# Proposition of an accelerated cycling procedure for rocks with low porosity

Natália de Faria Silva
*Universidade Federal de Viçosa, Viçosa, Brazil*

Eduardo Antonio Gomes Marques
*Universidade Federal de Viçosa, Viçosa, Brazil*

Carolina Crissafe dos Santos Lemos
*Universidade Federal de Viçosa, Viçosa, Brazil*

Carolina de Souza Pires Costa
*Universidade Federal de Viçosa, Viçosa, Brazil*

ABSTRACT: A relevant method for study weatherability of rocks is the accelerated alteration simulation which intends to describe susceptibility to weathering and its products. Nevertheless, it can be difficult to set which methodology should be adopted, as the initial state of sample must be reconciled with the environment to which it'll be exposed, so that, in experimental time scale, it's feasible to observe aspects of increasing alteration and modification in properties. In a weatherability study of a metamorphosed hydrothermalized basalt with very low initial porosity, an accelerated cycling throughout immersion in sodium sulfate was adopted. Even subjecting the rock to 100 cycles, samples have only shown signs of no significant modification of physical properties. To produce substantial weathering change, a much larger number of cycles would be required, so some modifications to the test procedure are proposed, allowing the execution of a greater number of cycles without increase in duration of the experiment.

*Keywords: Weatherability, weathering, accelerated cycling, alteration simulation.*

## 1 INTRODUCTION

Because the increasing record of collapse episodes involving apparently resistant and fresh rock structures that quickly lost their competent properties, it was noted the importance of understanding how weathering acts on rocks, awakening a search for knowledge of its susceptibility to weathering and not just its resistance properties to attend design requirements.

In the engineering field, alteration is any process that modifies the characteristics that affect the performance of a rock. The process of alteration in a rock consists of the set of transformations to stabilize it at the temperature and pressure of the environment in which it is exposed, succeeding in its disintegration and decomposition, mechanisms related to physical and chemical weathering, respectively (Frazão 1993). The alterability of a rock is related to its greater or lesser propensity to the action of alteration, and as exposed by Aires-Barros (1971) must be considered a dependent function of the characteristics of the rock, the external aspects related to the environment in which it has been found and the time factor.

Weathering is often the mechanism that controls the speed of rock deterioration, especially in countries like Brazil, due to the prevailing climate, as it offers climatic conditions such as high rainfall and high average temperatures that act as catalysts for weathering reactions, main cause of the great thickness of the weathering profile registered in the country (Marques et al. 2020).

In the study of the alterability of rocks, there are difficulties related to the nature of weathering, resulting from several variables, intrinsic and extrinsic to the material, which makes it hard to define a single methodology that can be easily applicable to different types of rocks. Many works record the investigation for parameterization of alterability studies, but the methods found must still be reconciled with the particular characteristics of the rock studied and the environment to which it will be exposed, varying for each specific case. There are direct and indirect methods for the study, the most frequently used is the direct method of degradation, or durability, in which the rock has subjected to an accelerated simulation of alteration under environmental conditions that approximate those existing in the environment to which it will be applied.

Indirect methods are procedures in which tests are performed on the material in order to characterize them in the initial state and other states found for a comparison and description of the states of alteration of the rock and how its properties undergo modifications.

## 2 METHOD

This work was done with a focus on the study of the alterability of rock formation samples from a mine located in the Serra dos Carajás in the state of Pará, North of Brazil. The rock can be characterized as metamorphic and hydrothermalized basalt, and there was a search on the prevailing climate in the region where the rock was located. The adopted methodology associated the direct method of degradation with indirect methods, with tests to monitor the changes suffered by the sample.

Associating the state of receipt of the sample, characterized in the macroscopic analysis as grade W1, according to the classification of alteration of the ISRM (1981) for not presenting minerals with signs of discoloration and without visualization of the existence of pores, and the climatic data of the region where it would be exposed, which indicate high rainfall and high average temperature, it was decided to use accelerated cycling in sodium sulfate, as it is the most aggressive viable medium found in the literature and favors the activity of chemical change, such as in the exposure environment.

