Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

HGM02-P02 会場:コンベンションホール 時間:5 月 23 日 17:15-18:30

建造物を構成する岩石の塩類風化に関する室内実験
Influence of environmental conditions and test method on sodium sulfate weathering of four Japanese building stones

Swe Yu[1*], 小口 千明 [1]
SWE, Yu[1*], OGUCHI, Chiaki T.[1]

[1] 埼玉大学地圏科学研究センター, [2] 埼玉大学地圏科学研究センター
[1]Geosphere Research Institute of Saitama University, [2]Geosphere Research Institute of Saitama University

Many standard and laboratory salt weathering tests have been elaborated to investigate the mechanisms of salt damage, which have threatened our priceless cultural heritage made of porous stones. The tests are also used to investigate the relative destructiveness of salts, and durability of different rocks for selecting proper ones for restoration works. Some results of these studies, however, have become debatable due to employing different test methods and environmental conditions. So far, comparative studies about test conditions are scarce. In addition, there are arguments about sodium sulfate, which is the most widely used salt in laboratory tests, as to which phase of the salt, i.e. thenardite or mirabilite, is responsible for the sodium sulfate damage. To solve these arguments, a series of laboratory experiments was performed by using two types of salt supply techniques: continuous partial immersion (CPI) and cyclic total immersion (CTI). Both tests were conducted under three different environmental conditions: (i) 20^{o}C and 60% RH for 24 h (CPI 1); (ii) 45^{o}C and 40% RH for 24 h (CPI 2); (iii) 45^{o}C and 30% RH for 12 h and 10^{o}C and 70% RH for 12 h (CPI 3); (iv) 3 h immersion at 20^{o}C, 19 h drying at 45^{o}C, and 2 h cooling at 20^{o}C (CTI 1); (v) 3 h immersion and 21 h drying at 45^{o}C (CTI 2); and (vi) 3 h immersion at 20^{o}C, 17 h drying at 105^{o}C, and 4 h cooling at 20^{o}C. CPI 2 and CTI 2 tests were designed to investigate the destructiveness of sheer thenardite. All tests were run for fifty 24-h cycles. Prismatic specimens (5 x 5 x 15 cm3) of four types of Japanese building stones, namely Oya Tuff, Ashino Tuff, Indian Sandstone, and Tago Sandstone were used. A range of hydromechanical properties were investigated. For salt supply, saturated sodium sulfate solution (at 20^{o}C) was used in all tests. It is observed that durability ranking of the rocks did not perfectly reflect their hydromechanical properties. Oya Tuff was consistently the least salt resistance in all of the tests, mirroring its properties. However, in contrary to their hydromechanical properties, Tago Sandstone, Ashino Tuff, and Indian Sandstone showed different durability against sodium sulfate in different tests, indicating the unreliability of rock properties in predicting salt susceptibility. Differing to what have been perceived, at the same upper-limit temperature, CPI tests were found generally more destructive than CTI tests, except for the extraordinarily aggressive CTI 3 test driven by a very high drying temperature. The results of CPI 2 and CTI 2 tests revealed that thenardite alone could cause significant damage, although the induced damage was smaller than that of mirabilite-involved tests such as CTI 1, CTI 3, and CPI 3. This suggests that in addition to the immense power of mirabilite attack, the contribution of thenardite in rock decay during drying cannot be discounted in CTI tests. In fact, it was the cyclic conversion of thenardite-mirabilite mechanism, which causes severe damage, no matter what salt supply technique is employed. Moreover, the two salt supply techniques produced markedly different damage patterns: CTI tests induced granular disintegration, spalling, fragmentation, or crumbling, whereas CPI tests mainly produced scaling, cracking, or efflorescing depending on environmental conditions and rock properties. The reason behind this is the continuous accumulation of salts deep inside the CPI-specimens, which produced severe internal cracking and thick scaling, in contrast to the cyclic disintegration of outermost surfaces of CTI-specimens, which did not favor the salt accumulation.

キーワード: 塩類風化, 継続的部分浸漬, 全体浸漬サイクル, 硝石, 含水硫酸ナトリウム
Keywords: salt weathering, continuous partial immersion, cyclic total immersion, thenardite, mirabilite