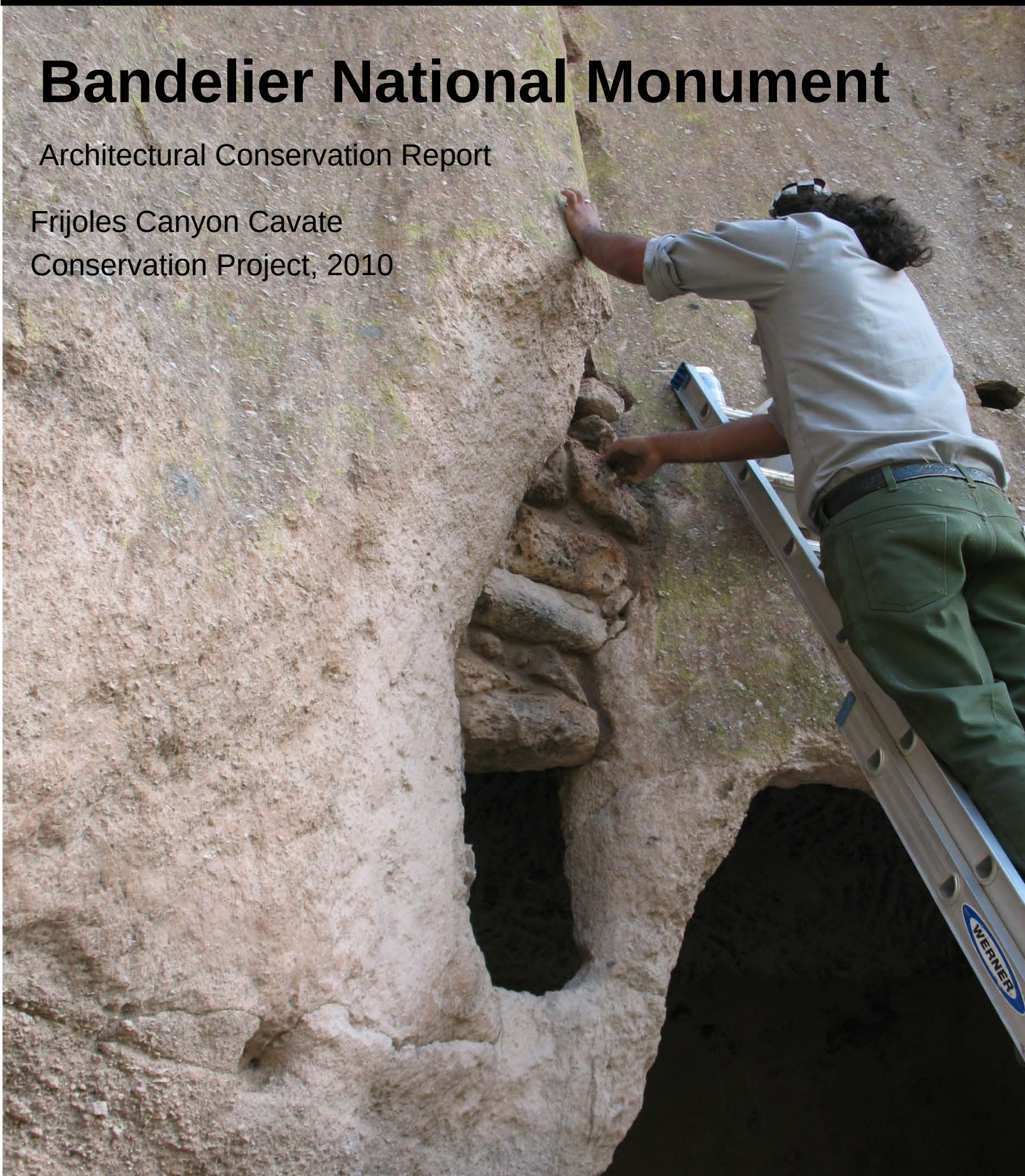
National Park Service

U.S. Department of the Interior

Bandelier National Monument

Architectural Conservation Report

Frijoles Canyon Cavate
Conservation Project, 2010



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Bandelier National Monument
New Mexico

Vanishing Treasures Program
Bandelier National Monument
Los Alamos, New Mexico
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In 2000, the Vanishing Treasures Program (VT) at Bandelier National Monument (BAND) began a project aimed at documenting and conserving the unique archaeological architecture known as cavates (cliff dwellings) in the park. This project is ongoing and its principal aim is to develop appropriate methods to identify, document, conserve, and maintain the cavates as both constructed and natural heritage. Additionally, through Native American consultation and planning, the project aims to create a culturally adaptive management strategy that addresses the physical conservation of the cavates in their constantly changing landscape. Between 2000 and 2008, approximately 1055 cavates in Frijoles Canyon were documented and assessed, and ninety-six cavates were treated through masonry stabilization, drainage control through the installation of silicone drip lines, tuff consolidation and infilling, and graffiti mitigation.

The 2010 field season focused on documentation and stabilization of High and Medium priority cavates in Frijoles Canyon and worked toward a complete photo archive of the Frijoles Canyon Cavates. In addition to field work performed by VT staff, research and cooperative support was provided by three CESU agreements which had fieldwork components active during FY10.

Frijoles Canyon Cavate Conservation Project 2010

Frijoles Canyon Cavate Pueblo Conservation Project Summary

Stephen Merkel and Angelyn Bass Rivera

The Frijoles Canyon Cavate Conservation Project began in 1999 with the principal aim of developing appropriate methods to identify, document, conserve, and maintain the cavates as both constructed and natural heritage. Additionally through Native American consultation and planning, the project aims to create a culturally adaptive management strategy that addresses the physical conservation of the cavates and their landscape, while acknowledging and responding to federal policies and affiliated groups' past identities and present day needs, expectations, and beliefs (Matero, 1998).

There are thousands of cave dwellings, called cavates, in the Jemez Mountains of northern New Mexico. Cavates are chambers that were hand-carved into the volcanic tuff cliffs. Cavate pueblos are groups of cavates and masonry structures clustered as villages. The cavates in Bandelier National Monument were occupied from the fourteenth to the sixteenth century C.E., and were the ancestral dwellings of Native Pueblo people. Modern Pueblo people acknowledge the cavates as an integral part of the landscape to which they are strongly and deeply connected.

There are approximately 1,100 cavates concentrated on the north side of Frijoles Canyon, along a mile and a half stretch where the canyon widens before descending to the Rio Grande. This is the highest concentration of cavates in any of the canyons in the Jemez Mountains. Interior cavate spaces range from less than one cubic meter to over sixty-nine cubic meters. Cavates were often rear rooms to the now-collapsed multi-story masonry buildings constructed against the cliff face. Cavates were also living spaces unto themselves, with features such as smoke holes and earthen plastered floors, walls, niches, and fire pits. Natural breaks in the canyon formed by drainages or geologic unconformity separate thirteen clusters of cavates, now designated by archaeologists as Groups A-M.

Cavates are a unique form of architecture in the American Southwest. The extensive modification and use of the natural environment and geology for habitation, the high density of dwellings, and the excellent preservation of some interior architectural features is extraordinary. The cavates are also severely threatened from disintegration and loss due to the inherent instability of the volcanic tuff, erosion from water flowing over surfaces and into openings, wind-blown particle abrasion, and to the negative impact of over a century of tourism.

In 1999, the three-phase Frijoles Canyon Cavate Pueblo Conservation Project began. There are numerous components of each phase. Phase 1 (1999-2001) included designing and testing comprehensive data collection methods and protocols, and conducting archival research and preliminary material analysis of the tuff. Phase 2 (2002-2003) involved systematic data collection and analysis of architectural features and conditions, treatment type and location prioritization, and pretreatment investigations including initiation of environmental and materials analysis, additional archival research, and field testing of pilot conservation treatments. Phase 3 (2004-present) focuses on the preparation and implementation of a Conservation Plan for the Frijoles Canyon Cavate Pueblos,

including completion of baseline documentation, enhancement of documentation and photography techniques, and ongoing testing and evaluation of conservation treatments.

Activities and accomplishments of the Project (1999-2010) include:

- 1,055 cavates have been documented and assessed for archaeological significance and physical condition;
- A relational database has been created to store and query information about the cavates. Field data for all cavates have been entered into the database and analysis has been completed for Groups A, C, E and M, as well as for eighty-four high priority units;
- General digital and black and white photography has been completed for approximately 670 cavates; large format photography (4x5") has been completed in the occupational zone of the cliff face in Group D (Long House); and landscape-level photography (also large format) has been completed for the north escarpment of Frijoles Canyon within the 1.5-mile study area;
- Laser scanning has been completed for small clusters of cavates in Group M and a ten Meter long section of Long House, as well as for cavate MQ160;
- Preventive and remedial conservation treatments of the cavates and their natural environment have been field-tested in ninty-four cavates. Test treatments range from preventive measures such as water diversion, to direct intervention such as tuff consolidation, plaster reattachment and graffiti mitigation, to detailed documentation by laser scanning and large-format stereo photography.
- Archival documents, including field notes, photographs, and publications have been collected and copied from local archives;
- Detailed graphic condition assessments have been completed for eighteen high priority cavates;
- A Priority Treatment Schedule that recognizes the archaeological significance and physical condition of the cavates has been drafted. It recommends general, immediate and long-range treatments and monitoring activities for each cavate in the canyon;
- A Geographic Information System has been created for Group M cavates, and maps have been created for all cavate groups (A – M) which display the treatment priorities using GIS software (ArcMap); and
- Much of the paper and digital materials that have been produced by the project have been archived, and data related to these materials have been entered into a bibliographic database (ProCite) and a materials database (Microsoft Access) in order to facilitate location of materials and to store relevant information.

The 2010 Field Season

Stephen Merkel

The Frijoles Canyon Cavate Conservation Project continued in FY2010 which began in October 2009 and ended in September 2010. Work focused on emergency conservation and stabilization of cavates and associated masonry, photography, mapping and data management. The following list is a summary of the work accomplished in FY2010.

- Laser scanning of Cavate B 002
- A Graffiti Mitigation field school was undertaken by students of the University of New Mexico. Six cavates in Group B were treated. A report was prepared by project participants.
- A total of eleven masonry walls associated with cavates in Groups A, I and M were stabilized. Masonry walls were photographed and graphic documentation was used to document past stabilization and current stabilization.
- Drainage in RM I 026 was redirected by the addition of a lime-tuff mortar ridge on the interior of a smoke hole.
- The floor of Snake Kiva, RM E 021, was cleared of fill, mapped, and photographed. The fill was replaced afterwards. Negatively impacting vegetation was removed and drainage patterns were modified.
- A methodology for performing orthorectified photography was developed and was implemented in cavates E 021 and in M 033. The processing of these photos is underway.
- A methodology for recording cavates using 360° digital photography was developed. Photography was performed in Frijoles Canyon in cavate D 156/2A and Group F.
- The entrances of 171 cavates throughout Frijoles Canyon were photographed with identification, and the photography of Medium Priority cavates was completed.
- Gelatin and grouting treatments were tested on plasters in two cavates in Group M and one cavate in Group F, and the results of the testing were analyzed.
- Lime mortar infill treatments performed since 2003 were examined and evaluated. This treatment was implemented in ten cavates in Groups A, K, and M between the years 2003 - 2008. It was determined that this treatment should no longer be used in its current form and more research is required. The results of this evaluation are in **Appendix Q**.
- Samples of detached prehistoric and historic stabilization mortars were collected from Group M and Group I as part of a larger study to characterize mortar compositions in VT sites at Bandelier.
- The Pro-Cite database was updated and cleaned of redundant citations

Masonry Stabilization

Stephen Merkel

Introduction

Masonry stabilization was a focal point of the 2010 season. Previously stabilized and original masonry walls associated with cavates and non-cavates were evaluated and stabilized when determined to be necessary. The first phase of the project focused on the masonry in the cavate cluster around M 100, researching the excavation and stabilization history, identifying and documenting stabilization mortars, limited and careful removal of cement mortars, and the repointing with both amended and unamended earthen mortars. After this phase was completed, the masonry associated with M 123, I 010, I 022, A 060 and A 013 were researched, documented and stabilized.

Treatment history for the masonry walls near M100

The first images of this cavate group appear in 1882. The cavates and associated masonry were the subject of two watercolors painted by Matilda Coxe Stevenson.[1] The walls and cavates are realistically represented in the paintings and are a great asset in understanding the relationship of architectural features because elements of the structures are continuously being lost. The doorway to the exterior in cavate M092 is no longer recognizable as such in the 1930's. The tops of the unstabilized, unexcavated walls of the ground level masonry rooms are also documented. The earliest photo of this small section of cavates is from 1891, and several photos were taken between 1910 and 1920.

Robert Lister included two cavates in this section in his CCC-era 1940 "Stabilization of Cave Ruins" in Frijoles Canyon. He stabilized the masonry in cavates M092 and M094 by placing mortar in some of the joints where the mortar had washed away. In the case of M092, two stones were inserted at the base of the wall, requiring that some of the tuff beneath the wall be carved away so the stones could fit. The earthen mortar that was used is somewhat lighter in color and more gray-yellow than the more orange-tan prehistoric mortar and the CCC mortar contains pieces of charcoal in it, making it easily distinguishable. Pre-treatment and post-treatment photos were taken and filed with Lister's report.

This site was revisited in 1943 by Hendron, who excavated five rooms at the base of the cliff prior to stabilization of the masonry and cliff-face. In his excavation report he documents the wall conditions, the evidence of roof construction and its construction sequence. Although he attributes much of the construction to "later inhabitants" of Frijoles Canyon, it seems that he is referring to Classic period occupation differentiated from the earlier Coalition Period inhabitants of the site. He argues that historic occupation was transitory in nature, such as camping and herding activities.

After excavation, Hendron added several courses of stones to masonry to the ground-level rooms presumably to help buttress the overhanging cliff that supports the second-level enclosure walls of Cavates M092 and M094. Clear pre-treatment and post-treatment photos were taken and filed with the report indicating where modifications were made. Two types of mortar were used. Soil cement was

[1] Watercolors are held at the National Archive, see **Appendix F** for illustration

used to set stones. The weak soil cement is gray in color with distinctive quartz sand aggregate which is white to pink/red. The soil cement was pointed over with an earthen mortar with tuff sand aggregate and charcoal inclusions.

