A comparative study in desalination methods for mass-conservation of archaeological iron


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Introduction

A four year conservation project at the Swedish National Heritage Board is aimed at conserving objects excavated between 1960 and 1990 on Gotland, Sweden. The estimated number of archaeological objects for the project is about 30 000 of which a significant part are iron artifacts in varied condition.


Archaeological iron from the mass conservation project

Aim of the study

A comparative desalination experiment was initiated to decide on a method suitable for the projects specific material. A relevant method should be:

- Effective in chloride removal
- Easy to operate, minimal handling time
- Enabling simultaneous treatment of large batches of iron
- Environmentally friendly

Experimental Methods

- Seven desalination methods were tested on stored project material and newly excavated material to clarify whether amount of time between excavation and desalination significantly affects the level of chloride extraction.
- A condition survey of previously conserved archaeological iron was conducted to assess the long term stabilization of certain conservation methods

Chosen desalination test methods:

1. **0, 1 M NaOH**
2. **0, 5 M NaOH**
3. **0, 1 M NaOH+0, 1 M Na2SO3**
4. **5% w/v Sodium sesquicarbonate**
5. **Deionised water**
6. **Deionised water flushed with Nitrogen**
7. **4% EDTA followed by 1% Na2HPO**


Example of test material for desalination

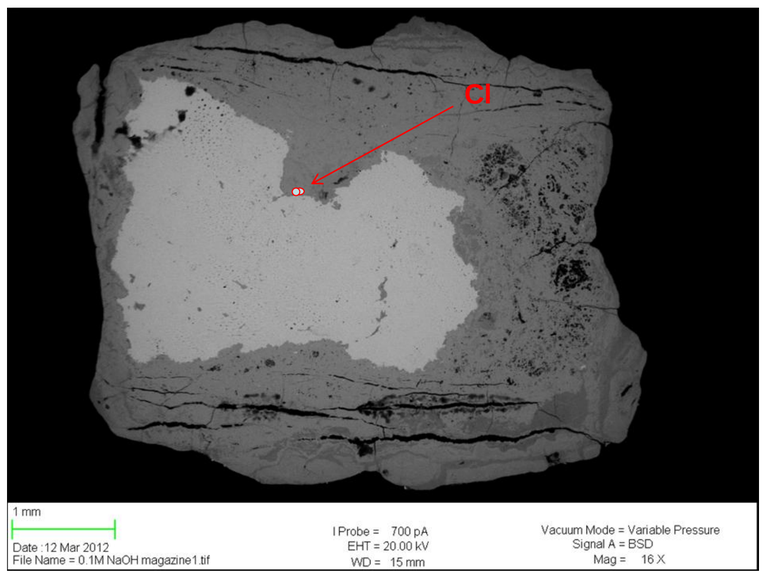
The various treatments were compared by:

- Extracted chloride levels
- Analysis with Scanning Electron Microscopy.
- Assessment of flash corrosion, increased fragility and flaking of original surface during the desalination process
- Practicality and handling time.
- Accelerated corrosion test after finished desalination.


Test material in humidity chamber for corrosion test

Results

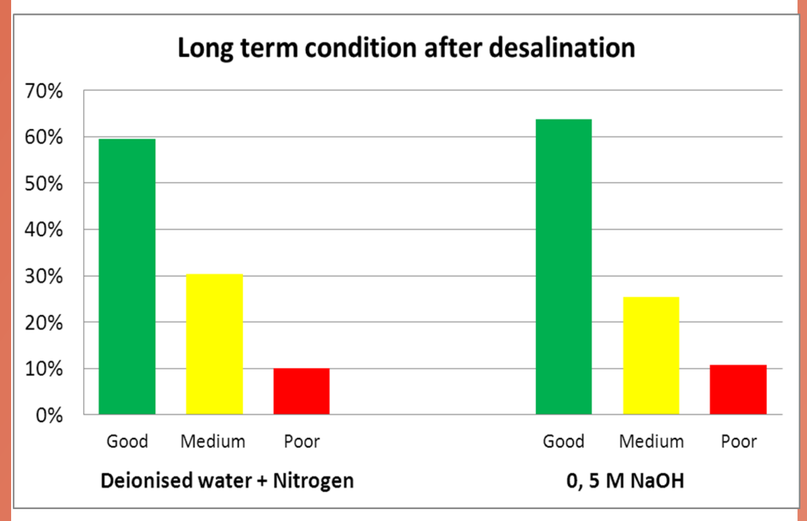
- Extracted chloride levels were similar for all tested methods
- Highest chloride extraction level was achieved with 0.5 M NaOH solution, but the difference to the other methods was minimal.
- Little difference in chloride levels between stored samples and those newly excavated
- Flash corrosion was most intensive in deionized water and 0.5 M NaOH and least intensive in deionized water + Nitrogen
- The accelerated corrosion test demonstrated little difference in corrosion rates



- SEM analysis of cross-sections proved inconclusive due to insufficient amount of chloride for quantifiable comparisons


Flaking of original surface in NaOH-solution

- Fragility and flaking of original surface most prominent in samples treated with methods with the highest pH, and lowest for samples treated with deionized water + Nitrogen



- The condition survey also indicated little differences in long term stability.

Conclusions

None of the desalination methods tested proved to be clearly more efficient than the others. The soil conditions on Gotland may be contributing to the low and uniform chloride extraction levels. The similar results for the newly excavated samples may be due to the chloride-containing products being allowed to oxidize at excavation site prior to desalination.


Desalination tank with Nitrogen flush system

Applied method today, desalination in continuous thermostat controlled deionized water flushed with Nitrogen, is therefore based on practicality in handling, avoidance of flash corrosion, appearance of the treated iron and environmental considerations.

Further investigations and relevant studies could include:

- An evaluation of the whole handling and conservation routine from excavation site to storage.
- Conservation experiments on freshly excavated iron that has not been allowed to dry out before desalination.
- Large condition surveys for the study of long term effect of conservation methods.