2016 SARDIS METALS SURVEY

Visual Glossary

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Emily Frank

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IRON

"Knight (1982) distinguishes between two essential disintegration mechanisms for mineralized iron; he describes these as spalling and cracking. In the process of spalling, the object may break up into wedges or flakes. Wedge-like fragments detach themselves from the corroded object as it gradually loses physical cohesion. Cracking, which may be associated with the dehydration of the iron oxyhydroxide crust or with changes in volume due to the reaction of chloride ions within the iron, leaves the surface fissured with deep cracks, which being lines of stress may result in the object falling apart along the crack lines" (Scott and Eggert 2009, 102).

"[Orange-brown powdery corrosion] is due to the slow formation of akaganéite, often on the underside of corroded or partially laminated fragments. The crystallization of akaganéite may disrupt the surface, forcing off small flakes of corroded metal. [This is] almost certainly due to the oxidation of ferrous chloride solutions still active within the pores of the object…[I]f these crystals are cleaned away, and the object exposed to humid air, more akaganéite appears...[S]low changes in the ferrous chloride content within iron result in further akaganéite formation with the result that the volume expansion cracks the oxide corrosion layers and the mineralized parts of the corrosion crust fall apart" (Scott and Eggert 2009, 101).

Unstable; fragmentary

This category of instability was used to describe iron objects that have been reduced to a fragmentary state (with fragments greater than ~1 cm), presumably as the result of one or more of the corrosion mechanisms described above.

Objects in this category of instability should receive the following treatment: excavate the areas of akaganéite crystals under magnification (if present), dry the object completely, consolidate/coat any newly excavated areas with 7.5%-10% B48N (so future corrosion is visually apparent), save fragments and larger bits in a small polyethylene bag, and seal the object in a desiccated or (in cases where the object has an organic component) a deoxygenated microenclosure. In cases where a large fragment of the object that provides information about its surface or shape is at risk of being lost from its original location or crushed, excavate the areas of akaganéite crystals under magnification (if present), tack the fragment in place with 40%-50% B48N, dry the object completely, and seal the object in a desiccated or deoxygenated microenclosure.

See the following images for examples of objects marked as **Unstable; fragmentary**.

Unstable; fragmentary; Untreated was assigned in cases when untreated iron objects (with significant remaining burial soil) have been reduced to a fragmentary state (with fragments greater than ~1 cm), presumably as the result of one or more of the corrosion mechanisms described above.

Most objects in this category of instability should receive the following treatment (unless they are deemed a priority by the director, in which case they should be treated as a newly excavated find following the current standard treatment for iron objects): dust off the powdery areas, save fragments and larger bits in a small polyethylene bag, and seal the object in a desiccated or (in cases where the object has an organic component) deoxygenated microenclosure. In cases where a large fragment of the object that provides information about its surface or shape is at risk of being lost from its original location or crushed, excavate the areas of akaganéite crystals under magnification (if present), tack the fragment in place with 40%-50% B48N, dry the object completely, and seal the object in a desiccated or deoxygenated microenclosure.

See the following images for examples of objects marked as **Unstable; fragmentary; Untreated**.

NOTE: The large fragment in the upper left of the above image gives the object “fragmentary” status. The smaller bits of iron in the Petri dish would otherwise be classified as “spalling bits” (see below).

Unstable; spalling bits

This category of instability was used to described objects that showed minor spalling (with fragments smaller than ~1 cm), presumably as the result of one or more of the corrosion mechanisms described above.

Objects in this category of instability should receive the following treatment: excavate the areas of akaganéite crystals under magnification (if present), dry the object completely, consolidate/coat any newly excavated areas with 7.5%-10% B48N (so future corrosion is visually apparent), save fragments and larger bits in a small polyethylene bag, and seal the object in a desiccated or (in cases where the object has an organic component) a deoxygenated microenclosure.

See the following images for examples of objects marked as **Unstable; spalling bits**.


