assessment and gradual accumulation of understanding of the Earth's richness and natural variety has led to the formulation of new avenues of research. From the fields of biology and the earth sciences, new concepts have been proposed and associated with new terminologies, such as «biodiversity,» «natural diversity» and «geodiversity,» some of which have received broad social acceptance. The concept of biodiversity was introduced in 1988 as a scientific term to define the variability of the Earth's living organisms and its «biological diversity». This term included «the diversity within species, between species and ecosystems ».
The term geodiversity first appeared in articles from Tasmania, Australia, in the mid-1990s and was subsequently adopted by many countries of the U.N. Convention at the Earth Summit in Rio de Janeiro in 1992. Using the terms "*biodiversity*" and "*geodiversity*" helps to indicate that nature consists of two equal components, living and non-living, which, taken together, could help to promote a more meaningful approach to nature conservation than the traditional biocentric focus.

Geodiversity can be defined simply as *"the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landform, physical processes), and soil features. It includes assemblages, relationships, properties, interpretations and systems"*(Gray 2004). Its application in the protection and management of the natural environment requires an exhaustive knowledge of the structure and components of the area to be protected. "The right call to action began in 1996 during the 30th International Geological Congress held in

Beijing (China), where the proposed concept of the geopark reinforced the initiatives of geoconservation. From that moment, geodiversity experts became more concerned with conservation and geoheritage."

Understandably, preserving thousands of minerals identified on the Earth, especially the rare ones, is significantly important. These diverse minerals have created a variety of rock types, supporting millions of fossil species. Commonly used terms like fold mountains, plateaus, rivers, glaciated valleys, and gorges often do not include various other features in a named landform category. Physical processes like landslides, seaside, and mountain erosion are sometimes so complex that they defy classification under existing classification systems.

There is as much geodiversity in the world as biodiversity

The diverse forms of geological features that include the morphological framework of the natural objects need protection from the destructive habits of the animal world, primarily from the human race. Through its unknown forces, nature sculpts the Earth's crust into curious forms and occupies space in its own right. These geological features constantly change their appearance over time under the onslaught of nature's rhythms and are often destroyed by irrational human activities for short-term monetary gains. On the other hand, the 'geoheritage' is in the line of physical inheritance of inanimate objects like cultural, historical, and social features. We inherit an object, feature, or social custom without spending our time and money. Heritage features are those that were produced, sculpted, or changed by our ancestors. At the same time, different generations of the human race created cultural and social features that the present generation inherited from the past. It is not essential that we perpetuate these traditional practices but only keep them in a synthetic and reduced form to create windows to observe the past. Therefore, geodiversity is a more appropriate and logical term than geoheritage. The term 'geoheritage' should therefore belong to the field of anthropology and history where human constructs played the role and leave their tell-tale stories in the form of tools, human remnants, weapons, forts, palaces, and localized cultural hotspots. Geoheritage under the current definition will have more direct scientific, cultural, educational, and economic value. In contrast, geodiversity could not be given the same status due to the masses' lack of understanding and ignorance about the inanimate natural features and the absence of a dedicated geological community willing to propagate and educate their importance among the masses. Geodiversity can be protected only under the garb of protection of geoheritage sites and camouflage it with the values already attached to other parameters like scientific, educational, and economic.

Gray (2004) summarized thirty recognizable values of geodiversity appropriated from protected areas. He referred to this as "geosystem services" to indicate equivalence with the standard of ecosystem services approach often used to justify wildlife conservation. Gray further wrote that intrinsic or existence values are those associated with things simply for what they are rather than what they can be used for by humans (utilitarian values). Intrinsic values of abiotic nature are free of human valuations. On the other hand, cultural values may originate from folklores associated with the origin of rock formations or landforms. From ancient times, many geologically diverse features fascinated the human race, and they attributed them to some mystical traits or culturally compatible features.

