CONSERVATION TALK

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Why Sandstone Monuments Have So Many Problems

Whether in the Carolinas, Utah or Massachusetts many sandstone are in very poor condition. Why? And perhaps even more importantly, what can be done?

Sandstone is a sedimentary rock, meaning that minerals or organic particles have settled in layers and the layers have gradually formed into rock. They often (but not always) have distinct bedding planes—or layers. Geologists generally divided sedimentary rocks into three categories and most of what we see in cemeteries may be classified as "clastic." These are formed by the accumulation of mechanically distintegrated rocks that are cemented together.

Sandstones are composed of quartz, feldspar, silicates, mica, hornblende, and clay minerals that are cemented with either siliceous or carbonate/calcite cement (see Table 1). It is largely these cementing materials that affect the longevity of one sandstone over another. Sandstones containing silica are quite hard, strong and decay resistant, whereas those containing calcite resemble limestone in their susceptibility to acid damage. Those containing clay absorb water and deteriorate more easily. Thus, weathering of sandstone depends on its porosity and permeability, generally determined by the presence of minerals, clays, and cementing materials.

Table 1.
Types of Sandstone and Predominant Binder Material

Sandstone Type	Binder Material
Ferruginous	Iron oxides
Calcareous	Calcite
Argillaceous	Clay
Silicaceous	Silica
Dolomitic	Dolomite (Gypsum)
Micaceous	Mica

Different authors have devised a range of different terminology to describe the deterioration that occurs to sandstone. Recently ICOMOS-ISCS produced the Illustrated Glossary on Stone Deterioration Patterns, describing cracks, detachments, material loss, discoloration, and biological colonization. The decay specific to sandstone includes exfoliation, blistering, cracking, and detachment, although some authors use the terms scaling and erosion for some of the problems. While a standard terminology is always useful, what we really want to know is what causes these problems—right?

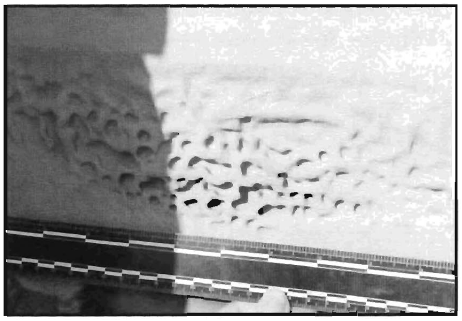
Like many of the problems seen by conservators, the biggest cause is the effect of moisture, brought on by capillary action, humidity and even a monument's environment and micro-climate. Sources not related to moisture include solar and UV radiation, as well as structural issues—although I don't believe any of these are as important as moisture. Contributing to the problems caused by moisture are salts and air pollution.

So let's look at a few of the more common problems. Keep in mind that relatively little conservation research has been conducted concerning these problems, so there remains much debate—and few simple answers.

Air pollution can cause what are known as pollution crusts—often hard and brittle, leaving the stone beneath soft, friable, and disaggregating. They may also be known as carbon deposits. Found in urban settings they are formed from pollution products, including calcareous material (from the stone or mortar), sulfur and carbon. Treatment has included different cleaning efforts. Chemical cleaners are generally more effective than water washing, although the use of various hydrofluoric acid-based cleaning, alkali-based cleaning, and combinations present problems of their own. Sand-blasting or other aggressive cleaning will pit sandstone and encourage its re-soiling more rapidly.

Pollution Crust.

Alveolar erosion is often seen on sandstone, especially on larger monuments. It is characterized by the formation of smooth, hemispherical depressions in the stone that join together to form a honeycomb-like appearance. This deterioration is thought to be associated with pockets of salt that weather into pockets (or alveoles). Most conservators believe it is associated with areas with wind turbulence that can accelerate drying and salt crystallization, as well as promote wind erosion of the stone. Treatment is difficult since there has been relatively little study of the problem—although it can be common in some locations. Most conservators infill the alveoles with a repair mortar to eliminate the depressions and improve water and wind flow.



Alveolar Erosion.

Soluble salts may also cause **blistering**. This problem is evidenced by rounded blisters forming on the top of the stone. The blisters are hollow, frequently break and expose friable stone below. Associated with what is known as contour scaling, these may reveal locations of salt concentrations. Generally it is best to leave these blisters alone for as long as possible to maintain the historic fabric. Eventually it may be necessary to remove salts through brushing and poltices. Some conservators also remove the friable stone to solid material and infill the areas of loss.

Blistering.

