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THE STUDY OF THE POROSITY OF THE LIMESTONES IN SOME OF THE SCREE IN LEAOTA MASSIF

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Abstract
The screes are the result of interaction between pre-existing rocks and exogenous agents, forming by mechanical disintegration processes, mainly due to cryoclastic (gelivation) processes. Cryoclastic processes are generated by the pressure exerted by water from pores or cracks and microcracks of the rocks. The result of these processes is known in the literature as cryo-nival relief. The main representatives of the cryo-nival relief are the screes; these are detritus mobile rocks, with angular ranges of various sizes (unsorted). This scree, in most cases, are areas that are unaffected or less anthropically affected; they represent habitats with certain microclimatic peculiarities, named mesovoid shallow substrate (MSS) or shallow subterranean habitats (SSHs) by the specialists.
These terms being outlined and being used more and more frequently since the 1980s. One of the most important peculiarities of the MSS is represented by the high relative humidity values, a main ecological factor that depends on the interclastic porosity but also on the microporosity of the clasts that are part of the scree. Moreover, the processes of chemical and biochemical alteration are dependent on the presence of water in the rocks and therefore, indirectly, on porosity. For this reason, we examined the porosity of limestone clasts belonging to the scree. The generation of the scree itself, disgregation process on the masses, depends on the geomechanical characteristics of the rocks from which the nude slopes are made, how rock behaves in the cryoclasting processes, which is fundamentally influenced by porosity.

Keywords: cryoclastic processes, limestone scree, mesovoid shallow substratum (MSS), porosity, shallow subterranean habitat (SSH)

1. INTRODUCTION

The limestone located in the geographical area of North-Western sector of Leaota Mts. are geologically the same with the ones in the neighboring massif, Piatra Craiului, in fact representing their continuity (Fig. 1), with all the retinue of specific karstic phenomena. We chose the limestone scree as study object, as they represent a very interesting type of habitat from the ecological perspective, relatively not enough studied in Romania, and, up till now, missing from the studyes about Leaota Massif. The rocks' porosity defines their behavior against the cryoclastic (gelivation, gelifraction) phenomenon, which leads to the formation of scree and the development of the MSS. Porosity also plays a determining role in the ability of the rocks to retain moisture. The high relative humidity values in the MSS throughout the whole year, often to saturation or close, are an ecological feature of the MSS (Dorobăț, 2016; Mammola et al., 2016) and very important for many species of invertebrates (Nitzu et al., 2014; Nitzu, 2016).

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2. MATERIALS AND METHODS

Researches carried out in this part of the Leaota Mountains were divided in five areas (Fig. 1) with colluvial limestone scree, set at the basis of the slopes. Extraction of samples from the scree was done randomly, for all five sites. We collected as many representative samples as possible from the limestone scree, showing no evidence of chemical alteration and/or cracks. Given that the behavior of the rock collected and analyzed in the laboratory is not influenced by the scale effect, then the laboratory results can fully provide their parameters in the MSS from which they were collected (Georgescu et al., 1971), as is our case.

In order to determine the *open porosity* (p_o), *total porosity* (p), we use standard methods according to the SR EN 1936:2007 Standard, which we will show in the following lines:

The specimens used for this standardized methods of geomechanical analysis should be made at standard cubic dimensions of 5 or 7 cm or cylindrical with diameter and width of the same dimensions as those specified above (Fig. 2).

At least 6 samples are prepared for each location. The samples are dried at a temperature between 65°C - 75°C, by heating them in an oven, in order to remove the water. When the difference between two successive weighings over a period of 24 hours (± 2h) is not more than 0.1% (constant mass) we can assume that the sample is completely dry.

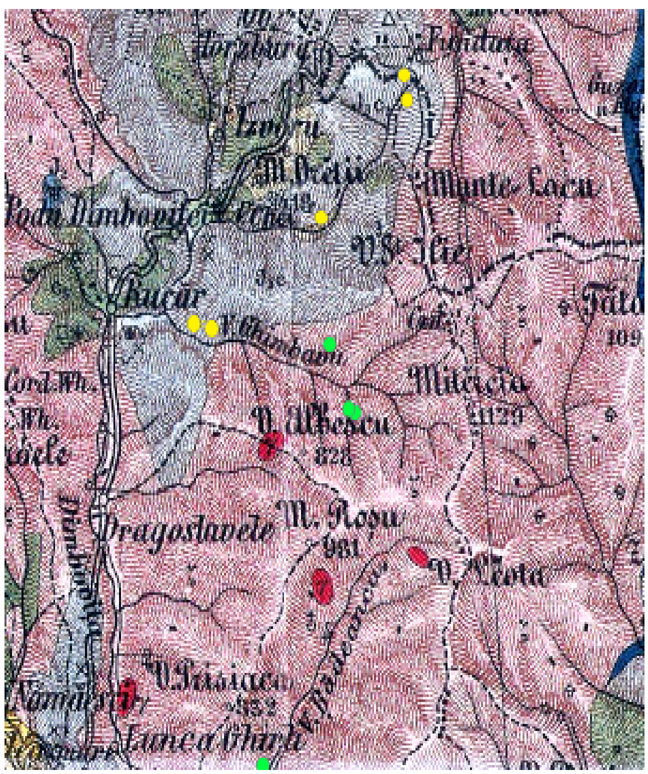

Figure 1. Distribution of the rock types in the NW region of the Leaota Massif (after Popovici-Hatzeg, 1899) and location of the areas from which samples were taken

Legend: crystalline shists limestone areas where limestone samples were taken

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Figure 2. Samples made of the klasts in the limestone scree according to the standards

Each sample is taken from the desiccator, is weighted, its dried mass (m_d) is written down, then it is placed in a vacuum device and the pressure is gradually lowered until it reaches the value of 2 kN/m^2, with a tolerance of ± 0.7kN/m^2. Softened water is then poured in the tube at a temperature between 15°C and 25°C, the samples having to be covered by water in maximum 15 minutes. The pressure in the tubes increases until the pressure reaches normal values (the one of in the atmosphere) and the samples are kept for another 24 hours (± 2 hours).

