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VULNERABILITY OF TOURISTIC GEOMORPHOSITES IN TRANSYLVANIAN SALIFEROUS AREAS (ROMANIA)

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Abstract: Our study focuses on the impact analysis of contemporary geomorphological processes on tourism activities in the diapiric regions of Transylvania. The methodology implies identifying the causes of geomorphological processes that induce territory's vulnerability and restrict tourist activities. Inside the study area, in the anticlines of Praid - Sovata and Turda, the saliferous geomorphosites were identified, along with the geomorphological processes and human activities that lead to their deterioration. The study required the use of topographical maps (1:50000 scale), aerial photographs and orthophotomaps besides the field investigations. The methodology led to the identification of the opportunities offered by the diapir geomorphologic landscape in order to outline complementary or alternative tourist activities that would ensure permanent tourist activities.

Key words: vulnerability, saliferous geomorphosites, geomorphological processes, Transylvania

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INTRODUCTION

The aim of this study is to analyze the vulnerability of saliferous geomorphosites. The vulnerability of a geomorphologic system can be defined according to its sensitivity, its feedback capacity to interior or exterior changes and its adapting ability to new states. They include both the impact of human activities on the relief form and the effect of contemporary geomorphological processes in its evolution (Irimuş, 2006). The

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Transylvanian sedimentation basin appeared in the process of slow and continuous sinking of the initial crystalline one that started at the end of Cretaceous.

The studied areas are the anticline Praid - Sovata, situated in the eastern part of the Transylvanian Depression and the salt massif at Turda, situated in west (Irimuş, 1998). The following geomorphosites where identified in the area: the salt mine in Praid, Dealul Sării (Salt Hill) or the Natural Reserve of Sohat, the salt lakes and helio-thermal lakes in Sovata and the salt mine in Turda. The result of our study will be the identification of geomorphological processes and human activities that lead to the degradation of the geomorphosites and in some cases restrict the tourist activities.

THE STUDY AREA

The Transylvanian basin took shape at the end of Cretaceous and the beginning of Palaeocene, during subsidence processes, while at the margins, through orogenesis processes, the Carpathian Mountains appeared. The sodium chlorine, known under different names, salt, kitchen salt, rock salt, halite, is both a mineral and a rock, a monomineralic rock. The Transylvanian basin's genesis, at the end of Cretaceous and beginning of Palaeocene, consisted of a slow but continuous sinking. The salt in the area, aged 13-14 million years, resulted from the isolation of the Transylvanian basin from the Pannonian one, due to the decrease of the planetary ocean level during the Badennian era (Horvath, 2002).

The climate was a temperate-Mediterranean one, but the main cause of salt precipitation was represented by the isolation of the basin and not climatic conditions. Initially, salt deposited in horizontal layers, between other rock layers; afterwards, due to tectonic movements and its plasticity, it concentrated on low resistance lines of the other rock layers, forming different shapes (lamellar, ovoid, feather, massif) that compose the existing salt ore alignments. Therefore, salt appears both in depth, as a layer thick of hundred of meters, and at the surface or close to it, as diapiric alignments (axial areas to anticline folds) in the eastern and western part of the basin, linked by those in the north and south. The salt-core diapirs of different shapes and sizes, have generated through the uplift of salt to the surface, various specific landforms. Therefore, during the uplift generated particularly by its plasticity, the layers on top were vaulted or fractured (Irimuş, 1998; Irimuş, 2006).

The Praid-Sovata anticline is represented by two diapir columns that are situated in the area of Sovata-Corund and are the best example of exploitation and capitalization of salt and salty waters. The evaporitic layer comes to the surface both in Sovata and Praid as salt massifs. The salt in Praid has a macro or micro-crystalline aspect, being impure due to the mechanical syngenetic dispersions that consist of clays, marls, sandstones and, crystalline limestones; they appear as disseminations, impregnations, layered inclusions or enclaves of different dimensions.

The clays inside the salt of the "*cap-rock*" ore cover contain rock elements of foreign origin, that being Carpathian, Triassic, Jurassic and Cretaceous formations, sandstones, crystalline limestones, gneiss or quartz. These elements were probably originated in the decomposition of the Mio-Pliocene conglomerate during the orogenic folds or were transported from the neighboring continental area. Rarely, clays with crystalline aggregate of secondary gypsum appears.

