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Cleaning Minerals: practical and ethical considerations

Key words: mineral, conservation, clean, ethics, development

Abstract

Mineral specimens have a dual nature, both as a scientific resource and an aesthetic pleasure. Combine this with a long history of sampling for study, and the developed nature of most specimens on the commercial market, and it is difficult to relate to the ethical principles of conservation when cleaning minerals.

Introduction

There is a vast amount of information available in published journals and online regarding mineral “cleaning” but little regarding the ethical considerations necessary for undertaking this work. Both supergene and associated minerals are considered sacrificial by many collectors and dealers, as they develop their specimens to enhance aesthetic value at the expense of scientific truth. Within the museum environment the term “cleaning” is used for a completely different concept: removing particulate contaminants and other alien matter accumulated during periods of storage or display. This article explores the ethics and practical aspects that must be considered when cleaning minerals within a museum collection.

Ethical Considerations

The conservator must strive for a balance between protection and access, between preservation for future use and use now, between the needs of science and the other interests of people (Pye 2009, 136). Conservators use ethics to aid these decisions. The guiding principles include reversibility, minimal intervention, discernible alteration, stakeholder consultation, scientific approach and authenticity. When these are applied within the context of cleaning, problems immediately become apparent: cleaning is not reversible, even if the soiling is retained separately; minimal intervention is inherently obscure and, when undefined, unhelpful: minimal intervention to achieve different goals requires different levels of intervention. There is a difference between the minimum amount of intervention required to stabilise a mineral and to make it pristine, and the latter is a matter of individual taste and expectations. Discernible alteration is also problematic when applied to cleaning, should a small area be left dirty so there is a contrast for the observer? Documentation of chemicals and techniques, and digital images of the object before and after treatment, can largely solve the ethical questions of cleaning.

Stakeholder consultation poses less of a problem for minerals than for ethnographic artefacts, as long as curators, conservators and exhibition designers are in agreement. A scientific approach is easy to comprehend: understanding the chemistry of the specimen, and the cleaning products, and testing all treatments before proceeding. The most confusing ethical principle, when considering cleaning, is that of authenticity.

Authenticity incorporates physical, conceptual, aesthetic and historical aspects of an object. Physical authenticity demands that the original state of the object should be preserved, which is impossible if any deterioration has occurred, and also leads to complex arguments about true authentic states differing at different points in time: Muñoz Viñas (2009a, 35) proposes that earlier conditions are memories or hypothetical states, which no longer exist. The only authentic state of an object is its current condition. All attempts to recover an “authentic” state are therefore preferences, not reality. Muñoz Viñas (2009a, 36) maintains that conservation cannot make an object more, or even less authentic. This would mean that any action would result in the object’s new true state, nullifying the concept of authenticity.

Since minerals are not man-made, conceptual authenticity (religious and cultural meanings, or artist’s intent) does not usually require consideration, but the remaining two forms of authenticity are both relevant and often in conflict with each other: aesthetic authenticity requires that the object be returned to its original appearance, whilst historical authenticity demands preservation of all stages of an object’s history, including dirt and damage. To repair an object returns it to its original aesthetic state but destroys its history and physical truth (with the addition of new chemicals). If the repair is not obvious then it restores aesthetic authenticity but does not fulfil the principle of discernible alteration; if a repair is readily discernible then it has not restored aesthetic

authenticity. Cleaning destroys, at least part of, the historical authenticity of an object, but restores aesthetic authenticity and can also improve other values: a clean object is easier to interpret, easier to study, less likely to contaminate other objects and has higher aesthetic value. The attitude to secondary minerals here is unclear, should they be considered part of the specimen and its history or is it ethical to remove them because they are not strictly part of the original assemblage? Moreover, species resulting from supergene influences are often altered forms of the original minerals. Can there be a concept of aesthetic integrity, and does this refer to the authentic appearance of the mineral before or after secondary minerals are formed?

“Every conceivable conservation treatment has negative effects...whenever an object is treated, some of its original features are altered, some portions of the object’s history are obliterated, and some information conveyed by the object is hidden or lost.” (Muñoz Viñas 2009b, 52)

When deciding to clean a mineral, the history of the soiling should be considered, and the gain in aesthetic or scientific value achieved by cleaning, must be weighed against the loss of other attributes. The specimen must then be recorded through a condition report and digital images. Once these have been completed the nature of the object and the nature of the soiling should be established, both chemically and physically. For example, self-limiting tarnishes such as those sometimes observed on stibnite (Howie 1992a, 63) form a protective layer that should not be removed, whilst dull or brown tarnish on pyrite can be considered a passivating film (Howie 1992b, 76).

