Galvanic Cleaning of Meteorites
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Purpose of this Article

The purpose of this article is to describe a galvanic method of cleaning and preserving meteorites that is both cost effective, and available to both private and public collections.

Introduction

Meteorites, and in particular, those found in humid areas, or those with long terrestrial history, can be subject to a rather aggressive form of decay involving chloride. The carrier of this chloride is stated as either the mineral Akaganêite[1] or ferric chloride (lawrencite). The mineral Akaganeite is described in the Cambridge Encyclopedia of Meteorites page 62 as a primary carrier of chloride, having between 0.3 wt% and 5.4 wt% Cl. Thus also in the Cambridge Encyclopedia of Meteorites (page 311), the formula for this mineral is given as beta FeO(OH,Cl). The chloride ion will react with the iron to form a hydrous ferric chloride that will continue the cycle of destruction through a complex set of reactions. The ferric chloride, once formed is deliquescent and will then react with oxygen to continue a cycle of destruction in the meteorite. It affects not only irons, but chondrites as well. As stated in The Cambridge Encyclopaedia of Meteorites "It is academic as to whether to chloride comes from Lawrencite or Akaganéite. Its affect on the meteorite is the same". As such, it is not the purpose of this paper to argue the origins of the chloride, but to describe a reaction that will reduce the amount of aqueous chloride present in the meteorite.

The first most collectors will see of this reaction is a greenish aqueous solution “weeping” from the meteorite. The ferric chloride solution will oxidise to form a ferrous chloride solution that reduces, in the presence of iron, to form more ferric chloride, slowing destroying the specimen. As the reaction requires both oxygen and water (generally humidity) to proceed, most methods of control have concentrated on removing the specimens from air and/or humidity. Sealed, nitrogen purged, humidity controlled cabinets having also been employed. Some specimens are coated in oil, or a coating of a protective polyurethane. This is not desirable for ordinary chondrites, as it may affect their visual appearance.

I have always felt that this is only part of a solution, and that removal of chloride and a stabilisation of the meteorite should be tried first. The search for a solution to this problem came about from our public display of meteorites at Bathurst Observatory, and our desire to display them in a way that would be pleasing to the

[1] Cambridge Encyclopedia of Meteorites, O. Richard Norton. An excellent reference book, that describes in detail the decay of meteorites via reaction with the chloride from this mineral.

public. We also have a business acquaintance (Crystal Encounters[2]) in the meteorite dealer field, that provides us with a number of specimens.

In particular, the people from Crystal Encounters were having problems with a number of their specimens for sale showing signs of “weeping”. Also, I provide a service to Crystal Encounters by cutting, slicing, polishing and preparing some specimens for them and in return get to retain some specimens for our public display. A number of the specimens that I have worked on show effects of chloride reaction, to varying degrees.

As a result, I sought a solution that would be easy, and involve chemicals that are generally available to the general public and thought that some experimentation with the galvanic reaction may yield results.

Method Background

The method described in this article, was used in the past by myself for cleaning other metals. I first came across it at a flea market, where a salesperson was selling a “magic metal” that would clean your silverware. The “magic metal” was about 10 by 15 centimetres with a few holes drilled in it. You placed your silverware on the metal, added hot water and “washing soda”. After a while, “presto” your silverware could be wiped off and was clean. The cost of the “magic metal” was around $20 U.S during the 1980’s and my father purchased one.

My father then presented me with this metal and the directions, as he knew I was studying chemistry at the time and may be interested in how the “magic metal” worked. I soon discovered that the “magic metal” was indeed just a square of aluminium. I then was able to demonstrate to my father that he could have saved the $20 and used aluminium foil instead. I then proceeded to clean other objects, such as my native copper and silver, coins and such using aluminium foil, hot water and washing soda (sodium carbonate). After completing my chemistry, I later understood how this reaction worked. Very basically, more reactive metals (in this case aluminium) will donate electrons to a salt of a less reactive metal (ferric and ferrous chloride in our case), to reduce the less reactive metal ions to solid metal (in this case iron). The more reactive metal then forms a salt. Later, during the 1990’s I again used this method for preserving some shipwreck items for a work colleague.

