MESILLA VALLEY PRESERVATION, INC.

P.O. Box 1780 • Mesilla, New Mexico 88046 • Phone: 575.526.1230
E-Mail: mvpres@gmail.com Web: mvpres.org

Remediating Salt Attack in Adobe

Authors: Mesilla Valley Preservation, Inc (MVP): Eric Liefeld, David Rockstraw, PhD, P.E, and Gregg Henry; with Pat Taylor of Pat Taylor, Inc.

Abstract:

Adobe and earthen structures are strongly affected by salt attack. Driven by prevailing soil alkalinity and evaporation from aridity, crystalizing salts can exert significant forces, literally undermining and destroying adobe structures in the process. MVP's first Salt Attack paper (EarthUSA 2013: "Understanding, Detecting, Measuring, and Remediating Salt Attack in Adobe and Earthen Structures") explained the basics of salt attack and presented preliminary information on detecting and visualizing salts. This paper further details our processes and focuses on effective remediation involving permeable earthen and lime plasters.

When salts attack

Salt attack (or salt weathering) is a naturally occurring process. Though salt attack is a particular concern in adobe, newer masonry construction is likewise vulnerable through time, even when constructed of concrete, stone, or brick. Misunderstanding salt attack over the last 100 years has lead to ill-informed remediation attempts, often with disastrous unintended consequences for historic earthen buildings.

Much remediation in adobe has been focused on moisture. While water is certainly a part of the process, moisture alone doesn't begin to account for the damage seen in affected structures. Instead, the salt cycle (Figure 1) involves an intricate interaction between moisture and salts:

- Ground moisture dissolves naturally occurring salts in alkaline soils.
- Capillary action draws salt-laden moisture upward through wall bases, where it evaporates on the surface of the wall, typically just above ground level.
- Crystalizing salts form on the surface (efflorescence) or with microscopic pores of the adobe (sub-florescence).
- As sub-florescing crystals outgrow the surrounding pore structure, they exert enormous crystallization pressures on pore walls (e.g., Sodium Chloride has a crystallization pressure of 56 MPa, or 8,122 pounds per square inch!).
- As the substrate gives way, salt crystals fall to the wall base where they dissolve and increase the salt concentration, driving a viscous cycle.

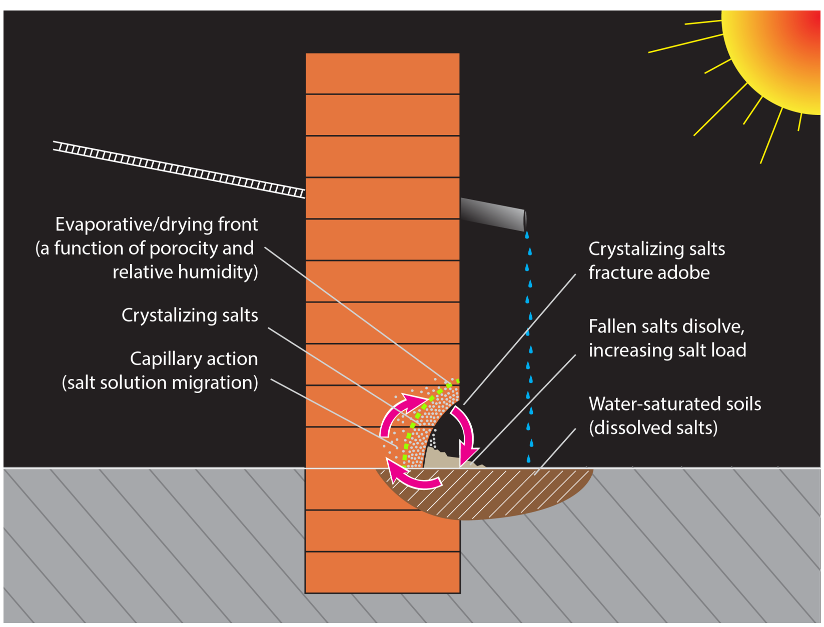

Figure 1. Evaporation drives the salt attack cycle.