The accelerated cycling process in sodium sulfate was done as an adaptation of the procedure described in DNER-ME 089/94, specified for the evaluation of the durability of aggregates. The alteration cycle consisted of immersing the specimens in the sodium sulfate solution at a concentration of 200 g/L of water for 18 hours, with the specimens being removed for mass measurement on a dry surface, subsequently submitted to the drying period in an oven at 105-110 °C for 12 hours. After removing the test specimens from the oven, the dry mass of the set of test specimens was recorded to control mass loss as an indication of the wear suffered by the sample. From the end of one cycle to the beginning of the next one, the specimens were cooled to room temperature for approximately 18 hours until immersion in a new solution. The duration of each cycle was approximately 2 days, and the study subjected the sample to 100 cycles, with the removal of a few specimens in some stages of this period for carrying out tests that would allow monitoring of possible changes in the physical and mechanical properties of the sample.

At each stage of tests to characterize the state of the sample after a certain number of cycles performed, the properties of porosity, absorption, specific weight, wave propagation velocity, petrographic description, and resistance to point load were tested and recorded. The results of these tests and their variation over the cycling period were submitted for publication in a journal article and are outside the scope of this article. However, qualitatively it can be stated that there was no significant change in properties due to sulfate attack, with very low variations in all measured properties.

In addition to the quantitative evaluation, the observation of the state of the test specimens throughout the process also indicates the resistance to sulfate attack, with only superficial action thickness of sulfate being observed, characterized as an increase in roughness, only closer to the end of the 100 cycles. However, specimens that previously had surface cracks or suffered cracking during cycling (physical weathering) were more susceptible to sulfate impregnation, with the observation of precipitated sulfate on the inner walls of these specimens (Figure 1). This behavior may have occurred more due to the variability of mineralogical and textural composition between the specimens than because of cycling.

The location of the cracks observed during the cycling process was repeated in most of the specimens adjacent to the veins of different mineralogical compositions, which must possibly be related to the different coefficients of expansion of the minerals exposed to the temperature variation of the immersion to sulfate solution and oven drying (Figure 2 e Figure 3).

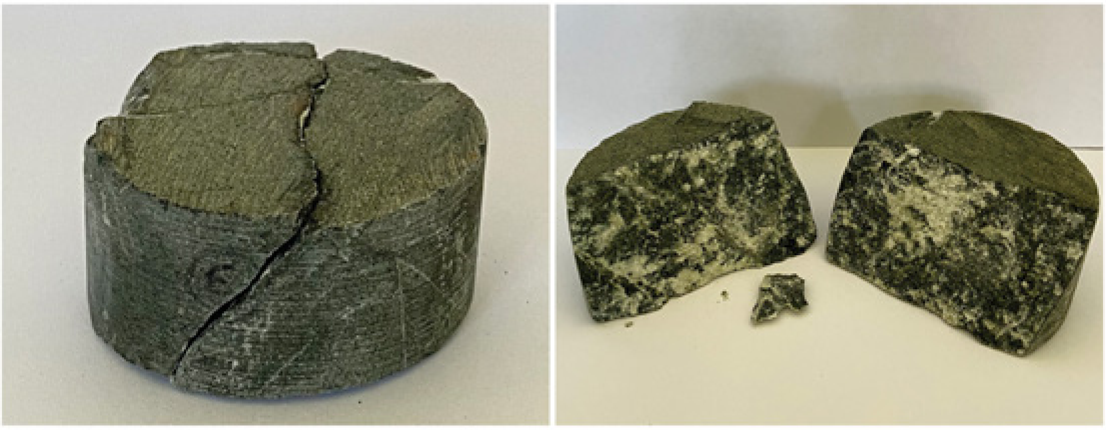

Figure 1. The specimen in which failure have developed on existing fractures and showed impregnation of sodium sulfate on the internal walls.


Figure 2. Visual evolution of specimen n° 4-2, on cycles 60, 75, 90, and 100. Note the precipitation of salts in the fracture between portions with different textures of the sample.

