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Water Rock Interaction [WRI 14]

Influence of water on rock discontinuities and stability of rock mass

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Abstract

Water is an important weathering factor that can play a role with respect to rock discontinuities, and thus rock mass behavior. The increase of rainfall (frequency and intensity) highlights new problems concerning rock mass stability. The aim of this research is an analysis of the importance of the role of water on rock alteration. This study will discuss how water causes discontinuity degradation, which can affect the stability of the rock mass. The accurate study of water-rock alteration is based upon two aspects, on the one hand the study of the intrinsic properties of water, and on the other hand, the study of the response of the discontinuity to alteration. The present study is based on two spatial scales, laboratory and in situ (the latter will not be discussed in this article).

Keywords : weathering; chemical;, water; limestones; rock discontinuities; rock stability; roughness.

1. Introduction

The stability of the rock mass depends on the presence of discontinuities, more specifically on their mechanical properties which are related to their morphological features such as opening, roughness. The study aims at evaluating the influence of water flow on the rock mass' stability. Water can be defined by many parameters; temperature, pH, salinity, hardness (bi-carbonate concentration) and many others [1]. We will observe the influence of the pH in two cases, when water is in a static mode or in dynamic mode. In the experiment where water is in a dynamic mode, we will observe the evolution of the roughness [5].

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2. Influence of pH on water alteration

A study carried out by Kupper (1985) proposed a relation between the rate of limestone erosion, the water flow velocity and the pH of the fluid. An equation was deduced [2]:

$$\text{Log}\,(Ve)=5.103 + 0.423\,(\log\,(Vw)) - 0.442\,pH$$

Where *Ve* is the erosion velocity expressed in [10^{-6} m/years] and *Vw* is the water flow velocity expressed in [cm/s], pH is the pH of the solution (water).

In our experiments we choose an acidic solution at pH equal to 2 (sulfuric acid) whereas in situ pH is those of rain water around 5. This choice had been done in order to accelerate the chemical processes in laboratory. Using Kupper relation we obtain:

$$Ve(2) = 21 * Ve(5).$$

So the erosion velocity is multiplied by 21.

The pH is directly related to the concentration of [H+] and depends on the temperature.

We thought about two possibilities for alteration by water. Two experiments were made. In the first one, limestone samples are immerged in a solution of acidic water at room temperature. In the other, the solution of acidic water circulates on the surface's limestone samples at room temperature.

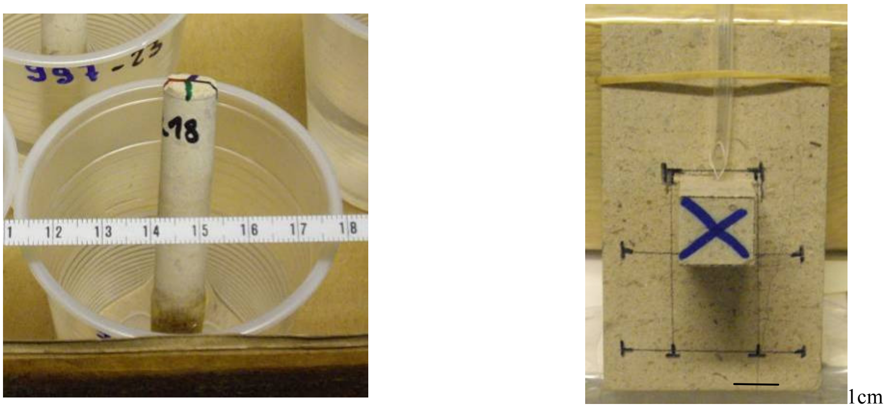

Figure 1: (a) Experiment 1 : limestone samples are drilled; drill-core is 10 cm long, and radius is 0.6 cm ; it is soaking in acidic water solution (b) Experiment 2: limestone samples are 5*5*8 cm parallelepiped with a rock bridge, of 1.5 cm of side; acidic water is added drop wise with a velocity of 1 liter per day.

The time evolution of the pH was measured during each of these experiments (Figure 2). We showed that the pH evolves differently. The experiment 1, showed an increase of the pH (2 to 7) whereas the pH remains around pH 2 during the experiment 2.