Metric
1
2
AIC PhD Target
©2011 AIC


Metric
1
2
AIC PhD Target
©2011 AIC

Unstable; spalling bits; Untreated was assigned in cases when untreated iron objects (with significant remaining burial soil) showed minor spalling (with fragments smaller than ~1 cm), presumably as the result of one or more of the corrosion mechanisms described above.

Most objects in this category of instability should receive the following treatment (unless they are deemed a priority by the director, in which case they should be treated as a newly excavated find following the current standard treatment for iron objects): dust off the powdery areas, save larger bits in a small polyethylene bag, and seal the object in a desiccated or (in cases where the object has an organic component) a deoxygenated microenclosure.

See the following images for examples of objects marked as **Unstable; spalling bits; Untreated**.

NOTE: As mentioned above, the large fragment in the upper left of the above image gives the object "fragmentary" status. If that fragment wasn't present, the smaller bits of iron in the Petri dish would be classified as "spalling bits."

Unstable; weeping pustules

"The formation of reddish-brown pustules or droplets exuding from the surface of an iron object is, naturally enough, not a good indication for future preservation. This kind of instability, usually exacerbated by poor storage conditions with fluctuation in RH [relative humidity] conditions, or no humidity control, is a serious indication that chloride ions are still promoting active corrosion of the iron" (Scott and Eggert 2009, 101).

"The weeping pustules often have a thin brown solid film floating on the surface of liquid which, if dried out, can produce a series of hollow shells on the surface of the iron. These films or shells are an indication that oxidation and hydrolysis are occurring within the iron chloride solution" (Scott and Eggert 2009, 102).

This category of instability was used to describe objects with clear weeping pustules. In rare cases, deliquescence was visible on the surface.

Objects in this category of instability should receive the following treatment: excavate the areas of weeping pustules or akaganéite crystals (if present) under magnification, dry the object completely (especially if deliquescence was observed), consolidate/coat any newly excavated areas with 7.5%-10% B48N (so future corrosion is visually apparent), save fragments and larger bits in a small polyethylene bag (if present), and seal the object in a desiccated or (in cases where the object has an organic component) deoxygenated microenclosure.

See the following images for examples of objects marked as **Unstable; weeping pustules**.


10°
15°
25°
Metric
1
2
3
4

Less frequently used combinations

Throughout this survey “fragmentary” and “spalling bits” should be considered mutually exclusive, with “fragmentary” being the more severe category and taking precedence when both phenomena are present. “Weeping pustules” might be used in combination with either “fragmentary” or “spalling bits,” and any of these combination categories might be “Untreated.”

See the following image for an example of an object marked as **Unstable; fragmentary; weeping pustules**.

NOTE: The large fragments give the object "fragmentary" status. The smaller bits of iron in the Petri dish would probably otherwise be classified as "spalling bits"; however, "fragmentary" and "spalling bits" are mutual exclusive, so only the more severe "fragmentary" was used here. The pustules surrounding the circular hole are described as "weeping pustules".

See the following image for an example of an object marked as **Unstable; fragmentary; weeping pustules**.

NOTE: The above object would be placed in a deoxygenated microenclosure because of the bone component.

The following combination categories were employed as necessary but are not represented in this visual glossary.

Unstable; fragmentary; weeping pustules; Untreated

Unstable; spalling bits; weeping pustules; Untreated

COPPER ALLOY

Active bronze disease

"Bronze disease is a progressive deterioration of ancient copper alloys caused by the existence of cuprous chloride (nantokite [CuCl]) in close proximity to whatever metallic surface may remain" (Scott 2002, 125). "The condition is manifest by light green, powdery excrescences of eruptions within the surface…loose material often falling from the object and dropping onto the surrounding area. In extreme cases, very acidic light or dark green liquid may ooze from the bronze and stain surrounding tissue or foam supports. Ultimately, bronze disease can reduce an apparently solid object into a heap of light green powder" (Scott 2002, 126).

