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Impact of a changing environment on the built heritage

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Stone monuments are degraded by both climate and pollution. Deterioration by pollution was especially intense from the 1700s and until the late 20th century the dominant impact of air pollution was the sulfation of surfaces. The parallel deposition of soot caused blackening and on some surfaces dark coloured crusts. The decrease of sulfur and soot from coal combustion during the last decades of the 20th century led to cleaner air in cities, a decrease of pollution-decay rates on building stones and a public desire for cleaner buildings. Although there were decreases in SO_2, it was replaced by ozone, nitrogen oxides and particles richer in organic compounds, the result of an extensive use of automobiles. Deposited organic compounds can oxidise in modern urban environments in a yellowing process.

The future may reveal variation in building colour from biological growth in a changing climate. In urban atmospheres with less sulfur, biological growth is more effective. A greater rate of delivery of nitrate to building surfaces that acts as "airborne fertiliser" favours colonisation. Depending on climate, there might be different processes (e.g. greening or reddening) and patterns of colouration.

Climate is also a relevant factor in the weathering of monuments. Recent research suggests the concept of Heritage Climatology in the study of climate interactions with monuments, materials and sites. These parameters concentrate on aspects and combinations of meteorological variables that relate to material damage. The Köppen-Geiger climate classification can be a good approximation for some heritage risks. For instance, the number of salt transitions shows distinct seasonality which can be related to Köppen-Geiger climate types and their change during the 21th century.

The study of changing pollution and climate impacts on the built heritage needs the output of pollution emissions and climate change models, which are prone to uncertainties. The use of multiple climate models or ENSEMBLES may improve the accuracy and reliability of predictions. This approach has been used to predict salt damage. However, more work is needed on the uncertainty in predictions and the way this affects the management of stone heritage. There is public availability of climate and pollution data, but frequently these need to be unified and made user-friendly for cultural heritage researchers in many countries, e.g. the UKCP09 user interface is a good example of friendly-availability for probabilistic projections and downscaled climate change data, but available data are limited to the UK. The utilisation of these improved techniques can contribute to better strategies for managing buildings.