INTERCONDITIONALITY GEOMORPHOSITES AND NATURAL HAZARDS

FLORINA GRECU[1]

Abstract.- Interconditionality geomorphosites and natural hazards. This work presents the inter-dependency reports between hazards and geomorphosites, even proposing the term of geohazsite for the sites generated by hazards. There is a double significance of the geomorphologic hazards in relation to geosites: of sites generation and of site alteration, vulnerability or even destruction. The geosite can be vulnerable not only at the generating hazard but also to other hazards, generally associated. The geosites constitute into a sequence of temporary dynamic equilibrium of an evolutive system. In this respect, correlations must be done between geomorphosites as a landform and the geomorphologic hazards, in the perspective of dynamic geomorphology.In the process of geomorphosite identification and selection some characteristics of the landform as response to natural and/or antropic hazards are taken into account. Geomorphosites thus become elements at risk, vulnerable to the environmental factors and to the natural and/or antropic hazards.The study is partially integrated in the **digital platform on geomorphosites**. This e-learning device was initiated and developed by the University of Lausanne, Switzerland (Emmanuel Reynard, director, Luci Darbellay) in collaboration with five universities: University of Modena and Reggio Emilia, Italy (Paola Coratza), University of Savoie, France (Fabien Hobléa and Nathalie Cayla), University of Minho, Portugal (Paulo Pereira), University of Bucharest, Romania (Laura Comanescu and Florina Grecu), University of Paris IV – Sorbonne, France (Christian Giusti). The course, developed with the Learning Management System Moodle, is a completely free-access course. It is divided into four parts: (1) Generalities; (2) Methods; (3) Conservation and promotion; (4) Exampl

Key-words: hazard, geomorphosite, dynamic equilibrium, impact of hazard, geomorphohazsite, e-learning

[1] florinagrecu@yahoo.com, grecu@geo.unibuc.ro

1. THE SPECIFICITY OF HAZARD-GEOSITE-HAZARD INTER-CONDITIONALITY

1.1. The notion of geomorphohazsite

First used with the restrained meaning of landforms with a certain value (Panizza, Piacente, 1993), the notion of geomorphosit was completed and explained through theoretical and regional-applyied researches (Panizza 2001; Pralong 2006; Reynard 2008; Reynard & Coratza, 2005, 2007; Reynard et al., 2007; Ilies & Josan 2007; Comănescu & Nedelea 2010; Grecu & Iosif, 2014). Thus, the delineation of the scientific content has been made/is being made from the need of development of the applied character of sciences, as a response to the inter-relations with human society. The relation of active/dynamic geosites with the human society results from the association of their hazard and risk content. The geosites are a sequency of dynamic and temporary equilibrium of an evolutive system. In this sense, correlations between geomorphosites as landform and the geomorphological processes and hazards should be made, in the perspective of dynamic geomorphology. This is the base of all the phenomena and it can always be highlighted as *geosites* or *geomorphosites* (Grecu, Palmentola, 2003). Geomorphology proves in this manner its conceptual scientific character (Panizza, 1996). In geosites studies, it stands next to geography and geology (Reynard et al 2004). This way emerged the need of geosites protection (including within the frame of other concepts – geo-heritage, geodiversity, A Perret 2014) in front of the social and human aggression, excluding natural hazards. Apparently, this geomorphosites versus natural hazards approach would exclude the social component. Nevertheess, the purpose of this kind of approaches is to emphasize the values with importance for society through their utilitarian quality (Martin, 2012).

In our acceptation, Geosites (term which also includes the geomorphologic sites) are relief forms with a scientific, aesthetical, ecological, economical, and cultural value, in respect of human perception, that complete the total heritage of a given territory, including the biodiversity and human creation. Geomorphological hazard is defined as a probability for the occurrence of some phenomena liable to changing the dynamic balance of slopes hence visible effects on the environment and human activity. Consequently, the geomorphological processes (erosion, transport and accumulation), through the action exerted on ground surface comes to create forms/geosites vulnerable to both human interventions and to natural hazards. The dynamics and evolution of these forms/geosites lead to the deterioration and destruction of the geosite, to the generation of a new geosite or to the disappearance of the geosite. The reconstitution of disappeared geosites is important for paleo-geographical reconstructions (Reynard et al., 2011), an essential role being played by the correlated deposits. The question is in what degree the missing geomorphosites can be reconstructed? And what was the role of hazards in their destruction? (e.g. the reconstruction of a meander following the vegetation, the humidity excess that show the dynamics of the river channel).

