



Characterising and modelling geohazard susceptibility in the UNESCO World Heritage Site of the Derwent Valley Mills (UK)

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The PROtection of European Cultural Heritage for GeO-hazards (PROTHEGO) project aims to make an innovative contribution towards the analysis of geohazards in areas of cultural heritage in Europe. The Derwent Valley Mills World Heritage Site (WHS) in central England is one of the project's four case study sites being used to demonstrate how novel space technology based on radar interferometry (InSAR) could be used at sites potentially at risk from geohazards.

Derwent Valley Mills WHS was inscribed by UNESCO in 2001 because it is regarded as the birthplace of the factory system, therefore having huge historical and technological interest. The site is complex containing a number of early industrial mills, each telling their own story, as well as the associated housing and buildings, and infrastructure networks such as canals and railways. Together they illustrate the socio-economic development of the area during the 18th and 19th centuries.

The assessment of geological hazards susceptibility within the area has been conducted utilising InSAR data and British Geological Survey's geological and geohazard datasets. This methodology enabled the identification of ground motion areas within the heritage site that are potentially at risk to specific geohazards thanks to the phase difference in the radar signal collected from the Sentinel-1 two-satellite constellation between 2015 and 2017.

The analysis reveals that flooding from fluvial water flow (e.g. for over 50% of the site) and emergence of groundwater at the surface (e.g. for over 40% of the site), and landslides, with 44 events identified, are the main geohazards that the WHS are susceptible to impact from, either directly affecting the historic mill complexes, or the surrounding infrastructure or landscape. When modelled against UKCP09 (The UK Climate Projections 09) climate change scenarios, many areas show increased geohazard susceptibilities in the coming century. In particular, three areas require careful consideration and further investigations: Near the villages of Starkholmes and Ambergate InSAR data confirms, with displacements up to 10mm/yr, the active state of landslides; and in Belper radar data possibly identify the damage connected to recent flooding and resulting in uplift rates of $\geq 10\text{mm/yr}$.