Between August 1964 and June 1965 Jim Maxon led a campaign to stabilize the masonry walls and cliff-face around M 100.[2] A number of pre and post-treatment photos exist in the Bandelier Archive. The photos show that a large amount of soil-cement (7:1) was used in the mortar joints, around wall abutments, and at the base of the second-story masonry wall of M094. A fissure in the rock in Cavate M095 was grouted with fairly pure Portland cement. The section they were trying to save has fallen since, but there is still grout adhering to the cliff-face. Treatment documentation other than photographs has not been found. Creutz, in his stabilization summary of Bandelier, states that during May and June, 1965, the excavated sections of Group M were cleaned, and the walls were stabilized with a sandstone/adobe sealer developed by the Texas Refining Corporation, but his summary says nothing about the repointing.



Figure 1: M100 Group, after treatment, 1943



Figure 2: M100 Group, before treatment, 2010

Little is known about the stabilization of the M 100 group in 1975. Only a note was found on a scrap of paper that states "9/17/75 – Group M – Stabilized, measured walls. Used 4 gallons of water. Repacked walls & cave walls, - used pictures." There is no mention of the materials used during this stabilization campaign. They may have used Portland cement as was done in 1965. In some areas it appears that an earthen material was used

[2] See **Appendix F** for photographs

over the 1965 Portland cement. This may have been an effort to disguise the cement but the date of this material has yet to be determined. In summary is unknown what type of mortar was used to stabilize the masonry in 1975.

The document from 1975 was the last mention of stabilization of the masonry around M100. Sometime between 1965 and the Bandelier Archaeological Survey (BAS) in the 1980s, a large portion of the masonry enclosure of cavate M094 collapsed. By 1964, many of the low south-facing masonry walls seen in 1943 were gone, but their foundations were still present at ground level.

Stabilization of the M100 Group

Concerns about the structural stability of the walls and over-hanging cliff-face required close inspection of the M 100 group before any work could start. The walls perpendicular to the cliff-face act as a buttress for the over-hanging ledges and second story cavate enclosure walls, and it appears that Hendron had this function in mind when he stabilized this area in 1943. Erosion and partial collapse of the over-hanging ledges caused the catastrophic failure of a large section of masonry above RMs 93 and 95. The over-hanging sections of tuff have structural cracks which appear to have worsened in the last seventy years, resulting in visible signs of stress and movement in the buttressing walls. Preston Fisher, structural engineer for the VT program, inspected the walls and the abutting cliff-face and judged stabilization of the ground-level masonry walls to be safe, so long as no chiseling or hammering to the walls occurred. Catastrophic failure of the second-level masonry is deemed inevitable; all that can be done is to slow the process by stabilizing the walls that function as buttresses.

Work began with the documentation of the masonry wall sections. Each ground level wall was photographed perpendicular to the wall-face and obliquely from the south. Graphic documentation of the condition of each wall face commenced, documenting voids, cracks, prior stabilization campaigns, and original wall fabric. The graphic documentation of pre-existing conditions is included in **Appendix G.**

For the sake of durability, mortar amended with a 25% El Rey acrylic solution was used in areas with the greatest exposure to the elements. These areas of greatest exposure have already lost integrity through past stabilization campaigns or are not original prehistoric construction. Unamended earthen mortar was used in more protected areas and areas in close proximity to original prehistoric mortar and plaster. The stabilization mortar is composed of 1:1 Garcia Tan adobe dirt to sand. Stones larger than a centimeter in diameter were removed from the mortar. Mortar was mixed on-site. Graphic documentation showing the location and type of mortar used are included in **Appendix H**. Marty Davenport, Eli Logan, Johnny Holdsworth, Karim Hassanein, Sarah Stokely and Stephen Merkel participated in the stabilization.

M 087 East Interior

The base of this wall was swept out to bedrock. The northern half of the wall was stabilized with unamended mortar and chinking stones. The stone at the base of the wall on the south end was loosened in the process, and once the cement was removed was reset in amended mortar with chinking stones.





Figure 3 & Figure 4: M 087 E Int. before and after treatment

M 091 West Interior

Loose cement at the wall/cliff abutment was removed and replaced with unamended mortar. The base of the south end of the wall was swept out. The stone at the base of the wall on the south end was loosened by the process, and once the cement was removed was reset in amended mortar with chinking stones.





Figure 5 & Figure 6: M 091 W Int. before and after treatment

M 091 East Interior

The cliff-face is receding at the lower wall/cliff abutment. This area was pointed with unamended mortar and a rodent burrow in this crack was filled. Loose cement at the base of the wall was removed and replaced with unamended mortar and chinking stones.





Figure 7 & Figure 8: M 091 E Int. before and after treatment

M093 West Interior

Loose cement was removed at the base of the wall/cliff abutment and the void was filled with chinking stones and unamended mortar. The coving at the base of the wall was also pointed with unamended mortar.





Figure 9 & Figure 10: M 093 W Int. before and after treatment

M093 East Interior

The tuff behind the cement repair at the wall/cliff abutment was heavily eroded. The loose cement was removed and the void was filled with unamended mortar. The stones at the southern edge of the wall were loose, so voids were packed with chinking stones and mortar. For this repair, amended mortar and unamended mortar was used.





Figure 11 & Figure 12: M 93 E Int. before and after treatment

M 095 West Interior

The wall is fairly stable. The stones at the southern edge of the wall were loose, so voids were packed with chinking stones and mortar. For this repair, amended mortar was used until the El Rey ran out and then unamended mortar was used. At the abutment with the cliff, a deep void was filled with unamended mortar.





Figure 13 & Figure 14: M 095 W Int. before treatment



Figure 15: M 095 W Int. after treatment

M 095 East Interior

Only the southern third of the wall was stabilized. The large void in the lower southern section of the wall was filled with amended mortar and chinking stones. The coving at the base and the lintel were repointed with amended mortar.





Figure 16 & Figure 17: M 095 E Int. before and after treatment

M 099 West Interior

On the southern half of the wall, coving was an issue and there was no mortar left under the south side of the lintel. These areas were stabilized with amended mortar. In addition to this, several cracks and voids were filled with unamended mortar on the south half of the wall. The weight of the detached section of tuff on the cliff-face seems to be pushing down and out from the cliff, causing structural cracks below the 'window' and movement of the lintel.





Figure 18 & Figure 19: M 099 W Int. before and after treatment

M 099 East Interior

Coving is an issue at the base of the wall. On the south quarter of the wall-face, amended mortar was used and unamended mortar was used to point the base of the wall and the crack where the wall abuts the cliff-face. One rodent burrow was filled with mortar.





Figure 20 & Figure 21: M 099 E Int. before and after treatment

M 102 West Interior

Cement mortar and water sitting at the base of the wall has caused substantial damage to original stone and mortar underneath. Cement mortar was removed when possible. Cement was not chiseled but pried off or "worried" out. Salt efflorescence could be seen in the mortar underlying the cement. Unamended mortar was pointed over the original prehistoric mortar at the base of the wall. Two rodent burrows were filled with mortar on the south half of the wall and a large void was filled at the north abutment.

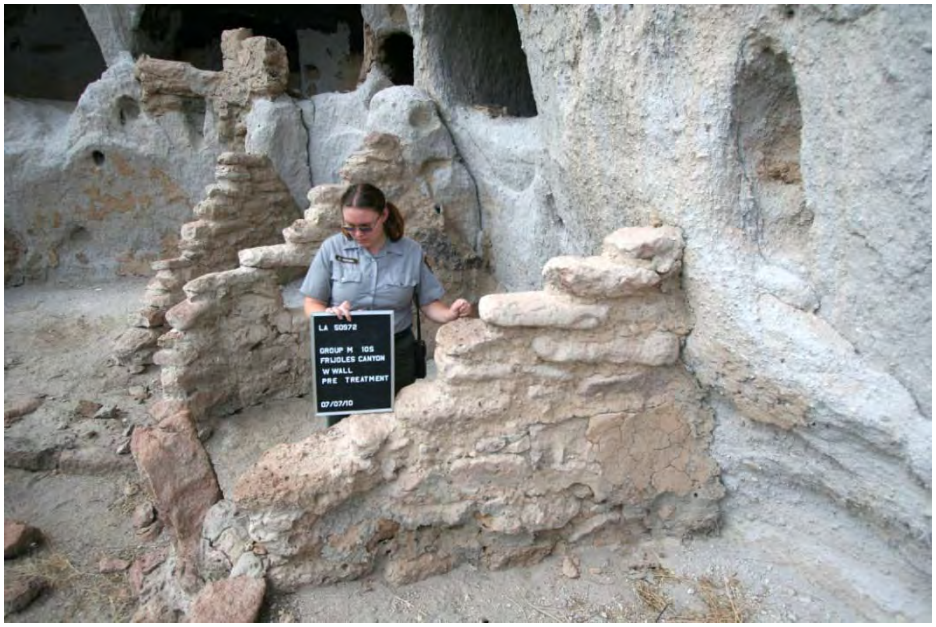




Figure 22 & Figure 23: M 102 W Int. before and after treatment

M 102 South Exterior

There is no original mortar left in this wall, and coving is evident. Loose cement was removed either by "worrying" or light tapping with a chisel, which was acceptable because there is nothing sensitive on or abutting this wall. No stones were re-laid. The wall was pointed with acrylic-amended earthen mortar.





Figure 24 & Figure 25: M 102 S Ext. before treatment (above); after treatment (below)

1988 Excavation of M 123

Washington State University excavated four archaeological sites within Bandelier National Monument included a section of cavates and talus units in Group M. Rooms M 122, M 123, and M 124 were specially selected because of their high potential for the preservation of organic materials.[3] The top of the doorway to M 123 may have been visible prior to the excavation of M 122, the posterior room. The site was presumably backfilled after excavation, but the fill levels and the erosional patterns indicate that that M 123 and M 124 are now impacted by occasional flooding, a problem that has not been mitigated.

Substantial loss of tuff and mortar can be seen around the doorway to M 123 since photos were taken of this feature in 1988. This masonry feature had never been stabilized, and continued erosion of the tuff and mortar would eventually undermine the stability of the lintel.



Figure 26: M 123 doorway after the excavation of room M 122 in 1988

Stabilization of M 123 Masonry Doorway

To slow the erosion of the tuff and mortar above the stone lintel, earthen mortar was packed into the voids. Since the doorway has never been stabilized, and the high rate of erosion is poorly understood, an unamended earthen mortar was used, as to lessen the potential impact to the surrounding original materials.

[3] See **Appendix F** for photos from the excavation

The stabilization mortar is composed of sieved Garcia Tan dirt mixed with a small amount of aggregate collected nearby. The stabilization mortar used at M 123 is different from previous masonry stabilization treatments done by VT. It quickly became evident that the unamended Tyuonyi mortar mix[4] is far too sandy to have an acceptable durability. In order to increase the longevity of the unamended stabilization mortar, Garcia Tan dirt was used which naturally has the ratio of 33% fine particles to 67% sand.[5] The Garcia Tan dirt was sieved or hand-cleaned of large aggregate (>1cm) and was used with little to no added aggregate. The large proportion of sand and silt was high enough to prevent cracking upon drying, and the higher clay content increases the durability of the mortar





Figure 27 & Figure 28: M 123 doorway before treatment (above); after treatment photo (below)

[4] The mix is 4:3:1, Sand: Garcia Tan: Garcia Red, and contains approximately 17% fines and 83% sand

[5] See Appendix F, in M. Slater and R. Miller, Tyuonyi Pueblo Stabilization, Stabilization Mortar Test Walls, Architectural Conservation Report (Los Alamos: Bandelier National Monument, National Park Service, 2003).

Treatment History and Condition of I 022 Masonry

Lister pointed the masonry around the doorway and the walled-up opening in the south wall of cavate I 022. From the 1940 photographs, it appears that there is no prehistoric mortar left in the masonry joints. Likewise, during the 2010 pre-treatment documentation, only a fragment of the decomposed 1940 stabilization mortar remained in the doorway. Four large stones have been lost since it was last stabilized: three from the threshold and the bottom stone from the masonry above the doorway. Five stones have been lost from the walled-up opening, but the remaining stones are still secured with the 1940 stabilization mortar.

As of 2010, the stones above the door are currently stacked six courses high. The bottom stone relies on friction alone for support. The second stone from the bottom is fitted into carved grooves on both sides of the crack giving it stability, but the upper four courses are free-standing, balanced upon this stone.

Stabilization of I 022 Masonry

This section of masonry was stabilized with unamended mortar (Garcia Tan) and chinking stones, collected on site, were added to fill larger voids. The masonry was stabilized over several days to allow stabilization mortar to dry, lessening the weight added. The bottom stone was mortared into place first, both on the inside and out. The rest of the masonry was pointed on the exterior only because the fragile floor prevented access to the higher courses. The seven previously existing chinking stones appear to have been put in by Lister, and were left in place. A large number chinking stones were added, due to the large number of voids.

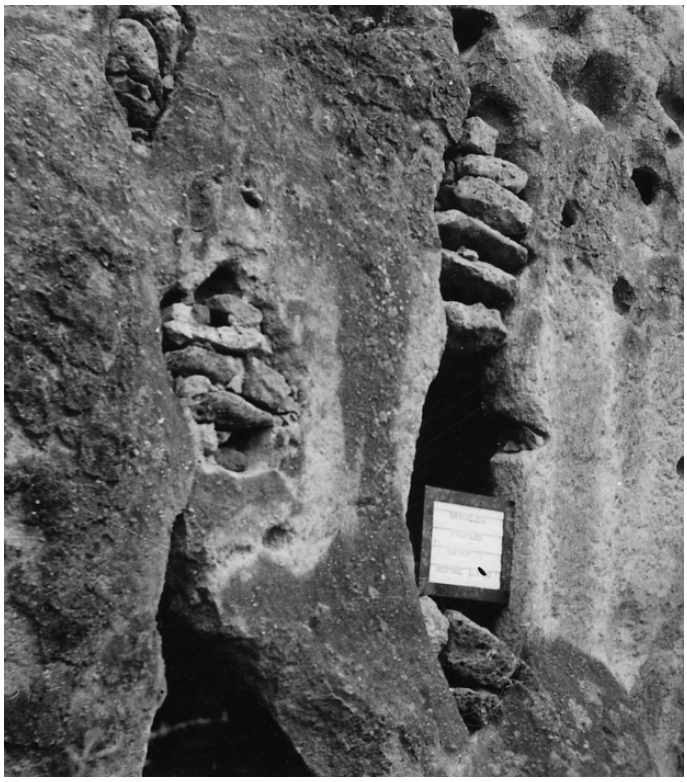


Figure 29: I 022 before treatment, Lister 1940

The masonry units to the left of the doorway were left unstabilized. These were not seen as a priority for treatment because of the amount of stabilization mortar from Lister's 1940 campaign still present, although the higher of the two sections was not fully evaluated and may need stabilization in the future.