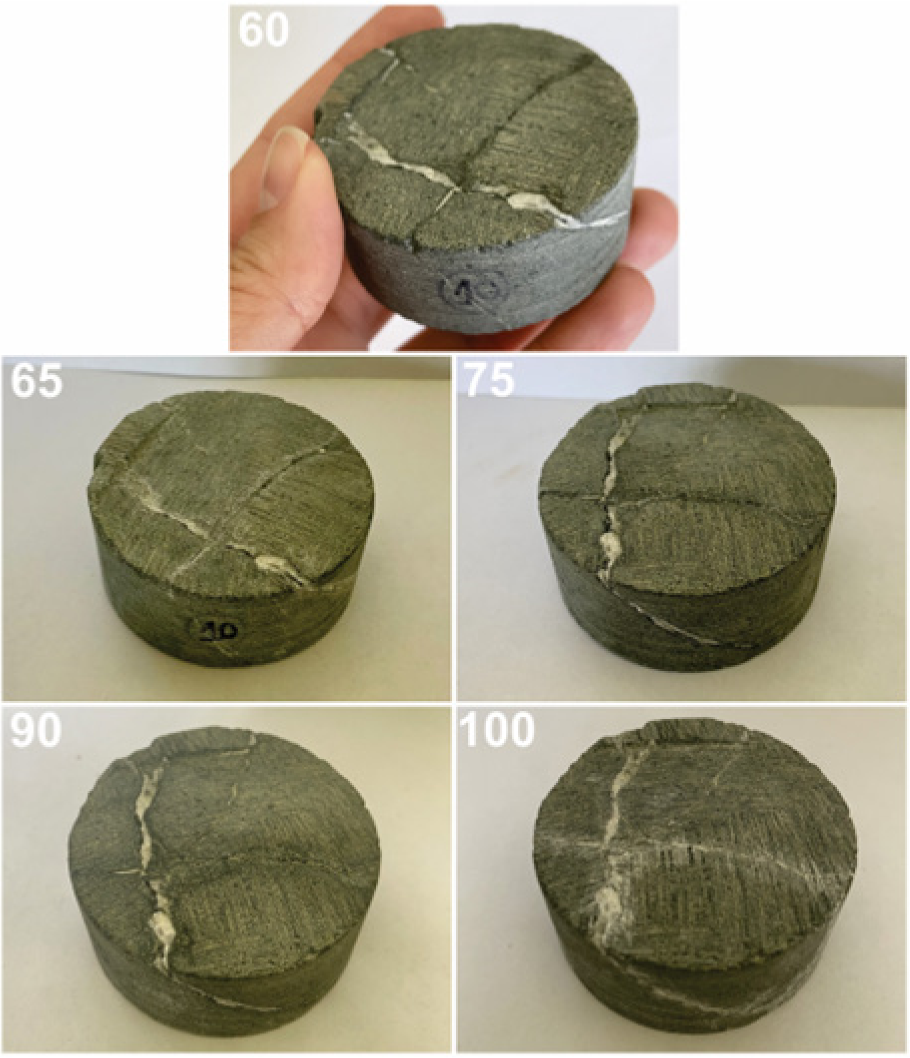

Figure 3. Evolution of the visual state of specimen n° 10 on cycles 60, 65, 75, 90, and 100. Note that on photo of the 100 cycle it can be seen a concentrated precipitation of salts in the fractures.

# 3 CONCLUSION

The evaluation of the sample after cycling showed that the sulfate attack was able to cause only an initial physical weathering in the sample, without observing signs of chemical weathering, which would be expected because of the attack on the rock at the concentration of salts used. The sample presented an initial condition of very low porosity, with a value of n=0.35%, which separately analyzed is considered as a contributing factor for the sulfate attack to have occurred only superficially in the sample, making it difficult for the solution into the sample through the interconnected pores.

Physical weathering the predominant process during the carried-out cycles, evidenced by the cracking observed with a preferential location adjacent to the veins of different mineral compositions, leads to the conclusion that the cracking was motivated by the difference in the coefficients of expansion presented by the minerals. Considering the microfabric state of the sample, the low porosity, and the registered cracking process, a modification in the cycling procedure is suggested to favor the activity of physical weathering, which often works as an initiator of the chemical process by providing an increase in the contact surface of the rock and, therefore, greater water flow in internal portions of the sample.

The indication for studying the alterability of rocks with this aspect of very low porosity is the application of the direct method of cycling by wetting and drying with shorter periods of immersion in the solution, of approximately 6 hours, so that the specimens are submitted more times to the temperature variation procedure imposed by immersion in solution and subsequent drying, for more 6 hours, favoring the greater occurrence of physical weathering mechanism. This also reduces the duration of a cycle from approximately two days to one day allowing the realization of more cycles in the same time interval used in this work, which may result in greater alteration stages that allow a better characterization of the alteration on the rock.

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