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Geodiversity, and the geoethical principles for its preservation

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ABSTRACT

The history of the origin and evolution of the term 'geodiversity' is described, and its present definitions are given. Several types of values of geodiversity are considered. Moreover, a new type of value is defined: the information value of geodiversity, as developed from the ethical principles of geodiversity preservation.

1. Introduction

In the ordinary sense, diversity is the existence of disparate, non-recurring, items and a lack of uniformity.

Natural diversity is a fundamental feature of Nature. It reflects the set of structural and functional characteristics of the natural organization that has been implemented during evolution. It currently ensures sustainable development of planetary life, of the biospheres and geospheres, and it supports ecological balance and ecological stability, while at the same time allowing the development of the true potential of Nature. In science, there are several points of view of the concept of 'natural diversity': sometimes, it is treated as being synonymous with biological diversity, sometimes as a combination of all species of animals, plants and microorganisms, and of all ecosystems, and their place in ecological processes. Accordingly, there are three levels of biodiversity:

– genetic diversity (the amount of genetic information contained in the genes of all species of plants, animals and microorganisms);

– species diversity (the number of species);

– ecosystem diversity (the number of different habitats, biotic communities, and ecological processes).

In biology, diversity is associated with the fundamental features of life and its organization, while its proliferation in geosciences originally had a purely pragmatic aspect of preserving natural values. Geodiversity and the concept of its preservation are new definitions for most people. The concept that the physical features of the Earth (rocks, subsoil, mineral resources) need good management and preservation is not obvious for the majority, as the structures on the surface of the Earth and within its subsoil look strong, solid and stable. In the past 15 years, the problems of preservation and use of the geological environment has prompted the formation of geodiversity and landscape diversity concepts.

2. Geodiversity and its value

In the modern sense, the term 'geodiversity' was first used in Tasmania, shortly after the adoption of the Biodiversity Convention at the International Summit in Rio de Janeiro in 1992. However, before 1992, geoscientists used terms such as the "diversity of the Earth", and "geomorphological diversity". It was a direct consequence of the parallelization with biodiversity and use of terms such as "landscape species" and "landscape community" in biodiversity theory. Thus, in the early 1990s when biodiversity became an accomplished event, Tasmanian geologists quickly adapted it for the geological equivalent geodiversity, to describe the variety within abiotic Nature (Table 1) [Australian Heritage Commission 1996, 1999, 2002]. The basic definitions of geodiversity are given in Table 1.

All of these definitions come from a variety of rocks and minerals, landforms, soils, mineral resources and geological processes, or from the inseparable connections between geologic formations, systems and processes, and the people associated with our natural heritage, such as biodiversity and geodiversity, and our cultural landscapes, and more.

Note these defining characteristics of geodiversity. First, it involves both endogenous and exogenous geological processes. Second, the definition implicitly includes past and present geological time and space. However, all of these definitions have one disadvantage. They do not include the different levels of geological systems, and the complex interactions between these geological systems that do not involve the use of different scales, from global (continents and oceans) to elemental (atoms and ions) [Krut' 1978].

Endogenous and exogenous geological processes have a leading role in the formation, preservation and destruction of the variety of subsoils, surfaces and land-

Year	Author of the definition	Definition
2004	Murray Gray	The natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landform, processes) and soil features. It includes their assemblages, relationships, properties, interpretations and systems [Gray 2004].
2004	David Roche	The variety of rocks, minerals, landforms etc., and the processes that have formed these features through geological time.
2002	Collin Prosser	The variety of rocks, fossils and minerals and natural processes [Prosser 2002].
2002	Mick Stanley	The link between people, landscape and culture; the variety of geological environments, phenomena and processes that make those landscapes, rocks, minerals, fossils and soils that provide the framework for the processes of life on Earth [Stanley 2002].
1997	Rolan Eberhard	The natural range (diversity) of geological (bedrock), geomorphological (landform) and soil features, assemblages, systems and processes. Geodiversity includes evidence for the history of the Earth (evidence of past life, ecosystems and environments), and a range of processes (biological, hydrological and atmospheric) that are currently acting on rocks, landforms and soils [Eberhard 1997].
1995	Chris Sharples	The range (or diversity) of geological (bedrock), geomorphological (landform) and soil features, assemblages, systems and processes [Sharples 1995, Houshold and Sharples 2008].

Table 1. Basic definitions of geodiversity.

scapes of the Earth, because of their great power and duration, which is not comparable with the duration of the existence of the human species.

Now the human impacts on the Earth as a geological body are only related to the lithosphere, which they affect in terms of the following basic activities:

– geological surveys and exploration (carried out without any material surface integrity);

– mining;

– construction and maintenance of underground facilities unrelated to mineral production;

– formation of lithospheric technical zones under territories of cities and industrial developments;

– dumping of household and industrial wastes, including radioactive and toxic wastes;

– lithospheric (geological) weapons that use catastrophic geological processes (earthquakes, volcanic eruptions, large-scale rock falls and landslides) as adverse factors.

At the present time, no questions have been raised about the possible limits of this damage, and about the resistance of the lithosphere, and the other geological spheres, to this damage.

The creative human activities in the sphere of subsoil use are not so great. These are limited to the special protection of geological features of scientific, cultural, aesthetic, health and recreational values (scientific and training grounds, geological reserves, wildlife and geological sanctuaries, natural monuments, caves and other underground areas).