After this period of time, each sample is weighted under demineralized water and its covered by water mass is written down (m_h). Then, each sample is taken out, it is rapidly wiped with a wet textile material (or with a sponge), it is weighted and thus we determine the mass of the water-saturated sample (m_s).

The open porosity (p_o) is calculated through the division of the open pores volume and the apparent volume of the sample and it is expressed through percentages:

$$p_o = \frac{m_s - m_d}{m_s - m_h} \, x \, 100$$

where:

m_h = the mass of the water covered sample; m_d = mass of the dry sample; m_s = mass of water-saturated sample.

The total porosity (p) is calculated by dividing the total volume of the pores (opened and closed) and the apparent volume of the sample. It is expressed in percentages.

$$p = (V_p : V_t) \, x \, 100$$

where:

V_p represents the volume of the pores; V_t represents the total volume of the rock (the volume of the mineral structure, V_s + the volume of the pores, V_p).

The volume of the opened pores, expressed in milliliters (cm^3) is calculated through the relation:

$$V_o = \frac{m_s - m_d}{\rho_{rh}} \, x \, 1000$$

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The apparent volume is calculated through the formula:

$$V_b = \frac{m_s - m_h}{\rho_{rh}} \ x\ 1000$$

where, ρ_{rh} *= 0,998 g/cm*^{3} *represents the density of the water at 20°C.*
All the values of the geo-mechanical parameters are calculated as an average of the individual values for all the at least 6 samples in each location, as for the results to be relevant.

RESULTS AND DISCUSSIONS
The total porosity shows the percentage of the pores in a rock, reported to the total volume of the rock.
From our perspective, the opened porosity of a rock is interesting, namely the total volume of the pores that communicate in-between and which have a large enough section which allows the circulation of water.
This type of porosity determines the absorption capacity of the water and it influences its permeability, as well as the frost-defrost resistance. It is determined through the saturation of the rock sample with water. The more opened pores are also called inter-communicating pores, communicating both in-between and with the exterior environment.
A large opened porosity lead to a high vulnerability of the rock against gelivation, the freezing and the defrost of the water in the pores leading, in time, to its fracturing, to the falling of the slope and to the gravitational accumulation, forming scree at the basis of the slope (colluvial MSS). Under the action of frost, the water increasing its volume by 8-9% (Florea, 1982; Stematiu, 2008).
The determined total porosity (the average of the values, reached for the samples of limestone scree) is $\mathbf{P_{t\ limestone} = 1.46}$%.
The open porosity is calculated as the ratio between the total volume of the open pores and the total volume of the rock. For the samples of limestone, we have reached the average value of $\mathbf{P_{d\ limestone} = 0.38\%}$.
By lowering the temperature around the value of 0^0C, free water freezes. The freezing begins from the surface of the rock. The maximum pressure exerted by rock gelling is recorded at minus 22 °C (Rădoane et al., 2000).
Higher open porosity leads to the infiltration of a higher volume of water in the rock and to a higher vulnerability of the rock against the chemical and biochemical reactions between the water and the mineral structure; 1cm^3 of freezing water increases its volume to 1.051 cm^3 and exerts pressures up to 200-600 N / mm$^{2.}$ (Rădoane et al., 2000).
Alongside the chemical alteration, the biochemical alteration also takes action; thus, as the chemical and biochemical processes act at the same time, the accelerate the degradation degree of a rock from 10 - 100 times faster, especially through the contribution of the algae and autotrophic bacteriae (Ielenicz, 2004; Rădoane and Rădoane, 2007).
In the case of the limestone scree, their significant inter-clastic porosity does not allow the stagnation of water in liquid state at their surface until frost, but this happens more frequently in the case of the schist scree, at the contact of the klasts with the residual clay stratum from bellow (Dorobăț, 2016).

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4. CONCLUSIONS

In the case of the analyzed limestone samples, the micro-porosity has relatively low values, compared to the ones of other sedimentary or metamorphic rock types.

The high inter-klastic porosity, combined with an insignificant volume of clay minerals in the limestone from this studied areas of Leaota Mts., is responsible for the impossibility of water stagnation in scree; the interclasts spaces are empty, they are not filled with residual clays. This being true at least for depths of more than 1.1 meter, depths to which we conducted our research.

All the above mentioned lead to the conclusion that the time in which the water is in contact with the rock is not to long, without being stored in the pores and also draining from the scree in a fast manner.

The evolution of the solification process is slow, as the chemical and bio-chemical altering (bio-meteorization) happens only when the limestone is located in a wet environment, making contact with the water for a long period, as it happens mostly in the lower parts of the scree.

The appearance of the vegetation covering the scree is possible only in the area where the soil is sufficiently developed; on this surfaces the mobility of the scree disappears, these becoming over time fixed, with fewer empty spaces, the rest of the cavities are being filled with residual clay or already formed soil and the movement of invertebrates is more difficult.

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