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Procedia Earth and Planetary Science 17 (2017) 324 – 327

Procedia Earth and Planetary Science

15th Water-Rock Interaction International Symposium, WRI-15

A critical discussion of salt weathering laboratory tests for assessment of petrological features susceptibility

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Abstract

It is presented a discussion of several features of salt weathering tests with relevance to assessment of stone susceptibility to these rock-solutions interaction processes.

Peer-review under responsibility of the organizing committee of WRI-15
Keywords: petrological modelling, geologic materials, built environment

1. Introduction

Laboratory accelerated alteration tests are a classical procedure to study water-rock interactions under controlled conditions. By definition, accelerated alteration tests use conditions that are different from those found in the field, in order to obtain, in a shorter time, the effects of the studied processes. Salt weathering is the main erosive process in the built environment (in the sense that it is the more widespread even if other process might achieve more intense effects). In terms of salt weathering tests, while several variations have been proposed, the prevailing standardized conditions are similar to those found in the European Standard 12370 ("Natural stone test methods. Determination of resistance to salt crystallization") that use immersion in sodium sulphate solutions. There is also another European Standard related to salt weathering (EN 14147 "Natural stone test methods. Determination of resistance to ageing by salt mist") using atmospheric deposition of NaCl spray. In this publication are discussed the issues of salt weathering tests that influence their use as a tool for comparative petrological assessment in the search for intrinsic features that might affect rock susceptibility to this weathering process

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Peer-review under responsibility of the organizing committee of WRI-15
doi:10.1016/j.proeps.2016.12.082

2. Discussion

The present analysis will be focused on the relevance for the assessment of rock susceptibility to salt weathering of the following main conditions: specimen geometry (size and shape), salt contamination conditions, drying conditions, stopping criteria and the recording and reporting of results.

2.1. Specimen geometry

In this section both size and shape will be considered. The question of size is linked to the well known "size effect" of laboratory tests. It has been referred[1] that reducing the specimen size speeds up the decay test. Erosive effects could present decay patterns that have been typified[2] as homogeneous, in the sense of following the specimen's contour and tending towards increasing rounding or heterogeneous. In the case of heterogeneous patterns, the effect of specimen's size on the stone assessment will depend on the way results are reported: if it is just reported the final mass variation (in relation to initial mass), the studied rocks could, in principle, either show increasing or decreasing results with increasing specimen size, depending on spatial frequency of the more susceptible features and the effects of sampling. However, other ways of reporting could minimize and perhaps even void this issue, as will be discussed further on. The presence of heterogeneities with dimensions similar to the specimen size could promote a greater dispersion of results[3]. In the case of rocks that can be considered homogeneous (when the size of heterogeneities is much smaller than the specimen's size and they have a statistically homogeneous distribution), and assuming that salts crystallization is concentrated nearer the surface, one will expect increasing mass loss with decreasing specimen size (as the affected zone will have an increasing proportional importance and since the capillary feeding reservoir will be smaller). Hence, it will be advisable to consider classic materials engineering recommendations of sample representativeness, using specimens where the smaller dimension is at least a certain factor greater than the larger heterogeneous feature present in the tested material. The ratio surface/volume is affected by the shape of the specimen. In the case of statistically homogeneous rocks, and assuming a given depth of salt crystallization, increasing ratios surface/volume will imply increasing importance of the affected zone. Additionally, this ratio can affect the drying conditions and their relation to the capillary feeding reservoir. However, geometric modelling could produce results that need to be assessed carefully. For example, for a parallelepiped of square base "b" and height "h", keeping "b" constant and increasing "h" will imply decreasing the surface/volume ratio. But in terms of salt weathering of building materials, surface decay is of major importance and increasing length might imply increasing probability of having at least one instance of a more susceptible feature.

2.2. Salt contamination conditions

Three main procedures have been proposed: immersion (e.g. EN 12370), capillary directional imbibition and surface deposition (as in EN 14147). Starting with this last procedure, its conditions simulate those where only the surface of the materials is exposed to pollutants and hence this test is useful in studying surface reactivity (e.g. stones exposed to seaspray) but does not assess the effects of bulk rock features. Capillary directional imbibition has been proposed for salt weathering tests[4] as it reflects a common situation (capillary rising solutions - "wick effect"). However, it is necessary to consider that: a) the presence of heterogeneities can affect the extension of salt pollution on the specimen and a variable position of these features will imply a greater dispersion of results; b) the previous situation can exacerbate the size effect. Immersion conditions are not very commonly found in the built environment but they are not as strongly affected by the previous issues and will reduce the dispersion associated with the testing conditions. Additionally, in a perspective of assessment of petrographic features susceptibility, it is expected that immersion tests would produce more clear results in a smaller number of cycles (they will represent a conservative approach). They also test the surface susceptibility as crystallization happens at the surface (at least in the beginning of the test) but, in most circumstances, they might be harsher than surface deposition tests and, if only the final result is considered, the information regarding surface susceptibility might be lost.