ANANLYSIS AND TREATMENT OF THE FIRE-DAMAGED MARBLE PLAQUE FROM THOMAS JEFFERSON'S GRAVE MARKER

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Abstract

The original grave marker for Thomas Jefferson (1743-1826), third U.S. President, consists of a granite cube and obelisk, into which was set a white marble plaque inscribed with his epitaph. After damage led to replacement with a copy in the cemetery at Monticello, the original grave marker was given to the University of Missouri. Granite portions were installed in front of the university's main building, while the plaque was placed inside for safekeeping. The building burned down in 1892, and the plaque fragmented, portions disaggregated and were lost, and fire-related materials accreted on its face. Soon afterward, the plaque was reassembled atop a new marble block with hydraulic lime plaster. When examined more than a century later, the pieces were found to be misaligned, and areas on the face had deteriorated, with further loss of lettering and some instability. Instrumental analyses were done prior to conservation treatment. Stable isotope analysis sourced the stone to Vermont marble quarries. Other analytical techniques indicated that the marble had calcined and to some extent recarbonated, and they identified elemental constituents in the surface accretions deposited during the fire, including copper, tin, lead, and sulfur. Treatment included disassembly and reassembly of the plaque using Paraloid B48N, reconstruction of missing areas using a Paraloid B72/ground alabaster mixture for surface fills and a filled epoxy to support the fill material where there was a large loss, surface cleaning, and consolidation. Two reproductions were made using photogrammetry, and one was installed on original granite portions of the grave marker on the University of Missouri's David R. Francis Quadrangle.

Keywords: fire, Vermont marble, calcination, recarbonation, photogrammetry

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1. Introduction

The original grave marker for Thomas Jefferson (1743-1826), third U.S. President, was made according to his instructions and erected in 1833 in the graveyard at Monticello, his Virginia home (Peden 1953). It consists of a granite obelisk resting on a granite cube, with the epitaph carved in a white marble plaque set into the obelisk (Jefferson famously omits that he had been president in his epitaph). After the grave marker was damaged by souvenir hunters and replaced by a copy at Monticello in 1883, the original was given to the University of Missouri. Granite portions were displayed in front of Academic Hall, the university's main building, while the plaque was placed inside it for safekeeping. Academic Hall burned down in 1892, and the "sacred relic ... cracked and burned" (Peden 1953, p 13). In 2012, the university requested examination and possible treatment of the plaque by the principal author, and the following year it was sent to the Smithsonian for treatment. At that time the plaque was enclosed in the same display case and exhibited essentially the same fragments and fills as in an historic photograph from the 1890s (Fig. 1). Moreover, it was photographed on the granite structure of the tombstone in front of the ruins of the fire-damaged building, suggesting repair soon after the fire. After the display case was removed in 2013, discarded printed matter from the 1880s and 1890s was found used as shims, confirming this hypothesis.

Fig. 1: Thomas Jefferson's grave marker displaying the repaired plaque in a frame following the 1892 fire, on the grounds of the University of Missouri. Courtesy, University of Missouri Archives.

2. Examination and analyses

2.1. The marble

Marble grains on the plaque range from 0.25 to 0.6 mm; accessory feldspar and quartz are found at grain boundaries. In the absence of documents sourcing the marble, it was hypothesized that its small grain size limited possibilities to marble imported from Carrara, Italy, or quarried in Vermont. Carbon and oxygen isotopes for samples from the plaque were compared to reference isotope datasets from Carrara and quarries in the northeast U.S. (Dooley and Herz 1995) and found to best match those of Dorset, Proctor, West Rutland, or Pittsford, Vermont (Fig. 2).