I decided that I would experiment using this method a number of ordinary chondrite meteorites and some Campo del Cielo irons and observe the results[3]. The advantages of this method, is that only soluble salts will be reduced to metal, and the iron inclusions or other non- soluble minerals are not affected.

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[2] Crystal Encounters www.crystalencounters.com.au

[3] After completing my tests, I found a link to an article describing this method for cleaning marine iron artefacts. The link is on Eric Twelker’s great meteorite purchasing and information site. www.meteoritemarket.com The link is part 1 on preserving iron by Donny L Hamilton, Nautical Archaeology Program, Texas A& M University.

Method

For this study, Crystal Encounters provided me with a sample of JAH 055 L4 to L5 chondrite. The specimen was an end of about 64 grams, with the cut face having been polished. The polished face showed corrosion over most of its surface, with liquid and corrosion prominent around the middle of the cut face. A hand lens also revealed that the end of the meteorite was covered in small liquid drops. At the time, I was also cutting and preparing a number of other unclassified specimens from North West Africa (NWA), and some of these also showed liquid droplets under a hand lens.

The JAH 055 was the most severely affect specimen. A ph test was carried out on the liquid ferric/ferrous chloride from this sample. The ph was around 1! This also indicated the presence of hydrochloric acid in the sample, which can be a harmful by-product of incomplete reduction of ferrous chloride.

We also have on display a large 61 kilogram Campo Del Cielo, and like most meteorites from this location, it is susceptible to weeping from chloride decay. In the past, we have kept this specimen treated in a light oil. Even so, it requires cleaning and a reapplication of this oil every six months. After testing the method on the JAH 055 and other NWA specimens, it was decided also to carry out the method on this iron as well.

Care should be used at all times, as even though the chemicals used and generated using this method, are not by themselves too dangerous, the use of them with hot water could cause burns. I advise undertaking the reaction in a ventilated area, away from children and pets. Also, use gloves and safety goggles.

To prepare the smaller meteorites for the galvanic reaction, a glass jar was cleaned and the meteorite specimen was then wrapped loosely in aluminium foil. A large plastic bin was used to treat the Campo Del Cielo. The sample should be wrapped so that parts of it are still visible, and liquid is still free to move between the sample and the foil. Meteorite slices can just be placed on the foil, and if desired the edge of the foil can be bent around the slice. The amount of foil needed will be dependent on the size of the specimen, but should be sufficient to be able to cover the specimen, with some extra.

Hot water, (preferably distilled water) was then added to the jar and the foil wrapped specimen until it is fully immersed. This is followed by adding about 1 teaspoon of washing soda (sodium carbonate[4]) per 250ml of water.

The reaction appears vigorous, as carbon dioxide is produced and the aluminium slowly dissolves. The reaction itself is complex, with a number of processes taking place simultaneously. The carbonate and hydroxide ions produced will help remove the chlorides from the specimen and force them via the galvanic reaction into solution. The carbonate serves to neutralise the hydrochloric acid, as well as provide the strong oxidising agent for the aluminium. Simply put, the iron chlorides are reduced to solid iron via the sacrificial anode of the aluminium (a simple galvanic reaction). This iron can eventually be seen as a dark residue on the remaining

[4] Be sure not to add sodium bicarbonate (baking soda), as it is not suitable.

foil, or as a precipitate in the jar. The presence of iron can be tested by holding a magnet to the side of the jar. The chloride ions are then in an aqueous state within the solution. The aluminium ions will eventually form a colloid of aluminium hydroxide, settling to the base of the jar. The reaction will also complete, once all the available chloride ions have been forced into solution by the reaction.

I generally leave the reaction to take place in a warm area. The reaction proceeds quicker at higher temperatures. The reaction is finished when the aluminium hydroxide colloid can be seen and/or the aluminium foil is completely oxidised and no more gases are being produced. For large specimens, the treatment may need to be repeated. Generally I leave the specimens for around 2 to 4 hours (depending on their size) for the reaction to complete. The specimen can then be removed from the solution and rinsed well with distilled water. The discarded solution will then contain the aqueous chloride ions. The specimen being also rinsed off thoroughly of the reaction solution. I have then left treated specimens to air dry. If left too long in solution, an iridescent coating may be seen on cut faces of the meteorite. This is the formation of the mineral limonite (basically iron hydroxide). If this occurs, the sample can be quickly polished or rubbed with a cloth and the coating removed.