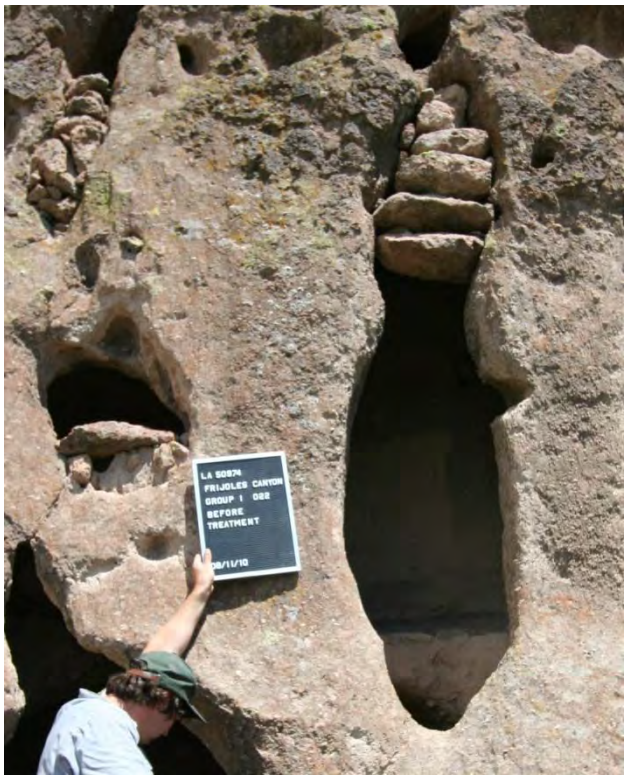




Figure 30 & Figure 31: I 022 before treatment (Left) and after treatment (right)

Stabilization of I 010 Masonry

Cavate I 010 has three courses remaining of an exterior enclosure wall. This short wall has never been stabilized before and in some joints has original mortar, but it was determined to be in an unsafe state with much of the mortar lost and its foundation undercut. The masonry was extensively photographed and documented before and during stabilization. Joints were repointed with unamended mortar composed of hand-cleaned Garcia Tan dirt. One capping stone was relaid in new mortar, and one stone was added at the east corner for stability. All chinking stones were left in situ, with the addition of one chinking stone. Some vegetation was removed on the east side of the wall.





Figure 32 & Figure 33: I 010 before treatment (above) and after treatment (below)

Treatment History and Condition of A 013 Masonry

This masonry segment is fairly well protected by the over-hanging cliff. It was stabilized in 1940 by Lister, and much of the stabilization mortar as well as prehistoric mortar is present. At the top of the wall, where the masonry meets the cliff above, a large void had formed caused by water flowing down the cliff face. The large void had been inhabited by rodents and birds as evidenced by the ample feces and nesting material. The void left unfilled may lead to more loss of both tuff and mortar and may cause further separation of the masonry from the cliff face.

Stabilization of A 013 Masonry

In August, 2010, the void at the top of the wall was cleared of debris and was filled with unamended mortar composed of Garcia Tan with the large rocks removed. Shoes were removed to prevent damage to the exposed plaster floor.



Figure 34 & Figure 35: A 013 before treatment (left) and after treatment (right)

Treatment History and the Stabilization of A 060 Masonry

The only mortar left in the masonry of A 060 appears to be from Lister's 1940 stabilization. Much of the mortar is gone and the stones are relying on friction with the cliff and gravity for support.

Stabilization of A 060 Masonry

The masonry was stabilized over several days to lessen the burden of wet mortar. Unamended earthen mortar was pointed in the joints of the wall. The previously existing chinking stones were left in situ and a number of new stones were added where the voids were large. The masonry was pointed only on the exterior. A single stone was re-set at the top of the wall due to its instability.



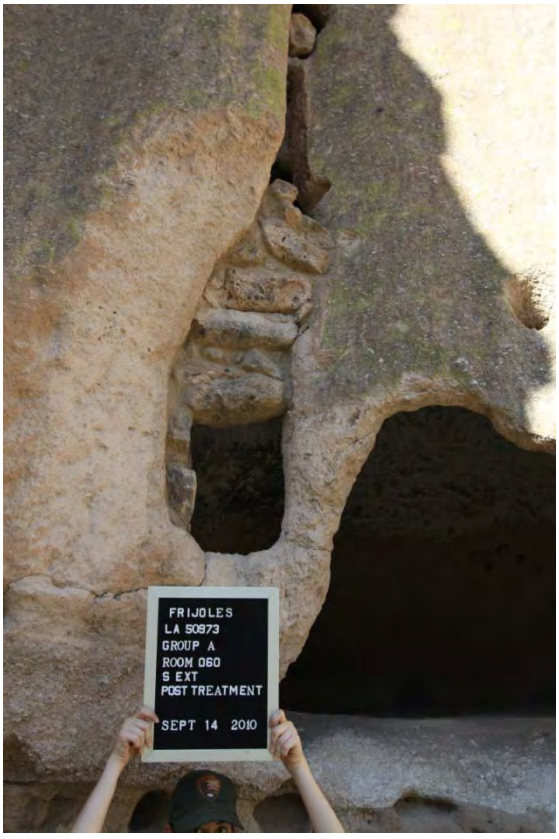


Figure 36 & Figure 37: A 060 before treatment (left) and after treatment (right)

Conclusions and Recommendations for Masonry Stabilization

Of the eleven masonry elements stabilized in 2010, nine had previously been stabilized by Lister, Hendron or the Cordero brothers. One of the two previously unstabilized walls seems to have experienced accelerated erosion due to improper back filling after excavation, while the other wall was in severe danger of failure due to extensive loss of mortar and undercutting at the base of the wall. During a condition assessment of cavate-associated masonry performed at the beginning of the season, twenty walls were identified as needing treatment and were prioritized for treatment based on their archaeological significance and threat level. Although the majority of threatened masonry segments have now been stabilized, but there are still a number of wall fragments that still require stabilization.

Group	Cavate#	Previously Stabilized	Threat Level	Comments
A	022	-	Low	Masonry stabilization needed
B	**100**	**1940**	**High**	**Masonry stabilization needed**
B	**140**	**1940**	**High**	**Masonry stabilization needed**
B	**149**	**-**	**High**	**Masonry stabilization needed**
F	B014	-	Medium	Masonry stabilization needed
F	F014	-	Low	Masonry stabilization needed
K	069	-	Medium	Masonry stabilization and stabilization of wood lintel needed
K	070	-	Medium	Masonry stabilization and stabilization of wood lintel needed
M	**151**	**-**	**High**	**Masonry stabilization needed**
M	**153**	**-**	**High**	**Masonry associated with M 151 needs stabilization**

Table 1: Cavates with masonry still in need of stabilization as of October, 2010; threat level was determined in a conditions survey in June 2010

Although it is mentioned earlier in this report, it is important to reiterate why the stabilization mortar used in the 2010 season changed over the course of the field season. The walls of the M 100 group have been heavily stabilized in the past and are typically more exposed than most cavate associated masonry, and this is the reason acrylic amended mortar was used. Unamended mortar was also used in the M 100 group where the acrylic amendment was not deemed necessary. Both mortars used in the M 100 group were based on the Tyuonyi mortar mixture developed by Mary Slater. She determined that the mixture contains approximately 13% Fine particles to 87% sand, which is ideal for the use of an acrylic amendment due to low shrinkage and low clay content[6], but when unamended it is guaranteed to erode quickly. After the stabilization of the M 100 group, variations of Garcia Tan Dirt were used without amendment. Garcia Tan Dirt more closely resembles the composition of traditional earthen mortar. It is recommended that the walls stabilized with Garcia Tan Dirt be closely monitored, since this mixture has not been as rigorously tested as the Tyuonyi Mix has.

[6] Hartzler, R. 1996 Acrylic-Modified Earthen Mortar. Intermountain Cultural Resource Center Professional Paper No. 61. National Park Service. Santa Fe, New Mexico.

Samples Collected for Mortar Analysis

Introduction

Little work has been done to characterize the various mortars at Bandelier National Monument. Due to the lack of detailed records over much of the 20th century, much information has been lost regarding when and where stabilization has occurred. Information can be extracted from the type of mortar and its aggregate. Work is currently underway to collect samples of stabilization mortars throughout the Monument and to develop a methodology for analysis.

Prehistoric and Stabilization Mortars in the Cavates

Prehistoric and Stabilization mortar samples were collected in Frijoles Canyon during the 2010 season. Sample collection was a careful process and collected samples were loose or entirely detached and were either in danger of losing their context or needed to be racked out for stabilization. A total of 12 samples were collected from cavates in Frijoles Canyon.

Mortar	M093 E / M095 W wall	Jul-10	Prehistoric earthen mortar
Mortar	M093 E / M095 W wall	Jul-10	Prehistoric earthen mortar
Mortar	M093 E / M095 W wall	Jul-10	Prehistoric earthen mortar
Mortar	M099 E Interior Wall	Jul-10	Earthen mortar, possibly prehistoric
Mortar	M099 E Interior Wall	Jul-10	Earthen mortar, possibly prehistoric
Mortar	M102 W Interior Wall	Jul-10	Prehistoric earthen mortar
Mortar	M091 W Interior Wall	Jul-10	Earthen Mortar, 1943 Stabilization
Mortar	M095 W Interior Wall	Jul-10	Cement, 1943 Stabilization
Mortar	M099 E Interior Wall	Aug-10	Prehistoric earthen mortar
Mortar	M095 E Interior Wall	Jul-10	Cement, probably 1964
Mortar	I022 S Exterior	Aug-10	Earthen Mortar, 1939 Lister stabilization
Mortar	M123 Exterior Door	Oct-10	Prehistoric earthen mortar

Table 2: Prehistoric and stabilization mortar samples collected in 2010 from Cavate Groups in Frijoles Canyon

Samples are kept on file in the Vanishing Treasures Field Office at Bandelier National Monument awaiting analysis. Analysis will include sorting by grain size, identification of aggregates, and acid digestion of calcium carbonate. Analysis will likely occur in 2011.

Plaster Stabilization

Rachel Adler

Introduction

Many of the cavates in Frijoles Canyon have sheltered interiors, meaning a relatively high proportion of them retain original surface finishes. These finishes include both applied earthen plasters and sooted tuff, which is often found on cavate ceilings and may have served to stabilize the material and reduce its friability. Applied plasters may have served a similar purpose, creating a reparable barrier between the easily eroded tuff and detrimental environmental and cultural factors.

The fragility of earthen plasters makes them a rare occurrence at many archaeological sites, and their presence is one of the characteristics that can contribute to a cavate's significance. For this reason, the Vanishing Treasures crew began testing strategies for plaster consolidation and reattachment during the 2010 field season. The methods, materials and results of the tests are explained in this section.

Plaster Reattachment Testing Precedents

Other Parks

Plaster reattachment treatments have been implemented in other National Park units, including Mesa Verde National Park (MEVE) and Aztec Ruins National Monument. In 1994, MEVE partnered with the Architectural Conservation Laboratory of the University of Pennsylvania to create the Conservation of Architectural Surfaces Program for Archaeological Resources. The goal of this program was to develop a comprehensive and consistent procedure for the survey, analysis, stabilization, and interpretation of the earthen finishes found in the cliff dwellings of Mesa Verde. The results of this program have been useful in other park units as well.

Bandelier

Plaster reattachment testing was implemented at Bandelier National Monument during the 1999 field season under the direction of Angelyn Bass Rivera.[7] Testing materials and methods were based on previous work done in the park units mentioned above. At that time, a 10% acrylic emulsion solution thickened with Acrysol 6038A™ was used as an adhesive. The solution was injected behind loose areas of plaster with a narrow gauge #21 needle, and then the treated area was pressed back against the tuff substrate with a cosmetic sponge and held until the area was secure. In many cases, the area to be treated was prewet with a light mist of water and the underlying tuff was consolidated with a 10% acrylic emulsion solution. The acrylic used in all cases was Rhoplex E-330™.

[7] Bass Rivera, Angelyn. "Conservation Treatment Report, Cavate Preservation Project, Bandelier National Monument." Submitted to the National Park Service Intermountain Support Office-Santa Fe, Architectural Conservation Projects Program, September 1999.

This treatment was implemented in Cavate 014 (65755-98-08, BAS 14), in LA 65755 on Tsankawi mesa. Conservators intended to assess the appearance and efficacy of the treated areas in one year's time, however it is unclear whether or not these observations were carried out. In addition, conservators recommended that laboratory tests be conducted on the acrylic materials used in the reattachment testing to gain a more thorough understanding of its compatibility with earthen materials. Again, no documentation is available to suggest that these laboratory tests were carried out. S. Merkel and R. Adler completed an informal conditions assessment at the beginning of the 2010 field season during which they observed current conditions in the areas of treated plaster in Cavate 014, LA 65755. This assessment confirmed that the treatments implemented in 1999 were performing well and appeared to have no detrimental effect on the appearance or physical integrity of the prehistoric plasters.