1.2. The hazard character of some geomorphosites/The impact of hazards on relief

The double significance of geomorphologic hazards in relation to geosites is clearly expressed: first by the geosite formation and second by its alteration, vulnerability increase or even destruction. The geosite can be vulnerable not only to the generating hazard but also to other hazards generally associated. Thus, three independent approach levels can be distinguished:

1. Process ➔ Hazard➔ Landform

2. 🡻 Dynamic equilibrium ➔ Geosite

3.🡻 Disequilibrium ➔ hazard-vulnerability-risk

- Changes in geosite morphology
- Perished geomorphosites

Basically, the geomorphologic hazard results from the geomorphologic action/process (erosion, transport, accumulation) upon the ground with the generation of landforms with potential negative effect on the environment or society, representing, in other words, the morphological modifications of the ground surface with a direct impact on the environment and an indirect one on the society (Grecu, 2009,2016).

1.3. Geomorphosites vulnerability to natural/geomorphological hazards

Knowing the vulnerability of geomorphosites to natural hazards is necessary for the prevention, fighting and diminution of the vulnerability factors action. The utilization of some vulnerability indicators by the scientific community is still a desideratum, even the term vulnerability often being replaced with more general terms such as susceptibility, dangerousness etc which foresee the vulnerability itself. According to the Terminology on Disaster Risk Reduction (UNISDR, 2009) vulnerability is “The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard” (p.30) {les caractéristiques et les circonstances d’une communauté ou d’un système qui le rendent susceptible de subir les effets d’un danger}, including the exposure element. www.unisdr.org/publication. The vulnerability concept refers to (Birkmann 2006, Grecu 1997, 2009, 2016):

– Social vulnerability, that is humans susceptibility to natural or antropic conditions required for living.

– Bio-physic vulnerability, which is the response of some natural systems to the changes of other connected environmental systems.

In this last context, the vulnerability of geomorphosites is rather to be studied as an environment component.

– There are two concepts generally agreed in the relation between vulnerability and risk (Birkmann 2006, cited by Grecu, 2009):

– The concept that places vulnerability in the range of risk factors, which does not assume a direct relation, conditioned at risk reduction;

– The concept that places vulnerability as a step in the development of the entire extreme event. Geomorphosites are, thus, elements at risk, vulnerable to environmental factors and to natural and/or antropic hazards. The question is in what degree such geosites, in their essence dynamic, are compatible to the concept of heritage (Joly cited by Perret, 2014 p18).

1.4. The identification, evaluation and selection of the geosites vulnerable to natural hazards

In the process of identification and selection of the geomorphosite there are several shape characteristics that are taken into account as a response to natural and/or antropic hazards, from which we mention:

– The degree of resistance to the environmental factors which depends of the structure of the system (the bio-pedologic one – vegetation cover degree, soil type, petrography) and of the response to the hydro-meteorological inputs (thermal variations, rainfalls torrentiality, level and discharge variations of the rivers).

– The resilience degree, which is the capacity of the geosite to correct the effects of a danger, to return to its initial shape after a hazard occurrence.

– The adaptation capacity to environmental changes.

– Temporal and spatial dimensions which are the geomorphologic time and the space of existence/the occupied surface.

The geosites formed in hard rocks are generally more resistant to hazards but may also have a more reduced resilience capacity than the ones shaped in soft rocks.

Fig.1a Geomorfosit Babele (Carpathian Mountains- M.Bucegi) http://www.profudegeogra.eu/

Fig. 1 b Geomorphosit Grunj in the chanel Slanic –dacitic tuf (Foto Grecu)

The necessity of evaluation and selection depending on duration/the geomorphologic time of the geosite becomes obvious, as this dimension is different for singular geosites in comparison to the ones that create geomorphological landscapes. The singular geomorphosites are specific to the areas with high resistance and long geomorphologic time (the Sphinx and Babele in Bucegi Mountains - Fig. 1 a, Grunj in the chanel Slanic- dacitic tuf - Fig. 1 b).

