

RELEVANT GEOLOGICAL FEATURES IN TERMS OF REGIONAL GEOGRAPHY ANALYSIS AND THEIR GRAPHICAL REPRESENTATION. CASE STUDY: THE LAND OF HAȚEG

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ABSTRACT – Regional geography studies should approach the interrelations between the components of the territorial system and highlight those distinguishing features which will act as levers for future development. Speaking of the geological features, the graphical representation both of the evolution and of the current situation is considered important. Cartographic resources and the GIS software make possible many spatial analyses that can help in quantifying the implications of the geological evolution on the present state of a region. The cartographic representation in regional context of the deposits was considered necessary for the Land of Hațeg, as well as the reference to the national tectonic context. Together with these, the spatial representation of mineral resources, the evolution of the exploitation sites, as well as the potentially attractive areas were the subject of another chart, where graphics were inserted to quantitatively highlight the impact of the petrographic features on the morphometric parameters.

Keywords: geological evolution, petrographic features, morphometric parameters, regional geography, graphical representation, GIS software, Land of Hațeg

INTRODUCTION

The paper starts from the premise that there are little chances that each of us refines and masters several fields in the context of rapid scientific and technological progresses. This is the very reason focus is placed on the individual ultra-specialization. In regional geography, it is necessary to identify the implications of each constituent element on the operation of the territorial system as a whole. Therefore, the expert, in our case, should know enough from everything to understand the operating laws. Otherwise, the expert's proposals meant to improve the operation of the system will have an opposite, inhibiting effect. The regional geography experts' solution when they have to highlight the implications of geological evolution on the past, present and future of a territory is represented by the existing geological maps (performed by geologists). The processing of these maps by GIS software helps identify numerous correlations between geology and other elements, without them having thorough geology knowledge. A regional geography expert is considered able to handle one of the GIS softwares, which enables quantitative, statistical etc. analyses in the given spatial context.

The significance of a retrospective look in the geological past of the research area is indisputable. The fact alone that relief, the result of a geological evolution within a given climate context, is simultaneously a support and resource for the development of most human activities is enough motivation to pay special attention to it throughout the research. In addition, we consider that all the other elements of the natural environment, to a lesser or greater extent, may receive a specificity value depending on the petrographic features. Perhaps the most important example is that of water

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resources, whose chemism and/or spatial distribution is significantly influenced by the geological features.

Although the geologic evolution (with specific phenomena and processes) still continues nowadays, this aspect is rarely mentioned. It receives little importance, even when analyzing the geomorphologic and/or hydrological risk phenomena whose development and magnitude is, in many cases, determined by the petrographic features. A spatial distribution map of the main types of geological formations provides us explanations for the presence of various mineral resources, which, on quite a few occasions, due to their economic value, play quite considerable roles in the evolution of the society.

This paper finds its use in the context of the development of many regional geography researches, over the last years, at national, but also international level. Among these, one should mention the papers addressing the “land”-type regions, the so-called “*țară*” in Romanian. The “lands” of Romania are being analyzed under the supervision of Professor Pompei Cocean, who imposed the mental criterion necessary for their delimitation. Under his and other professors’ coordination, the Faculty of Geography within Babeș-Bolyai University was involved in several land use planning projects, which, as opposed to the first two types of studies, go into more details on the evolution and the present context of the territorial system, with a proposals section of around 50% of the material.

While in most of the land use planning studies the implication of each element of the system on the operation of the whole was identified, accompanied by an adequate cartographic representation, the studies on the “lands”, but also on other types of regions in Romania, have the imprint of the author’s vision of the functionality of the territory. Consequently, we will meet different attitudes regarding the importance of the geological evolution in the past, present and future of the territorial cut. Without examining in detail, categorize and exemplify the types of approaches of the geological component, an oscillation can be observed between the partial highlight of correlations with the other component elements and the assertion of the lack of importance in the territorial equation. The same note is kept also when it comes to the cartographic resources, most of the time the result of some trivial cuts from geological maps at various scales. They lack the quantitative and qualitative information on the correlations involving the geological component.