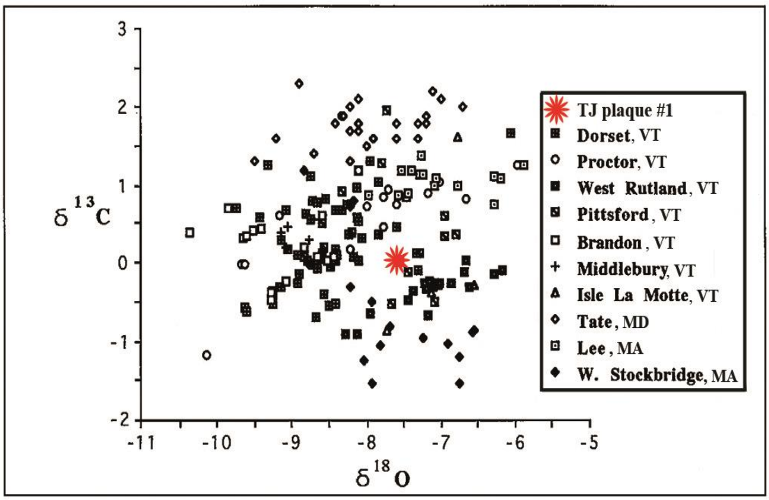

Fig. 2: The stable isotope average for TJ #1 is plotted on a graph showing averages for marble samples mainly from Vermont and Massachusetts, after Dooley and Herz (1995).

2.2. Condition of the plaque before treatment

Examination of the plaque at the Smithsonian revealed considerable fire-induced damage, including breakage into five pieces, numbered in Fig. 3. After disassembly, break edges were found to have the convex shapes characteristic of fire damage, known as conchoidal fracture (Steiger *et al.* 2014, p 227-228). Disaggregation along broken edges suggested that fragmentation occurred from simultaneous expansion and contraction of anisotropic calcite crystals, which can induce strain in marble at temperatures as low as 60^{o} C (Siegesmund and Dürrast 2014, p 149-150). The rate of transmission of heat through the 5-cm-thick block would have been highest at corners, consistent with detachment of the small triangular pieces designated 1 and 4, as well as the formation of oblique cracks across the lower left corner visible in Fig. 4. Losses can also be readily seen in Fig. 4 because of the irregular surfaces of fills that replaced them. They are significant along broken edges, particularly at the left edge, where as much as 3 cm of the plaque is missing (apart from small areas at top and bottom corners) and may indicate the direction of the fire. Adjacent to this loss, a layer about 1-cm thick is missing on the back face, suggesting that the plaque may have been in a wooden case that burned in the fire. The plaque is slightly convex on the back, probably from residual expansion caused by greater exposure to the fire; concomitantly, it is slightly concave on the front. Front surfaces at the left and bottom are partially calcined, distinguishable by whitening (Fig. 3). Expansion of these areas can be felt where they intersect sound stone. Partially delaminated areas with voids below were also found to have expanded, preventing readhesion; during treatment, the voids were filled instead. Since the historic photograph was taken in the 1890s, lettering has been lost at the left edge, visible as bright areas, e.g., where the first letter of "AMERICAN" is missing.

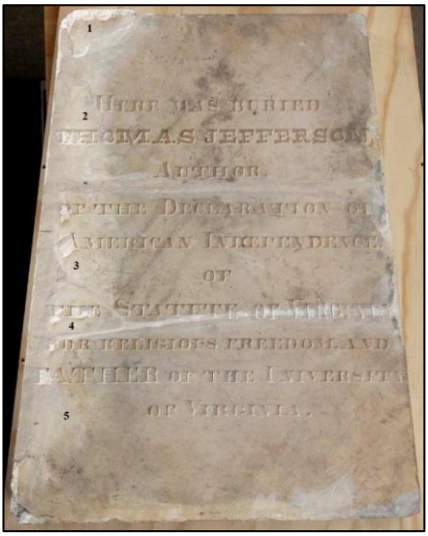

Fig. 3: The tombstone plaque before treatment; fragments are numbered at left. Height = 74cm. Photo by Don Hurlbert