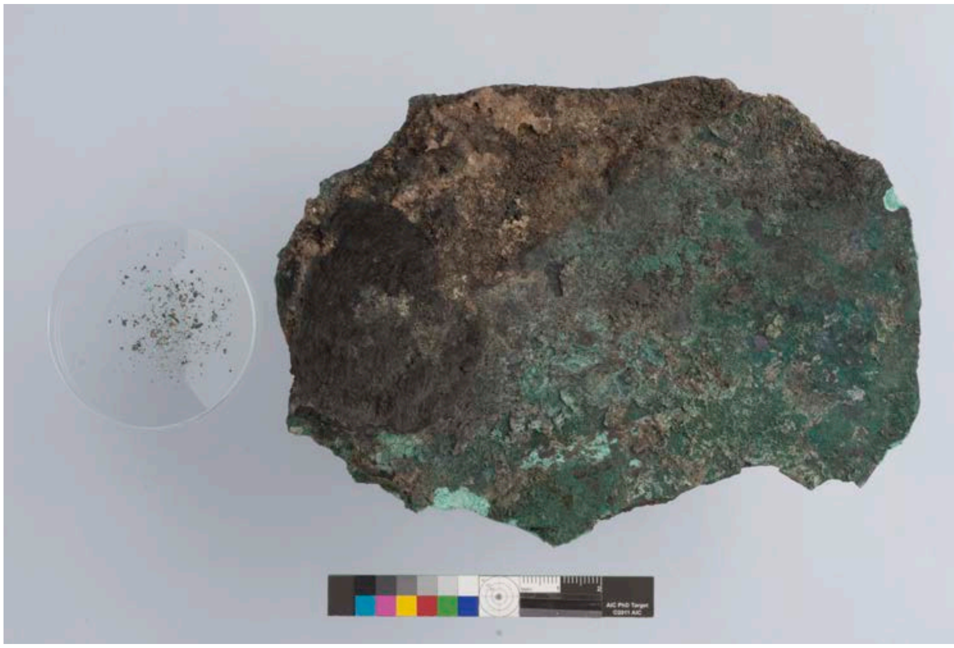
This category of instability was used to describe objects clearly suffering from bronze disease, including those that have turned completely into a pile of light green powder.

Objects in this category of instability should receive the following treatment: excavate the powdery areas of corrosion under magnification, dry the object completely, consolidate/coat the newly excavated areas with 7.5%-10% B48N (so any future outbreaks of bronze disease are visually apparent), and seal the object in a desiccated or (in cases where the object has an organic component) a deoxygenated microenclosure.

See the following images for examples of objects marked as **Active bronze disease**.


Metric
1
2

NOTE: The above object would be placed in a deoxygenated microenclosure (because of the bone component).




Metric
1
2


AIC PhD Target
©2011 AIC


Metric
1
2

Active bronze disease; Untreated was assigned in rare cases when untreated objects (with significant remaining burial soil) were clearly suffering from bronze disease (as described above).

Objects in this category of instability should receive the following treatment (unless they are deemed a priority by the director, in which case they should be treated as a newly excavated find following the current standard treatment for copper alloy objects): dust off the powdery areas and seal the object in a desiccated or (in cases where the object has an organic component) a deoxygenated microenclosure.

See the following image for an example of objects marked as **Active bronze disease; Untreated**.

Bronze disease?

"The existence of some chloride containing corrosion products within the patina of a bronze does not mean that the object is necessarily suffering from bronze disease but may simply represent a localized or superficial chloride corrosion process" (Scott 2002, 126).

This category of instability was used to described two phenomena: (1) when visual indications of past bronze disease were clearly present on the object (usually consolidated light green areas) but it was not completely clear if the object was currently powdering or if a past treatment had successfully pacified the active corrosion, or (2) when objects had very small areas of potentially powdery corrosion but access to the area of the object was limited such that active bronze disease could not be confirmed with the naked eye. In many cases, objects marked with "Bronze disease?" have endured multiple retreatment campaigns.

Objects in this category of instability should receive the following treatment: if relevant, excavate any questionably powdery areas of corrosion under magnification and dry the object completely, consolidate/coat any newly excavated areas with 7.5%-10% B48N (so any future outbreaks of bronze disease are visually apparent), and seal the object in a desiccated or (in cases where the object has an organic component) a deoxygenated microenclosure.