The analysis of the geological component and the representation errors at the level of the regional geography studies represent the reason a potential approach model could be developed. It is clear that differences occur depending on the characteristics of the territory, but the principle of using the specialty cartographic resources, geological maps in our case, by processing data in shapefile or raster format, spatial analysis and the generation of relevant thematic maps, is maintained regardless of the approached component.

METHODS

Broadly, the research is based on cartographic resources (geological and topographic maps), which were processed for spatial analyses or just for graphical representation. The geological maps had two primary sources:

- a) *The tectonic map of Romania and surrounding areas* and *The geological map of the Southern Carpathians* (Mutihac V. and Mutihac G., 2010, sheets III and XXIV);
- b) *The geological map of Romania*, scale 1: 200 000 (Geological Institute, 1968).

The first source was used only for graphical representation, while the second was used for spatial analyses. The result of their processing is found as shapefile data.

The topographic maps required a longer processing, the digitized contour lines (shapefile format) made possible the generation of a digital elevation model (DEM) (raster data), which, then, reclassified and converted into shapefile format enabled the identification of the correlation geology - altitude by means of the intersect command in Arc Map 10.1. The procedure was repeated also for the other morphometric indices (slope and fragmentation depth), generated in raster format, based on the DEM.

The information regarding the existing mineral resources and the geological and palaeontological areas of interest for the Land of Hațeg was obtained from bibliographical sources

(Mihăilescu and Grigore, 1982, etc.) and from field works, when several photographs of the *in situ* formations were taken.

RESULTS AND DISCUSSION

The present features of the natural environment and its evolution, materialized by the attraction or repugnance induced by its elements in order to develop various human activities, may find answer in the geological past. Hence, in contouring the functionality of the Hațeg Basin, the summarizing of the palaeogeographical evolution and identification of its present implications by analysing the correlations petrography-relief, petrography-mineral and/or palaeontological resources were considered necessary.

The palaeogeographical evolution

Seen in a broader, Central-European geostructural context, the Hațeg Basin belongs to the Carpathian domain corresponding to the active edge of the Eurasian Plate, impacted by an increased dynamics of the geological evolution, with most diverse quantitative and qualitative repercussions for the present geographic background.

In this context, at the end of the Hercinic cycle, a rift (later the Tethys Sea) was formed, which would split Pangaea into two continental masses (Gondwana and Laurasia). The edges of the two continental plates have evolved as unstable areas (active plate edges), capable of generating folded structures and mountain ranges. The Cretaceous, 146 – 66 Ma⁴, the last period of the Mesozoic era is related to the most significant geological features of the research area. Chronologically, one can identify an evolution within one of the islands of the Tethys Sea, 70 million years ago, and then as an orogen and sedimentation basin (with continuous evolution since the Middle Cretaceous).

Although the evolution within the island has ceased, its existence is proven by the fossils of 12 dinosaur species and other contemporary vertebrates, affected by dwarfism, due to the life environment characteristics, a medium-sized island which limited diversity and amount of food (Benton et al., 2010, pp. 438-454). This probably extended “[...] over the Apuseni Mountains, as well as parts of the western Transylvanian Basin, the Southern Carpathians and perhaps to areas of the present-day Pannonian Basin as well” (Codrea et al., 2010, p. 391). The interest in these grew together with the discovery of some nests with dinosaur eggs and embryos.

Punctually, in the West of the depression, there are proofs of an intense Cretaceous volcanic activity with the most probable origin “[...] in an island arc field, being plotted very close to the active continental margin field” (Bărzoi and Secleman, 2010, p. 316).

The tectonic evolution of the Southern Carpathians starts with the opening in Jurassic, followed by the closing in Cretaceous of the Severin unit (Willingshofer et al., 2001, pp. 379-395). Immediately after, in the Late Cretaceous, there follows the collision between the Supragetic and Getic (upper plate) unit and the Danube (lower plate) unit, finalized with the complete cover of the latter, and the settlement of the Getic nappe (Mutihac and Mutihac, 2010, p. 375).

