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Unfrozen water migration in fully saturated sandstone during short-term freezing and thawing

Hailiang Jia, Gengshe Yang, Liyun Tang, Yanjun Shen, and Wanjun Ye

School of Architecture and Civil Engineering, Xi'an University of Science and Technology, Xi'an, Shaanxi, China (jia.hailiang@outlook.com)

Researchers have gradually reached a consensus that ice segregation mechanism plays a dominant role in damaging rock in the case of long-term freezing, while volumetric expansion mechanism could lead to fatigue failure of rock after repeated frost action (usually short-term). In the latter regime, the outmost pore water is assumed to freeze in situ at early stage of freezing, consequently an inward water migration is driven by volumetric expansion, raising pore water pressure. In this study we test the above tenet through a real time monitoring of water migration in fully saturated sandstone via nuclear magnetic resonance (NMR) method under a short term freeze-thaw regime. Water migration is delineated by measuring water content change in different layers of the sample. The whole test lasts for 12 hours, in the first 6 hours temperature changes from 10°C down to -30°C; then rises back to 10°C in the following 6 hours. NMR scanning is undertaken half-hourly. Our results indicate that:
(1) in early stage of freezing, water content at the outmost zone does not reduce significantly, however water content at the core does, this unexpected change demonstrates an outward water migration;
(2) water migration proceeds primarily within temperature range of -1°C— -4°C;
(3) around 20% water keeps unfrozen at even -30°C, where no measurable water migration is observed;
(4) in the thawing period, slightly reversed migration appears.
Accordingly we come to the initial conclusion that the extensive assumption that volumetric expansion upon in situ freezing could drive inward water migration may be not authentic.