Many religious communities used small and large caves to conserve their practice and functionality. These ancient people found it helpful to preserve and conserve caves that they could use as living spaces and develop art and culture. Many cave paintings manifest a culture that helped protect the caves over thousands of years. The most attractive posting in India are based on religious sentiments. Attaching religion to a geologically exciting feature can do magic. In Banda town in the Bundelkhand area of Uttar Pradesh, the Bambeshwar Mahadeo Temple dedicated to Lord Shiv has preserved a rare, large

dolerite boulder (possibly phonolite) which resonates with distinct sound when tapped with a metal or even stone. It is locally known as 'Tuntunia Pahar' due to the sound (believed to be ethereal) it produces. Basaltic rocks, in many parts of India, due to their unique joint system, have produced spectacular morpho-geological columnar structures. Shankaracharya Temple in the Kashmir valley has successfully prevented mining of the Triassic carbonate rocks of the region.

Shankaracharya Temple near Dal Lake, Srinagar, Kashmir

Similarly, some geological features may have spiritual value. The Jatashankar Temple in Panchmarhi in Madhya Pradesh is a gorgeous cave temple with stalagmites and stalactites. It has remained protected and safe as these are considered Lord Shiv's flowing locks (Jata). All Ajanta Caves with unique ancient paintings have helped preserve the region's dark grey basalt through the centuries. Jwalamukhi Temple with an everlasting gas flame and Vaishno Devi Cave Temple on the Proterozoic carbonates are other examples of geoheritage preservation in the garb of religious sentiments. Badrinath, Kedarnath, and Mount Kailas are the sacred vision quest sites. Despite large-scale religious tourism, Kedarnath, Badrinath, and Mount Kailas still offer excellent rock sections for geological studies. Someone has said,

"The cultural value of geodiversity is the value placed by society on some aspect of the physical environment because of its social or community significance."

Jatashankar Temple, Panchmarhi, Madhya Pradesh

Jwalamukhi Temple at constant and everlasting gas flame, Himachal Pradesh

Some mountain peaks survived destruction by the uncouth public due to the location of temples and monasteries. Small temples built on top of the hills in many parts of India helped get protection from the rock-mining mafia.

The Petroglyph monuments exemplify links between rock sites and archaeology in Ladakh. Ajanta Caves connects with the Deccan Basalt, while Konark Temple links with Khondalites. Khajuraho Temples and Red Fort used Vindhyan sandstones, while the Taj Mahal used Makrana Marble. Mount Thomas has only Charnockite, to name a few. In the mountains, one can relate many folklores to unusual animal-like features of the hills and mountains. Toad Rock in Mount Abu, Camel's Back in Mussoorie Hills, and Elephant-like hills in many places are preserved for the cultural and touristic (economic) values. Before the mid-sixties of the last century, the entire hill slopes in Kanpur-Matoon-Jhamarkotra areas in the Udaipur district were called in the local parlance as Magarmachh Patthar (Crocodile-skin rock) due to irregular weathering of carbonate rocks. They remained untouched till these features were attributed to differentially eroded phosphatic dolomitic stromatolites.

Moreover, these rocks provided much-needed phosphatic fertilizer raw material for the green revolution in the country. The Jhameshwar Temple at one end of the Jhamarkotra phosphorite mine has protected some of this region's characteristic columnar phosphatic stromatolites. It is not easy to preserve such unique geological features in totality due to their use in sustaining the human race. Producing a chemical fertilizer for better crop yield becomes more important than preserving a unique geological feature.

Aesthetic values include local landscapes of mountains and sea shores. Today, the stunning scenery of Himalayan glaciers, the grandeur of the Narmada rift valley, scenic bare rocks of the Spiti and Zanskar ranges, and lakes of the Himalaya, Nilgiri ranges, and the Western Ghats draw the attention of local and foreign tourists. Indirectly, geotourism is becoming popular in the garb of ecotourism. Geotourism in the Spiti valley, Ladakh, Valley of Flowers, Himalayan peaks, glaciers of Uttarakhand, lakes of Kashmir, Kumaun, and Nilgiris, can be easily attached to the geodiversity framework of the region. Leisure activities include skiing in Gulmarg, rock climbing in Darjeeling, Chamoli, Panchmarhi, and Ooty, and river rafting in the Himalayan and Peninsular rivers. Rock climbing, water rafting, and glacier hiking require specific landscapes or geological environments. Likewise, many valued landscapes have inspired painters, sculptors, poets, and musicians to create significant artworks.

