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2D-resistivity surveys of deteriorating historic stonework in Oxford, UK

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Historic stonework deteriorates in often very complex ways and despite many years of research on the topic, we are still a long way from being able to predict its occurrence and severity. As most deterioration processes involve water, techniques which provide a better picture of the moisture contents and fluctuations within stonework are very valuable in attempts to improve understanding. 2D resistivity methods can provide useful information about moisture distributions within porous historic stonework. We report on a series of experiments on historic walls within the centre of Oxford, UK, which illustrate varying degrees of deterioration including catastrophic decay. Using medical electrodes we have been able to carry out non-invasive and non-destructive 2D resistivity surveys to study the distribution and amount of water stored in deteriorating limestone walls. Fifteen vertical profiles, each 2-2.5 m in length, have been monitored at five sites. Furthermore, simulated driving rain experiments have been carried out at two sites.

The data indicate the diversity and complexity of moisture distributions within these walls. Replacement stone patches show consistently higher moisture conditions than the surrounding stone. Some profiles show wetter sections towards the base of the wall, usually where a plinth is absent. Conversely, hard stone plinths obviously reduce capillary rise from ground water. However, at several sites we noticed a wetter zone immediately above the top of the plinth which often correlates with the occurrence of catastrophic decay – indicating that the plinth may encourage concentration of decay. Most profiles indicate the presence of wetter patches 5-10cm behind the wall face under blackened crusts. Such patches of heightened absolute moisture contents could play a very important role in encouraging catastrophic decay. Severely decayed sections of profiles often exhibit wetter near-surface conditions than surrounding stonework, whilst areas with shallow but active decay are often much drier than surrounding crusted stone. The results give preliminary confirmation of a simple model of catastrophic decay.

The driving rain experiments show that rainfall penetrates in predictable ways, with clearly defined wetting and drying fronts. Stone blocks with highly weathered surfaces exhibit the most rapid and high levels of water uptake, but also dry out more quickly than crusted or sound blocks. Thus, positive feedbacks may be encouraged whereby more water is cycled through damaged blocks, thereby enhancing the potential for further damage. However, some very badly weathered (exfoliated) parts of the surface proved to be surprisingly water-repellent. On the other hand, thick black crusts as observed at many sites in Oxford do not seem to hamper water ingress as much as might have been expected. Most of the moisture fluctuations take place in the outermost 10 cm. At greater depth, only small changes in water content are observed. However, the sheer variety of mean moisture contents and moisture distributions observed on our 15 profiles implies that, for historic walls with complex histories of decay and conservation, untangling the causes of, and managing the future of, rapid deterioration may be very complex.