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Field measurement of erosion rates: time-lapse monitoring of rapid stone flaking at Howden Minster, UK

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The use of a solar-powered, field time-lapse camera and environmental monitoring system enabled measurements of the pattern and rate of loss of stone from the surface of Howden Minster, an abandoned monastery in Yorkshire dating to 1380 AD. Acquiring a photograph every 1-3 hours allowed the stone damage to be correlated with local environmental conditions. Image comparison techniques borrowed from observational astronomy, such as blink comparison, were used to determine what elements had changed from image to image. Results indicate that loss is episodic rather than continuous and in several cases is related to specific environmental conditions, such as condensation/dew formation or high winds. Damage was found also to be synchronous, with surface change (flaking, granular disintegration, and loss of flakes) occurring at the same time on different stone blocks. Crystallization pressure from magnesium sulfate phase transitions appear to be the main cause of the loss of stone surfaces. Significant variation in surface loss rates was observed and appears to be related to variations in salt concentration. An examination of stone texture by ESEM/EDS revealed signification variations and suggests that salt concentrations are controlled in part by stone micromorphology.

Quantitative data on rates of surface loss are not available from most monuments. Time-lapse methods permit the relatively inexpensive acquisition of this type of data, which is needed to aid conservation decision-making and the evaluation of interventions. Such tools should also prove useful to geomorphologists studying honeycomb weathering, the moving rocks on Death Valley's Racetrack Playa, and other phenomena that are otherwise difficult to study.

Context: The rapid deterioration of magnesian limestone structures in the north of England has been a serious problem for more than one hundred years. While air quality in England has improved during this period, the rate of stone loss in these carved stone structures has not slowed. Thus far, conventional stone conservation treatments have not been successful in mitigating this decay, and large-scale stone replacement has been proposed to deal with the problem for buildings such as York Minster and the world heritage site of Fountains Abbey.