Contour scaling is a specific decay pattern similar to blistering and delamination, but it follows the surface contours of the stone, rather that the bedding planes. The material spalling off may range in thickness from a few millimeters to as much as several centimeters (as seen in the example). Conservators hold different opinions as to the cause. At one time it was thought that the scaling was related to the limits of moisture penetration (and thus salt transportation). Today, the generally held belief is that gypsum from either mortar or other atmospheric sources forms in the outer layer change the mechanical behavior of the stone. Consequently, the spalling is associated with mechanical stress and fatigue. Treatment usually involves desalination using poltices, removal of friable stone, an injection grout to stabilize edges,and finally infilling to stabilize the stone.

Contour Scaling.

Delamination, also known as exfoliation, consists of the stone separating along its bedding planes (whether those planes are visible or not). The split sections can be thin, affecting the stone only near the surface, or they can be several centimeters thick. This is often one of the most problems observed in sandstone. Its cause is associated with weakening of the bedding planes. The ones lost may be more permeable or may contain more soluble material. These problems allow more water access into some parts of the stone than others. Delamination may be aggravated by setting stones so their beds are exposed to water penetration. Treatment depends on the extent of damage and whether the bedding plans are accessible. If they are, treatments include the use of injection grout to reattach loose material and seal the cracks to prevent additional water penetration. Where edges cannot be accessed, it becomes necessary to drill holes to facilitate injection of the grout. Some conservators have also used acrylic resins, although they tend to swell in moist settings. Damage may be so extensive that there is little option but to remove

Delamination.

the loose material (which will likely be eventually lost) and patch the surface to replicate the original profile and match the cleaned color.

Efflorescence is visible soluble salt crystallization on the surface of the stone. It may be loose, powdery and white or it may crystallize internally and be hidden from view. Salts may come from herbicides (such as Round-Up), fertilizers, de-icers used on nearby sidewalks or roads, or even from Portland cement repairs. Salts are associated with many of the problems already discussed, including delmination and blistering. Treatment includes first identifying the source of the salt (and moisture that carries the salt) and resolving those problems. The stone must also have salts removed using poltices or other desalination techniques.

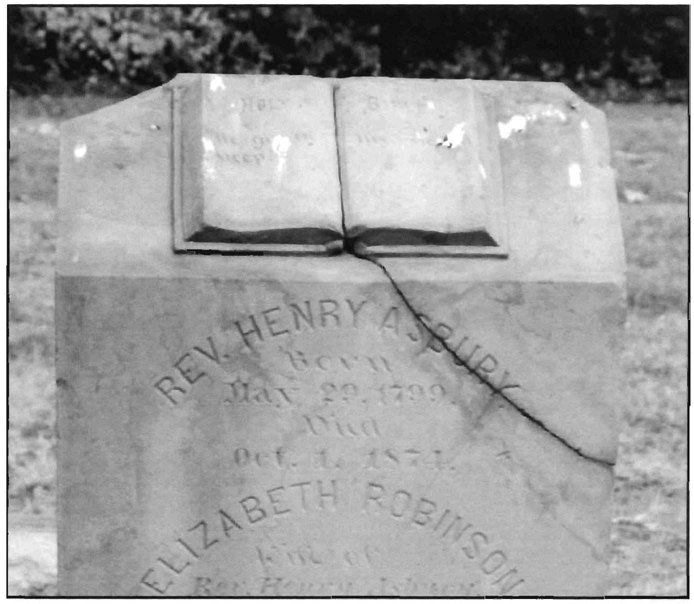
Efflorescence.

A special type of efflorescence problem, combined with severe stone loss, appears in the next photograph. Water carrying soluble salts is wicked into the stone from the ground through capillary action. Eventually the water cannot rise further, evaporation takes over and the salts are

Severe efflorescence with stone loss.

deposited. The stone begins disintegrating and the problem is often exacerbated by splash back of rain to erode the stone surface. Ultimately the stone will fail.

The final problem we'll talk about is **cracking**. Macro-cracks may result from natural flaws in the stone, errors during quarrying, rust-jacking or structural causes. While micro-cracks may be caused by fluctuations in wetting and drying and seem inconsequential, they likely indicate more serious problems to follow and consideration should be given to treating them with injection grout. Macro-cracks, on the other hand, may indicate more serious structural issues, especially if they occur in a structure such as a mausoleum. Simply pointing such cracks may overlook more critical problems associated with settlement,



Macro-crack.

subsidence or loading changes. Bonding large cracks can be problematical, but an effort should be made to seal out water that will cause additional problems.

So, to return to the title of this article, "why do sandstone monuments have so many problems," the answer involves the geology and chemistry of the stone, the presence of water and pollutants and often the lack of adequate—or appropriate—conservation intervention.

A final word dealing with consolidation is perhaps worthwhile. The discipline is divided over the appropriateness of consolidation for a variety of reasons. We should understand that consolidation is not curative. It treats symptoms, not the underlying problems. Yes, consolidants may reduce water uptake and they may even help the stone resist atmospheric pollutants, but they won't resolve the critical issue of salts. ♦