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Effect Of Freeze-Thaw And Heating-Cooling Processes On Permeability Of: Lushan Sandstone

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Abstract: Rocks are usually exposed to freeze-thaw and/or heating-cooling conditions in many environments. In cold regions, rocks are affected by long-time freeze and several freeze-thaw cycles. In addition, rocks are exposed to significant heat in some cases, such as explosions and fires; they are then cooled down due to fire extinguishing or cold ventilation and a heating-cooling- process occurs. Therefore, it is necessary to investigate the effects of these processes on the physical and mechanical properties of rocks, including permeability. In this research, sandstone specimens of Lushan area were applied to investigate the impact of number of freeze-thaw cycles and the effect of temperature in the heating-cooling process on sandstone permeability. The freezing temperature of -16°C was considered to study the effect of number of cycles. In this state, the tests were carried out on the specimens withstood 1, 5, 10, and 20 freeze-thaw cycles. To study the effect of heating-cooling, the tests were conducted on the specimens that withstood one heating-cooling cycle. The specimens withstood temperatures of 60, 100, 200, 400, 600, 800, and 1000 °C at the heating process and then cooled in the laboratory environment. Results indicated that permeability rate was reduced after one cycle of freeze-thaw cycles the reduction continued to 5 cycles; although, permeability reduction was negligible from cycle 1 to cycle 5. Permeability increased slightly in 10 cycles and the increase was significant in 20 cycles. Sandstone permeability was reduced up to 100 °C and then was increased with the temperature increasing at the heating-cooling process. Permeability changes in the heating-cooling process were consistent with the variations of velocity of longitudinal waves, dry unit weight, and effective porosity. CT scan images were used to examine permeability changes in the heating-cooling process and the CT value calculated by the images confirms the permeability variations.

Keywords: Sandstone, Permeability, Freeze-thaw process, Heating-cooling process, Rock.

INTRODUCTION

Northwestern and western provinces of the country have temperate summers and cold winters. High precipitation and cold weather is characteristic of winter in these regions. At these conditions, rocks are

exposed to long frosts and numerous freeze-thaw cycles. It is therefore necessary to investigate the effect of these processes on the physical and mechanical properties of rocks, such as permeability.

The review of literature indicates that most studies have investigated the subject of temperature, the effect of heating and cooling, and the effect of freeze-thaw processes on physical properties including: specific gravity, longitudinal wave velocity, water absorption percentage and porosity, as well as mechanical properties including uniaxial compressive strength, elasticity modulus and tensile strength. In this research, sandstone specimens of Lushan area were used to investigate the impact of number of freeze-thaw cycles and the effect of temperature in the heating-cooling process on sandstone permeability.

METHODS

The sandstone sample used in this study was obtained from the Lalun formations of the Lushan region, which consists of 15 percent Quartz, 7 percent Feldspar, 15 percent Calcite, 8 percent Chert, 7 percent opaque minerals, and 48 percent of this rock were small quartz and clay particles.

The experiment stages for investigating the effect of the number of freeze-thaw cycles on permeability are as follows:

A) The samples were placed in the water basin for 48 hours to be saturated.

B) The samples were placed in the freezer for 18 hours at -16 °C.

C) The samples were placed in 20 °C water for 6 hours. A freeze-thaw cycle is completed by going through steps A through C. To investigate the cycle number effect, the freeze temperature was set at -16 °C. Samples that were subjected to 1, 5, 10 and 20 freeze-thaw cycles were experimented on in this condition. An experiment was also performed on the sample that was not subjected to the freeze-thaw cycle.

The experiment stages for investigating the effect of the number of heating-cooling cycles on permeability are as follows:

A) The samples were put in the oven. The rate of temperature rise is set to 3 °C/min.

