Salt extraction by poulticing in the archaeological site of Coudenberg

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The palace of Dukes of Brabant, 12th century
The sister of the Emperor Charles VI fails to extinguish the candles: Fire of 1731,

The drama left half of the palace destroyed. The ruins of the palace were left almost completely abandoned for forty years and were nicknamed the “Burnt Court”

The Royal Quarter of the 18th century
1984-1995-2006 Archaeological digs
1. Main building (11-12c)
2. Rue Isabelle (Isabella Street) (ca. 1620)
3. Aula Magna (1452-1460)
4. Chapel (1522)
5. Hôtel Hoogstraeten (Hoogstraeten House) (16c).
The Coudenberg archaeological site is characterized by decay phenomena inherent to its history as well as the environment to which it is exposed after excavation.
1. Main building (11-12c)
2. Rue Isabelle (Isabella Street) (ca. 1620)
Salt damage to recent walls in the museum
Salt damage to old walls in the subterranean site

The main salts detected (IC)

- gypsum (CaSO$_4$)
- sodium chloride (NaCl)
- calcium nitrate (Ca(NO$_3$)$_2$)
- sodium sulfate (NaSO$_4$)
- sodium carbonate (Na$_2$CO$_3$)
Water infiltrations, rising damp and increasing salt damage
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Deterioration → **major water infiltrations** → crystallization cycles $\text{CaSO}_4 \cdot \text{H}_2\text{O}$

Colorful crystals on the surface → $\text{Fe}($$\text{SO}_4$$)$·$\text{7H}_2\text{O}$
Salt Extraction Experiments

3 poultice types, 12 experiments in 5 locations
1. **Poultice KCS**

   (pre-wetting with 0.5, 2 or 4 l/m², 11 days application)

   cellulose fibres, kaolin clay & sand
   smaller pores compared to the substrate $\rightarrow$ advection

2. **Poultice C**

   (pre-wetting with 0.5, 2 or 4 l/m², 19 days application)

   cellulose fibres
   large pores compared to the substrate $\rightarrow$ diffusion.

3. **Poultice KS**

   (no pre-wetting, 56 days application)

   kaolin clay & sand
   smaller and larger pores compared to the substrate $\rightarrow$ advection and diffusion
Characteristics of the building and poultice materials for the desalination experiments
Samples are lifted at intermediate depths from brick and mortar to a depth of 20 cm (0-1, 1-3, 3-5, 5-10, 10-15 and 15-20 cm) Before and after each experiment to evaluate the efficiency

Keep in mind: the salt content is corrected considering the density of the poultice compared to the density and the surface area of brick and mortar in the wall kg.m$^{-2}$ (per sample depth)

The quantity of anions ($\text{Cl}^-$, $\text{NO}_3^-$, and $\text{SO}_4^{2-}$) and cations ($\text{Na}^+$, $\text{K}^+$, $\text{Ca}^{2+}$, and $\text{Mg}^{2+}$) is measured by ion chromatography (IC, Metrohm).
Including CaSO_4

More salts after application?

1. Poultice KCS (advection)
Excluding CaSO₄

1. Poultice KCS (advection)
When the masonry is already wet before application an oversaturation of the mortar is seen with salts being transported to the brick and vice versa if the masonry is dry beforehand.

In almost all cases salts are being transported to lesser salt contaminated areas which easily results in the impression of a successful desalination.

The white haze left behind by KS is unacceptable and successive cleaning can be problematic for the archaeological remains.
2. Poultice C (diffusion)

What seems as a positive result
Is in fact not, salts are not found in the poultice.

2. Poultice C (diffusion)
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The white haze left behind by poultices KCS and KS is unacceptable and successive cleaning can be problematic for the archaeological remains.
3. Poultice KS (advection & diffusion)

Same conclusion: wrong interpretation when considering CaSO4
3. Poultice KS (advection & diffusion)

Same conclusion: hardly any salts in the poultice
Poultice KCS Efficiency 4%
Salt decrease 4%

Poultice C Efficiency 1%
Salt decrease 18%

Poultice KS Efficiency 4%
Salt decrease 14%
Poultice KCS Efficiency 4%
Salt decrease 4%

Poultice C Efficiency 1%
Salt decrease 18%

Poultice KS Efficiency 4%
Salt decrease 14%

advection

advection & diffusion

diffusion

Poultice KS Efficiency 4%
Salt decrease 14%
The white haze left behind by poultices KCS and KS is unacceptable and successive cleaning can be problematic for the archaeological remains
The experiments have shown that the tested poultices hardly extract salts, migration into the depth and to lesser salt contaminated areas occurs when diffusion plays part in the process, it is unclear how long it will take before the salt concentration increases near the surface again. Eventually the treatment will need to be repeated.

In the case of the archaeological site of Coudenberg the use of poultice C was recommended

(suggestions to change the name ‘salt extraction poultice’ are welcome)
Thank you