Complicating matters, salts are alts are constantly on the move:

- Salts are hygroscopic (water attracting) and will attract moisture from surrounding soils, or from out of the air.
- Salts are deliquescent, and will dissolve themselves in the water they attract.
- Salts can literally migrate through soils and structures, carried by capillary action, crystallization, and dissolution.

Ironically, these same properties enable effective remediation in salt-affected adobe structures.

Accurately measuring salts in the field

Understanding whether or not adobe damage is related to salts is essential in order to select appropriate preservation treatments. If salts are involved, it is likewise critical to be able to ascertain relative salt concentrations and the depth of salt loads in adobe walls. MVP has been working for several years to develop inexpensive tools that allow the identification and measurement of salt loads in the field. This work has recently been greatly assisted by a generous grant from the National Center for Preservation Technology and Training (NCPTT). Our innovations include:

- **Sample collection**. Our specially designed tool allows samples to be extracted at arbitrary intervals (1-inch was used for our testing) from a roughly ½-inch diameter core (Figure 2). The tool fits into a conventional cordless drill for ease of use in the field. After each sample is taken, the hole is carefully vacuumed with a special attachment to avoid cross contamination of the samples.
- **Calibration and sample processing.** To measure salinity, a small amount of adobe material from each sample is mixed with water and the conductivity of the resulting slurry is measured using a properly selected conductivity probe. The probe is first calibrated against known concentrations of aqueous sodium chloride solutions, permitting the calculation of an equivalent sodium chloride to adobe mass ratio for each sample. Equivalent salt concentrations are plotted against linear position into the wall, yielding a direct measure of the salt concentration gradient across the wall.

Figure 2. Core samples are taken at one-inch increments using a specially designed coring tool, with care to avoid sample cross-contamination.

The importance of permeable sacrificial renders

By its nature, water will always seek the path of least resistance, and evaporation will happen where water contacts air, usually in an area of greater permeability. While capillary action draws water upwards through microscopic pore structures, it is the destructive power of salt crystallization through evaporation that causes the damage in salt attack. In most cases, the moisture is not coming from the wall surface, but from beneath the wall foundation itself. As a result, efforts to "seal" the wall's surface are counter-productive and likely to have more negative effects. Only recognizing how salts travel and crystalize can result in effective remediation.

Ramifications of concrete, cement, elastomeric, and other treatments

People are used to worrying about moisture with adobe and earthen structures, and it is only natural that they have tended toward less permeable renders and treatments. For over 100 years people have unsuccessfully applied less permeable concrete and cement in the form of sidewalks, concrete collars, and cement plasters in a misinformed attempt to deal with the effects of salt attack. In the last few decades, elastomeric coatings have emerged as a heavily marketed solution. Some buildings in the Mesilla Valley have had these products applied quite frequently due to continual repeated failures, resulting in considerable expense and frustration. Unfortunately, not only do these products not solve the problem, they often exacerbate the situation by forcing moisture (and, therefore, evaporation and salt crystalization) into the softer and more permeable adobe material. If people are ultimately successful in sealing the exterior wall surface, moisture and salts will simply seek the path of least resistance and migrate to interior wall surfaces, where damage is less desirable still, and more costly to repair.

Migrating salt loads out of load-bearing structure with permeable renders

In contrast to concrete, cement, elastomeric, and other approaches, permeable renders and other sacrificial elements provide a unique opportunity to actually migrate salts out of load bearing structure. Both mud plasters and lime plasters constitute suitable sacrificial renders that provide similar permeability to the adobe wall itself.

Perhaps the most important aspect of these materials is that they allow the evaporation plane (or drying front) to move outward toward the surface of the wall. As moisture evaporates at or near the surface of the plaster, salt loads are literally migrated out of the load-bearing structure. MVP's salt attack toolkit has verified this ability to migrate salts as described in the sections that follow.

Identifying, evaluating, and remediating salt attack in the field

To evaluate the usefulness of MVP's approach to measuring salt attack, measurements were taken at several ongoing adobe preservation projects, as described in the sections that follow.

