

Investigating Fire Suppression Impacts on Cultural Resources
Lessons Learned from the Long Mesa Fire of 2002
Mesa Verde National Park

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Introduction

This brief report synthesizes the impacts and effects of fire retardant usage on historic and prehistoric surfaces and materials during the Long Mesa Fire of 2002. It is a result of investigation, research and field observations undertaken in response to fire suppression activities, which started on July 29, 2002. The suppression efforts succeeded in avoiding disastrous losses to historical buildings and structures within the Park, but they also left a number of cultural resources heavily impacted by the use of fire retardant. Up to this point, information regarding such impacts to historic fabric has been scarce to non-existent. This synopsis will illuminate key areas were related to these impacts.

The Resources

Mesa Verde National Park is known world-wide for its remarkable archeological resources. These resources were considered significant enough for the entire Park to be designated as a World Heritage Site by UNESCO in 1978. Hundreds of alcove sites and thousands of surface sites provide pristine examples of the ancestral puebloan architecture of the Colorado Plateau region. Constructed primarily of sandstone, mud mortar, and wood, these structures are important repositories of archeological and historical information.

In addition to archeological resources, the Park also provides stewardship over five Historic Districts, one of which was designated as a National Historic Landmark in 1987. These districts all lay within close proximity to one another, and are located on Chapin Mesa. Four of the five Historic Districts were impacted in some way by the fire and/or fire retardant use. Impacts included the complete loss of two historic buildings to fire; retardant impacts to 23 historic structures; and, smoke, ash and soot damage to the interiors of 55 buildings.

One of the hardest hit areas by retardant was the Headquarters Area, which is a National Historic Landmark District. The buildings in this district are stylistically defined as 'Modified Pueblo Revival'. This style is characterized by its rough cut sandstone masonry, large peeled fir logs, hand hewn doors and lintels, pierced tin lighting fixtures, and decorative finish work. The style was developed in the 1920's by Jesse Nussbaum, one of the early superintendents of Mesa Verde National Park. This unique architectural style has become synonymous with the Park's identity.

The other area that was hit hard by retardant use was the CCC built historic 'white house' loop, or residential cabin loop. Rustic in design, they incorporate wood and stone into a well crafted housing design that is also a significant part of the park's identity.

The Historic Fabric:

The architecture of the park has several materials that are commonly used in most of the historic and prehistoric construction. These materials are:

Sandstone: The masonry structures at Mesa Verde National Park are constructed of several types of sandstone, which include Dakota Sandstone, Point Lookout sandstone, Upper Cliff House sandstone and Lower Cliff House sandstone. The surface rock capping much of the Mesa Verde, and the most common type of building block throughout the Park is the marine Late Cretaceous Cliff House Sandstone. This sandstone is a very porous, soft sandstone. Its permeability makes it particularly vulnerable to weathering and surface conditions. The sandstone is typically cemented with calcium carbonate and locally with some fine clay. The sand grains are mainly quartz with some occasional grains of feldspar, hornblende, iron oxide, and other minor constituents.

Mud Mortar: Both prehistoric and historic buildings within Mesa Verde incorporate the use of indigenous mud mortar as a cementitious bond in the masonry coursing. In prehistoric sites this is obviously the most prevalent mortar, although portland based cements have been used extensively in past stabilization work. In the historic stone structures, mud mortar can surprisingly still be found in the more sheltered aspects of the architecture, such as in courtyards, portals, and overhanging eaves. As expected, mud based mortars are very fragile and vulnerable to weather and climactic conditions.

Metal: Historic structures at Mesa Verde incorporate the use a variety of metals. The primary metals of historical value in use on the exterior of the buildings are the pressed tin light fixtures and historic door and window hardware found within the Administrative Area Historic Landmark District. These fixtures date to the 1920s-1930s.

Wood: Wood is used extensively throughout the historical districts and in the prehistoric alcove architecture. At MEVE, our cultural resources contain a mixture of both natural and painted wood surfaces. Within the archeological sites, various species used include juniper, cottonwood, pine, fir and spruce. In the historic districts, you will also commonly find fir and spruce vigas, posts, lintels and sills. The natural wood finishes face the most serious risks since their pore structure can be penetrated by retardant. These are found primarily in our prehistoric structures. Our Historic structures typically have painted wood surfaces, but some natural wood finishes do exist. Untreated wood is at risk from both slurry based and gel retardants.