Figure 38 Before **treatment photograph of plaster reattachment pilot test area, Cavate 014, LA 65755, 1999**



Figure 39. Angelyn **Bass Rivera performing plaster reattachment treatment, Cavate 014, LA 65755, 1999**



Figure 40. After treatment photograph of plaster reattachment pilot test area, Cavate 014, LA 65755, 1999



Figure 41. Photograph of treated area taken 10 years after treatment, Cavate 014, LA 65755, 2010

Existing Plaster Conditions

Despite their relative protection from the elements, many of the extant earthen finishes associated with the cavates of Frijoles Canyon have suffered and continue to suffer from serious deterioration. The factors leading to this deterioration include water infiltration, disintegration of the tuff substrate and visitor impact. These in turn lead to a variety of conditions, all of which result in loss of finishes and the information they can provide.

Partial loss, disaggregation, detachment and delamination are some of the most common conditions affecting plasters in Frijoles Canyon. An illustrated glossary of conditions is found in **Appendix C.** Many of these conditions occur as a result of movement within the plasters. The clays that make up an integral component of the finishes take on moisture through rising damp or as the relative

humidity inside the cavate rises. This causes the clays to swell and deform as the plaster takes on moisture and then the plaster shrinks and potentially cracks when it dries out. As this happens over centuries, the plasticity of the plasters decreases and they become brittle or disintegrate completely. This process can also cause discrete layers of plaster to separate from each other or from their stone substrate, which ultimately leads to their loss, as debris collects behind plaster layers and pushes them away from the wall.

A separate condition that also exists in many of the plastered cavates is the degradation and erosion of the tuff to which the plaster was applied. In this situation, it is not the plaster that detaches from its tuff substrate, but rather the tuff detaching from itself and sagging away from the wall. This creates a layer of plaster with a layer of tuff attached to it that gradually separates from the cavate wall, sometimes creating a gap of several centimeters. This condition is unique in that it represents a failure of the substrate, as opposed to a failure of the finish material. As yet, no successful way of treating this condition has been established. The information gained through the testing program described here will hopefully provide insight into possible solutions to this problem.

In the Bandelier Final Project Report from 2002-2003 created by the Vanishing Treasures program, cavates from four of the thirteen lettered groups in Frijoles Canyon were analyzed, and prevalent conditions were quantified. Data showed that in Groups A, C, E and M, 49.7% (216 cavates) showed at least partial loss of plasters, while 50.1% (220 cavates) exhibited plaster detachment. Overall, Vanishing Treasures recommended that 30.8% of the cavates in these groups (134 cavates total) receive finishes conservation.[8] Action on this recommendation is still pending.

Methodology

Application methods and materials used during the 2010 field season for plaster stabilization were similar to those used during the 1999 field season. However rather than of using an acrylic solution as an adhesive, gelatin, a natural, animal-based substance, was used. This material has been tested and used successfully at Mesa Verde National Park since the late 1990s. For testing in Frijoles Canyon, solutions of 2.5%, 5%, and 10% gelatin were used. The formula for these solutions is as follows:

2.5% Gelatin	5% Gelatin	10% Gelatin
35mL cold water	35mL cold water	50mL cold water
100mL hot water	100mL hot water	85mL hot water
½ packet Knox Gelatine	1 packet Knox Gelatine	2 packets Knox Gelatine
15mL Glycerin	15mL Glycerin	15mL Glycerin
½ capful isopropyl alcohol	½ capful isopropyl alcohol	½ capful isopropyl alcohol

Table 3: Formulas used for plaster reattachment

[8] Bass Rivera, Angelyn, et. al. *Interim Project Report, Frijoles Canyon Cavate Pueblo Conservation Projectand Field School in Site Conservation and Heritage Management, Bandelier National Monument, New Mexico*. Los Alamos: Bandelier National Monument, National Park Service, 2002.

The procedure for mixing all three solutions is the same. The dry gelatin powder is placed in a glass jar and prewet with the cold water. Once all of the gelatin is saturated, the hot water is added and the solution is mixed until the gelatin is dissolved and the liquid is a clear yellow color. The glycerin and isopropyl alcohol are added last. The glycerin aids in making the solution more viscous, allowing it to flow easily through a small gauge needle, while the alcohol prevents insects and biological growth from being attracted to the damp material. As the solution dries, the alcohol evaporates.

The gelatin solutions can be stored in the refrigerator for up to two weeks. In the field, the glass jars are placed in a hot water bath, which turns the gelatin from a solid to a liquid state. Syringes are then filled with the liquid solution and also stored in a hot water bath. Gelatin can also be used cold, as a gel, which limits the amount of moisture introduced into prehistoric material and has the potential to prevent staining. For this technique, syringes are filled with a hot solution and then placed in a cold water bath. A larger gauge needle (#16) is then placed on the syringe to allow the less viscous solution to be dispensed. Loose plaster on which cold gelatin is used is set into plane with a dry cosmetic sponge, again to limit the introduction of moisture and its potential to cause staining.

Testing Areas, Group M and Group F, Frijoles Canyon

Plaster reattachment testing during the 2010 field season took place on the exposed masonry walls of the M100 group, located at the east end of Group M in Frijoles Canyon. This location was chosen for several reasons. The area had been previously excavated, stabilized and partially reconstructed, meaning that further careful interventions would not significantly affect the archaeological integrity of the site and its surroundings. In addition, the masonry walls are exposed to the elements, allowing conservators to observe accelerated weathering and deterioration patterns that may affect, or be caused by, treatment materials. For a detailed excavation and stabilization history of this area of cavates, please see the above section on masonry stabilization during the 2010 field season.

East Interior Wall, Room M093

For this area, the first on which we tested plaster reattachment methods, a 5% gelatin solution was used, which in past uses at other parks has proven to be a strong enough adhesive for most plasters while having little potential for staining. Conservators working on this test area were R. Adler, S. Merkel and K. Hassanein. Before any treatment was undertaken, areas of delamination and detachment were identified and marked on a black and white photograph of the area placed inside an acetate sleeve. Conservators then used canned compressed air to clear voids behind loose plaster of dust and debris, which would have impeded the adhesion of the plaster to its masonry substrate. The hot 5% gelatin solution was then injected into these voids using a #21 gauge needle, using the smallest amount necessary to replasticize the finish layers and make them pliable. These areas were then set back against the masonry substrate with a damp cosmetic sponge and held for several seconds until the area was stable. Areas treated with the 5% hot gelatin solution were marked on a separate overlying acetate sheet with a special hatch mark to denote the treatment.

Treated areas were assessed one day later, after the gelatin solution had dried completely. Assessments focused on whether or not the treatment was successful in readhering the plaster to the masonry substrate, and whether or not the treatment left visible staining. The treatment proved to successfully adhere loose plaster to its masonry substrate in most cases, although in areas where the plaster was of greater than average thickness, some space remained between plaster and substrate. In these cases, the voids behind the loose plaster were reduced in width. Several of the treated areas exhibited minimal staining, especially those areas in which a large amount of gelatin solution had been used. For example, areas that exhibited relatively thick layers of detached plaster required a greater amount of solution to saturate and replasticize clays. In areas where the layers of treated plaster were relatively thin, staining was not evident.



Figure 42: M93 E Interior, before treatment



Figure 43: M 093 E Interior after treatment

West Interior Wall, Room M099

In an effort to prevent staining, the 2.5% gelatin solution was tested next. Because the staining during previous testing appeared to have been directly related to the amount of gelatin used, it was thought that a weaker gelatin solution would decrease the chances of a stain appearing. The 2.5% gelatin solution was prepared as described above, and applied using the same method as was used for the 5% gelatin solution. Two areas of severe blistering and detachment, as well as one area of delamination were chosen for testing.

Treated areas were assessed the following day. The delaminating area showed no staining and the treatment appeared to have been successful in adhering the detached plaster layers to themselves and to their masonry substrate. The blistered areas, however, showed severe staining, much worse than had been seen with the 5% gelatin solution used previously. The staining in these areas was of a different nature and was most likely due to the presence of soot underneath and between the detaching layers of plaster. In this case the staining mechanism would have been the presence of water drawing the soot to the surface, as opposed to the presence of the gelatin. This is supported by the fact that the gelatin treatment in the delaminating area, which did not exhibit sooting, did not cause staining, despite the fact that the same 2.5% gelatin solution was used. The two stained areas discussed here were blotted with cosmetic sponges soaked in very hot water in order to draw out the staining and remove it from the surface of the plaster. This appeared to be successful, and while

it did not remove the staining completely, it was reduced by a significant amount.



Figure 44 & Figure 45: M 099 W Interior, area of delamination before (L) and after (R) treatment



Figure 46 & Figure 47: M 099 W Interior, blistered area before (L) and after (R) treatment

West Interior Wall, Room M099, Test 2

Two more areas on the west interior wall of Room 099 were tested next. The first was a very large blister located approximately 18 inches from the ground towards the north end of the wall. The surface of the blister was coated with cyclododecane, which in this case was applied using an aerosol spray can. Cyclododecane is an organic compound categorized as a volatile binding medium. It is a waxy substance that can be used to form a protective hydrophobic layer over water sensitive materials. This prevents the evaporation of liquids from the coated surface, and forces

them to move elsewhere within the material, decreasing the probability that particles will migrate to the surface and be left there after evaporation to cause staining. The cyclododecane eventually sublimates, or transforms from a solid to a gaseous state. The amount of time necessary for this phase change varies depending on atmospheric pressure, humidity and temperature.

A hot solution of 2.5% gelatin was injected behind the area covered in cyclododecane, in the hopes that it would replasticize and reattach the detached plasters beneath while not causing the soot particles between the plaster layers to move towards the surface. The area was then pushed back against the masonry substrate with a damp cosmetic sponge. When the cyclododecane had sublimated completely several days later, the area was inspected and showed severe staining. The cyclododecane did not appear to have prevented the soot particles underneath the plaster from migrating to the surface. This area was treated in the same manner as the stained areas mentioned previously: a cosmetic sponge soaked in very hot water was pressed repeatedly over the stain to draw it to the surface and away from the plaster. While not removing the stain completely, this did substantially decrease its visibility.



Figure 48: M 099 W Interior, Detail of staining caused by 2.5% hot gelatin solution injected behind blister; photograph taken before further treatment to remove stain with hot water

On the same day, a solution of 10% cold gelatin was tested as an adhesive for another area of plaster that had detached from its masonry substrate. When gelatin is used cold, it has the potential to transfer less moisture to the plaster it comes in contact with, reducing the risk of staining caused by particle movement by water to the surface of the plaster. However, it is also more difficult to work with, as it is semi-solid and does not flow easily through a narrow gauge needle. A #16 gauge needle was used with the cold gelatin in order to more easily direct its flow to the void behind the detached plaster. Once a sufficient amount of gelatin was dispensed, a dry cosmetic sponge was used to press the plaster back to the substrate. When the area was checked several days later, it appeared that the treatment was unsuccessful. This was mostly likely due to the thickness of the

plaster and its brittle nature. The lack of water in the cold gelatin solution means that the clays in the plaster on which it acts are not replasticized, and the plaster layers must rely solely on the adhesive properties of the gelatin to secure them to their masonry substrate. In this case, the adhesive was not strong enough to hold the plaster in place. In addition, when the plaster was pressed back to the substrate with the cosmetic sponge, excess gelatin was forced out around the edges of the plaster and onto the surface. This gelatin caused a slight darkening of the surface layer that remained visible after the gelatin had dried completely.





Figure 49 & Figure 50: Blistered area before (L) and after (R) treatment with cyclododecane



Figure 51: Blistered area after cyclododecane had sublimated. Note severe staining around treated area.

North Interior Wall, Room M093

The north interior wall of room M 093 has two layers of reddish plaster with no layer of soot between them. The underlying layer is disaggregating and causing the upper layer to peel away from the wall, which consists not of masonry blocks, but of exposed tuff cliff face. This upper layer is currently exhibiting areas of detachment, blistering and delamination. On September 20, 2010, we used a 2.5% hot gelatin solution to reattach some of these areas to the underlying plaster layer and to the tuff underneath. When the treatments were observed the following day, they did not exhibit staining, but appeared to have been successful in adhering the thin upper layer of plaster to the layer beneath it, and in consolidating the underlying plaster layer to make it less friable.



Figure 52: M 093 N Interior overall view before treatment



Figure 53: M 093 N Interior delaminating before treatment



Figure 54: M 093 N Interior delaminating area after treatment

East Interior Wall, Room Fb013

In October 2010, after testing gelatin plaster treatments on the exposed walls of the M100 group with limited success, we chose to use the same techniques in cavate Fb 013. This is an enclosed cavate with no more than three layers of reddish plaster on the walls. While it does have a sooted ceiling, there do not appear to be layers of soot between the plaster layers. In addition, the plaster

of cavate Fb 013 contains a number of potentially significant instances of historic imagery, possibly from the Pueblo Revolt period and from the later period of occupation by sheepherders. Imagery includes geometric patterns, masks and a cowboy figure riding a horse. Most of this historic imagery is etched lightly onto the plaster's surface, and in many areas, the plaster is beginning to detach from the wall. This may eventually lead to the wholesale loss of large pieces of plaster, including those on which the images are incised. Plaster stabilization in this cavate will hopefully prevent or postpone that occurrence.



Figure 55: FB 013 E Interior modern graffiti before treatment

Also in cavate Fb 013 are instances of modern graffiti. This graffiti is etched deeply through all layers of plaster and into the tuff beneath, creating a situation in which the plaster can easily detach from the wall and create a space that is subject to infiltration by moisture and debris. As moisture and debris collect behind the plaster, and also as changing relative humidity causes the plaster to shrink and swell, the probability that the plaster will fall away from the wall increases. Treating this area with gelatin will potentially slow this process. We focused on an area on the east interior wall of Fb 013 where there was a section of undated modern graffiti reading "D. D." This graffiti had already caused some plaster loss, and plaster adjacent to the incised letters was beginning to detach.



Figure 56: Fb 013 E Interior after treatment

A 2.5% hot gelatin solution was used to reattach detaching and delaminating plaster in the immediate vicinity of the graffiti. The treatment was ultimately successful and did not cause noticeable staining, although there was a small amount of mechanical plaster loss associated with the conservation process.

Grouting and Edging

Although plaster stabilization was the main objective of this testing program, we also did some experimentation with grouting and edging. There were several areas in which large pieces of thick plaster and mortar had separated from the masonry walls in the M100 group, and these pieces were too heavy for gelatin to act as a successful adhesive in securing them to their substrates. In these instances, a soft lime grout was injected behind the areas to stabilize them and prevent them from detaching from the walls entirely.