B) All samples were placed in the lab environment to cool down and for their temperatures to reach the lab ambient temperature (25 °C). A heating-cooling cycle is completed by completing stages A and B. This experiment was performed on samples that were subjected to one heating-cooling cycle, and also were subjected to temperatures of 60, 100, 200, 400, 600, 800, and 1000 degrees in the heating cycle and cooled down in the environment.

C) The samples were placed in the water basin for 48 hours to be saturated.

D) Performing the permeability test.

FINDINGS AND ARGUMENT

This study investigated the effect of freeze-thaw and heating-cooling processes on the permeability of Lushan sandstones. In addition to permeability tests, experiments were also conducted for determining effective porosity, specific gravity, and longitudinal wave velocity. The results of this experiment are as follows:

In the freeze-thaw process:

- The amount of permeability is reduced after one cycle and this reduction continues for 5 cycles.
- In the tenth cycle, the permeability is slightly increased, and in the twentieth cycle the increase is significant.
- In the twentieth cycle, permeability is 1.3 the initial amount.

In the heating-cooling process:

- Increasing temperature to 100 °C reduces permeability.

Increasing temperature beyond 100 °C increases permeability. This is compatible with the findings of YU et al. in 2015 [1].

- Up to 100 °C, longitudinal wave velocity (Figure 1) and dry specific gravity increases while porosity decreases.
- After 100 °C, longitudinal wave velocity and dry specific gravity is reduced while porosity is

increased.

- The amount of CT obtained from CT scan images indicate that increasing temperature from 200 to 600 °C increases the damage variable.

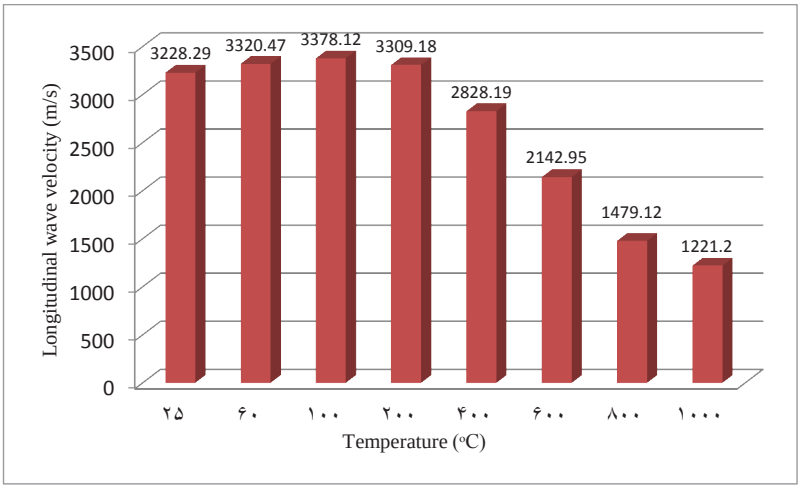

Figure 1. Longitudinal wave velocity as a function of the temperature

CONCLUSIONS

In this research, sandstone specimens of Lushan area were applied of the investigation of the influence of number of freeze-thaw cycles and the effect of temperature in the heating-cooling process on sandstone permeability.

Results indicated that permeability rate was reduced after one cycle of freeze-thaw cycles the reduction continued to 5 cycles; although, permeability reduction was negligible from cycle 1 to cycle 5. Permeability was increased slightly in 10 cycles and the amount of increscent was significant in 20 cycles. Sandstone permeability was reduced up to 100 °C and then was increased with the temperature increasing at the heating-cooling process. Permeability changes in the heating-cooling process were consistent with the variations of velocity of longitudinal waves, dry unit weight, and effective porosity. CT scan images were used to examine permeability changes in the heating-cooling process and the CT value calculated by the images confirms the permeability variations.

REFERENCES

[1] Yu, J., Chen, X., Li, H., Zhou, J. W., and Cai, Y. Y. (2015). *"Effect of freeze-thaw cycles on mechanical properties and permeability of red sandstone under triaxial compression"*. Journal of Mountain Science, 12(1): 218-231.