These ones can partially be integrated in the range of geological sites. In soft rocks, the geosites create geomorphologic landscapes such as, for example, badlands (Râpa Roşie, Sebeş- Fig. 1 c) or landslides (the glimee relief Fig.1d) and mud vulcanoes (Fig.1e).

Fig.1c Geomorphosit Rapa Roșie (Transylvanian Depression)

Fig.1e Mud volcanoes (Foto Grecu 4 iunie 2015)

Fig.1d Geomorphosit glimee relief (Transylvanian Depression) (Movile, Apold, Cornatel - foto Grecu 2009, 2013)

The landform, gully or singular ravine is not geosites, due to their ephemeral condition. Some torrential organisms that last longer in time bat are vulnerable to environment factors can suffer changes in shape and morphometry elements, the decay and destruction of shape occurring gradually in time (see Canaraua Fetii in Dobrogea). The scientific value results precisely from this experiment in nature.

Upon their complexity, the geosites can be isolated forms, assemblies of forms (groups), complexes of forms or geomorphologic systems (Grandgirard, 1995, 1997, 1999). In order to elaborate the map of geosites vulnerability to natural hazards, the geosite type/types are considered upon the degree of complexity. Concerning the scientific value (Fig.2), its importance should address one or more of the following utilizations (Panizza, 2001):

– model for a geo(morpho)logic process;

– object used in educational purposes;

– paleo-geo(morpho)logic model;

– ecologic support in the case when it represents the only habitat of a plant or of an animal specie.

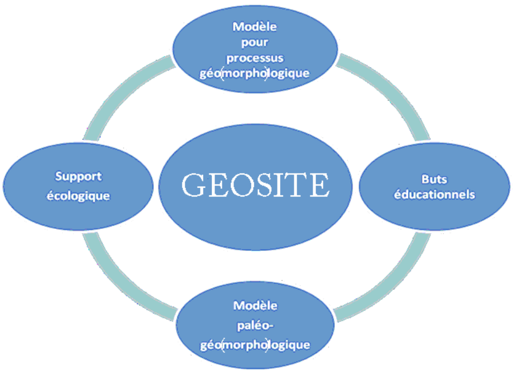

Figure 2. Diagram presenting the main values of a geosite (Grecu & Iosif, 2014)

1.5. Research methodology

In elaborating the research methodology, the research principles in dynamic geomorphology are considered, specific ones being the principles of dynamic equilibrium, selectivity, complexity, singularity, progressive development and of actuality (Grecu, 2008).

The identification and analysis of the factors from the morphogenetic environment of the geomorphosite drive the research towards the identification of hazard and geomorphosite types(Table1).

The problem of geomorphosite cartographic representation has been analyzed by some authors (Carton, Coratza, and Marchetti 2005, Regolini 2012, Regolini-Bissig and Reynard 2010 etc). There are also numerous approaches to the mapping of natural hazards, focusing on the active geomorphologic processes. In our opinion, the cartographic representation of the geomorphosite/hazard dualism is given by the map of vulnerability of the landscape created by the singular geomorphosites and/or of the geomorphosite to natural hazards. This is the complex, general or special map that varies in content depending on the addressed topic and on the representation scale (Grecu et al, 2012). The vulnerability map is a qualitative one, describing the intensity of geosite/geomorphologic landscape risk exposure and it is elaborated on the basis of some quantitative indices and parameters.

2. MODELLING SYSTEMS AND TYPIFICATION OF GEOMORPHOLOGIC HAZARDS AND GEOMORPHOSITES IN ROMANIA

2.1.The glacial (passive) and periglacial system, the gravitational system, affect the mountain areas with alpine and sub-alpine climate. Cryo-clastic processes (weathering), nival and cryo-nival processes occur. Snow avalanches and rockfalls are frequent. The gravitational system affects the high slope units (landslides, falls), and also the ones with vertical material displacement in porous rocks (suffusion and compaction).

