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## Assessment of marine and urban-industrial environments influence on Built Heritage sandstone using X-ray fluorescence spectroscopy and complementary techniques

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### Abstract

The sandstone used in the construction of the tower of La Galea Fortress (Getxo, north of Spain) shows a very bad conservation state and a high percentage of sandstone has been lost. The fortress is located just on a cliff and close to the sea, and it experiments the direct influence of marine aerosol and also the impact of acid gases ( $\text{SO}_x$  and  $\text{NO}_x$ ) coming from the surrounding industry and maritime traffic. This environment seems to be very harmful for the preservation of the sandstone used in it, promoting different pathologies (disintegration, alveolization, cracking or erosion blistering, salts crystallization on the pores, efflorescences etc.). In this work, a multianalytical methodology based on a preliminary in-situ screening of the affected sandstone using a handheld energy dispersive X-ray fluorescence spectrometer (HH-ED-XRF) and a subsequent characterization of extracted sample in the laboratory using elemental ( $\mu$ -ED-XRF, Scanning Electron Microscope coupled to an X-Max Energy-Dispersive (SEM-EDS) and Inductively coupled plasma mass spectrometry (ICP-MS)) and molecular techniques (micro-Raman spectroscopy ( $\mu$ -RS) and X-ray Diffraction (XRD)) was applied in order to characterize the original composition of this kind of stone and related deterioration products. With the whole methodology, it was possible to assess that the sandstone contain a notable percentage of calcite. The sulfation and nitration of this carbonate detected in the stone led to the dissolution process of the sandstone, promoting the observed material loss. Additionally, the presence of salts related with the influence of marine aerosol confirms that this kind of environment have influence on the conservation state of the sandstone building.

**Keywords:** handheld ED-XRF, marine aerosol, greenhouse acid gases, Raman spectroscopy, ICP-MS.

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