



Influence of humidity and water on subcritical crack growth in marble

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For the prevention of natural hazards related to the failure of rock, it is essential to investigate time-dependent deformation and fracturing in various rock materials. In addition, to ensure the long-term stability of a rock mass surrounding various structures, information of subcritical crack growth is essential. Subcritical crack growth is one of the main causes of time-dependent fracturing in rock. It is known that subcritical crack growth is influenced by not only stress but also surrounding environment. Studies of subcritical crack growth have been widely conducted for silicate rocks such as igneous rocks and sandstones. On the other hand, information of subcritical crack growth in carbonate rocks is not enough. Especially, influence of surrounding environment on subcritical crack growth in carbonate rock should be clarified to ensure the long-term integrity of a rock mass. However, influence of surrounding environmental conditions on subcritical crack growth in carbonate rock has not been clarified yet.

In this study, we investigated subcritical crack growth in carbonate rocks. Specifically, we investigated the influence of relative humidity and water on subcritical crack growth in air at a constant temperature (50 °C). A marble obtained in Skopje-City in Macedonia was used as a rock sample, because this is a homogeneous, fine-grained and brittle carbonate rock. To measure subcritical crack growth, we used the load relaxation method of the double-torsion (DT) test. In order to investigate the influence of environmental condition, all measurements by DT test were conducted under controlled temperature and relative humidity.

It was shown that the crack velocity in marble in air increased with increasing relative humidity at a constant temperature. Additionally, the crack velocity in water was much higher than that in air. It was also found that the crack velocity in air was higher than that predicted from a calculation theoretically at 100 % relative humidity. It is considered that water has a significant influence on subcritical crack growth in marble.

Since the crack growth was accelerated by the increase of the humidity, it is considered that weakening and breaking of chemical bond structures at a crack tip in marble occurred under tension. This can be a stress corrosion reaction in carbonate materials such as marble. Additionally, since the crack velocity in water was higher than that predicted from the dependence of velocity on the relative humidity in air, it should be necessary to consider the effect of disappearance of the capillary condensation on water around the crack tip in the water-saturated environment. It is concluded that the relative humidity and water influence subcritical crack growth in carbonate rock. From the results obtained in this study, it can be suggested that the condition with low humidity in air is desirable for the long-term integrity of a carbonate rock.