A cleaning treatment must be able to remove the unwanted material without causing short or long-term damage to the primary mineral or any accessory minerals that are present. A conservator must first check that the mineral is not soluble in, or sensitive to, the chemicals in question. The method posing least risk to the assemblage should always be tried first and, when a treatment has been decided upon, a small, unobtrusive area of low scientific value should be test-cleaned first. The potential removal of lacquers and old repairs should also be considered. Common associations must also be noted, such as stilbite and pyrite, in case this has any bearing on potential risk from the treatment. Damage to any labels attached to the specimen must also be considered. Once the treatment has been completed, a record must be created of the technique, date and chemicals used. This will allow the long-term stability of the specimen to be monitored, will aid future conservators when deciding which treatments can be repeated (and which should be avoided) and will enable future researchers to understand why certain chemicals are present on, or absent from, the specimen.

Preparation

There are many internet forums for mineral collectors that consider the removal of unattractive mineral species from an assemblage to be “cleaning”. Online recommendations include oxalic acid, hydrochloric acid, household vinegar, household ammonia, ultrasonic baths, sandblasting, Rust-Out, water gun, brine, air scribe, brass brush, and dental picks. This “development” of assemblages equates to a loss in scientific value, and is a contentious subject (Davidson 1942), it can also cause instability in the remaining assemblage (King 1982, 42). Brunton *et al.* (1985, C3) view the removal of secondary weathering products as unethical, but do not feel the same about cutting rock specimens to create slides or removing the matrix from fossils. It is difficult to judge minerals in the same way as other types of museum objects when there is a long tradition of destructive processing of specimens for scientific research. Price (1992, 7) believes that, as long as it is done carefully, and fully documented, mineral development may be allowable if at least some of the associated mineral remains. This would require some type of resin or wax barrier if the preparation technique includes immersion. Kile and Wilson (1997) believe that minerals have a dual nature: scientific and aesthetic, but are disposed against both enhancing a specimen to a state better than it has ever been and also treatments that may make future scientific analysis unreliable. An understanding of the chemistry and relative solubility of each mineral species is essential, and conservators must beware of intermediates between end members of a mineral series.

Strictly following conservation principles, only handling greases, particulate contaminants and deteriorated resins should be removed, but the true value of a specimen may sometimes only be revealed through more extreme measures. This should always be considered carefully and on an individual basis.

Dry Cleaning

The potential damage caused by particulate contaminants should not be underestimated. Aesthetic considerations are not the only motive for dry cleaning: dust can be surprisingly damaging. Particulate pollution can contain abrasive grit, carbon particles, oil droplets, skin, vegetable matter, textile fragments, bacteria, mould spores and myriad chemical compounds. These can cause abrasion, changes in colour and lustre, can retain moisture on the object's surface and accelerate the spread of fire, attract insect pests, be acidic or contain salts and metallic catalysts (Hatchfield 2005, 34). Dust can also obscure early signs of deterioration, such as cracks, colour changes and efflorescence.

There are many options for dry cleaning and the physical properties of a mineral should be considered when making a choice. Very delicate, acicular and villiform crystals should only be cleaned using an air puffer. Compressed air should only be used on more robust specimens with extreme caution, especially when the mineral is highly cleaved. Larger particles may be carefully fished out using vacuum tweezers or a small piece of Groomstick on the end of a cocktail stick. For more physically robust crystals a soft mop style brush may be used, with a museum vacuum cleaner on a low setting to suck up particles. A piece of muslin can be fixed over the nozzle of the vacuum cleaner to catch any mineral particles that may be dislodged.

Excellent results have recently been achieved at the Natural History Museum (London, UK) using latex-free cosmetic sponge (Fig. 1). For complex specimens, slits can be incised into the sponge to allow it to follow the topography more closely (Fig. 2). Cosmetic sponge is very soft and will not abrade the mineral surface or leave behind chemical residues. It will not drag on the surface like Groomstick or crumble like smoke sponge. It will pick up more particulate contaminants than a brush would dislodge, and it also has the advantage of not generating dust.

An absence of chemicals means no risk of contamination, no potentially damaging residues, no chemical alteration of the specimen or accessory minerals, and no risk of removing old repairs or coatings. Dry cleaning should always be attempted before any chemicals are introduced.

Laser Cleaning

Lasers have become extremely popular in building and sculpture conservation (Alves and Sanjurjo-Sánchez 2015), and excellent results have been achieved at the NHM on soot-blackened specimens (Personal Communication, L.Cornish, NHM, 2016). They are highly directional and monochromatic so, once a suitable wavelength and fluence (energy density) has been chosen, they can be easily controlled. Another advantage of laser cleaning is that it can remove materials of different chemical composition simultaneously (Samolik *et al.* 2015). The selection of the correct wavelength, pulse length and fluence, however, is a matter of trial and error, and the investigation of chemical and microscopic physical change is essential (Grammatikakis *et al.* 2015).