Case Study #1: San Albino Basilica Diocese building

Likely dating to at least the 1890s, the adobe building currently housing the San Albino Basilica Dioceses had suffered severe salt attack, and had concrete collars, concrete sidewalks, and cement plaster applied in past years. Pat Taylor, Inc. initiated removal of the concrete sidewalk, concrete collar, and conducted basal wall stabilization. It was assumed that salts would return, and a sacrificial adobe collar was installed along with a tinted lime plaster in 2013 (Figure 2). Due to budget constraints, cement plaster was left on the building above a height of three feet, with a painted wooden drip edge installed.

By 2015, the remediated wall was showing considerable cosmetic staining, and MVP was asked to help determine the nature of the stains. Salt testing easily verified that only the lower stains represented salt concentrations, with the upper stains simply resulting from oxidized paint from the wooden drip edge (Figure 3). This determination greatly simplified plans for future maintenance. The exponential nature of the salt concentration gradients demonstrates that the majority of the salts have indeed concentrated at the outer surface of the wall, as desired. With the largest salt concentrations now located in the outer inch of mud and lime plaster, they can be precisely targeted and surgically removed from the wall. Doing so dramatically lowers salt loads and effectively sets the clock back for the building, dramatically reducing the chances that salts will affect the building in the future.

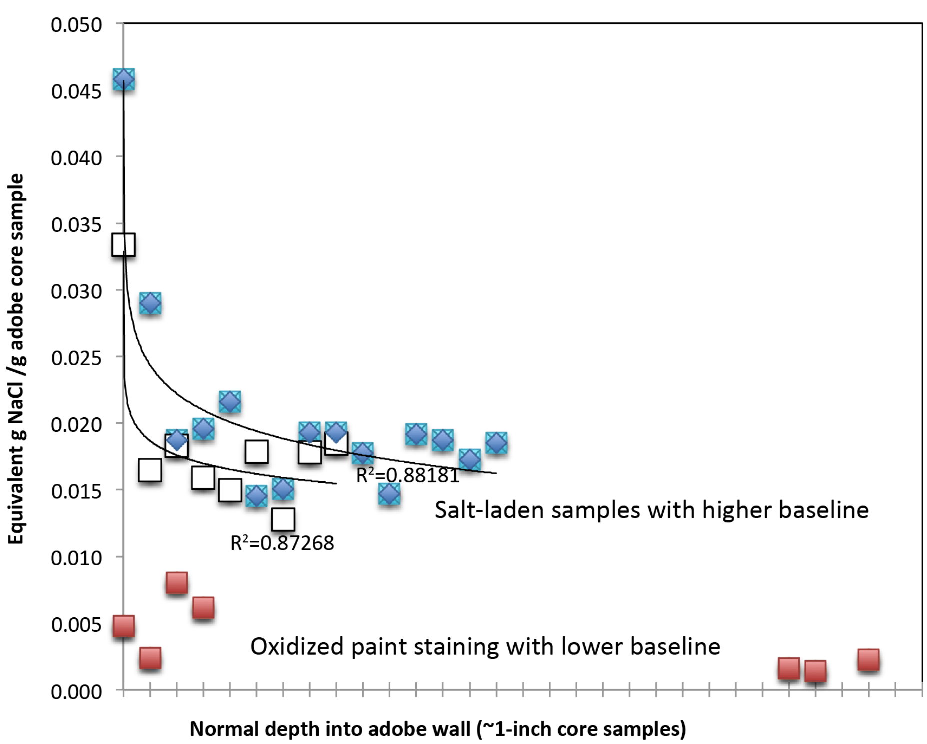

Figure 3. MVP's testing validated that upper stains were paint run-off, not salts, and verified that salts in other areas had migrated to the outer surface of the wall.

Case Study #2: The Nestor Armijo House

At the beginning of recent rehabilitation, the 1866 Nestor Armijo House was showing significant salt damage. In the past, it too had been subjected to concrete patching, concrete sidewalks, concrete collars, cement plasters, and elastomeric coatings. Unfortunately, these earlier remediation attempts only succeeded at sealing the outer wall surface to the point where moisture and salts were driven to the interior wall surfaces—even through three-foot thick adobe walls.

