Conservation Considerations for Iron Meteorites in the University of Alberta Meteorite Collection.

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Purpose: The University of Alberta Meteorite Collection contains 499 iron meteorite specimens. Some of these specimens have been observed to experience ongoing active corrosion, despite the use of a dehumidifier to control the relative humidity (RH) within the collection storage area. The storage area consists of a Class 1000 clean room; curation conditions are outlined in [1]. Exposure of iron meteorites to terrestrial surface conditions results in corrosion which forms mineral products such as goethite, lepidocrocite, maghemite, magnetite, and akaganéite (β-FeOOH) in the presence of chloride ions, which may penetrate into the interior of the meteorite along grain boundaries and cracks [2]. Ni-rich taenite and Ni-poor kamacite are intergrown in these meteorites, and kamacite is selectively attacked relative to taenite [2]. Corrosion of these meteorites is slightly more complex because of the additional Ni-, S- and P-rich phases, which may influence pH levels [2]. Corrosion will continue during storage unless preventative measures are taken. Corrosion-causing chlorides are ubiquitous throughout the environments meteorites are likely to be recovered from, and so it is likely that any iron meteorite may be contaminated and require treatment [3]. Similar conservation procedures for archeological iron artifacts typically involve chemical stabilization treatments and/or environmental controls [4]. Chemical stabilization treatments have not been proven to be 100% effective at removing chloride ions and halting corrosion. These techniques carry with them the potential for chemical contamination of the meteorite surface, as well as for the chemicals used for treatment to penetrate into the meteorite interior and cause changes to their mineralogy. Additionally, the high heat and pressures associated with some of these treatment options may alter the specimens' metallurgical characteristics [5] in ways that have not been sufficiently investigated, especially with regards to meteorites. For this reason, as well as because these techniques can require significant costs and infrastructure to implement, and could be time consuming when considering the scale of the collection, such treatments are not recommended for broad implementation. As a result, the treatment plan outlined here focuses on preventative measures such as climate control and the establishment of microclimates. This plan has been developed based on a review of the current literature and a survey of storage methods in two other institutions. The methods and next steps for the conservation of these objects are outlined here.

Collections Survey: The first step in the project was a complete inventory of all iron and stony-iron meteorites in the UAlberta collection, including polished and unpolished slices, epoxy mounts and thin sections, and completely or partially fusion crusted specimens. A list of samples was compiled, and a visual examination of each sample was performed to determine whether corrosion was present, and to what extent. Samples where advanced stages of active corrosion were present and significant enough to pose a threat to the physical integrity of the specimen were given a *priority one* rating. Such damage could include flaking, cracking, weeping, blistering, and delamination. Flaking and cracking were observed most often in this category, with several specimens showing evidence of blistering as well. In total, 42 specimens were placed in this category, requiring immediate intervention and treatment to prevent further damage. Samples where evidence of active corrosion was present, but not yet extensive enough to threaten sample integrity, were given a *priority two* rating. This group includes specimens partially or completely covered in surface corrosion. In total 335 specimens were placed in this category. The third and final category included specimens with no signs of active corrosion; 43 specimens were placed in this category. The large number of specimens in the priority one and two groups necessitated a way to prioritize treatment even among these groups. Group one was addressed first. Specimens from group one which have been in the collection for less than ten years were considered unstable, and were chosen for the treatment pilot project outlined below.

Project Plan: This project will employ ESCAL film and RP-A agent as the most effective and appropriate methods of isolating individual corroded meteorite specimens within anoxic and low RH environments to prevent further corrosion. These specimens will be heat-sealed within ESCAL film and enclosed with RP-A sachets and an oxygen indicator to monitor the future presence of oxygen. Specimens will be monitored periodically for at least one year to verify the effectiveness of the technique at halting corrosion. Along with these sealed specimens, two polished slices taken from the same stone of the Pinawa meteorite and prepared at the same time by the same methods will be used to directly compare the effects of the microclimate storage against those of storage at ambient conditions. One of the specimens will be sealed as described above, with the other stored unsealed within the collection storage room. The RH of the space will be continually monitored, with a dehumidifier used to maintain the RH of the space at or below 30%. The condition of these slices will be assessed bi-monthly to determine whether any corrosion has occurred.

References: [1] Herd, C. D. K. et al (2016) *Meteoritics & Planetary Science,* 51(3):499-519. [2] Sjøgren, A., and Buchwald, V. F. (1991). *Studies in Conservation, 36(3):*161–171. [3] Allington-Jones, L. (2020) *Journal of Natural Science Collections,* 7:83–91. [4] Rimmer, M. et al. (2013) *English Heritage.* [5] Mardikian, P. (2006) *Special Publication, Australian National Centre of Excellence for Maritime Archaeology No. 13: 113-116*