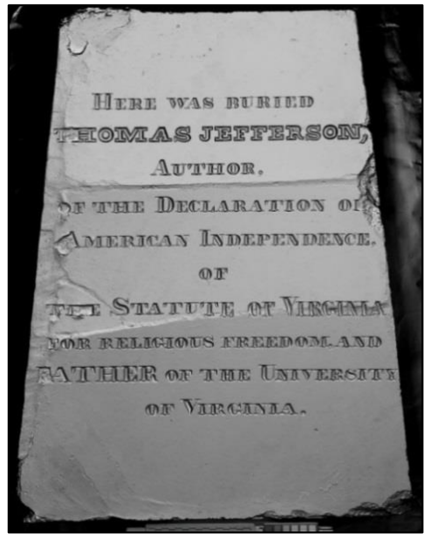

Fig. 4: RTIViewer screenshot in the specular enhancement mode shows surface irregularity of the plaque before treatment. Photo by E. Keats Webb

2.3. Deterioration of the marble

Decomposition of calcite ($CaCO_3$), or calcination, occurs at temperatures above 700°C; carbon dioxide (CO_2) evolves, leaving calcium oxide (CaO) behind. The CaO can subsequently recarbonate in air to form poorly cohesive calcite. The calcined upper part of a marble sample from the plaque appears chalky white to the naked eye (Fig. 5), and a thin section shows that the marble's granular texture there has been replaced with an opaque material (Fig. 6), which is very fine. Micro-X-ray diffraction analysis of samples from such areas found both calcite and calcium hydroxide [$Ca(OH)_2$], and preliminary thermogravime-tric analysis (TGA) indicates about 95% calcite and 5% $Ca(OH)_2$. In the intermediate zone between calcined marble and smoke-darkened marble grains below (Fig. 7), hyperspectral energy dispersive analysis using the SEM indicated that rims of grains had calcined and recarbonated. Below this zone, smoke-darkened marble retains its structure but is disaggregating (Fig. 5 and Fig. 6), presuma-bly because of the heat-induced residual stresses in calcite grains.

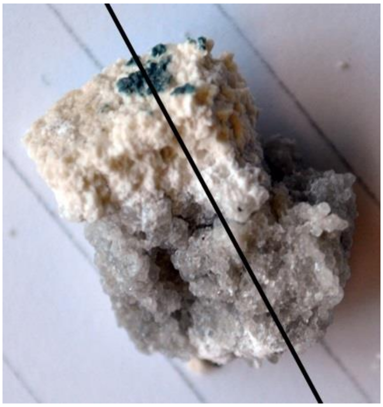

Fig. 5: Damaged sample from the plaque. The calcined surface is opaque and white, with a dark blue spot on top; below, smoke-darkened marble grains are disaggregating. The black line marks the plane of the thin section in the next image.

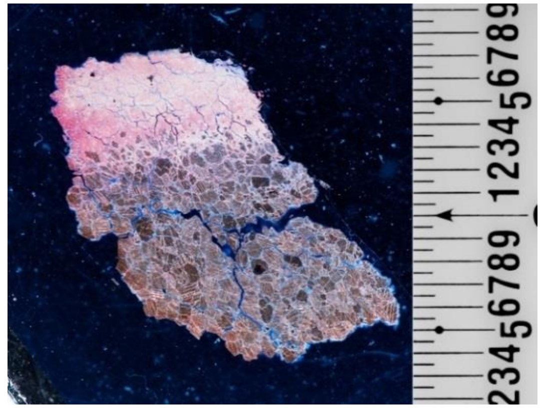

Fig. 6: Thin section made from the previous sample in darkfield illumination, with mm scale at right; stained red for calcite. The calcined upper surface has lost its marble texture, while grains and cleavage planes can still be seen in the smoke-damaged disaggregating marble below. The partially calcined zone in between is shown at higher magnification in the following figure.