The following grout mixture was used in the areas we treated in the M100 group:

2 parts Hydrated Hydraulic Lime

1 part sieved sand (passing through a #60 sieve)

1 part 3M Z-Light ceramic microspheres

This dry mixture was prepared in advance, and mixed with water as needed at a ratio of 1 part water: 2 parts dry grout mixture. Water and dry grout mixture were combined in a one pint Rubbermaid plastic container and mixed for at least 2 minutes using a paint mixing drill bit attached to a variable speed hand held power drill. This ensured even mixing to create a uniform fluid, which is essential for dispensing the grout through metal cannulae and syringes.[9] The mixture was then drawn into a 10mL syringe and dispensed through a 12 gauge, 2 inch stainless steel dispensing needle.

[9] Materials, amounts and mixing procedures are adapted from "Performance Analysis of Hydraulic Lime Grouts for Masonry Repair," a master's thesis by Victoria I. Pingarron Alvarez completed in 2006 for the University of Pennsylvania.

East Interior Wall, Room M093

The area tested here consisted of a concrete patch that had been applied to the wall in the 1960s or 1970s, and was not an original prehistoric component. There were cracks in the concrete that were good candidates for filling with grout, and allowed us to test the efficacy of the grout preparation and application without disturbing fragile prehistoric materials. The crack to be filled was first flushed with water to dampen the surface to which the grout would bond. Adjacent cracks in the concrete were dammed with loose cotton in order to prevent liquid grout from leaking to the surface and drying there. Finally, the grout was dispensed as previously described into the void behind the concrete. Upon inspection several days later, the grout treatment appeared to be successful in that the grout filled the void behind the concrete without causing any visible alterations on the surface.





Figure 57 & Figure 58: M 093 E Interior before and during treatment

West Interior Wall, Room M099, Area 1

This area contained both prehistoric mortar and plaster materials, as well as concrete stabilization material that had been applied over top of the original materials. The concrete had apparently been applied to the wall in an effort to patch a large diagonal crack running downwards from the north end of the wall to the south. While this concrete did somewhat disguise the crack, it did not fill the void, and in many areas the thin layer of stabilization material had come loose. It was decided to remove the concrete in areas where it most likely would have fallen of its own accord, but to leave in place concrete that seemed stable, the removal of which might take original materials with it and cause damage to the walls.

Once the necessary concrete was removed, it was discovered that there was in fact a sizable void that went deep into the wall behind it. Without knowing how large the void actually was, it would have been irresponsible to attempt to fill it entirely with grout, as this may have affected internal parts of the wall we had no view of. However, we proceeded to work with smaller, more contained areas of the crack. We began by flushing a small area towards the bottom of the crack with water, and that section of the void was filled with grout. Work was completed from the bottom up in order have better control over the liquid grout as it was dispensed into the crack. The grout was successful in filling the void in this area; however, the original flushing with water caused severe staining of the plaster surrounding the crack, where the water had leaked out. It was decided that this step would be omitted when grouting the remainder of the crack in order to preserve the visual integrity of the original plasters.



Figure 59: M 099 W Interior before treatment

A large amount of grout was dispensed into the crack moving upwards. In some areas, entire syringes of grout would disappear into the wall and did not seem to be making progress towards filling the void. In these cases, we moved on to upper sections of the crack, which were narrower and more easily filled. This continued until the entirety of the crack had been worked on to some extent. In cases where the concrete had not been removed, but could have potentially come loose from the wall, the grout was successful in securing it to the wall and keeping it in place.

In areas where the crack was too large and deep to fill with grout, it was decided that soil edging would be applied to seal the crack. This would hopefully serve to prevent water and debris from entering the wall, undermining its integrity from the inside. For all of the edging in the M100 group, a mixture of "garcia tan" dirt and water was used. Just enough water was added to the soil to make it into a workable, clay-like material. As much soil mixture as possible was pushed into the existing large voids, and the finishing surface was made flush with the wall surface.

Edging was also used to disguise areas where the grout was near the surface. The grout is very light grey in color, and stands out easily against the prehistoric masonry and mortar. Thin layers of soil edging were therefore applied over visible areas of grout to retain visual integrity. Overall this treatment appears to have been successful. The soil used for edging dried to a color that matches the color of the original materials very well. In addition, the crack, while not completely filled, seems to be sealed from materials that may enter the wall and cause instability.





Figure 60 & Figure 61: M 099 W Interior before and during treatment

Edging has been tested at Bandelier before, as part of the same program led by Angelyn Bass Rivera that tested plaster reattachment in 1999. However, application techniques and materials used then differ from what was used during the 2010 field season. In 1999, conservators used a low-shrinkage mortar composed of soil, hydrated hydraulic lime and ceramic microspheres as their edging material. This material is similar to what we currently use as a grout.

The object of the 1999 testing program was to use edging to re-adhere partially detached and unsupported plaster edges to the underlying tuff. This was accomplished by consolidating the

underlying tuff with a 10% acrylic emulsion solution, and then applying the conservation mortar carefully behind the detached plaster using a microspatula. Edging testing was performed in Cavate 014 of LA 65755, the same cavate in which plaster reattachment testing was tested. Although it was recommended that the area be assessed in one year, there is no evidence that this was ever completed.[10]

West Interior Wall, Room M099, Area 2

Towards the ground on the west interior wall of Room M 099 was an area of cracked mortar and plaster that had detached from the wall and was in danger of collapsing completely. The detached pieces in this area were of substantial weight and thickness and needed some kind of support to stabilize them and reattach them to the wall. Grout was very carefully dispensed behind this area in order to bond the detached pieces to the masonry substrate beneath. This was first done in a few strategic places to stabilize the area, after which more grout was dispensed in order to fill the void between the finishes and the substrate. When the grout had cured, the treatment proved to be successful. The detached pieces were no longer loose or in danger of falling from the wall. The grouted areas were then edged with the "Garcia tan" dirt mixture, both to hide the grout and to prevent water and debris from getting behind the finishes and causing them to detach again.



Figure 62: M 099 W Interior before treatment

[10] Bass Rivera, Angelyn. "Conservation Treatment Report, Cavate Preservation Project, Bandelier National Monument." Submitted to the National Park Service Intermountain Support Office-Santa Fe, Architectural Conservation Projects Program, September 1999.



Figure 63: M 099 W Interior after edging treatment

West Interior Wall, Room M099, Area 3

Another area of the west interior wall of Room M 099 exhibited a thick layer of plaster that was detaching from the wall, creating a void that was large enough to allow in water and debris, but not large enough to warrant treatment with grout injections. This void was instead sealed with soil edging made of the "Garcia tan" dirt mixed with water. When this mixture dried, the color of the soil edging matched the color of the original plaster very closely, allowing the area to be protected without disturbing visual integrity.



Figure 64: M 099 W Interior edging soon after application

Conclusions and Recommendations

Plaster stabilization has been attempted sporadically at Bandelier in the past, and although treatments were successful, the information gained from these tests was never used to plan a systematic plaster stabilization program that would be beneficial to the hundreds of cavates in the Park with original, prehistoric earthen finishes. The testing implemented during the 2010 field season provided the information necessary to understand what is feasible in terms of plaster assessment and stabilization at Bandelier. Although much work remains to be done to develop a complete program, we now have the tools necessary to begin planning.

Testing during the 2010 field season showed that treatments with a 2.5% gelatin solution can be used successfully in cavates which have up to three layers of plaster delaminating or detaching from their substrate. Solutions with a higher proportion of gelatin are more like to cause surface staining and should therefore be avoided. It is important that treated areas do not exhibit surface or subsurface sooting, and also that the tuff supporting the plaster is not disaggregating and causing the plaster to come off of the walls. While the use of cyclododecane was not successful in preventing staining during the 2010 tests, more testing should be done to determine whether the use of this material is a possibility for treating sooted areas. The 2010 field season was the first time cyclododecane was used in aerosol form, and it is possible that it was applied incorrectly, or that not enough of it was used to perform the desired task. When applied as a melted wax with a small brush, cyclododecane is easier to apply in thick layers, and it is also easier to control its flow and direction. In the future, tests should be done using the traditional application of melted cyclododecane as well thicker coatings of the aerosol version.

In addition to continued testing of materials, a formal system of assessment and treatment planning and documentation specifically for plaster stabilization needs to be developed. Although conditions

assessments have been completed for most of the known cavates in Frijoles Canyon, these assessments did not focus specifically on plasters and earthen finishes, and therefore do not present an accurate picture of what can or should be treated. With the knowledge gained from the 2010 plaster stabilization testing and from future testing, an efficient, consistent, finish-specific assessment procedure should be developed that will allow conservators now and in the future to decide what cavates require treatment and how such treatments should be carried out.

With respect to using lime grout and soil edging to fill voids and create a protective barrier within masonry and tuff walls, more testing also needs to be performed. These techniques were only applied to masonry walls in 2010 and not to plastered walls on a solid tuff substrate. Further testing should be done on such surfaces to determine wither or not staining will be an issue and also whether such treatments can be effective without being destructive to original fabric or accelerating deterioration. Once this testing is performed, areas to be treated can be identified and described through the same assessment process used for the gelatin treatments.

Field tests during the 2010 season were informative and encouraging, and suggest that a comprehensive plaster stabilization program at Bandelier is a definite possibility. However, a great deal more planning and testing needs to occur before such a program is proven to be necessary, successful and beneficial to Bandelier's sensitive prehistoric resources.

Cavate Photography

Stephen Merkel

Introduction

Cavate photography is significant portion of the Frijoles Canyon Cavate Conservation Program. Photographs are used extensively by the VT Program at Bandelier National Monument. They tie physical structures to the numbering system, a system so extensive and complex that if photos did not link the two, much of the information concerning treatment and documentation could be lost. Photographs are actively used in planning conservation treatment, monitoring damage and erosion, and in data management.

Cavate Photography for the Archive

Relatively few photographs existed of cavate interiors prior to 2002, when the systematic photography of the cavate architecture of Frijoles Canyon began. The creation of a digital and Black/White Film archive is underway, and approximately 672 of the 1055 identified cavates have now been fully photographed. Cavates were photographed by priority which was determined in the 2002 to 2004 conditions assessment. All High and Medium Priority cavates have been photographed, and the remaining cavates are all Low Priority or Indeterminate Structures.

The focus during the 2010 season was to complete all Medium Priority cavates, re-shoot photographs of cavate exteriors that had been photographed without a signboard, and complete the records of cavates where exterior shots were not taken. A total of 171 cavates throughout Frijoles Canyon were photographed. Some required only a photograph of the entrance while others were recorded in full. A complete list of cavates photographed in the 2010 season can be found in **Appendix N**; photography methods, archival procedures, and copies of photography forms can be found in the appendices.

Photography information from the 2010 Season must be entered into the Cavate Database. The database has been unstable over the last year. Adding data to the database will resume once repairs are complete.

Orthorectified Photography

Orthorectified photography is defined as a method used to overlay stitched photographs onto a measured frame in order to produce high quality scaled photographs. The photographs, if care is taken in all stages of processing, can be of such a quality that measurements can accurately be taken from them. Orthorectification is a labor intensive process requiring diligence and care, and will only be used to record most significant features, imagery, and architecture. Several Bandelier VT staff members received training on orthorectified photography by Robert Jensen from Mesa Verde National Park. Three cavates were photographed: Snake Kiva, M 033 (Painters Cave), and E 059. None of the orthorectified photographs were completed due to a lack of computer programs and hardware. Processing of these photographs will commence in 2011, once all the necessary equipment is acquired and set up. Instructions for producing orthorectified photographs are in **Appendix P**. The goal of the

orthorectified photography program is to be able to print these images using archival ink and paper so that the records can be preserved.

360° Photography

This method of photography produces flat, cylindrical and spherical panoramas. With traditional photography it is difficult to get a sense of the three dimensional nature of cavate structures and how features relate, spatially, to each other. Spherical panoramas allow cavates to be viewed in three dimensions, which cannot otherwise be done without laser-scanning. It goes without saying that there are major differences between 360° photography and laser-scan photo-overlays. In 360° photography, there is no presumption of scale and the image is obviously distorted, but the sense of space and the relationships captured in a spherical panorama make it a valuable tool. A methodology for producing 360° photographs was developed in 2010, and instructions are in **Appendix O**. In Frijoles Canyon one cavate interior was photographed (D156/2A) and a panorama of part of Group F was also created. Much more 360° photography was done at North Mesa in the Tsankawi Unit.

Conclusions

The completion of the cavate photography archive is a priority. Most of the highly significant cavates have been photographed; all that remains are the Low Priority and Indeterminate cavates. Older cavate photography records need to be reconciled with the Cavate Database and new records need to be entered. The 360° photography showed promise and more cavates should be photographed with this technique. Further orthorectified photography should be put on hold until photographs already taken are processed and evaluated.

Floor Mapping and Stabilization: Snake Kiva

Rachel Adler

In June of 2010, the floor of Snake Kiva, LA 13664, Room Ef021, was cleared in preparation for the arrival of Kay Barnett, a VT staff member from Mesa Verde National Park. The purpose of the visit was to work with Vanishing Treasures staff at Bandelier to develop skills in detailed hand-drawn mapping and to work through some of the issues and difficulties of documenting and recording round walls and spherical spaces accurately and in two dimensions. The floor of Snake Kiva was chosen as a good candidate for mapping, as it contains several significant features, some of which have deteriorated or disappeared since the floor was cleared and mapped by Edgar Hewett in 1909. Although the floor of Snake Kiva is regularly covered by several inches of dirt fill and the kiva itself is now blocked by a metal guard rail, the fact that it is located directly on the paved visitor trail in Frijoles Canyon makes it especially vulnerable to degradation due to visitor impact. Besides the impacts by visitors, it is apparent that water flowing down the cliff-face was flowing over the floor. By remapping the floor, it can be shown how much has been lost in the last century.[11] For these reasons it was considered important to map the floor of the kiva and to document it fully before more information was lost.

