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Disintegration of sedimentary rocks used as building material: evaluation and quantification in 4D

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Many natural building stones are subject to weathering processes that may lead to their disintegration. When rocks are exposed to extreme exogenous factors such as a combination of water and freeze-thaw cycles, they can deteriorate and cause problems concerning the maintenance of the structure. Some rock types are more susceptible to weathering processes than others, in which fluctuating environmental factors as well as the position of the stone in the building and the endogenous or geological parameters of the stone itself play an important role.

In order to determine the influencing geological parameters (pore structure and interconnectivity, mineralogy, cementation...) several techniques are available. One of the techniques mainly focused on in this study is X-ray computed tomography (CT). This rapid and easy-to-use method enables to visualize internal rock structures in a non-destructive way and without any sample preparation. The obtained and afterwards processed digital information enables a better understanding in the 3D geometric rock properties. To obtain a CT-scan of the stone, the sample rotates 360° while digital radiographs are taken. In this study 800 radiographs were reconstructed (using the Octopus software package) to create virtual cross-sections through the object.

Although X-ray CT is a very valuable technique for 3D reconstruction, the single radiographs also contain a lot of information. They can e.g. be used to measure the contact angle of a drop of water and thus be compared to traditional optical contact angle measurement systems. As the sample stays fixed on the rotational stage of the CT-scanner, a drop of water is released onto the stone's surface. Capillary processes change the drop shape changes during time. After the subtraction of the initial dry state from the wet state, the contact angle of the water drop can be calculated. The advantage of this approach is that also the impregnation depth of the water inside the stone can clearly be visualized. This is an important aspect since most weathering processes take place in the presence of water.

To evaluate rocks used as building material, several standard durability tests (freeze-thaw cycle, thermal shock...) exist. The significance of these tests lies in the predictability of the stone's weathering behaviour or resistance under known external conditions. After the tests, the stone's new physical properties are evaluated with regard to its initial condition. Most of the time, these evaluations are based on visual inspection and qualitative interpretation. With the aid of X-ray computed tomography it is possible to quantify the deterioration of the stone in high resolution, before and after the durability tests. For that purpose several subsamples consisting of cylindrical cores with a diameter around 8 mm and standardized cubic samples with a length of 5 cm were scanned with high resolution. Quantification of the internal structure was calculated using the software package Morpho+. The scans were carried out at the "Centre for X-ray Tomography" at Ghent University (UGCT), Belgium. Micro-cracks, changes in pore structure and element migration were quantified with micrometer resolution. Orientation and length of cracks can be measured in function of time.

Based on these results, a clear difference in response to weathering can be observed over time with micrometer resolution.