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The effect of air pollution on the stone decay of the Cologne Cathedral

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Different building stones of the Cologne Cathedral show a large variation of weathering phenomena. The Drachenfels trachyte, which was the construction material for the medieval part of the cathedral, shows significant surface deterioration, back-weathering coexisting with flaking, crumbling or the massive formation of gypsum crusts. Wolff (1992) first mentioned the negative interferences between the Schlaitdorfer sandstone and the Londorfer basalt lava or the Drachenfels trachyte and the Krensheimer muschelkalk.

Crust formation on limestone, sandstone, and volcanic rock from the Cologne Cathedral as well as from the Xanten and Altenberg Cathedral are investigated. These three buildings are located in different areas and exposed to varying industrial, urban, and rural environmental situations. The material investigated range from dark grey to black framboidal crusts. This 3 to 10 mm thick cauliflower-like form of gypsum crust incorporates particles from the pollution fluxes. It covers the stone surface and mainly occurs at sites protected from wind and direct rain. Secondly, thin laminar black crusts trace the stone surface and may cover complete sections of the building's structure not necessarily preferring protected sites. This kind of crust seems to have very strong bonds between the thin black crust and the stone surface.

Major and trace element distribution show an enrichment of sulfur, indicating the presence of gypsum, lead and other typical pollutants (arsenic, antimony, bismuth, tin etc.), which generally can be linked to traffic and industry. This indicates that even though the SO_2 emission has decreased due to i.e. stronger regulations of waste incineration plants and the ban of leaded petrol, the pollutants are still present in the crusts on the building stones. From systematic SEM observations it becomes evident that the total amount of pollution is less pronounced in the Altenberg and Xanten Cathedrals as compared with the Cologne Cathedral. The formation of gypsum occurs at lower amounts in Altenberg, which correlates well with the measured SO_2 content. On the other hand, the increasing H_2O content in the trachyte and the crusts correlates well with an increasing phyllosilicate formation.

Through the combination of different analytical techniques it was possible to clearly distinguish samples from the industrial or rural environment. If the data is compared to actual pollutant emissions, the analyzed samples imply present but also past pollution fluxes. Thus, the soiled zones of the built environment can function as environmental indicators.