International Course on Stone Conservation SC13

SESSION: Salts and Frost Weathering

INSTRUCTOR: Alison Sawdy-Heritage

TIME: Friday, 17th May/ 9:30 – 11:00 1.5 (hours) & 11:30 – 13:00 (1.5 hours)

SESSION OUTLINE

ABSTRACT

The purpose of this session is to provide the scientific and conservation context for the decay of porous building materials by the action of salts and frost. Salt and frost weathering are phenomena with significant cultural and economic consequences resulting in: the continuing loss of porous building materials, carved stone, wall paintings, and archaeological objects. This session introduces the multidisciplinary nature of the study of salt and frost damage to porous building materials, providing an introduction to this complex topic and reviewing treatment options for salt-laden building materials.

OBJECTIVES

After completing this session you will be able to explain:

- What salts are and where they originate from,
- Why certain salts cause damage and others do not,
- The different mechanisms by which salts and frost damage stone,
- The relationship between salts, porous materials and the environment,
- Why some salts and environments are potentially more damaging than others,
- What the current options are for reducing salt damage,
- The principles of environmental control and the challenges faced,
- The range of methods used to test for salts

CONTENT OUTLINE

In this session we start with basic description of what salts are, where they come from, and what their main damage mechanisms are.

1 General introduction to salts & salt damage phenomena
   - DEMONSTRATION: SALT DAMAGE EXPERIMENT

2 Main characteristics of salts:
   - ionic bonding; crystalline materials
   - basic chemistry of salts
   - different types of salts

3 Origins of salts

4 Salt solubility
   - DEMONSTRATION: SOLUBILITY EXPERIMENT
   - Relationship between solubility and temperature

5 Salt damage mechanisms: salt crystallization
- DEMONSTRATION: CRYSTALLIZATION EXPERIMENT
- supersaturation and crystallization pressure

6 Freeze-Thaw: this is also an important damage process, the mechanism of which is very similar to salt crystallization damage.

7 Salt damage mechanisms: Hydration state change
- DEMONSTRATION: HYDRATION STATE CHANGE
- Discuss hydration state change

8 Summary of the phase transitions of salt/water systems:
1 Crystallization/dissolution/deliquescence;
2 hydration/dehydration

Session 2

In this session we start with a discussion of how soluble salts are affected by environmental parameters (RH, Temperature), to understand how salt damage processes are environmentally activated. Then we take a brief look at salt and moisture transport processes. We also examine the main methods used for reducing salt damage, and finish with a general introduction to salts analysis and sampling issues.

9 Relationship between salt phase transitions and the environment
- DEMONSTRATION: SALT BEHAVIOUR AND RH
- Single salts: Concept of RHeq
  a. Relationship between RHeq and salt solubility
  b. Relationship between RHeq and temperature
- Salt mixtures:
  a. Solubility changes in presence of other salts
  b. Thermodynamic behaviour of salt mixtures

10 Physical vs. Chemical damage processes
- physical damage processes
  a. phase transitions
  b. differential hygric expansion
  c. differential thermal expansion
- chemical salt damage processes
  a. chemical corrosion

11 Optimum conditions for salt damage
- Rapid drying
- Rapid cooling

12 Salt and moisture transport processes
- Re cap moisture transport
- Salt + moisture transport
  a. Diffusion
  b. Advection
  c. Osmosis
  d. Salt automigration

13 Treatment options
   a. So called "Desalination" (salt removal/redistribution)
   b. salt conversion
   c. inhibition
   d. environmental control

14 Environmental control of salt damage
   1 Concept
   2 Problems
      a. Salt mixtures
      b. Non equilibrium behaviour
      c. Porous materials
      d. Kinetics
      e. Practical application

15 Salt analysis methods (low to high tech; pros & cons)
   - Qualitative
   - Quantitative
   - Semi- quantitative

16 Salt sampling
   - Sample types, purpose and restrictions
   - Locations
   - Strategies

READINGS

📖 = Essential reading material
💻 = Available online

📖💻Arnold, A., and Zehnder, K. 1991. Monitoring wall paintings affected by soluble salts. In *The Conservation of Wall Paintings*. pp 103-135. Proceedings of a symposium organized by the Courtauld Institute of Art and the Getty Conservation Institute, London, July 13-16, 1987. Marina del Rey: Getty Conservation Institute.
http://www.getty.edu/conservation/publications_resources/pdf_publications/pdf/wall_paintings.pdf

📖💻Doehne,E, and Price, C. 2010. *Stone Conservation: An Overview of Current Research, Second Edition*. Los Angeles: Getty Conservation Institute. pp. 15-20
http://www.getty.edu/conservation/publications_resources/pdf_publications/pdf/stoneconservation.pdf

📖💻Sawdy, A. Heritage, A and Pel, L. (2008). A review of salt transport in porous media, assessment methods and salt reduction treatments. In *Salt Weathering on Buildings and Stone Sculptures* pp 1-28. Proceedings from the International Conference 22-24 October 2008, The National Museum Copenhagen, Denmark, Technical University of Denmark, Copenhagen.
http://193.175.110.91/repository/images/8/86/Heritage_Pol_SWBSS_2008.pdf

📖💻Steiger, Michael (2005): Salts in Porous Materials: Thermodynamics of Phase Transitions, Modeling andPreventive Conservation. *Restoration of Buildings and Monuments*, 11 (6), 419-432.
http://193.175.110.91/repository/images/d/dc/RBM%2C_Vol._11%2C_No._6%2C_419-432_%282005%29-Steiger.pdf

- Zehnder, K. 2007. Long-Term Monitoring of Wall Paintings Affected by Soluble Salts. *Environmental Geology* 52 (2): 395-409. http://www.springerlink.com/content/d83mgt447227h668/

- Salt wiki portal (http://www.saltwiki.net/) (also available in German at http://www.salzwiki.de/)