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Black crusts as past air pollution archives

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Since the Industrial revolution, emissions of pollutant (gas, aerosols) due to human activities increased and modified the composition of the atmosphere, causing air pollution and climate change. However, pollution measurements are relatively recent. In order to know past air pollution and assess its impact on monuments, proxies need to be found and studied.

One of these potential local proxies is black crusts that are a chemical alteration pattern mainly found on limestone or marble monuments. They are forming a dark mineralogical layer composed of gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) that results from the sulfation reaction between the calcite (CaCO_3) of the stone and the sulphur dioxide (SO_2) from the atmosphere. As gypsum is easily soluble, this pattern particularly affects sheltered area from the rain where particulate matter is trapped and accumulates. Therefore, black crusts act as passive sampler and could be used as an archive of air pollution.

To validate black crusts nomination as a new proxy and to find the best pollution marker, samples were collected at Père Lachaise cemetery on ancient tombs (dated from the 1820's). A specific protocol was applied to separate strata from each other. Then, multiple analyses were realised using SEM-EDS, ICP-AES, and ICP-MS. The results show a different particulate content as a function of the depth, with different contributions of fly-ash typical of coal and oil combustion. This is confirmed by the chemical analyses as the trace metal concentrations are in agreement with the pollution sources. This study demonstrates that laminar black crusts have an internal stratigraphy that can be crucial to reconstruct past air pollution and provides precious data on pollution sources.