The floor was cleared by Stephen Merkel and Ashley Crossen during the first week of June 2010. Both wore respirators for protection as they used soft, natural bristle brushes to sweep the floor fill away from the original prehistoric plaster, starting at the back of the room. As the pile of floor fill accumulated, it was periodically placed into five gallon buckets and removed to the floor of Cavate Ee022. Over twenty buckets of fill were removed from Snake Kiva. After the floor was cleared, staff were required to remove their shoes and only wear socks when inside the room. An additional sign notifying visitors of the work in progress and reminding visitors not to enter the cavate was placed on the visitor trail.

The floor map was begun by Kay Barnett in the process of teaching hand-drawn mapping skills to VT staff members Ashley Crossen, Johnny Holdsworth, Karim Hassanein and SCA intern Eli Logan. A cloth tape measure was laid flat on the floor of Snake Kiva across its approximated widest point. Another tape was laid flat perpendicular to this tape at its approximate center. These two center lines were drawn on a sheet of 11”x17” FADE-OUT® design and sketch vellum at a scale of 5cm: 0.10in. Staff alternated drawing points on the vellum and measuring points with a third tape measure. The measured points were called out to the mapper, giving first the numeric location on the stationary tape, and then the distance of the point being measured from that numeric location. Care was taken to ensure that tapes were perpendicular to each other at all times. Points were taken approximately every 10 centimeters. In this manner, the boundaries of the cavate floor were mapped.

The following day, Ashley Crossen, Johnny Holdsworth and Eli Logan were joined by Rachel Adler to complete the hand drawn mapping of Snake Kiva. Stationary tapes were placed in the same location as the day before with the help of small stones that had been placed the previous day to mark the tape ends. The process continued in much the same manner as it had before, with participants alternating

[11] The drainage problem was solved shortly after the floor mapping was completed, see next section

between drawing and measuring points. Once the floor boundaries of the cavate were completed, the boundaries of the existing floor features were drawn on the same map. These features included loom anchors and original floor plaster, as well as irregularities in the exposed tuff floor and a certain amount of unexcavated fill.

The mapping continued with drawing above-ground features of the cavate, including the boundaries of the sooted ceiling, two loom sockets, the edge of the plaster dado, and the general locations of embellishments, including an Awanyu and a small section of plaster mural. These measurements were taken by dropping a plumb bob from the location of the feature and measuring to where the plumb bob came to rest on the ground from one of the stationary tapes. These features were drawn on a separate sheet of vellum that was placed over the floor map. The lines representing the stationary tapes were traced, allowing the maps to be easily lined up and showing the relationship between floor features, ceiling features, and wall features.

A third sheet of vellum was used to map the masonry wall that marks the outside boundary of Snake Kiva, and the metal posts of the railing that blocks entry by the public. Also on this third sheet of vellum were the floor boundaries of the cavate that were closest to the cavate opening. Because of their position, it was difficult to map these from the original stationary tapes, and so auxiliary tapes were placed to allow them to be measured. Once finished, this third sheet of vellum was placed under the original map and the components on it were traced and incorporated into the overall representation.

Once all of the major floor and ceiling features and embellishments had been satisfactorily mapped, the floor of Snake Kiva was re-covered with the fill that had been removed to neighboring cavate Ee022 and the cavate was again opened for public viewing. The hand drawings were taken back to the Vanishing Treasures office and scanned on the Epson Expression 1600 scanner. These images were then opened in AutoCAD, allowing Stephen Merkel and Karim Hassanein to digitally trace the lines and assign distinct components, such as loom features and unexcavated fill, to different layers. Viewing the map in AutoCAD gives one more control over what layers are visible at one time, and provides tools for recognizing relationships between unique features. Floor maps and feature descriptions can be found in **Appendices D** and **E**.

Mapping the floor of Snake Kiva was an important part of this season's field work, both for the documentation it produced and for the educational opportunity it presented for Vanishing Treasures staff in terms of learning the skills involved in hand drawn mapping. Cavates are constantly being eroded by water and those located on or near the visitor trail are especially susceptible to damage and loss due to visitor impact. As the Snake Kiva Hewett Overlay in **Appendix D** shows, just under half of the original floor material of Snake Kiva has eroded since 1909. In addition, several floor features, including four loom anchors, have since disappeared.

Mapping the floors of highly impacted cavates allows them to be studied and documented with a minimum amount of exposure. While it is not necessary that all cavate floors be mapped, creating a collection of floor maps of those cavates with unique and instructive features may be a valuable resource for future research and interpretation.

Drainage Control and Vegetation Removal at Snake Kiva

Stephen Merkel

Damaging vegetation and drainage were identified on the left (west) side, of the cavate. A small pinion tree was growing into the cavate floor and was cracking the rock in which it was growing. The tree was cut near base of the trunk and the upper portion of the tree was removed. Water flowing down the cliff-face could enter the cavate and a large portion of the floor has been lost most likely due to this water flow. To prevent further deterioration caused by water flowing at the base of the cliff, three stones were added to the left side to redirect the water to the exterior. The masonry was laid with the Tyuonyi mortar mix with 25% El Rey Acrylic amendment. This mortar was also pointed into the gap that had formed between the bedrock and the low cement wall that was installed in front of the cavate some time ago. Dripping water from above may also have a significant impact to the floor. Driplines would be required to redirect this water, and this has not been done.

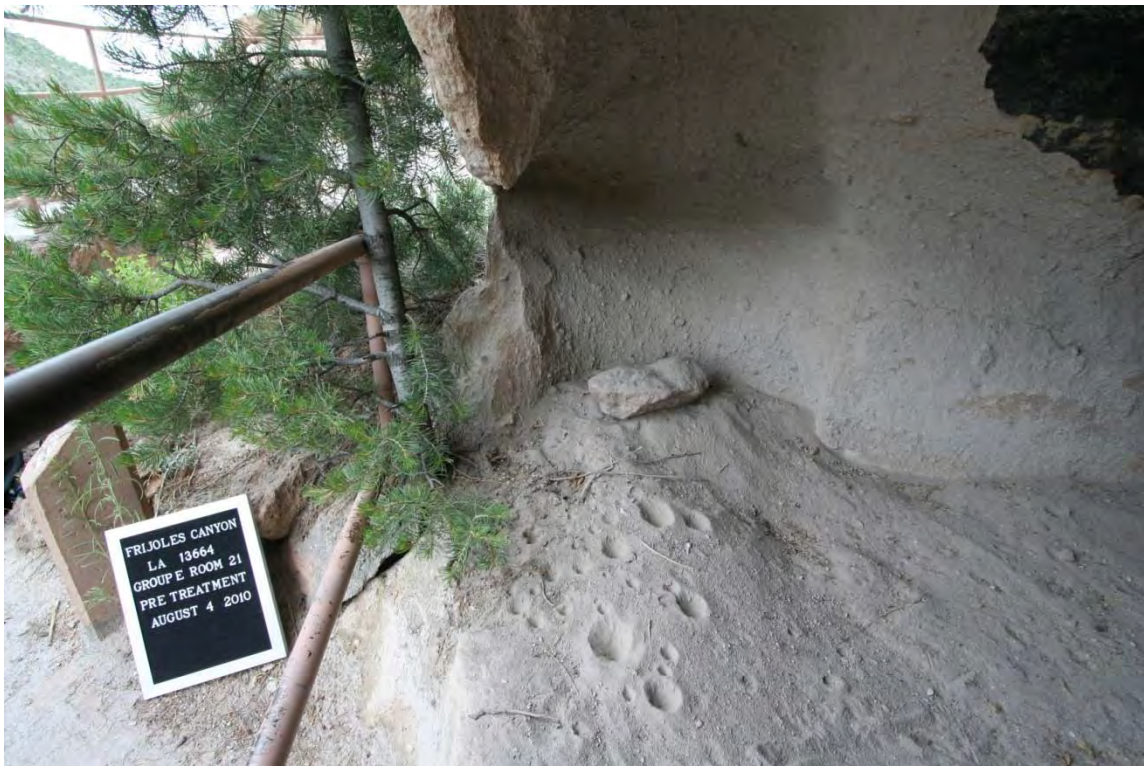


Figure 65: Snake Kiva before treatment showing the pinion tree and the water flow



Figure 66: Snake Kiva shortly after treatment showing pinion stump, the added masonry and areas where mortar was pointed below the cement wall. The mud flow above the left side of the cavate has not been addressed. It would require a dripline to redirect or control the water.



Figure 67: Snake Kiva after treatment

Drainage Control Treatment at I 026

Stephen Merkel

The smoke hole of cavate I 026 has been directing water and mudflows into the interior of the cavate. It is a high priority cavate due to its remarkably intact interior with unique floor features. The drainage problem above the doorway on the south side of the cavate has caused significant loss of original surfaces, erosion around the doorway and undercutting at the edges of the impacted areas.



Figure 68: I 026 Smoke hole exterior before treatment

Treatment involved applying a ridge within the smoke hole to redirect water flow away from the opening. The surface was wetted and cleaned of mud and a U-shaped ridge of mortar was formed on the interior of the smoke hole. The mixture used is 2 parts Group I tuff, 1 part Group A tuff, and 1 part hydrated hydraulic lime (HHL). The mortar material dried to a color lighter than the tuff, but as mudflows occur this will be covered over. In addition to this, the area where the ridge was applied is difficult to view if on the ground, and the area will eventually be coated in mudflow.



Figure 69: I 026 Smoke hole exterior after treatment

After the ridge was applied, the area around the smoke hole was tested for positive drainage flow. Water was sprayed above the ridge and it flowed away from the opening.

The color of the mortar used to construct the dam is lighter than the surrounding tuff, but it will eventually be covered with the same mud coating. The visual impact is negligible, and it will be even less so when it is naturally camouflaged by mudflows.



Figure 70: I 026 Exterior after treatment



Figure 71: Interior of Cavate I 026 showing damage caused by water flowing through the smoke hole.

Summary of Active CESU Agreements FY2010

Stephen Merkel

Introduction

A significant amount of work in Frijoles Canyon was carried out in conjunction with University of New Mexico (UNM) and New Mexico State University (UVM). In FY2010 there were four active CESU agreements. Work included analysis of the Bandelier Tuff, structural analysis and a field school in Graffiti Mitigation. The Scopes of Work for each of the four projects are reproduced in **Appendix R**.

Tuff Study with NMSU

In the Summer of 2009, Dr. Nancy McMillan and Dr. Frank Ramos began a study to characterize the anthropogenically altered layer of the Bandelier Tuff in Frijoles Canyon in order to understand weathering and erosion of the stone in which the cavates are constructed. Six types of stone were chosen for the study:

1. Case-Hardened Tuff with Lichen
2. Case-Hardened Tuff without Lichen
3. Fresh Tuff with Lichen
4. Fresh Tuff
5. Fresh Tuff with Clay Coatings
6. Fresh Tuff with Soot

Samples from Groups A and M were collected and subjected to numerous tests to characterize the physical and chemical properties of the stone. The testing is now complete and the report is currently in review. The expected completion date of this project is the 31st of August 2011.

Graffiti Mitigation Field School with UNM

In 2010, the National Park Service and the School of Architecture and Planning at the University of New Mexico jointly conducted a project entitled "Graffiti Mitigation in the Frijoles Canyon Cavates". This field school was organized by Doug Porter of UNM and Angelyn Bass-Rivera as a training workshop, and VT staff participated along with three UNM students. Field activities took place June 14-25, 2010 and were focused on treatment of graffiti in six cavates in the B group (B009, B012, B083, B132, B148, and B151). Graffiti damage in these cavates was typically incised in the sooted ceilings and plastered walls. Treatments were applied primarily to sooted ceilings in B132, B148, and B151; primarily to plasters in B009 and B083; and to plasters and sooted ceiling in B012. In all, approximately 21 instances of graffiti were concealed. The report is currently in review with an expected completion date of June 30th, 2011.

Structural Assessment and Monitoring of B 002, Phase I: Development of Project Methodology

This is a complex collaboration organized by Doug Porter and Angelyn Bass-Rivera with Western Mapping and engineers from MIT, Cambridge, the University of Vermont (UVM) and UNM. A virtual 3D model was created so that newly developed software could be used to determine the structural stability of the wall. The information obtained in this study will inform park staff as to the structural limits of the wall and what, if anything, needs to be done to protect it. Laser-scanning of the masonry enclosure wall of Cavate B 002 was undertaken early in FY2010 as part of an innovative structural assessment. With the model created from the laser-scan, John A. Ochsendorf, of MIT, developed software to do the structural analysis of the wall. The preliminary results show that the wall is structurally sound, but we are awaiting the final report, expected in the summer of 2011. A progress report for this project can be found in **Appendix S**.

Structural Assessment and Monitoring of B 002, Phase II: Tuff Testing and Analysis

This phase of the project is being undertaken by a student supervised by Doug Porter at UVM and is partially funded through this agreement and partially by a Barrett Scholarship. This phase of the study looks closely at the porosity and permeability of the stone around Cavate B 002 through a series of tests. By collating test results on volume porosity, pore area, pore size distribution, and water transport properties for each of the tuff compositions and weathering states, investigators will gain a basic understanding of their susceptibility to environmental deterioration. Profiles based on these measurements will provide powerful tools in the interpretation of weathering processes directly relating to cavate B002. These will play a critical role in subsequent research, including accelerated weathering, modeling of tuff hydrology, determination of erosion rates, and development of preservation strategies. The project will be completed by August 30th, 2011.

Frijoles Canyon Cavate Conservation Project Conclusions

Conclusions

The 2010 Field Season was successful in a number of ways. Masonry stabilization in the cavates has primarily been inactive since the mid-1970s, and little has been touched since 1940. Eleven masonry walls were fully documented stabilized using compatible earthen mortar. A water flow in Group I was redirected to mitigate water-caused damage in a high priority cavate. VT staff photographed 171 cavates for the Vanishing Treasures Cavate Photography Archive, two 360° spherical panoramas were produced of a cavate in Long House and a cavate cluster in Group F, and orthorectified photography was performed in two High Priority Cavates. The floor of Snake Kiva was mapped and photographed to document the condition of the floor today and to see how it had changed over time. Vegetation impacting Snake Kiva was removed, and a damaging waterflow was redirected outside the cavate. A plaster stabilization testing program initiated in 1999 was re-established and further developed.