In this orogenic context, it is possible that the resulting collision area must have led to the thickening of the plate and then to a crustal extension, frequently met in the case of the orogenesis processes. The crustal extension had the effects of metamorphic domes exhumation (Retezat and Țarcu Mountains) and formation of the Hațeg sedimentary basin (Willingshofer et al., 2001, pp. 379-395).

The Danube autochthon excavated by erosion in the South of the Land of Hațeg (Figure 1) is related to the Hercinic non-differentiated crystalline schists (insular occurrence in SW and NE of the Retezat Mountains), granitoids (the central part of the Retezat Mountains on the SW-NE direction and Țarcu Mountains), Petreanu-Rof. gneiss (on both sides of the middle course of the Râu Mare River), crystalline schists from the Lainici-Păiuș Crystalline petrographic entity (West of the granitoid massif in Retezat).

⁴ <http://www.geosociety.org/science/timescale/timescl.pdf> , retrieved on 13.03.2014.

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The Getic unit is present by granitoids (West), epimetamorphic crystalline schists from the Dăbâțca Crystalline (the Galbena-Cerna interfluve, pyrite exploitation area), mezometamorphic crystalline schists belonging to the upper (non-differentiated in the West, differentiated in the NE - manganiferous complex and micaschists complex) and lower (non-differentiated in the South of the Godeanu Mountains and NW or belonging to the gneiss, quartz-feldspatic complex in the North) Sebeș-Lotru Crystalline.

Within the limits of the Land of Hațeg there are two areas with sedimentary formations, one in the South (Permian, Jurassic and Cretaceous), with the Piule-Iorgovan Mountains representative in this regard and another, the most significant in terms of extension, corresponding to the depression unit which extends over the Șureanu Mountains, where diversified karst landforms developed in Jurassic limestones.

Some sedimentary formations are the result of the Getic nappe evolution, characterized by alternation: sedimentation domain – denudation domain. Starting with Jurassic, several areas are outlined which will work as sedimentary basins, one of these being the Hațeg Basin (Mutihac and Mutihac, 2010, p. 423). Under relative tectonic calm conditions, in Neo-Cretaceous (100-66 Ma), the deposited formations have been mainly removed, remaining only on the North-Eastern side of the Hațeg post-tectonic depression. At the end of the Eo-Cretaceous, the entire Hațeg Basin was uplifted. The erosion and alteration processes occurring in this period have led to the accumulation of a bauxite formation in the negative landforms of the karstic palaeo-relief (Mutihac and Mutihac, 2010, p. 434).

In the same continental evolution regime, but later, at the end of the Maastrichtian (66 Ma), lacustrine continental deposits accumulate. These may be found in the Central-Western part of the depression, known as “Sânpetru Formation”. The interest for these layers is due to the available faunistic remains (dinosaurs, crocodilians and chelonians).

The present image of the Hațeg Depression was formed in Paleogene (66-23 Ma), when, along with the Petroșani Depression, it was part of a golf of the Transylvanian Depression. Later, towards the end of the late Miocene (approx. 16 Ma), the Hațeg Basin was affected by an emergence phase, while in the middle Miocene (16 – 11.6 Ma) the sea went back (Mutihac and Mutihac, 2010, p. 487).

The Pleistocene (2.6 – 0.01 Ma), the first epoch of the Quaternary, characterized by climate cooling and warming successive periods, has caused in the Southern high mountain areas, due to the former periods, a spectacular glacial relief with many valleys, glacial cirques, moraine deposits and other landforms generated by the erosional activity of the glaciers, whose complexity stands out at national level. The presence of this type of relief made possible the occurrence of a large number of glacial lakes (87 within the limits of the Land of Hațeg only), which provides an additional value to the mountainous landscape.