The geological research made in Sovata revealed that the salt massif has an elliptic shape, longer on the north-east – south-west direction. The salt massive in Sovata appearing at the surface, is marked by drains, karrens and sinkholes that create interesting pseudo-karst features that appears associated with Ursu and Aluniş Lakes, the salty water ponds, salty muds, salty efflorescences and halophile plants (Horvath, 2002). The salt rock massif in Turda, is situated in the north-eastern part of Turda municipality, where the abandoned salt mines can be found. This ore is set on the same salt anticline as the salt mine in Cojocna, and it has a width of 1000 m and a depth of over 230 m. The elongated ore has intercalations of argillaceous schist and is covered by a layer of 1500 m of argillaceous schist and gravel. Close to the surface, the salt is pure, solid, crystallized and largely granulated, but in depth it contains fine disseminated sand. The concentration of sodium chlorine is of 98-99%. The estimated geological reserve is of about 38 750 million tons (Irimuş, 2006).

SALIFEROUS GEOMORPHOSITES

"*Geomorphosites are defined as forms of relief and geomorphological processes that gained an aesthetic and landscape value, scientific, cultural/historical and/or social/economic value, due to human perception or exploitations*" (Panizza, 2001; Reynard and Panizza, 2005).

According to J. P. Pralong (2005) "*Geomorphological sites may become natural and tourist resources, because of their scenic, scientific, cultural and economic interests, components of their tourist value, in order to develop recreational activities and induce economic effects*".

The salt massif in Praid, horizontally placed has a quasi-circular shape, slightly elliptic, with diameters of 1.2 and 1.4 km, while structural probes (S ACEX 401/1949, S 110/1973) estimated a depth of 2,6 to 2,8 km, being thus the most developed diapir structure in the country. Two geomorphosites already included in tourist activities were identified here: the salt mine in Praid and the Natural Reserve of Sohat (Horvath, 2002).

The Natural Reserve of Sohat (figure 1, 2) on Salt Hill has a surface of 6 ha and is surrounded by steep slopes of salt, forms that offer a unique view. Inside the geological reserve we can see karst formations that continuously change its appearance (sinkholes, swallow holes, globular concretions).

Figure 1. The Natural Reserve of Sohat

The rich vegetation consisting of species adapted to saliferous soils also contributes to the interesting aspect of the reserve. On clear sky, the Salt Mountain has a shiny-white glow, while on increasing humidity time its colour becomes dark-grey (Józsa, 2002).

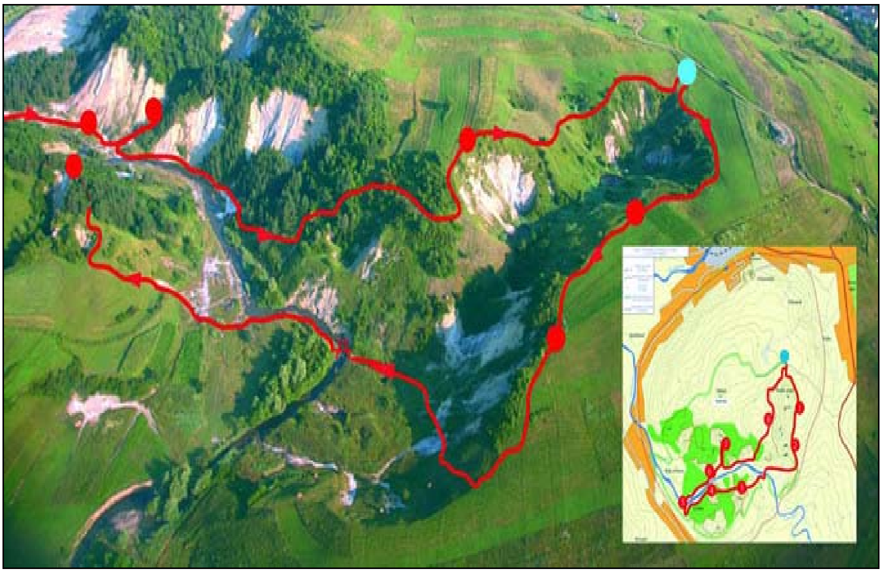

Figure 2. The limits of Sohat reserve

Another geomorphosite is represented by Praid salt mine (figure 3, 4), where salt is still exploited and treatment facilities where created. The latter are placed on the level +402 m, also called "*50*" in the area of inferior layers, and has a total surface of 9400 sqm. At this level, several facilities designed for tourists were created: the underground climatic treatment, with natural aerosols it is an unique microclimate in the country; a chapel for services in different religions; a children's playground; a museum of historical salt exploitation in Praid; permanent medical services; photography exhibitions; selling points for folkloric items, popular ceramics; arts exhibitions (sculptures, paintings on salt); internet café, etc. (Horvath, 2009).