See the following images for examples of objects marked as **Bronze disease?**.

10°
15°
25°
Metric
1

Bronze disease?; Untreated was assigned in rare cases when untreated objects (with significant remaining burial soil) had very small areas of potentially powdery corrosion but access to the area of the object was limited such that active bronze disease could not be confirmed with the naked eye. This category is not represented in the visual glossary.

Objects in this category of instability should receive the following treatment (unless they are deemed a priority by the director, in which case they should be treated as a newly excavated find following the current standard treatment for copper alloy objects): dust off the questionably powdery areas (if accessible) and seal the object in a desiccated or (in cases where the object has an organic component) a deoxygenated microenclosure.

Active corrosion?; chemical residue

Numerous and varied chemical treatments were used at Sardis from 1958 onwards. An initial survey of conservation reports and records from each year indicates that (at the very least) sodium carbonate/sesquicarbonate, silver oxide slurries, formic acid, alkaline rochelle salts, alkaline glycerol, and zinc/sodium hydroxide reduction (with variable rinsing afterwards) all have a history of use on copper alloy coins and objects at Sardis.

"Chalconatronite, $Na_2Cu(CO_3)_2 \cdot 3H_2O$, is the best known sodium-copper-carbonate mineral…Substantial layers of chalconatronite have been found on a number of…bronze objects known to have been conserved with sodium sesquicarbonate" (Scott 2002, 117-118).

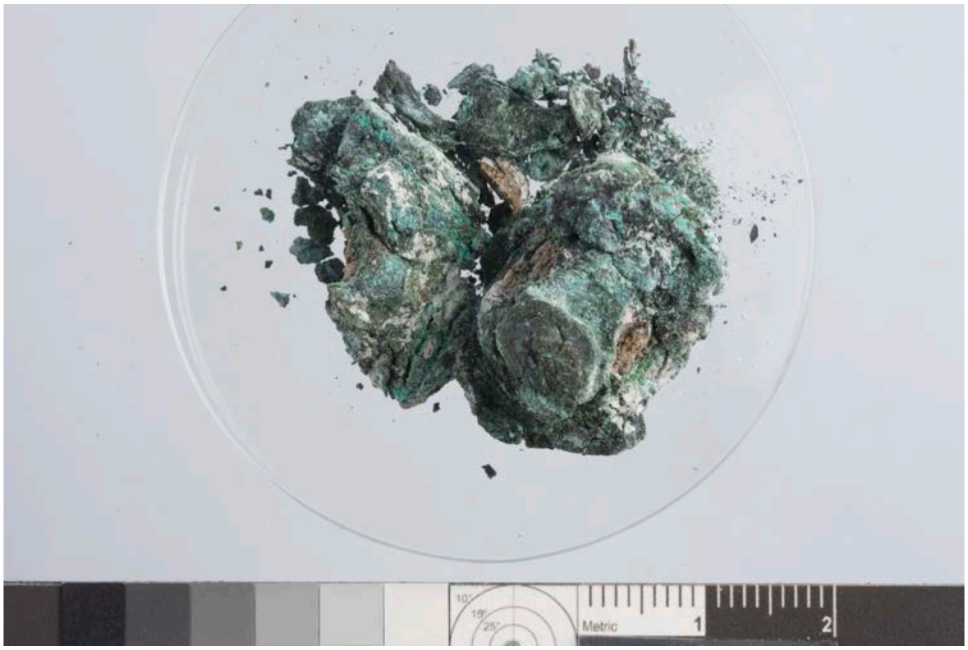
"Even when sodium sesquicarbonate cleaning is not suspected, residues from aqueous cleaning solutions may produce chemical alterations" (Scott 2002, 119). Based on our observations, these residues appear most commonly as a range of blue, bluish-green, and/or white powders and/or pustules.