Besides the accomplishments of our VT staff, much field work was undertaken by partnering institutions through CESU agreements. The University of New Mexico organized a field school in graffiti mitigation and treated 21 instances of graffiti in six cavates in Group B. Doug Porter is leading a multi-phase project to model and perform a structural assessment of B 002. Last, but not least, Dr. Nancy McMillan of New Mexico State University led a project to physically and chemically characterize the anthropogenically alter layer of the Bandelier Tuff in order to further understand the weathering phenomena impacting the cavates. We greatly appreciate the work undertaken by our partners, and we are looking forward to the final results and conclusions of the projects in 2011.

Future Recommendations

There are several areas for future work. In regard to masonry stabilization, ten cavates in Frijoles Canyon remain unstabilized, four of which have severe loss of mortar or are undercut and need stabilization. Cavate Photography needs to be continued to complete the Cavate Photography Archive. The 360° panoramic photography has proven to be an excellent way to record cavate interiors and work in this direction should continue. In the 2011 Season it is recommended that drainage control be closely considered, plasters be re-evaluated based on treatability determined in the 2010 Plaster Stabilization Report, and that further treatment testing to control drainage and stabilize plaster should be continued.

Appendix A:

Working Photos

Cavate Masonry Stabilization



Stabilization of the masonry lintel at Cavate M 123 with Johnny Holdsworth



Stabilization of masonry at A 010 with Stephen Merkel

Masonry Stabilization at the M 100 Group



Stabilization of masonry associated with Cavate M 095 with Eli Logan and Sarah Stokely



Pre treatment of I 010 with Karim Hassanein

Plaster Re-attachment



Stephen Merkel injecting gelating to reattach plaster in Cavate M 093 North Interior
Cavate M 093 North Interior



Rachel Adler cleaning delaminating plaster in Cavate M 093 East Interior before stablization

Documentation



Recording imagery in Cavate Fb 013 (Sarah Stokely and Rachel Adler)


Historic imagery in Cavate Ff 025

Backcountry Trip



Exiting Capulin Canyon



Resting at Turkey Spring (Ashley Crossen, Eli Logan, Stephen Merkel and Rachel Adler)



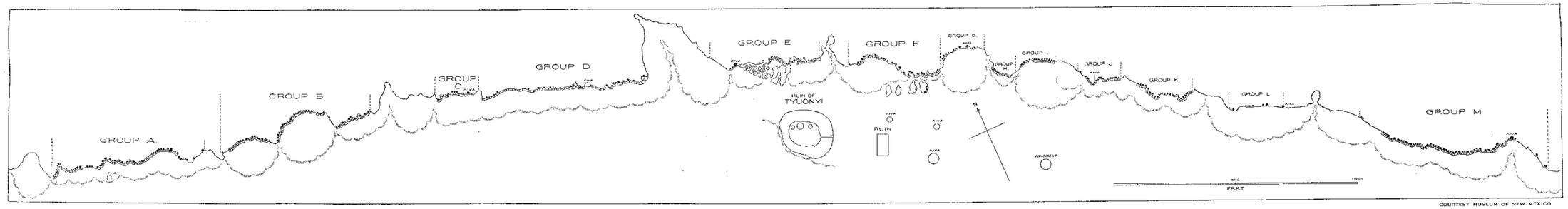
Will Goumas at a petroglyph panel near San Miguel



Front row (Left to Right): Will Goumas, Eli Logan, John Brenneman, Karim Hassanein, Cliff Hickey, Johnny Holdsworth, and Rachel Adler. Back row (Left to Right): Ashley Crossen, Stephen Merkel, and Marty Davenport. Unfortunately Shannon Dennison was absent.

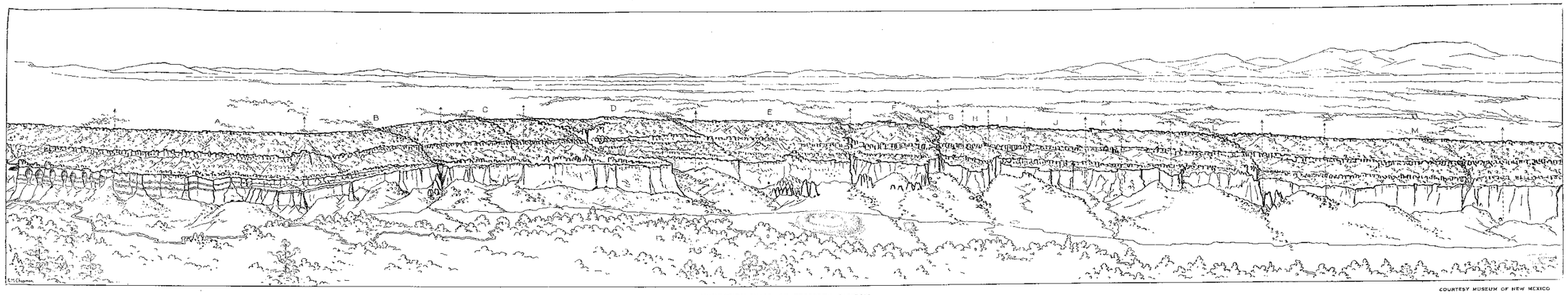
Appendix B:

Cavate Group Maps



GROUND PLAN OF FRIJOLES CANYON. RUINS AREA

COURTESY MUSEUM OF NEW MEXICO



NORTHERN WALL OF FRIJOLES CANYON

COURTESY MUSEUM OF NEW MEXICO

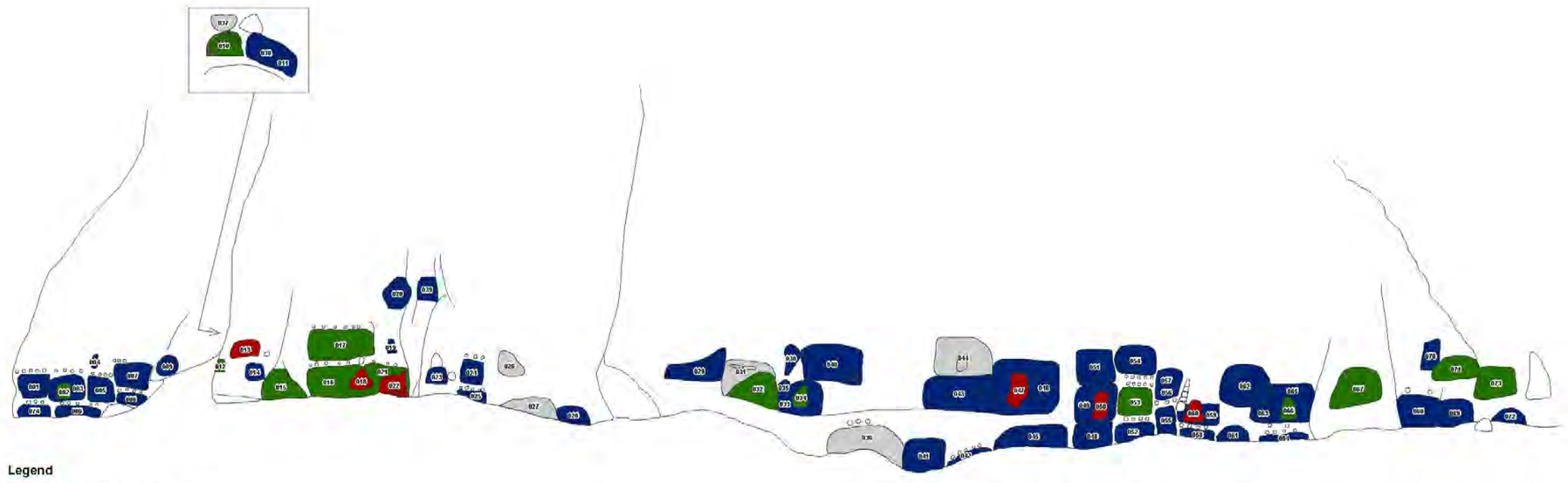
LA 50973
Frijoles Canyon Cavates

Group A West: Management Priorities

L. Meyer 2005 Based on M. Slater 1999, H. Toll 1986 (west half) / R. Winters 1999 (east half)

Scale (in meters)

0 10 20



Legend

- High priority for treatment
- Medium priority for treatment
- Low priority for treatment
- Indeterminate (unable to be assessed due to location or safety issues)
- N/A (see *Note)

*Note: Between 1986 (west half) and 1999 (east half), the Bandelier Archaeological Survey identified 150 units in Group A, Frijoles Canyon. Architectural and condition assessments for the group were completed in 2004, and at that time 8 of these were determined to be natural features. The areas in which these units were reported to be exhibit no evidence of human modification. They have been given a "N/A" designation for both structure type and management priority, but were not removed from the numbering system in order to retain continuity between projects. 142 units have been identified by the Frijoles Canyon Cavate Conservation Project in Group A. They are numbered consecutively; there are no panels and no numbers repeat.

Map No.:	1
Title of map:	Frijoles Canyon Cavates Group A West: Management Priorities
Prepared by: L Meyer 05/2005	Based on: M. Slater 1999
LA 50973	UNITED STATES DEPARTMENT OF THE INTERIOR NATIONAL PARK SERVICE BANDELIER NATIONAL MONUMENT

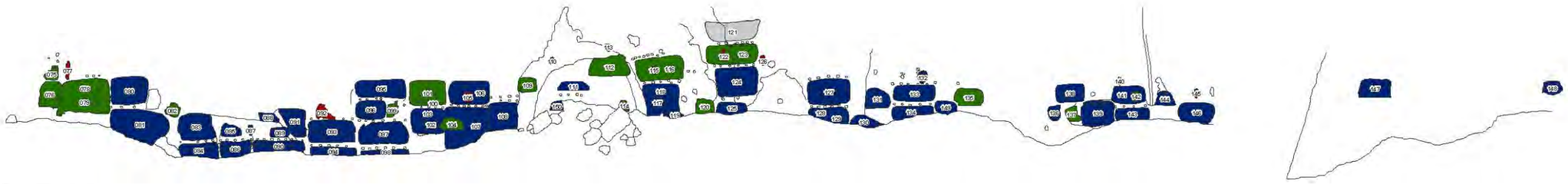
LA 50973
Frijoles Canyon Cavates

Group A East: Management Priorities

L. Meyer 2005 Based on M. Slater 1999, H. Toll 1986 (west half) / R. Winters 1999 (east half)

Scale (in meters)

0 10 20



Legend

- High priority for treatment
- Medium priority for treatment
- Low priority for treatment
- Indeterminate (unable to be assessed due to location or safety issues)
- N/A (see *Note)

*Note: Between 1986 (west half) and 1999 (east half), the Bandelier Archaeological Survey identified 150 units in Group A, Frijoles Canyon. Architectural and condition assessments for the group were completed in 2004, and at that time 8 of these were determined to be natural features. The areas in which these units were reported to be exhibit no evidence of human modification. They have been given a "N/A" designation for both structure type and management priority, but were not removed from the numbering system in order to retain continuity between projects. 142 units have been identified by the Frijoles Canyon Cavate Conservation Project in Group A. They are numbered consecutively; there are no panels and no numbers repeat.

Map No. 2

Title of map: Frijoles Canyon Cavates Group A East: Management Priorities

Prepared by: L. Meyer 05/2005

Based on: M. Slater 11/1999

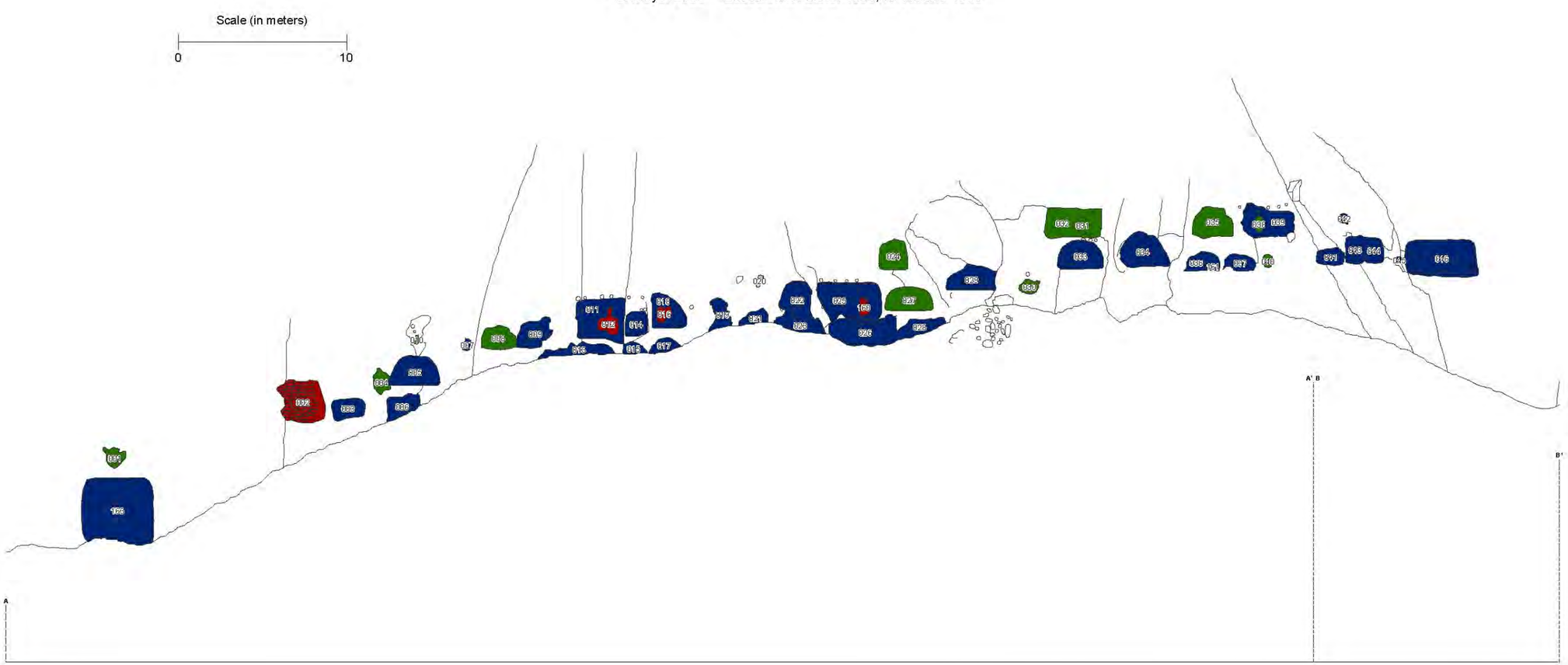
LA 50973

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
BANDELIER NATIONAL MONUMENT

LA 140939
Frijoles Canyon Cavates

Group B West: Management Priorities

L. Meyer 2005 Based on M. Slater 1999, R. Winters 1999



Legend

- High priority for treatment
- Medium priority for treatment
- Low priority for treatment
- N/A (see *Note)

*Note: 152 units have been documented in Group B, Frijoles Canyon. Architectural and condition assessments for the group were completed in 2004 by the Frijoles Canyon Cavate Conservation Project, and at that time 11 units that were identified during the intial mapping campaign in 1999 were determined to be natural features. The areas in which these units were reported to be exhibit no evidence of human modification. They have been given a "N/A" designation for both structure type and management priority, but were not removed from the numbering system in order to retain continuity between projects. The units in Group B are numbered consecutively, beginning in panel A and ending in panel G. Theree are no repeating numbers.