Salt testing was performed under the stairwell, where was significant focused damage. For instance, an 8-12 inch deep pile of powered/coved adobe had accumulated on the floor next to the coved wall. MVP's tools were used to take initial core samples all the way through the 36-inch adobe wall. The results confirmed a strong exponential salt gradient toward the interior surface of the wall (see "Interior and exterior before" core samples, Figure 4). At that time, concentrations toward the exterior were at baseline levels. This situation is precisely the opposite of what would naturally occur, and what would be desirable.

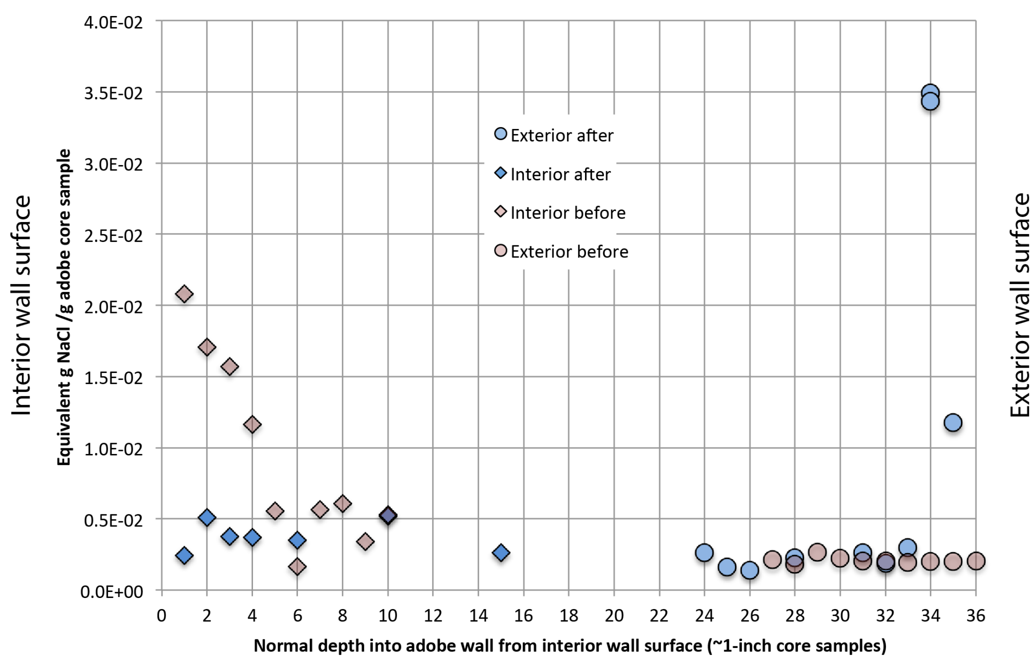

Figure 4. The salt gradient was reversed toward the outside wall surface through careful basal wall stabilization and application of a permeable lime render.

After manual removal of loose material, Pat Taylor, Inc. performed basal wall stabilization, building the wall out to its previous plane. The majority of this work was performed on the interior wall surface where the damage was worst. A protective sacrificial coat of lime plaster was applied to both the interior and exterior surfaces of the wall. After a period of time, salt testing was repeated to ascertain the level of remaining salts. As shown in Figure 4, not only had the previous exponential salt gradient toward the interior been eliminated, it had actually been reversed, with the highest concentration of salts appearing in the first inch of exterior plaster. Though there are not yet any visible signs of salt damage, the evidence indicates that salts are being migrated out of load-bearing structure.

Conclusion

Salt attack is a natural process, created by alkaline soils, aridity, and time. The ability of MVP's tools and methodology to precisely measure salt loads allows new visibility and insights. Salts can now be directly located and targeted for removal, either by mechanical means through effective basal wall stabilization, or by migrating them out of load-bearing structure using appropriate permeable sacrificial treatments. Removing the bulk of salts from effected walls—together with mitigating the situations that brought salt-laden moisture there in the first place—allows contractors and preservationists to effectively set back the clock and buy valuable time for valuable historic earthen structures.