Retardants used during the Long Mesa Fire

Firetrol LCA-R (slurry)

By far, the most extensively used fire retardant during the Long Mesa Fire was Firetrol LCA-R slurry mixture. Applied aerially by tankers, air base flight records show that over 106,000 gallons of this mixture was dropped over the Chapin Mesa area on July 29th. It is estimated that nearly all of that slurry was dropped on or near the developed areas. Several historic buildings and structures were heavily coated, and at least 23 were at least moderately impacted, including the north end of Spruce Tree House. Ingredients as listed on the Manufacturers Safety Data Sheet (MSDS) for Firetrol LCA-R are as follows:

- Mono Ammonium Phosphate
- Ammonium Sulfate
- Iron Oxide Coloring Agent
- Clay Thickener
- Sodium Ferro cyanide

The ingredients that are of most concern to us are the phosphates, iron oxides, and clay. It should also be noted that overall the entire mixture is slightly acidic, which can cause dissolution of calcium carbonate, the essential binder in sandstone. It can also facilitate corrosion in metals, particularly zinc and magnesium based metals. The phosphates in this mixture are essentially salts, which can cause serious problems when they enter the capillary area of sandstone. Iron oxides are harmless chemically, but will create permanent staining on both sandstone and wood surfaces when left untreated. The red staining is the most immediate and noticeable effect after the application of slurry. The clay thickener will quickly harden, and it can ultimately restrict the ability of water to evaporate from inside stone.

Barricade Gel (polymer)

The other retardant that was used on historic fabric is the gel based retardant 'Barricade' gel. This retardant is a water based mixture applied directly to the surfaces of threatened buildings. The mixture is a liquid concentrate of absorbent polymers (potassium polyacrylate) that essentially 'traps' water within its cell structure thereby providing a liquid shield to surfaces that may be impacted by fire. This polymer is a highly absorbent chemical, and once dried proved difficult to remove.

Retardant Risks and Impacts to Historic Fabric:

The risks from the application of these retardants to historic fabric arise from both chemical and mechanical factors. They can be noticed immediately or years after the initial application. The dangers from these retardants involve:

Salts:

The phosphates and sulfates used in the LCA-R slurry mixture contain salts. Salts have a destructive effect on sandstone when they enter into the stone's capillary structure. Salts that go into solution (from precipitation, for example) can easily penetrate into these capillary spaces. The salts then dry and crystallize, expanding upon drying. This

expansion breaks down the internal capillary structure, which ultimately damages the overall strength and integrity of the stone. If continued, it essentially ‘powderizes’ the sandstone over time. This process is called ‘efflorescence’, and over a period of time can completely undermine the strength of the structure. Another potential hazard of salts is their effect on prehistoric and historic woods. At this time, not enough observational data has been collected to determine these effects.

Corrosion:

As noted above, the chemical composition of the slurry is slightly acidic. This will cause corrosion in metals, particularly those that are magnesium and zinc based. In fact, corrosion was such a problem within the applicator machinery that Firetrol added a corrosion inhibitor – sodium Ferro cyanide. As an inhibitor, cyanide has been effective when in solution, yet this chemical creates potential problems in the natural environment when it changes from a ‘bound’ form to an ‘amenable’ form. Obviously, its use has been the topic of heated controversy. As of this writing, the US Forest service was banning the use of Ferro cyanide on National Forest lands.

Encapsulation

Staining:

