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Heritage hydrology: A conceptual framework for understanding water fluxes and storage in built and rock-hewn heritage

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Water plays a vital role in the deterioration and conservation of built heritage and management problems might be aggravated by climate change. However, there is as yet no overarching framework for understanding the processes and impacts of water interacting with building materials. The term 'Heritage Hydrology' is a holistic way of conceptualising the flows and stores of water involved in deterioration of built and rock-hewn heritage. We distinguish the following basic types: (a) stone-built buildings, (b) ruins and free-standing walls, and (c) rock-hewn sites which include carved rock art and large rock sculptures. We focus on a key knowledge gap: The spatial and temporal characteristics of water flows/stores and the challenges of using currently available techniques to provide information on these characteristics.

In our selective review we provide examples of spatio-temporal patterns of moisture in stonework at different scales. We raise six key points about the state of research on heritage hydrology, from which we develop a future research agenda. (1) Three characteristics of moisture regimes are important to deterioration, i.e. presence, fluctuations and saturation thresholds. (2) There is a wide range of different heritage hydrological settings ranging from masonry building walls to natural rock slopes, and as yet no clear understanding of the commonalities vs specificities of these different settings. (3) While there is now a wide array of techniques available to measure and monitor moisture regimes in lab and field settings, the understanding of how comparable different measurement approaches are is still lacking. (4) There are now many measurements of the spatial patterning of moisture, but lack of clarity about the causes of these patterns. (5) There has been less research focusing on the temporal dynamics of moisture on heritage walls than on spatial patterns. (6) Studies combining measurement and modelling have proved particularly useful.

A research agenda for the future for heritage hydrology should focus on addressing the following broad questions: What are the best combinations of methods available to measure and model spatio-temporal patterns in moisture on built and rock-hewn heritage? What are the major factors controlling spatio-temporal patterns in moisture, also considering climatic changes? Which spatio-temporal patterns in moisture are most important for driving deterioration, and how do their respective scales interact? Tackling these research questions requires a coordinated approach, linking different research teams and methodologies. It should be based on a combination of data

collected through laboratory experiments, detailed studies of test walls, and instrumented sections of walls at heritage sites. It should explore the causes and consequences of moisture regimes which provide fundamental links between climate and the deterioration of built and rock-hewn heritage.