Laser ablation exploits the fact that dark-coloured material absorbs light energy preferentially whilst light-coloured material is more likely to reflect light energy. The dark-coloured matter is heated and expands, detaching from the light-coloured substrate (Cooper and Larson 1996, 29). Infrared (1064 nm) is less likely to be absorbed by light-coloured material than green (532 nm) and ultra-violet (355 nm) light so the former is generally considered less likely to cause unwanted damage. For example 355 nm and 532 nm wavelengths can cause colour changes and pitting on gypsum, whereas 1064 nm does not (Grammatikakis *et al.* 2015; Samolik *et al.* 2015). At low fluence, the predominant mechanism is rapid thermal expansion of dirt layers, causing them to be ejected from the surface of the substrate. At higher fluence, plasma formation occurs and a shock wave causes the dirt to detach from the specimen (Cooper and Larson 1996, 32). The latter is far less selective and more likely to cause damage to the substrate. Laser ablation should only be attempted when the fluence removal threshold of the unwanted material is far below the damage threshold of the substrate (Grammatikakis *et al.* 2015) and is only successful if there is minimal penetration of dark material to be removed (Samolik *et al.* 2015).

Baude (2014) found infrared laser to be effective in removing black weathering crusts from marble and gypsum, and that no damage was caused to the substrate, concluding that, in this case, laser cleaning is self-limiting. The theory that dark material can be removed from pale-coloured material in a self-limiting reaction becomes problematic when the inhomogeneity of minerals is considered: Grossi *et al.* (2007) discovered that laser cleaning caused colour loss in pink potassium feldspars due to the alteration of iron minerals that were present in very fine cracks. Iron compounds are very sensitive to infrared radiation, which causes a reduction in red hue. Lasers can also create micro-fractures in quartz and cause biotite to melt (Grossi *et al.* 2007). Samolik *et al.* (2015) discovered an adverse reaction and colour change in TiO₂ when cleaning paint. This has implications for minerals such as brookite and rutile, and also illustrates the necessity of testing the effects of the laser thoroughly before using it to clean minerals.

The presence of moisture can improve the performance of laser ablation due to the explosion of the water vapour (Grammatikakis *et al.* 2015), but this presents similar risks to cracked, porous or strongly cleaved minerals as immersion in an ultrasonic bath, and in any case should not be attempted with water-sensitive specimens. In addition, laser cleaning should never be attempted on light or temperature-sensitive minerals.

Laser ablation can be an excellent method for cleaning, but it is an extremely complex treatment with many variables. If attempted on an unsuitable mineral, it can cause melting, surface microcracks (leading to a change in lustre and opacity), light and temperature damage. Laser cleaning should not be attempted without careful planning, testing and a consideration of both the mineral and the nature of the soiling.

Water

Inappropriate relative humidity is the largest cause of deterioration within mineral collections. High humidity can cause deliquescence, phase transitions, deformation, hygrostatic stress and mechanical failure (Waller 1992). In addition, many corrosion and oxidation reactions require the presence of water (Howie 1992a, 57). Waller (1992, 36-39) lists mineral species known to undergo humidity-related phase transitions, but estimates that the stability range of hundreds of minerals is unknown. Brunton *et al.* (1985) list groups that are vulnerable to damage when washed in water. Specimens may also be structurally unsuitable for cleaning with liquid: minerals with a strong cleavage may allow permeation, causing weakness and changes in opacity or colour (King 1992). With so much risk of damage from high humidity, the use of water as a cleaning agent should not be taken lightly. Moisture-sensitive specimens cannot be wet cleaned and then quickly dried in an oven because the warm minerals may absorb atmospheric moisture as they cool (Howie 1992b, 82). Elevated temperatures can also cause expansion damage, melting and colour changes, whilst rapid changes in temperature can be catastrophic for sensitive minerals (Pearl 1973, 68-69). Although not water soluble (Hamilton *et al.* 1974, 18), sulphur is so sensitive to temperature changes, that immersion in water, or indeed any liquid, that could have a different temperature to ambient room temperature, poses too high a risk (Wilson and Currier 2001, 337). Cleaning in an ultrasonic bath should never be attempted on well-cleaved, cracked or porous minerals (King 1982, 44), regardless of their chemical attributes, due to the damage caused by the generation and rapid expansion of bubbles. The nature and pH of water should also be considered before use: very weak acids affect carbonates but deionised water, purified of the ions that could adversely react with a specimen, can sometimes be acidic, and must be tested before use.