If chalconatronite or other chemical residues are coming from residual chemicals from treatment, then moisture can perpetuate the reaction. Conservators from the Brooklyn Museum Conservation Laboratory were in contact with David Scott recently on this topic. He wrote, "Sometimes the chalconatronite comes from the chemical salts used to treat the object together with the corrosion of the copper of the statue itself. Because of this, I would tend to remove all of it and keep it at a low RH to make sure that if it recurs, it is not staining or corroding more of the surface of your "lovely" bronze. I would try to swab it clean and then dry the statue out well and keep an eye on it as the slow movement of salts in these things seems to cause trouble over decades rather than weeks" (personal communication with Anna Serotta on 12.07.2016, EBF).

This category of instability was used to describe objects with powdery (non-bronze disease) residues or pustules on the surface. Powdery residues were most commonly white and/or light blue. Pustules were most commonly light green.

Objects in this category of instability should receive the following treatment: remove the powdery corrosion, dry the object completely, and seal the object in a desiccated or (in cases where the object has an organic component) a deoxygenated microenclosure.

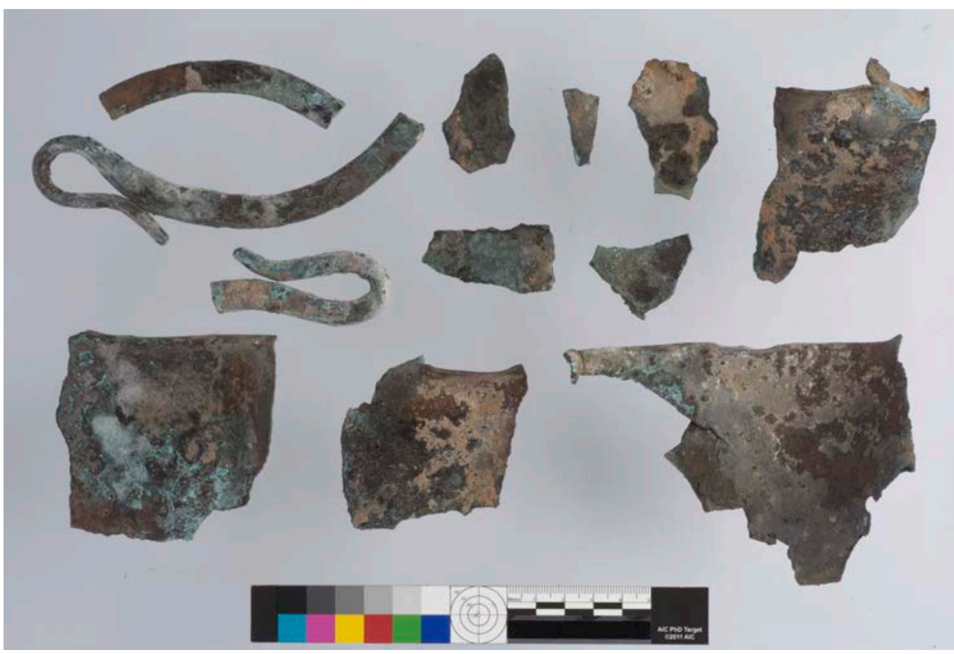
See the following images for examples of objects marked with **Active corrosion?; chemical residue**.


Metric
1
2


Metric
1
2


10°
15°
25°
Metric
1
2


10°
15°
25°
Metric
1
2



Active bronze disease; chemical residue

In a few cases, objects were plagued with active bronze disease as well as obvious chemical residues (both described in detail above).

Objects in this category of instability should receive treatment as described above under “active bronze disease” and “chemical residue.”

See the following image for an example of an object marked with **Active bronze disease; chemical residue**.

NOTE: The rubber band would be removed as part of this object’s treatment.

COPPER ALLOY AND IRON

In cases where objects were made up of iron and copper alloy components and both materials were unstable, combinations of the above categories were employed (e.g. **Unstable; fragmentary; weeping pustules (Fe); Active bronze disease (Cu); Untreated**).

Objects in this category of instability should receive treatment as described above under the relevant conditions.