The Economic Value of geosite preservation is directly related to energy resources, industrial minerals, gemstones, and soil connected to agriculture, horticulture, and forestry. Most of these are non-renewable resources, and their use and limits ought to be better understood than they are. Similarly, Functional values depend on operations of fluvial, coastal, desert, and mountain-building processes. The Scientific Value of this exercise is reflected in understanding the history of Earth, its evolution and processes that shape it, the evolution of life through time, and the identification and dating of unconformities. Also included are climate change, sea level variations, and pollution studies. Many of these physical systems are in dynamic equilibrium, and their continued functioning is vital to environmental systems. The physical evidence for further research must be conserved to ensure further studies and opportunities to train and educate professional geoscientists, university students, schools, and the general public are not lost.

How geodiversity should be conserved is a question that has bothered every geologist. Different ways are there to manage. Some of the possible approaches are:

1. Creating a protected area with supporting legislation and penalties. This, however, does not guarantee protection due to infringement of regulations or changes in political attitudes or funding. Fines are rarely substantial enough to deter commercial collectors. One of the most secure methods is physically restraining visitors from reaching sensitive sites by fencing or placing them within specially constructed buildings. For example, in Saketi Geological Park in HP, petrified tree trunks are kept in glass cases. Upcoming parks showcasing dinosaur eggs and bones in Rayoli and other places follow the same protective measures.

2. If we are dealing with rare fossils, minerals, or rocks, an effective means of protecting is removal and curation in a museum. This is the most common practice in fossil collections, where they are catalogued and preserved for further studies and comparison.

3. A third effective way of conserving nature is approaching and motivating government departments like the Geological Survey of India or Oil and Natural Gas Company to get the rights to maintain such sites with a well-defined provision of recurring grants in their annual budget. Private players like Adani, Tata, Infosys, Bajaj, or Reliance can be persuaded to buy the land hosting geoheritage features and structures and maintain them as geotourism localities.

4. One of the geosite protection techniques could be playing with human sentiments. Although this may lead to chauvinism or inter-region conflicts, making people proud of their surroundings may yield positive results. Scores of volunteers with messages enumerating the significance of someone's neighborhood may be sent in batches every Sunday and educate the local residents. Making someone proud of the soil in which he/she lives can be a constructive model, requiring neither finances nor significant time losses.

Some prominent examples of geosites preservation have been enumerated, aided by the religious sentiments of the local people. Many people in this country may not know that Swami Vivekanand was almost an atheist in his early youth but, in later years, admitted that in India, if someone wants to succeed in doing good for its people, it would be possible only by exploiting the religious sentiments. Many geologically important monuments in this country have remained protected due to the conversion of innocuous rocks into gods and goddesses.

Extensive country-specific discussion is needed to understand the threats to the geological heritage sites. These threats included dams and diversions, water-air-noise pollution, exploration drilling and mining, urban impacts like excessive numbers of cars and visitors, and a significant category of "et cetera". These and other threats continue to have an impact on the resources of the region. River and coastal engineering works disrupt the operation of natural geomorphological processes. Urban impacts and car numbers have continued to increase and are a severe threat to several sites of geoheritage importance. Unauthorized fossil collecting is a continuing concern in all societies. These human impacts have resulted in the loss of, or damage to, important rocks, minerals, or fossils, including remodelling of natural geomorphology and interruption of natural processes.

Without geodiversity, there would be little biodiversity, and an integrated approach to nature conservation and sustainable land management ought to be noticeable. The concept of geodiversity provides a fundamental basis for conservation and deserves worldwide applicability.

Gray, M. 2004. Geodiversity: Valuing and Conserving Abiotic Nature. Chichester, U.K.: John Wiley & Sons

Gray.M.2005. Geodiversity and Geoconservation: What, Why, and How? Article in The George Wright Forum.