Peering into the Rock: A 4D synchrotron study of salt solution movement within masonry sandstone.

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(Presented by Emma Fairley)

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The subsurface crystallisation of de-icing salts is one of the major decay mechanisms affecting the aesthetic and structural integrity of sandstone buildings. In Scotland, the road maintenance authority, Transport Scotland, currently employs sodium chloride (NaCl), magnesium chloride ($MgCl_2$) and an alternative organic compound as de-icing salts across the road network. Calcium chloride ($CaCl_2$) and blended chloride salts are also increasingly popular and commercially available de-icers that are used on public and private estates throughout the country.

Initial laboratory experiments on a range of Scottish sandstones using NaCl, $CaCl_2$ and $NaCl.MgCl_2.6H_2O$ have shown that NaCl salts are more damaging than $CaCl_2$, however $CaCl_2$ was absorbed to a greater degree than both NaCl salts. In order to fully understand the drivers of these stone and salt specific decay phenomena, it is important to understand both the internal structure of the material and the actual processes of solution movement and salt crystallisation within the stone. The mechanisms by which salts damage sandstones cannot be fully understood by invasive sampling and analysis after crystallisation because the key to the process lies in the feedbacks between salt solution movement, salt crystal growth and rock microstructure at the pore scale. µ Computed Tomography (µCT) Scanning allows the direct imaging and analysis of the stone interior at high resolution. Advances in synchrotron based tomography, which employs a high intensity X-ray beam, now allows for the 4 dimensional studies of these processes.

In order to explore these dynamic relationships a non-destructive 4D µCT study of the transportation of salt solution within sandstone was undertaken using I12 beamline at the UK Diamond Light Source Synchrotron. $1cm^3$ cubes of Blaxter and Locharbriggs sandstone, which are common building stones used throughout the UK, were subject to capillary uptake experiments using a 6M concentrated calcium iodide salt solution. Solution was absorbed into the stone by non-forced capillary suction from saturated filter paper. X-ray tomography scanning took place at three minute intervals during capillary uptake experiments at a resolution of ~12µm/pixel, whereby a 360^o scan was captured in 7 seconds. The initial pore network, subsequent liquid phase distributions and capillary movement at the pore-scale can be readily visualised and quantified in each repeat scan. The results from this initial study show distinct differences in solution movement and distribution between each sandstone and pave the way for further more in-depth research using this powerful technique. This study provides a proof of concept and a successful first pass at using a simple and reproducible experimental design.

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