A significant role was played by the faults formed by the crystalline – Mesozoic basement of the depression: in the East, the Peștera Boli fault (in relation to the Petroșani Depression), in the West the Iron Gates of Transylvania (they separate the depression from the Bistra corridor), in the North the Hațeg fault (in relation to Strei Depression), and inside, the Baru Mare and Ciopeia-Nucșoara faults (Mutihac and Mutihac, 2010, p. 489). All these divide the depression into several basins. If, in geological time, the above-mentioned faults have induced differentiations in evolution (coexistence of the subaquatic and subaerial evolution types), *at historic scale these have stand out as passes and gates which enabled the local communities to partially moderate the demographic inputs, often related to war periods.*

The relationship between geology and relief morphometry

The geological evolution in certain climate contexts results in the current relief, which, by its morphometric features (altitude, slope, depth and density of the surface fragmentation, etc.) represents a driving or inhibitory factor for the dynamics and functionality of the territory.

The assessment of the extent to which petrography determines the relief features was transposed by the identification of the genetic types of rocks percentage, which results in the following:

- sedimentary rocks: 42%, with a major distribution in the depression area;
- sedimentary and magmatic rocks: 52%, present in the South, North-West and North-East of the region.

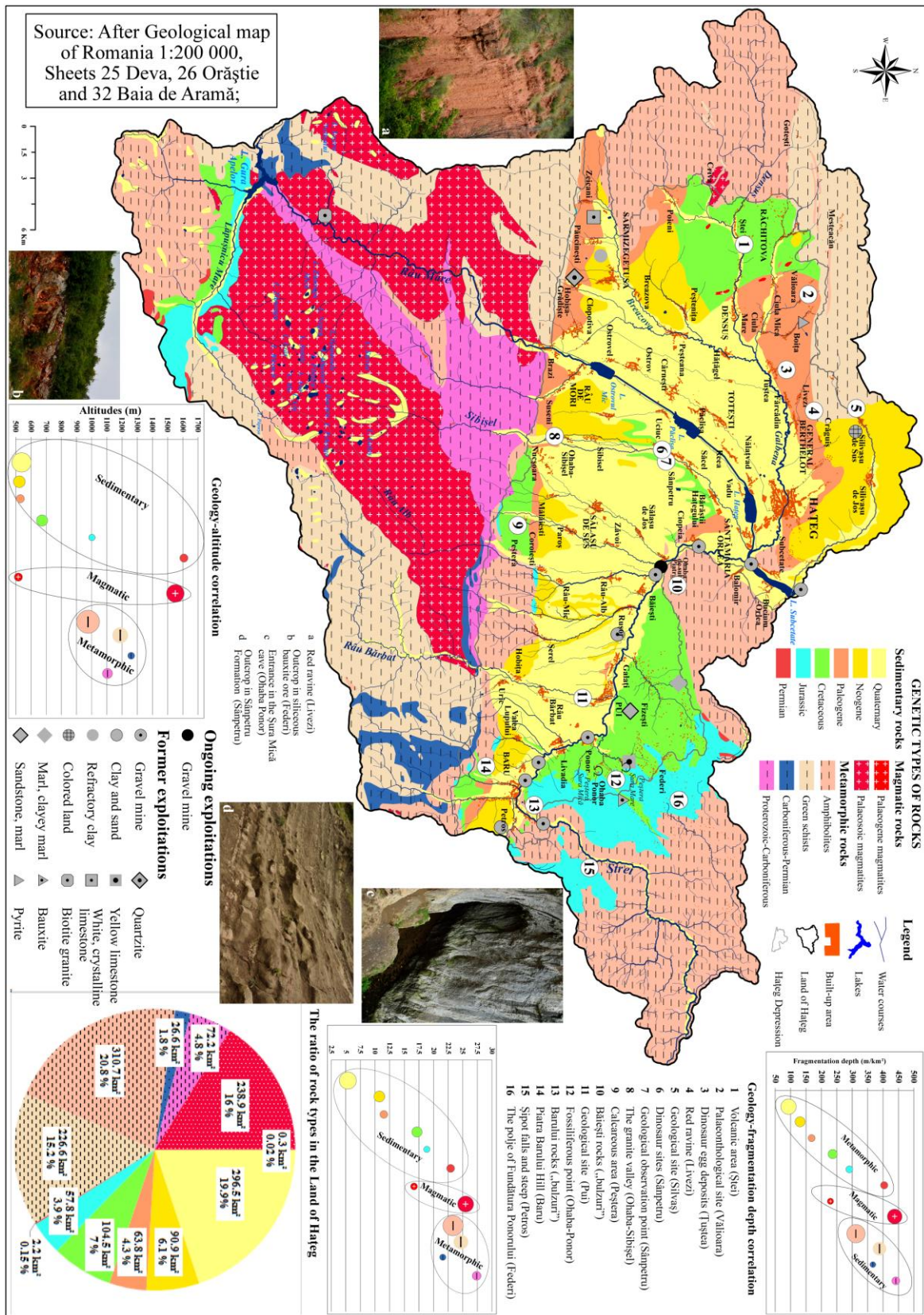


Figure 2. The graphical representation of the relationship between geology-morphometry, geology-mineral and palaeontological resources

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The result of the spatial analysis confirms the premise that rocks behave differently towards the external factors, depending on their hardness, which confers them a certain resistance to the action of the former.

The correlation graphics resulting from the three relevant indices (altitude, fragmentation depth and slope) indicate a *direct proportionality between the value of rock hardness and that of the indices* (Figure 2). The hypothesis that the metamorphic and magmatic rocks were the foundation of a specific mountain relief is justified, without excluding the role of the geological evolution (orogenic movements, etc.), while the sedimentary deposits have caused low values of the same indices, with implications on the other elements of the natural environment, respectively a *favourability for habitation and diversity of the economic activities in the depression area*.

The relationship between geology - mineral resources and palaeontology

The analysis of the geological evolution of the region highlighted a *relative resource scarcity genetically related to evolution* (mineral resources). However, three exploitation areas are identified: the North-Eastern, North-Western and Western area, where, except the bauxite and pyrite, only building materials are found (ballast, refractory clay and sand, sandstones, marls, limestone, quartzite, biotite granite, etc.), which proved useful especially during the hydropower works on the Râul Mare.