2.2. The pluvial-torrential system models the slopes with different declivity degree; it has a great frequency and intensity in the deforested areas from the hill, plateau and sedimentary mountain units (pluvio-denudation, torrentiality) (table 1)

Table 1 Typology of geomorphosites in Romania after genesis and related hazards

Relief Unit.	Mode-lling system	Geomor-phosite	Genesis Process/ hazard geosite	Vulnerability to natural hazards	Immi-nent risk	Observa-tions/ value
1	**2**	**3**	**4**	**5**	**6**	**7**
Moun-tain	Glacial passive	Bîlea glacial	Glacial erosion	High vulnerability to active periglacial rocesses	Risk to associated hazard	scientific touristic
	Periglaci al/Gra-vitational	Piatra Craiului debris slope Avalanche ouloirs	Weathering, rock falls	High vulnerability to gravitational processes	Risk to associated hazard	scientific touristic
	Aeolian	The Sphynx, Babele (Bucegi Mts.)	Differential aeolian weathering	High vulnerability to periglacial processes	Degrada-tion risk	scientific protected touristic
	Karst processe s	Scărişoara Cave (Apuseni Mts.)	Endokarstic processes	High vulnerability to climate changes	Degrada-tion risk	
Curva-ture Subcar-pathians	Gravita tional	Landlides (variety,landscap e)	Displacemen t through sliding	Very high V. to complex geomor-phologic hazards	Reactiva tion	scientific
	Pluvial-torrential Complex processe s	Meledic salt geosite, the Mud Volcanoes	Clastokarstic processes Pseudo-vol-canic proces-ses, tectonic processes	Very high V. to complex geomor-phologic hazards	Degrada-tion risk	Scientific protected touristic
	Fluvial	Putna waterfall	Fluvial erosion	Low vulnerability	Degrada-tion risk	Scientific /protected touristic
Hill/ Plateau	Gravita-tional	Glimee (Tran-sylvania plateau)	Displacemen t through sliding	Very high V. to complex geomor-phologic hazards	Degrada-ion risk	scientific/ protected touristic
	Pluvial-torrential	Râpa Roşie Sebeş	Pluvio-torre-ntial erosion	Very high V. to complex geomor-phologic hazards	Degrada-tion risk	Scientific protected touristic
	Fluvial	Braided channels (Suceava, Moldo-va rivers)	Fluvial cumu-lation and erosion	Very high V. to complex geomor-phologic hazards	Degrada tion risk	scientific/ protected touristic
	Karst processe s	Movile cave, Casimcei gorges (Db), Mehedinți plateau	Pluvio-torrential erosion	Very high V. to complex geomor-phologic hazards	Degrada tion risk	Scientific protected touristic

1	2	3	4	5	6	7
Plain (Roma -nian, Banat Crişa-nă)	Fluvial	Câlniştea Mean-ders, Olt Slatina, Dridu popina	Fluvial erosion	High vulnerability to channel processes	Degrada tion risk	Scientific protected touristic
	Suffusio n and com-pacttion	Crov (Bărăgan)	Subsidence	Vulnerability to humidity exces	Degrada tion risk	scientific/ protected touristic
	Aeolian	Sand dunes (Dăbuleni Oltenia Plain)	Aeolian acu-mulation	Vulnerability to antropic processes	Degrada tion risk	Scientific protected touristic
Danu-be flood-plain Danu-be Delta	Fluvial	Channels and islands	Fluvial accumulation	Vulnerability to antropic processes	Degrada tion risk	scientificp rotected
	Deltaic, marine	Ridge plains and islands	Fluvial marine accumulation	Vulnerability to antropic processes	Degrada tion risk	Scientific protected touristic
	Aeolian	Active dunes (Letea, Caraorman)	Aeolian accumulation	Vulnerability to antropic processes	Degrada tion risk	Scientific protected touristic
Black Sea coastl ine	Marine - erosion, accumul a-tion	South rocky quay of Constanța	Marine erosion	Vulnerability to antropic processes	Degrada tion risk	Scientific protected touristic
	Complex processes	Mamaia beach	Marine accumlation erosion	Vulnerability to antropic processes	Degrada tion risk	Scientific protected touristic

2. 3. The fluvial modelling system characterizes the hilly and plain regions as well as the mountain depressions (spreading and braiding, lateral erosion, meanders in plains and subsiding areas, accumulations in river channels).

2.4. The coastal system – on the Black Sea shore.

2. 5. The aeolian system – on sands (around 540000 ha, of which 100000 ha of mobile and semi-mobile sands) and at high altitudes in mountain units with effect in differential erosion (Grecu, 2002).

CONCLUSIONS

The two research domains on terrestrial relief have emerged from practical needs and represent the applied part of the dynamic geomorphology. The methodology of hazards geomorphology approaches also applies to the dynamics of geomorphosites which turn into elements at risk.

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