Chemical Cleaning

Online recommendations, sometimes bizarre and hazardous, include soap and water, milk, alcohol, ether, dry-cleaning compounds, nitric acid, hydrochloric acid, a mixture of vinegar and cigar ashes made into a paste, bleach, oxalic acid and cyanide. The health risks associated with these chemicals must always be considered (Brannock 1970). Recommended commercial cleaners should be approached with caution, even chemicals used within other conservation disciplines should be tested before use: products used to clean corrosion from metalwork, for example, are likely to contain phosphoric or citric acid and, whereas these might be safe to use on quartz, for example, they would cause severe damage to minerals such as aragonite or calcite. Some of these products are available in gel form, which allows a localised and more controlled application as opposed to complete immersion. Care should be taken however when rinsing away the gels, since the water could push

chemicals further inside the specimen. King (1992, 131) and Hansen (1984) recommend that a sodium salts solution developed by Waller (1980) should be used instead of acids to remove iron oxide films on silicates, but not on calcium or magnesium minerals. King (1982) warns of some of the side effects of accepted development treatments, for example a sodium citrate/glycerine/chalk poultice (commonly used to remove iron oxides) will etch calcite, whilst oxalic acid can produce a calcium oxalate residue and hydrochloric acid may cause ferric chloride to precipitate. The potential hazard posed by a mineral must also be considered before handling, cleaning and development (Freedman 2012), for example acid should never be used on arsenic minerals due to the risk of arsine liberation (Museum's North Natural History Panel 1996).

At the NHM objects on open display and in handling collections usually develop a thick layer of "visitor grease". This is first removed using wooden picks (as long as they are softer than the minerals themselves) and then a mixture of equal proportions of Stoddard solvent and de-ionised water (with up to 2% non-ionic detergent) is applied locally before rinsing with water, a treatment also recommended by the Victoria and Albert Museum (V&A 2016). If solvents are applied locally, and removed immediately using swabs, the risk of long-term damage is significantly reduced compared with immersion techniques.

Pearl (1973) provides an extensive amount of anecdotal but nevertheless extremely useful information and, even though written over fifty years ago, the recommendations are invaluable. The work is organised by cleaning technique, rather than by mineral, so careful study of the text is required. Some practices are outdated, such as rubbing pyrite oxidation with a bactericide and using proprietary radiator cleaner to remove oxides, but it is the warnings that can help curators and conservators the most. For example brown calcite geodes with a thin film of stilpnosiderite cannot be cleaned with liquids because their iridescence will be destroyed, whilst mica will delaminate in a liquid (Pearl 1973, 25; 28). Although this work should be considered in the light of modern principles of conservation, this sort of information is essential to reduce the potential for future damage, and it at least tells us what not to do. Wilson and Currier (2001, 338) detail an example where a black oxide was removed from prehnite with acidified hydrogen peroxide, but the minerals that had been removed turned out to be an extremely pure todorokite and far more important than the prehnite itself. Prior to chemical cleaning, a thorough investigation into the mineral assemblage is essential. King (1983) outlines the most common development techniques for different types of minerals, and this forms a useful reference for divining what may have already occurred to a specimen or assemblage. This is useful not only for academic analysis, but also when determining the cause of deterioration and assessing what techniques or chemicals should be used now without triggering an unexpected adverse reaction.

Conclusion

There is a great deal of advice to be found online and in published journals (although there is a paucity of recent published material) regarding the cleaning of minerals. Much of it is excellent, because it is based on many years of trial and error, but conservators should be extremely cautious. What is sometimes termed cleaning is in fact destruction of associated minerals, and therefore leads to a loss of scientific data. Many specimens will have already been prepared in this way before they enter a museum, and there is nothing that we can do to reverse these treatments. Our job is to ensure the long-term preservation of collections whilst also allowing access to researchers and the public. If cleaning a mineral is desirable for study or display then the ethics must be taken into account, the physical and chemical properties of the specimen, including all associated minerals must be investigated and the method that poses the least risk should be selected. The condition of the specimen prior to treatment must be recorded in detail (including colour digital images) and a treatment proposal agreed upon, before any work is undertaken. A record of all techniques and chemicals used must also be maintained.

Objects chosen for display must almost be viewed as sacrificial and anticipate suffering loss, since inappropriate humidity, inappropriate temperature, light and gaseous pollution will cause many minerals to deteriorate (Brill 1980, 223; King 1985; Saunders and Kirby 2004, 63). Modern conservation theory stresses balance and common sense - whereas the risk of a treatment must be considered and each mineral specimen evaluated on an individual basis, their aesthetic value as objects for exhibition cannot be ignored.

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Figure 1. Amethyst specimen after cleaning using a cosmetic sponge (in the foreground). Natural History Museum specimen; Lu Allington-Jones photo.

Figure 2. The finer topography of this stibnite is more effectively cleaned using a small scarified piece of cosmetic sponge. Natural History Museum specimen; Lu Allington-Jones photo.