The diversity and amount of the mineral resources are not impressive. Instead, *the palaeogeographic evolution heritage is substantial, giving an original character to the Land of Hațeg at national level*, and by some of the elements, even at worldwide level, representing the main brand of the region. The forefront in this regard is held by the fossils preserved in the Sânpetru Formation, among which one should mention 12 herbivore or carnivore dinosaur species, affected by insular dwarfism (unique discoveries worldwide), fossilized eggs nests, their embryos, crocodylians and flying reptiles (Hatzegopteryx), etc. The palaeontological resources have constantly raised scholars' interest, starting with the end of the 19th century, when "papers about Gyula Halaváts and Franz Nopcsa's discoveries were published in Budapest and Vienna, in 1897" (Grigorescu, 2010).

Impossible to be classified as palaeontological resources, but with a similar use, the karst relief in the North-East or the glacial relief in the Retezat, Godeanu and Țarcu Mountains are worth mentioning, as well as the relict plant species whose presence is due to the petrographic features (with implications on changing the soil temperature), substantially enriching the flora and dendrological heritage of the region.

An approach in compliance with the current situation is represented by the classification of the almost entire territory of the "Land" (99%) in the categories of Special Protection Areas of national interest (from scientific reserves to geoparks) and 47% in the Sites of Community Interest (SCI or SPA).

CONCLUSIONS

Beside the relationships analyzed above, two more aspects require detailed analysis in separate studies due to their relevance for a regional geography study. These are the implications of geology on the features of water resources and soil cover. The assessment of these connections can be performed by following similar principles, resulting in end products like detailed and relevant graphical materials of significant practical utility.

The importance of the geological evolution for the functionality of the Land of Hațeg territorial system materializes in the morphometry of the relief, chemistry of water resources, soil characteristics, quality and/or quantity of the mineral resources and, last but not least, in the abundance and uniqueness of the palaeontological elements. All these relationships need to be analyzed and considered regardless of whether it is a development strategy or a regional geography research. The statement remains valid even if we are speaking of a different area, where other relationships might occur that require further analysis (i.e. the influence of tectonics in the frequency and intensity of earthquakes, etc.).

The use of GIS in the quantitative assessment of any type of relationship between the constituent elements of the territorial system and its graphical representation, for a better practical utility, is a viable solution.

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