The iron oxides used in the slurry mix for coloring will stain historic surfaces, often permanently. With sandstone and unpainted wood, the oxides can penetrate into the pore structure of the material, creating a very hard and impermeable coating and a sort of ‘mechanical’ bond within the pore. Water alone will NOT wash off slurry from a sandstone or natural wood surface, and it is a fallacy to believe that slurry will just ‘wash off’ a building naturally. What does occur is that the hardened slurry eventually flakes off, usually with portions of the sandstone underneath. The removal of this dried slurry proved to be very difficult at Mesa Verde, requiring the use of a surfactant (borax) to loosen the coating enough for it to be gently brushed away with a light stream of water. The danger from cleaning slurry off sandstone is due to the invasive nature of the cleaning and brushing process. It is highly possible that the work may remove parts of the protective exterior ‘patina’, ultimately doing more harm than good. Bottom line - removing slurry from sandstone is an invasive and tedious process that may do more harm than good. It is a hard and impermeable coating when dry, and will require the use of a surfactant to loosen. Deciding what to do with slurried historic fabric is a difficult call to make, and should be evaluated on a case by case basis before beginning any type of cleaning process. Painted surfaces proved to be quite a bit easier to clean, since the enamel in the paint forms a fairly protective coating. If the slurry does not enter the wood pores, it is very likely that it can be removed with a mild soap and water solution. We were able to remove almost all of the slurry from the (painted) historic white houses within a couple of weeks of the fire. The sandstone foundations of these same houses proved to be more difficult. It is always better to begin the removal of the slurry as soon as possible after application, to prevent any permanent staining.

Encapsulation:

Another long term impact from the use of slurry has to do with the clay that is used as a thickener within the slurry mix. This clay creates a hard, almost impermeable barrier

around the coated stone when it dries. As mentioned earlier, this coating actually creates a mechanical bond within the exterior pores of the stone, making it very difficult to remove. This coating can vary in thickness, and will stay on the stone for years. Samples of slurried sandstone from earlier fire events were collected and sent to a geologist for thin section analysis. The analysis showed that the coating was still very much in place after almost 7 years. With enough thickness, this clay coating can prevent the normal transpiration of water from the stone, trapping moisture inside. Combined with freeze-thaw cycles, this can have a serious adverse effect on the surfaces. Pitting and spalling were clearly evident on these samples, indicating that these processes were impacting the stone.

Desiccation:

The application of absorbent polymer gels (Barricade Gel) on historic fabric has also been observed to impact historic fabric. The polymer used in this retardant is hyper absorbent, and when applied to wood surfaces, will pull moisture from the wood. They essentially act as a powerful desiccant on the wood finish. Observations noted just a few months after the fire showed peeling of wood varnish, and a 'drying out' of the surface that was evident from cracking and splitting. These peeling finishes were common on unpainted wood. On sandstone surfaces, the polymer was also observed peeling away the top surface layer when drying. A secondary hazard was also noted from the use of Barricade gel - the danger from slipping. Even after drying, Barricade will rehydrate when water is applied.

Cleaning Procedures

Following the fire, I initiated an assessment of the impacted structures on Chapin Mesa. This assessment involved building to building inspections as well as multiple consultations with various specialists, including Firetrol chemist Dr. Robert Crouch and Firetrol representative Lynn Biddison. The Colorado State Historical Preservation Office (SHPO) was also involved in this consultation. Based upon my assessment and the information I received in consultation with these specialists, I made the recommendation to immediately begin the cleaning of all affected buildings and structures. However, the method and materials used for the cleaning still required development and testing. Calls to NPS regional offices turned up no precedent for what we were about to initiate. To develop a cleaning procedure, I enlisted the help of Rebecca Carr, a conservator who works with the Archeological Site Conservation Program (ASCP) at Mesa Verde. Together, we tested various cleaning solutions, finally settling on a 10% borax solution to be used as a surfactant. This surfactant was essential in loosening the slurry coating from the sandstone enough for light brushing and a water rinsing. The cleaning was done by the Park's Ruins Stabilization crew, enlisted to meet this critical need. For the painted surfaces in the white house loop, we contracted the services of a cleaning contractor who would use more conventional methods.

The cleaning took about 4-5 weeks to complete. Tedious borax rinsing and brushing cycles were repeated over and over on the heavily impacted slurry surfaces. A generous donation by the Dial Corporation gave us the necessary borax (20 Mule Team) we needed

to finish the priority jobs. The painted surfaces cleaned off much easier, and the Barricade Gel was removed by hand brushing and mopping from the sensitive areas.

Several things were learned during the cleaning process, the most important being NOT to use power scrubbing methods on the sensitive stone and mud mortared surfaces. This could prove more invasive and damaging to the surface than the coating itself. It really came down to simple, gentle cleaning methods on the more sensitive areas – water, borax, and a gentle water rinse. Slow, tedious, but effective.