Figure 3. The chapel of Praid Salt Mine

Figure 4. Praid Salt Mine

The geomorphosite identified in Sovata consists of a series of salty and helio-thermal lakes: Ursu Lake (the main and largest lake), Alunis Lake, Green Lake and Red Lake. Ursu Lake (figure 5) appeared inside a depression formed after collapse, as a consequence of an intense process of salt dissolution, at the contact with other surface deposits, occurred during the period 1875-1880 (Alexe et al., 2006). The exact timing of the collapse can be given. It took place on the 27th of May 1875, 11 a.m, when a heavy rain shower generated high waters in Toplița and Auriu rivers that drained the new formed crater. Due to its bear skin shape, the local people called it Ursu Lake (City Hall Sovata, 2009). Four years after its formation, the helio-thermal phenomenon was mentioned. Aluniş Lake (figure 6) appear due to water leaking from Ursu Lake. The Red Lake (figure 7) and Green Lake (figure 8) are two lakes whose genesis was simultaneous with that of Ursu Lake, and their depth does not exceed 2 meters.

Figure 5. Ursu Lake

Figure 6. Aluniş Lake

Figure 7. Red Lake

Figure 8. Green Lake

Figure 9. Terezia Mine, Turda Saline

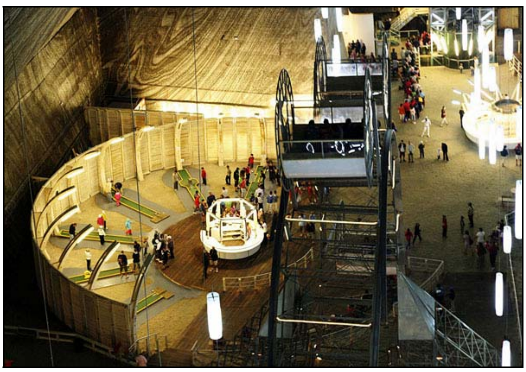

Figure 10. Rudolf Mine, Turda Saline

The geomorphosite in Turda salt mine was created by salt exploitation starting in the Roman period. In 1932 exploitations were permanently ceased. It was declared natural reserve of national interest in 2000, and today it became a real mining history museum.

The tools used for exploitation and transportation (figure 11) are in excellent conditions, due to the stability of the massif and rock in its ceiling. As a result, Turda saline mine was realigned and received an extended functionality. Thus, in Rudolf Mine (figure 10, 12) were made rearrangements in order to have a concert hall, a sports field, a bowling, a minigolf likewise a huge gondola and an elevator. Also, on the lake from Theresa Mine (figure 9) was built a dock with boats. Overall, the Turda salt mine's appearance has changed radically. The official opening after renovation was made on 22 January 2010 (Mera et al., 2010).

Figure 11. Rudimentary tools used for exploitation, Turda Saline

Figure 12. Rudolf Mine, Turda Saline

RESULTS AND DISCUSSIONS

Geomorphological processess and human activities leading to geomorphosites degradation are: natural dissolution of the salt massifs, settlements, infiltration from rainfall and salt exploitation. Natural dissolution of the salt massifs occurs in outcrops of the Salt Hill. Funnels dissolution and salt open rocks from Corund creek defile also landform surfaces susceptible to dissolution, especially during heavy rain periods. The main factor which makes the formation of salt karst is freshwater or slightly salted, causing the dissolution processes.

Salt rock is extremely susceptible to karstification, the dissolution process being very fast due to cracks, joints and bedding planes which constitute pathways for water infiltration in the existing material. After a period of active dissolution the water becomes saturated and its action is reduced only to a dynamic action resulted from the flow energy. Gradually, the water will leave the surface flow and will follow the underground ways.

Thus, exokarst from the beginning of the process will evolve into endokarst forms (dissolution caves, caverns, broad cracks, enlarged joints with irregular vertical development, corrosion caves, etc). In our study area, large caves cannot form because of the high degree of solubility of salt rock that would lead to overcoming of equilibrium conditions and to the collapse of the ceiling.

In areas where salt formations crops up the following forms of exokarst are formed: sharp limestone pavements, sinkholes (conical, asymmetric and elongated ones; collapse sinkholes, suffosions sinkholes) and enlarged cracks on salt surfaces which were generated by small sinkhole migration to the water infiltration place.

The gullies development is favored by chemical and hydrodynamic suffosion processes and settlement processes. Dissolution also has an important role in the genesis and evolution of suffosion and compaction processes.

CONCLUSIONS

In our study area, dissolution is the main geomorphological process leading to the vulnerability of geomorphological sites. This process causes cracks, joints, funnels, pseudokarst forms, etc. These ones can cause the geosites degradation and can destroy spectacular features of the geomorphosites.

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