The causes and significance of rapid surface stabilisation of building limestones

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Contrasting behaviour of limestones and quartz sandstones

Previous studies have suggested that the key to understanding the rapid retreat of sandstones in polluted environments is the continued supply of salts that drive equi-axial dissolution and the conditions that trigger associated positive feedbacks.

Preliminary studies of limestones suggest a greater significance for the rapidity with which spalled surfaces heal through the regrowth of a surface crust, and the importance of the factors that control crust growth.

Surface Stabilisation and Regrowth of Gypsum Crust following Contour Scaling

Gypsum Crust Development, St Matthias Church: the Importance of Rapid Dust Deposition

Hypothetical decay sequence and the importance of threshold behaviour

Gypsum Crust Development: the Importance of Biological Colonisation
Gypsum Crust Development: Controls Exerted By Moisture Availability

The Parliament Building in Budapest is in a locally moist environment. Increased moisture availability compared to St Matthias appears to inhibit crust regrowth and promote multiple flaking.

Multiple crust formation and spalling on the 'Wren' wall, Oxford

Detail of multiple crust formation and the importance of surface topography, 'Wren' wall, Oxford

Geo-Environmental factors

- Surface chemistry/mineralogy
- Variable atmospheric chemistry (short medium- and long-term)
- Variable crust deposition rates, flux (short medium- and long-term)
- Variable dust chemistry
- Facade topography, aspect
- Exposure to rainwash (amount, frequency, intensity)
- Drying rate (E/T, wind speed)
- Surface colourations – organics
- Surface wash in/wash out

The role of surface dust deposition

- Surface insulation (physical and chemical intermediary at the stone atmosphere interface)
- Direct source of gypsum
- Indirect source of gypsum (post-depositional transformation)
- Large specific surface
- Crystallization nuclei
- Catalysing reactions
- Chemical weathering, breakdown, phase transformations

Factors that allow surface crusts to form rapidly on new and newly exposed stone?

The role of 'organics'

- Adhesive surface coatings
- Depositional framework
- Modification of surface chemistry
- Biochemical processing of inorganic materials

Factors that allow surface crusts to form rapidly on new and newly exposed stone?
Sampling of dusts and crusts, Budapest and Oxford

Water soluble anions in Budapest dusts and crusts

<table>
<thead>
<tr>
<th>Location</th>
<th>Water soluble anions (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downtown (Mean of 3)</td>
<td>41, 565, 64</td>
</tr>
<tr>
<td>Parliament (Mean of 4)</td>
<td>309, 554, 70</td>
</tr>
<tr>
<td>Matthias Church (Mean of 3)</td>
<td>984, 1538, 8739</td>
</tr>
<tr>
<td>Matthias Church (Mean of 3)</td>
<td>69, 286, 893</td>
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<tr>
<td>Matthias Church (Mean of 3)</td>
<td>92, 6, 155</td>
</tr>
<tr>
<td>Matthias Church</td>
<td>3271, 9, 1180</td>
</tr>
<tr>
<td>Dust samples (Mean of 3)</td>
<td>5400, 3475, 9285</td>
</tr>
</tbody>
</table>

Dust sinks

BUDAPEST: Acid Digest

BUDAPEST: Water Soluble
Long-term crust growth, Oxford

Surface dust and fungal hyphae, Oxford

Paint fragment in surface crust, ‘Wren’ wall, Oxford

Modelling crust evolution

Modelling crust evolution
Decay choices: back to the future for Budapest and Oxford?