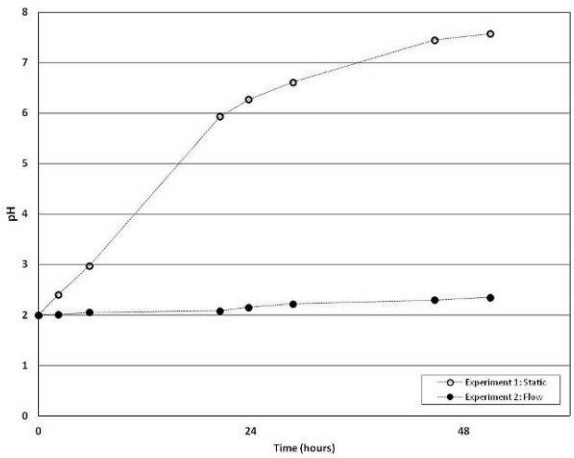

Figure 2 Evolution of the pH versus time (hours) for the experiment 1 and 2.

As it was expected in dynamic mode, the water flow maintains a high acidity level and therefore a high potential of alteration, which is not the case in “static mode”.

3. Role of the roughness on the rock mass stability

When considering rock discontinuity, water comes into and may dissolve the hanging walls having locally rock continuity named rock bridges opening more and more the discontinuity. Thanks to water flow, we can observe a decrease of the surface of rock bridges. The roughness is a characteristic of the surface state corresponding to the variation or amplitude of the height to the surface.

The measure of roughness is performed by a laser (Scan control) in order to observe the evolution of the surface submitted to an acidic water flow.

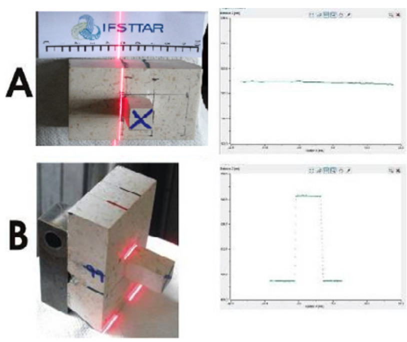

Figure 3: A: left: photograph of the laser beam on the surface; right: profile on the computer interface. B: left: photograph of the rock bridge scanned by laser; right: Profile on the computer interface.

It is well known that the dry friction coefficient is smaller on smooth surface than on a rough surface [3][4]. The experiment consists in putting some acidic water on the surface, and checking the evolution of the surface. The initial roughness was measured before the first drop of acidic water and defined as the reference state of roughness. After the first drop of acidic water we observe a diminution of the roughness. At the end of our experiment, the surface appears smoother than the reference state and we can also observe a hole in the surface after the acidic treatment. Each roughness obtained could be compared with the others. We consider two different steps, the first roughness is the initial roughness measured, the second one is the roughness measured after the acidic water flow.

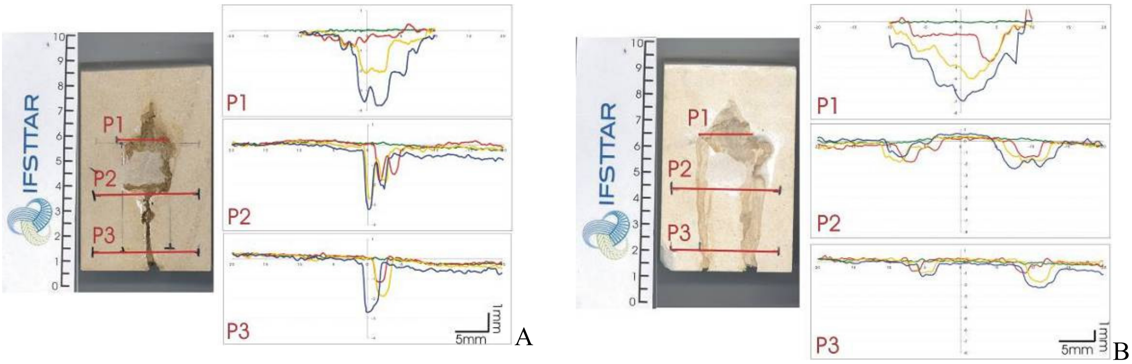

Figure 4: A : Weathered Comblanchien limestone sample (Φ<1%), P1 P2 P3 represent the three profiles of roughness measured, the first one smother than others is the reference and 3 states of alteration, after 8 days,11 days and 15 days of alteration. B. Weathered Lens Stone limestone sample (Φ>1%), P1 P2 P3 represent the three profiles of roughness measured, with 3 states of alteration and the reference.

4. Conclusion:

This study allows us to understand the processes of limestone degradation. The more important flow of water is, the stronger the alteration is. The rate of limestone erosion is determined by the evolution of the pH. The importance of roughness is also shown. Water flow controls the roughness and its evolution. The alteration by acidic water flow does not depend on limestone porosity. The study will be undertaken later, including the mechanical component (tensile test) and also the in situ scale.

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