

New guidelines for the desiccated storage of archaeological metal artefacts

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Corrosion of archaeological metals, particularly iron and copper alloy artefacts, is an ongoing problem for conservation and collections care. If not managed, corrosion can lead to reduction in value or complete loss of artefacts and collections. This paper presents the results of a long-term research programme at Cardiff University which investigated corrosion rates linked to humidity levels and best practice in creation of desiccated microclimates for corrosion prevention.

Surveying sector practices in the post-excavation storage of archaeological metals has revealed the complexity of the decision-making process and a distinct lack of evidence-based guidance to direct protocols. Immediately post-excavation, free water in corrosion product layers can create high humidities and drive destructive electrochemical corrosion. Advice on drying techniques is limited and conflicting, leading to ad hoc practices and consequent danger to objects. Once dry, chloride-bearing compounds mean archaeological and marine iron artefacts can remain unstable down to 15% relative humidity (RH). Therefore, for most museums and archaeological units, long-term corrosion control is by desiccated storage reliant on creating and maintaining low RH microclimates in plastic boxes. Success of these microclimates is driven by air exchange rates of boxes which are in turn dictated by box design and size. Along with the mass of silica gel included, these variables determine the lowest RH achievable and its longevity. Without evidence of the influence of these variables, effective management of storage procedures is impossible.

This paper delivers new data on the influence of post-excavation drying, storage box variables, mass of silica gel and gel regeneration cycles in successful creation of desiccated microclimates for medium and high RH external store environments. Combining this with corrosion rate data for iron and copper alloy objects between 20-80% RH allows predictions to be made about the risk to artefacts of following a range of common protocols. Guidance on best-practice drying and storage procedures to minimise corrosion and enhance object longevity are now offered to the heritage sector.

The research updates previous, generic guidance on storage box selection and silica gel use. Results of surveying practice indicate that the go-to guidance remains *First Aid for Finds*, the most recent edition of which was published in 1998. Advice on silica gel per volume of box in that publication was based on contemporary practice rather than evidence-based data and no guidance on box selection was offered beyond the ubiquitous Stewart Sealfresh. The synergy of conservation science and practice reported here combines laboratory experimentation using climatic chambers, oxygen consumption corrosion rate testing and air exchange measurements with an extensive survey of sector practice and close liaison with end users to produce pragmatic guidelines for practitioners and managers.

Supporting cost benefit decision-making in storage box selection and silica gel regeneration cycles, these guidelines will allow managers of archaeological metalwork collections to design bespoke storage protocols which have the potential to extend lifetimes of collections. Assessment of risk to objects can be weighed against hardware and human resource costs and variables manipulated to design workable, case-specific solutions to a widespread problem.

Nicola Emmerson is a Senior Lecturer at Cardiff University where she teaches Conservation and Heritage Science with a focus on research methods and analysis. Her Historic Scotland funded PhD investigated the performance of protective coatings for historic wrought iron and she is a qualified object conservator. She is Chair of the Metals Committee of the Institute of Conservation and is a member of the Technical Committee of the ICOM-CC Metals Working Group. Working closely with practitioners, her research centres on producing evidence-based guidance for end users in conservation practice.

Johanna Thunberg is an AHRC-funded PhD candidate at Cardiff University. Her research project aims to provide evidence-based, cost-benefit guidelines for management of archaeological copper alloys. She has a BSc and MSc in Conservation from Cardiff University where her theses focused on the efficacy of storing archaeological metals using microclimates. Between 2014-2018 she worked as an object conservator and teaching associate at Cardiff University.

David Watkinson is a Professor of Conservation at Cardiff University, where he teaches and researches conservation theory and practice, with emphasis on the corrosion and treatment of ferrous metals. His research into desiccated storage of unstable iron underpinned the conservation of Brunel's iconic steamship ss Great Britain, which won the Gulbenkian Museum prize in 2006. In 2010 he was awarded the Plowden Medal for his innovative research and for his contributions to the conservation profession. He is currently vice-president of Working Party 21 (Corrosion of Archaeological and Historical Artefacts) of the European Corrosion Federation and has served widely on committees and grant awarding bodies.