As stated earlier, this method was used on the JAH 055 meteorite, as well as a number of unclassified NWA chondrites slices, and on the large Campo Del Cielo. The NWA slices were identified as being most likely L5 and H5. One particular H5 slice showed liquid droplets on arrival and after polishing. It showed no more droplets after the treatment, despite being encouraged to do so by being stored in a humid area.

The JAH 055 sample was treated particularly harshly after its galvanic treatment. It was placed in a sealed bag with a few mls of water to create a humid environment. The sample was then left in a warm place for around a day. Upon examination using a hand lens, a few small droplets of ferric chloride could be seen on the cut face. As such, the galvanic treatment was again applied to this meteorite. After this second treatment, no further ferric chloride has been seen, despite repeated humidity.

The large Campo Del Cielo was expected to require more than one treatment. This was especially the case as it had previously been coated in oil. Most oil had been cleaned away with Acetone, but some oil, which had obviously penetrated the meteorite, did float to the surface during the treatment. As such, I expected that the treatment may not have reached all needed areas. The treatment was therefore repeated two weeks later, when some fine “weeping” droplets started to appear on the meteorite. Though no further weeping has occurred to this, or any other meteorite treated, it is expected that due to its large size, the Campo Del Cielo may need another treatment in the future.

Discussion

This method may not be cure as such for chloride decaying meteorite samples, but may help reduce the affects of the reaction. I assume that larger specimens may be required to undergo more than one galvanic treatment to stabilise them, as it may take a few treatments to penetrate the interiors. This may be because some meteorites have had long terrestrial lives and the mineral akaganeite may be present deep inside them. Also, some longer term monitoring of the meteorites will be required to determine if and how many future treatments will be required.

This method would also be suitable to other iron meteorites and most likely pallasites and mesosiderites as well. However, I would express caution when applying it to pallasites, as the hot water may cause differential expansion of the iron lattice and loosen the olivine. I would also not recommend it for carbonaceous chondrites (though rarely affected anyway). I would like to test the method myself one day on these other types of meteorites, but as yet have no access to the suitable meteorite material. However I have tested it to success on other meteorites in the LL, L and H ranges.

If air-drying is not satisfactory, I find that acetone is a very good drying agent, and use it frequently for irons. However, I have not used acetone for ordinary chondrites, preferring to air dry them. Acetone is available from hardware shops, but is extremely flammable and should be used with care. It will also remove organic compounds, and as such never used on meteorites such as Murchison carbonaceous chondrites.

Summary

In summary, the galvanic method using aluminium foil, hot water and sodium carbonate, is a useful and cheap way of reducing the affect of chloride decay on ordinary chondrites and irons (and most likely other types of meteorite). The long-term results of the galvanic treatment are still being observed, but it is expected that if not cured, some specimens may require further treatments.

Post Script, Further Observations

Recent rainfall and the increased humidity during the rainy weather was another test of the method. This rainy weather occurring over one month since the specimens were first treated using the galvanic method. It was interesting to note that during this weather, only two of my specimens had “weeping” symptoms. These two specimens had not undergone the galvanic treatment. All specimens that had undergone the galvanic treatment, including the previously most seriously affect JAH 055, showed no signs of corrosion or weeping.

No further reactions have been seen on any treated chondrite specimens. Observations continue on the larger Campo Del Cielo iron, but at this stage look very promising, with no further weeping having been noticed.

Other Sites of Interest

In preparation for this short article, I have mentioned a number of sites. I have included them in this section, as well as some other links related to this topic.

Cambridge Encyclopedia of Meteorites, O. Richard Norton. An excellent reference book, that describes all types of meteorites, parent bodies and impact structures. It is a must have for any collector.

Crystal Encounters, www.crystalencounters.com.au . A source of meteorites for those wishing to purchase and also they have provided a number of specimens that are displayed at Bathurst Observatory.

www.meteoritemarket.com Operated by Eric Twelker, another great place, not only to purchase a huge range of meteorites, but has a number of pages to help in education about meteorites.

Bathurst Observatory, www.bathurstobservatory.com.au . Bathurst Observatory is a public tourist observatory where visitors can learn more about space by looking through the telescope and viewing the display of meteorites and many other objects in the visitor centre.

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