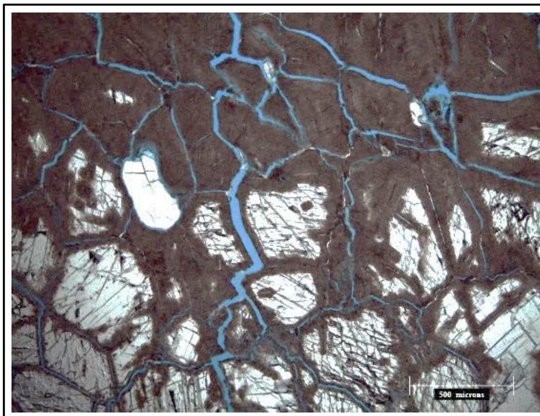

Fig. 7: An area in the intermediate zone of the previous thin section, at higher magnification in plain polarized light. Completely calcined marble (above) is dark. Calcite grains (below) are bright, except where calcined at rims and at cleavage planes. The brightest particle at center left is quartz. Blue epoxy medium can be seen in cracks, which to some extent follow grain boundaries. Bar = 500µm.

2.4. Surface accretions

A light cleaning using a surfactant and water revealed several materials disfiguring the front surface of the plaque. Constituents were analysed to determine which should be removed, and cleaning tests were done to determine removal feasibi-lity. Micro-scanning X-ray fluores-cence (XRF) analysis using a Bruker AXS Artax proved valuable for suggesting extraneous materials related to the fire by identifying elements in them compared to adjacent stone. Dark veins appeared to follow a diagonal pattern across the plaque from upper right to lower left (Fig. 3) but were sometimes difficult to dif-ferentiate from surfaces soiled by smoke. Scanning XRF confirmed locations of veins by finding silicon and potassium in them, consistent with quartz and feld-spars. No elements, other than calcium, were found in areas that appeared more likely to be darkened by smoke. This finding does not rule out the presence of carbon deposited from smoke, however, since this element is

not detectable by the XRF instrument. Cleaning tests found reduction but not elimination of soiling from smoke, apparently because smoke had penetrated the disaggregating stone. Disfiguring black spots and streaks of a type seen in Fig. 8 were found to contain copper, tin, lead, and sulfur as the main elements, confirmed by SEM EDS; they are probably metal sulfides derived from plumbing or other building materials burned in the fire. Microscopic examination of these accretions indicated that they were so intimately mixed with the stone that they could not be removed mechanically or by laser ablation without damaging the stone. Scanning XRF identified mainly sulfur and calcium in dark blue spots atop calcined areas (Fig. 5) but also small amounts of lead, confirmed by X-ray micro-analysis of a dark blue spot on both the thin section (Fig. 6) and a second fragment; this result suggests that lead sulphide may have provided the blue color. A sticky material on the surface of the plaque was analysed by Fourier transform infrared spectroscopy (FTIR) and found to have a spectrum similar to parchment. This would be consistent with application of a material such as animal glue during the 1890s restoration and its removal with an aqueous solution during the 2013 treatment.

Fig. 8: Copper, tin, lead, and sulfur were the main elements found in the black spot using scanning XRF and SEM EDS analyses. Bar = 0.5 mm.

3. Treatment of the plaque

Treatment included disassembly and reassembly of the plaque, reconstruction of missing areas, surface cleaning, and consolidation. During the restoration after the fire, the five fragments had been reassembled on a nearly 3-cm-thick marble block with hydraulic lime plaster, also used to fill losses. Individual fragments were not in the same plane, the composite was heavy, and fills were deteriorating and unattractive. It was decided to remove the original fragments from the newer marble support block, which would reduce the weight significantly, allow for improved reassembly, and provide an opportunity for replacing deteriorating fills. Disassembly was time consuming but more easily done than expected. The plaster was found to be poorly adhered to both the original and new marble, and it was often cracked, allowing relatively easy separation near edges. Toward the center, the plaster was sawn through to separate the original and new marble blocks.

