Building stone forms a significant component of the fabric of our towns and cities. However, as **Ewan Hyslop** and **Andrew McMillan** explain, even stone doesn't last forever and without proper care this important element of our cultural heritage is under threat.

# Our crumbling buildings

Think of any famous building or monument, and it will almost certainly be made of stone. Much of the character of cities such as historic Bath — made from honey-coloured limestone ('Bath Stone'), Aberdeen — 'the Granite City', and Edinburgh — the 'Grey Athens of the North', results from the use of stone. They all resonate an image and 'sense of place' defined largely by stone. The variability of the UK's geology — the geodiversity — means that the appearance and form of our historic buildings is often influenced by the local geology, and can vary greatly from place to place.

Today much of the UK's stone-built heritage is under threat, partly due to the age and condition of many of our stone buildings and monuments, but also because of a lack of scientific understanding as to how stone has responded to air pollution, stone cleaning, and poor quality repairs. The environmental conditions in which urban stone buildings exist have changed rapidly over the last century, and will change again over the next. Since the Clean Air Acts of the 1950s the levels of damaging airborne pollution have rapidly declined. However, rates of stone weathering are anticipated to increase due to the effects of climate change, and in many cases this will be exacerbated by previous damage to the structural, as well as aesthetic, characteristics of stone buildings.

Attempting to understand the current state of our stone-built heritage is an essential prerequisite to estimating the extent of the problem. In the first project of its kind in the UK, the BGS has been commissioned to carry out a city-wide 'health check' of building stone in Glasgow and develop a methodology for rapidly assessing building façades. The results will provide quantitative estimates of the amount and severity of stone decay, and calculate the volumes of replacement stone that are required for repairs. The project, 'Safeguarding Glasgow's Stone Built Heritage', is intended to produce hard facts and figures to help the city to maintain its built heritage in the future.

Significant damage to sandstone buildings has been done by stone cleaning, where the action of corrosive chemicals and abrasive methods

*Typical sandstone buildings showing variable appearance due to the use of different stone cleaning techniques. All the buildings are constructed from the same stone type. Inset shows damage to stone masonry surface due to the application of corrosive cleaning chemicals.*

has removed the external protective hard patina, exposing weakened underlying layers of stone which are prone to relatively rapid weathering. The introduction of expansive salts, during chemical cleaning, into the pore structure of sandstone has resulted in irreversible damage to the fabric of many stone buildings. New research is being targeted to determine the detailed damage mechanisms and to understand the effects of increased rates of decay on damaged stone in the face of climate change. The BGS has initiated two Ph.D. studentships specifically to investigate these issues.

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*Rectified image of a listed building in Glasgow digitally overlain with coloured areas highlighting different types of stone decay. This methodology has been developed to allow a rapid assessment of the stone condition of historic buildings.*

Most of the quarries that supplied the construction of our stone buildings are now closed. This is having a serious effect on our ability to correctly repair and maintain the built heritage. For example, in Scotland approximately 750 commercial-scale sandstone quarries operated during the mid nineteenth century, when much urban construction was taking place. Today, fewer than two per cent of these quarries are open, and most stone for repairs has to be obtained from alternative sources, including imports. Recent research into the performance of replacement stone shows that the use of incompatible stone types for repairs can lead to accelerated decay of the remaining original masonry. The geological characteristics of a building stone (such as mineral composition, porosity, and texture) are crucial in influencing its long-term behaviour, and there is a need for improved decision making in the selection of stone for repairs. The lack of local quarry sources means that careful geological matching is required, and in some cases the reopening of former quarries. Alternatively, new quarries may be the best way to ensure the survival of the built heritage. Locally quarried stone is also finding an increasing market for new build development, and allows new buildings to fit in with the local character.

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Many of the common perceptions of building stone are incorrect, for instance that it is everlasting, waterproof, and locally obtainable. Stone in a building can last for hundreds of years and more if it is looked after correctly, but if a building is not maintained properly stone masonry can decay in a couple of decades. Most damage to stone buildings in the UK is the result of water ingress, which acts as a catalyst for decay, particularly in stone that is already damaged. More effort is required to understand these complex processes, and to predict future trends in order to develop strategies to mitigate increasing decay rates. Increased use of local stone will lead to more appropriate and compatible stone types both in terms of visual character and long term performance.

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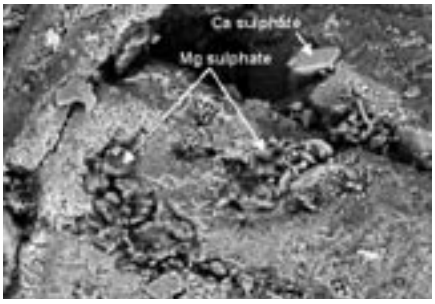


*Scanning electron microscope image of a building sandstone, showing magnesium sulphate salts on the surface of individual quartz grains as a result of contamination from chemical cleaning. These salts can expand resulting in the break-up of the sandstone, rapidly increasing the rate of stone decay.*