There are six types of values of geodiversity [Sharples 1995, Eberhard 1997, Prosser 2002, Gray 2004], which are:

– internal or intrinsic value: the intrinsic value goes back to the ethical approval that some things (in our case geodiversity of Nature) have value simply because they exist, not only because they can be used by people (utilitarian value); this is the most difficult value to understand and describe, as it involves ethical and philosophical dimensions of the relationships between society and Nature;

– cultural value: as geomythological, archeological and historical value;

– aesthetic value: this is the most tangible, real concept, as it is based on the visual perception of the physical natural environment, the positive physiological and psychological effects of various geological objects on health and human consciousness;

– economic value: determined primarily by the need to use subsoil, mineral resources, underground waters, landscapes, and underground cavities in the economic development of civilization;

– functional value: something that provides a substrate for the functioning of the terrestrial biosphere, for the existence of the atmosphere, hydrosphere and lithosphere;

– research and educational value: this provides the process of scientific cognition of the world, and is the basis for the monitoring of natural processes, including dangerous geological processes, such as earthquakes, floods and landslides.

In addition to these six types of values of geodiversity, there is one more: the information value of abiotic Nature, by analogy with the genetic diversity of species [Nikitina 2011]. Each geological object has its own unique geological information, and the complexity of this information is directly dependent on the hierarchical level of the geological object. At the present stage, only a small part of this information is available to our surveying and understanding.

Every year, tens of thousands of long-term geological carriers are withdrawn from the geological environment. As a result, the geologically complex hierarchy objects, sophisticated geological systems, and accompanying processes are deprived of their future (mineral deposits,

ore formations). New mechanisms for stabilizing the crustal processes are originated, which lead to the activation of deep faults. This withdrawal of complex hierarchical objects and sophisticated geological systems from the lithosphere without explaining their relevance to the geological and geophysical evolution of the Earth can be potentially considered as the start of planetary disorganization.

3. Geoethical principles for geodiversity preservation

Apart from the introduction of the term geodiversity into the geosciences, the major theoretical achievements of "the geodiversity doctrine" are:

1. The six core principles of sustainable development and use of mineral resources [Gray 2004] are similar to the principles of "deep ecology" that were suggested by Norwegian philosopher Alexander Naess in 1974 [Naess 1984, 1994]: accept that natural change is inevitable, work with the natural functions and processes, manage natural systems within the limits of their capacity, manage natural systems in a spatially integrated manner, use non-renewable Earth resources wisely and sparingly and at a rate that does not restrict future options. Use renewable resources within their regeneration capacity.

2. Classification of value types of geodiversity and creation of the concept of 'Nature and geological heritage'.

3. Develop a rationale for objective necessity to maintain geodiversity because of the responsibility of living generations to future generations, and recognize the hard benefit of sustainable development of natural resources to mankind and to the natural world.

4. Action-oriented recommendations for geodiversity conservation and practical realization [Limestone Landscapes 2010, Zwolinski 2010].

In general, the geodiversity doctrine is a significant achievement in geosciences. However, due to the insufficient development of the ethical foundations of this doctrine, we can see contradictions between its basic elements.

For example, the recognition of the internal (intrinsic) value of abiotic Nature essentially means that people do not have the right to reduce the geodiversity; in other words, people do not have the right to exploit objects that are abiotic in nature, or to interfer in the organization processes that occur in abiotic Nature. In this case, any proposed options for preservation of geodiversity will constantly lose competition to the mining industry, because revenues from this sector are obvious and tangible. The proposed principles for the preservation of geodiversity do not contain any indications of the boundaries of the right to exist. What geological features, objects, systems, processes and phenomena "have value simply because they exist"? How does this relate to the objective necessity for human use of mineral resources for the maintenance of the existing human civilization? Should we stop the spread of geological processes that are dangerous for us?

In developing the ethical principles of geodiversity preservation, I have tried to rely not on an abstraction of the universal validity of moral norms, but on their potential realizability.

1. Being a part of Nature, people should not re-organize geological systems, particularly on a global and regional scale. It is permissible to interfere with natural geologic processes on a local level in cases where they are a threat to human life.

2. People have no right to reduce geodiversity, except to meet basic needs.

3. Recognition of the need to establish effective limits of consumption and use of mineral resources, as components of the geological environment, on the basis of stabilization of the world population; to substitute the linear degradation of mineral resources using renewable resources and the recycling of mining wastes.

4. Opposition to an unregulated market economy, especially if it is a mineral-resources-based economy.

5. The use of mineral resources, and of objects and components of the geological environment should be based on the recognition of the objective laws of development and interactions between the geospheres and society, on the modern scientific and technological achievements, on the combination of possibilities of geospheres, and on the economic interests of society, providing real guarantees for the rights of citizens to benefit from the use of the subsoil (scientific principle).

6. Policies, strategies and tactics of geological heritage preservation should be formed as a complex interactive system of institutions and individuals: governments, public and social organizations, on the global, national and regional levels; geoscientists, geoexperts, and 'geological heritage consumers' (visitors to geoparks and geological museums, tourists).

7. In the 'man-and-abiotic-nature' system, the whole takes precedence over the singular, such that if the use of a geological object does not to lead to a decrease in the geodiversity of higher geosystems, then that object can be used).

Our proposed variant of ethical principles for geodiversity preservation is not the only feasible theory. We hope that our colleagues and/or 'opponents', especially for the ethics, will offer other projects, following the logic of which we will have an opportunity to improve the geodiversity concept.

4. Conclusions

Thus, in contrast to the concept of biodiversity, the term geodiversity, its value, and the need for its conservation, has not yet entered the broad academic community.

However, it is clear that in addition to biodiversity conservation, geodiversity (and in the future, the variety of animate and inanimate Nature) should also be a priority in any human activity on Earth. It is characteristic of the geological diversity, and ethical guidelines for its conservation should serve as a basis for policy, as we aspire to manage our mineral resources to ensure sustainable economic development.

Undoubtedly, in the third millennium, we have to search for new geoethical ideals in our subsoil use.

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