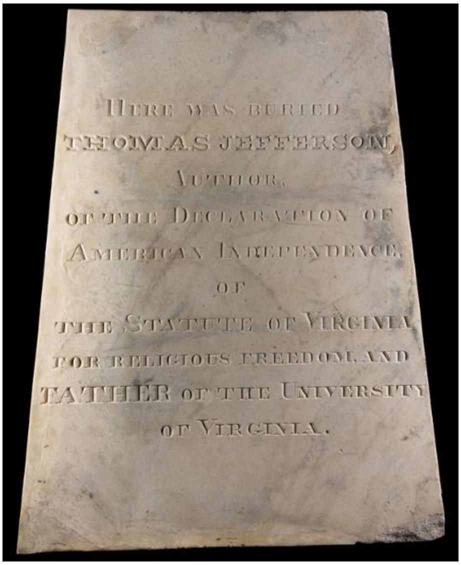

Fig. 9: Plaque front after treatment. Lighting is even; hence, lighter areas at left and bottom reflect calcination. Photo by Brittany Hance.

Fig. 10 Back of plaque after treatment. At the right, a structural fill completes the edge; next to it is an area missing a cm-thick layer of stone. In the light-colored central area, a thick layer on the surface has been calcined but remains. At the left, the marble is smoke damaged but more or less intact. Photo by Brittany Hance.

Fragments were separated from each other mechanically, and old fill material was removed. The five pieces were reassembled using the acrylic resin Paraloid B48N dissolved in acetone as adhesive. Small compromises had to be made in joining fragments, attributed to distortion by the fire. Reattachment of detached surfaces and consolidation of weakened stone was done with a second acrylic resin, Paraloid B72 in acetone. Fills were also made with that resin heavily bulked with alabaster ground to pass a sieve with 500 µm openings (Wolfe 2009). On the front, fills were made smooth and level with the stone (Fig. 9), but on the back they were recessed slightly and textured (Fig. 10). To begin recreation of the missing area on the left edge, a structural fill was made on the back using filled epoxy putty (Aves' Fixit) isolated from the stone with the acrylic fill material; the latter was also used to complete the left edge and cover the filled epoxy.

The front surface of the plaque was initially cleaned using mineral spirits, acetone, and an aqueous solution with a surfactant. Areas in good condition were further cleaned with methyl cellulose poultices; to prevent detachment of calcite grains, the poultices were bulked with silica and calcium carbonate powders and removed before dryness. Cleaning was limited on calcined areas at left and bottom edges because of their fragility. Treatment was completed with retouching of fills using watercolor and gouache paints to match the stone on the front (Fig. 9). Fills on the back were left lighter in color than the stone (Fig. 10).

Staff at the Smithsonian's Office of Exhibits Central made two replicas of the plaque using photogrammetry. Digital photographs of the conserved tombstone were taken, and files were manipulated using Autodesk's Recap (freeware) and Geomagic. From those results, a copy was milled in hard foam using a CNC (computer numerical control) machining center. After the copy was touched up, a silicone rubber mold was made. One copy was cast in glass fiber-reinforced gypsum (GFRC) for exterior display and a second in fiberglass. The replicas were painted with acrylic paints to imitate the plaque when it was new and coated with a flat automotive polyurethane paint for protection.

The conserved plaque was returned to the University of Missouri, where it is now displayed in a case indoors. The GFRC copy is displayed outdoors on the original granite portions of the tombstone, forming a "complete" grave marker for the first time in many years.

4. Conclusions

The study and treatment of the tombstone plaque is a rare contribution to the literature on burned marble artifacts. In addition, a sacred relic has been preserved representing the thoughts of a U.S. President as to his important contributions: the Declaration of Independence, the Virginia statute for religious freedom, and founding of the University of Virginia – but not his role as president.

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