Map No. 3

Title of map: Frijoles Canyon Cavates Group B West: Management Priorities

Prepared by: L. Meyer 05/2005

Based on: M. Slater 11/1999

LA 140939

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
BANDELIER NATIONAL MONUMENT

LA 140939
Frijoles Canyon Cavates

Group B Center: Management Priorities

L. Meyer 2005 Based on M. Slater 1999, R. Winters 1999



Legend

- High priority for treatment
- Medium priority for treatment
- Low priority for treatment
- N/A (see *Note)

*Note: 152 units have been documented in Group B, Frijoles Canyon. Architectural and condition assessments for the group were completed in 2004 by the Frijoles Canyon Cavate Conservation Project, and at that time 11 units that were identified during the intial mapping campaign in 1999 were determined to be natural features. The areas in which these units were reported to be exhibit no evidence of human modification. They have been given a "N/A" designation for both structure type and management priority, but were not removed from the numbering system in order to retain continuity between projects. The units in Group B are numbered consecutively, beginning in panel A and ending in panel G. Theree are no repeating numbers.

Map No. 4

Title of map: Frijoles Canyon Cavates Group B Center: Management Priorities

Prepared by: L M eyer 05/2005

Based on: M . Slater 11/1999

LA 140939

UNITED STATES DEPARTMENT OF THE INTERIOR NATIONAL PARK SERVICE BANDELIER NATIONAL MONUMENT

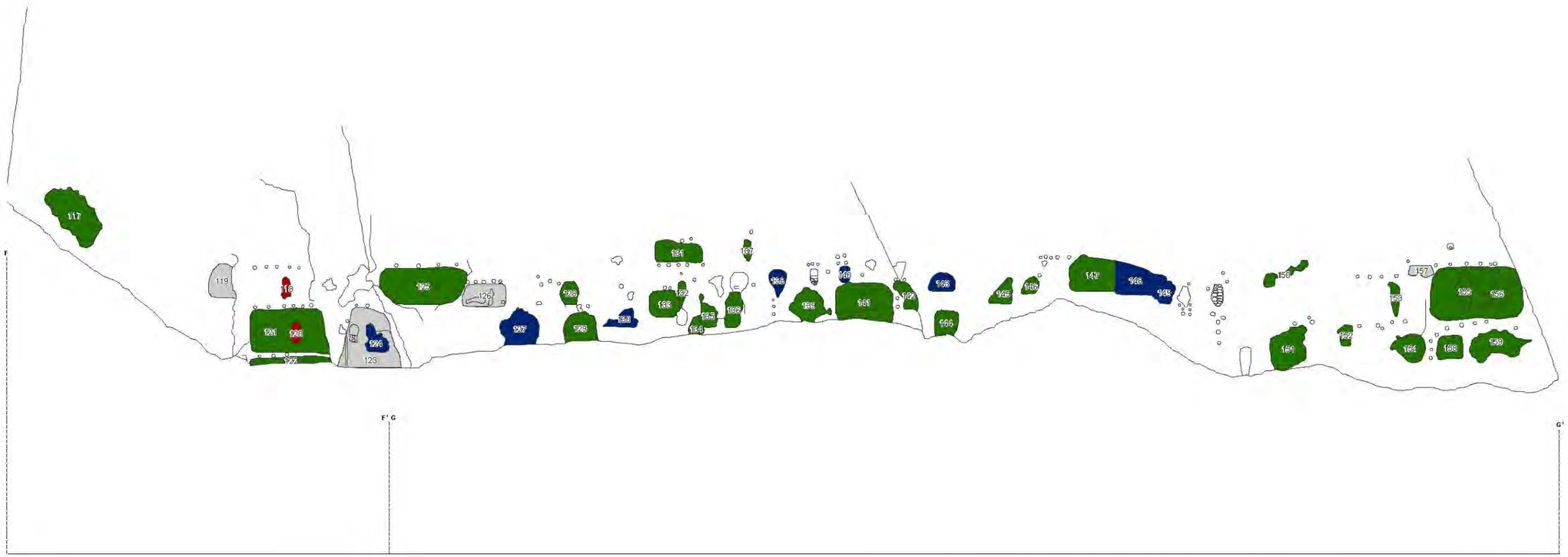
LA 140939
Frijoles Canyon Cavates

Group B East: Management Priorities

Scale (in meters)

0 10

L. Meyer 2005 Based on M. Slater 1999, R. Winters 1999



Legend

- High priority for treatment
- Medium priority for treatment
- Low priority for treatment
- N/A (see *Note)

*Note: 152 units have been documented in Group B, Frijoles Canyon. Architectural and condition assessments for the group were completed in 2004 by the Frijoles Canyon Cavate Conservation Project, and at that time 11 units that were identified during the intial mapping campaign in 1999 were determined to be natural features. The areas in which these units were reported to be exhibit no evidence of human modification. They have been given a "N/A" designation for both structure type and management priority, but were not removed from the numbering system in order to retain continuity between projects. The units in Group B are numbered consecutively, beginning in panel A and ending in panel G. Theree are no repeating numbers.

Map No. 5

Title of map: Frijoles Canyon Cavates Group B East: Management Priorities

Prepared by: L. Meyer 05/2005

Based on: M. Slater 11/1999

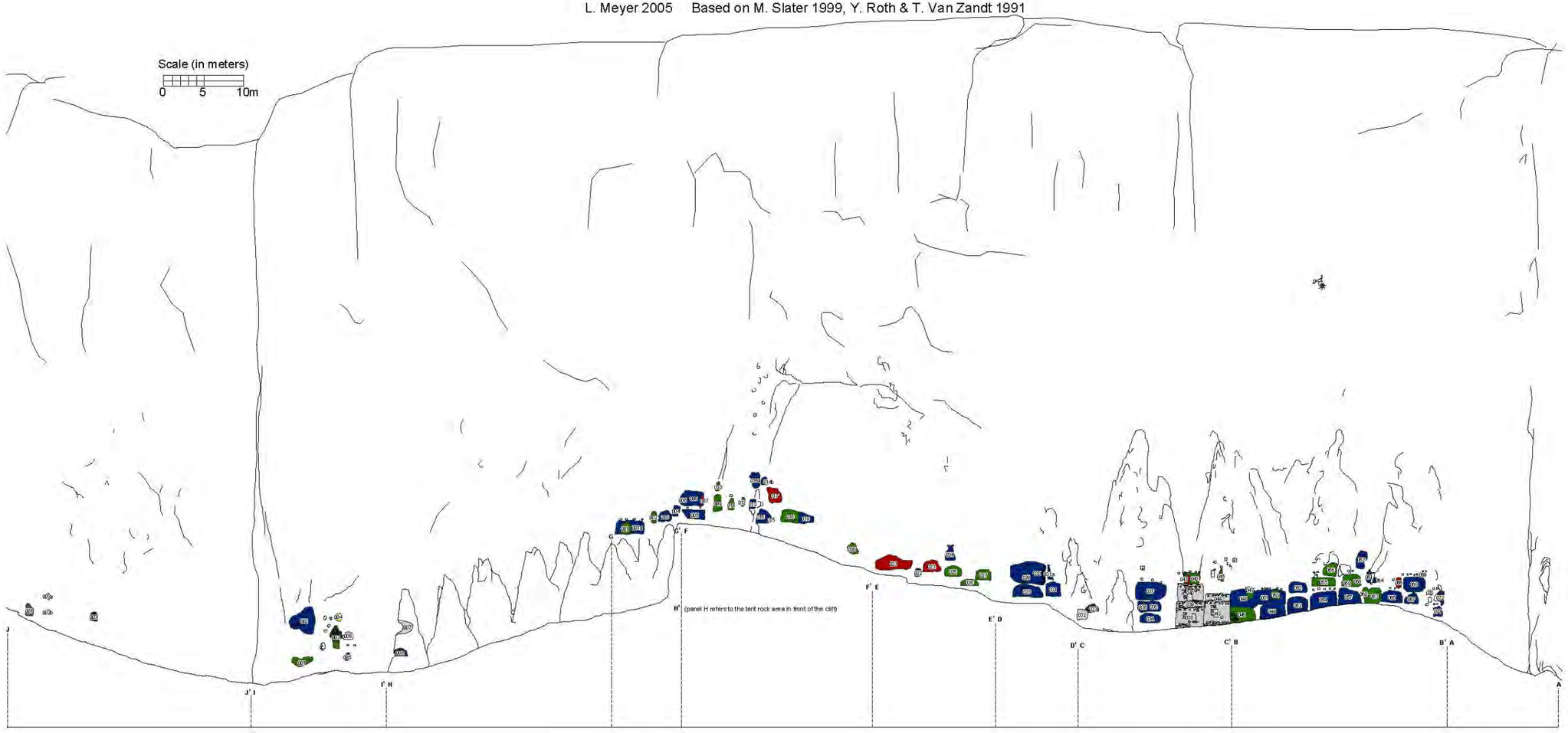
LA 140939

UNITED STATES DEPARTMENT OF THE INTERIOR NATIONAL PARK SERVICE BANDELIER NATIONAL MONUMENT

LA 13664
Frijoles Canyon Cavates

Group E: Management Priorities

L. Meyer 2005 Based on M. Slater 1999, Y. Roth & T. Van Zandt 1991



Map No.	9
Title of map:	Frijoles Canyon Cavates Group E: Management Priorities
Prepared by:	L. Meyer 05/2005
Based on:	M. Slater 11/1999
LA 13664	UNITED STATES DEPARTMENT OF THE INTERIOR NATIONAL PARK SERVICE BANDELIER NATIONAL MONUMENT

Legend

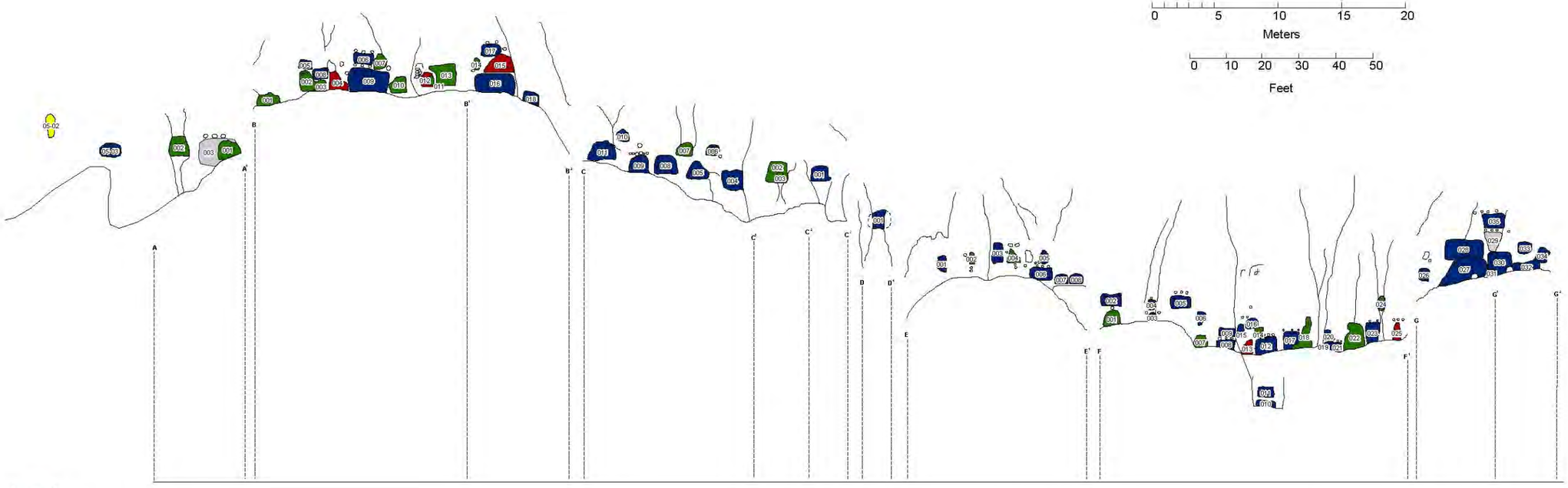
- High priority for treatment
- Medium priority for treatment
- Low priority for treatment
- Indeterminate (unable to be assessed due to location or safety issues)

*Note: In 1990, the Bandelier Archaeological Survey identified 82 units and 5 masonry rooms in Group E, Frijoles Canyon. Architectural and condition assessments for the group were completed in 2004, and at that time 3 of these units were determined to be natural features. The areas in which these units were reported to be exhibit no evidence of human modification. They have been given a "N/A" designation for both structure type and management priority, but were not removed from the numbering system in order to retain continuity between projects. The five rooms of talus house were also given a "N/A" designation for management priority, as they are masonry rooms that were not assessed in the cavate study. 79 units have been identified by the Frijoles Canyon Cavate Conservation Project in Group E.

LA 50975
Frijoles Canyon Cavates

Group F: Management Priorities

L. Meyer 2005 Based on M. Slater 1999, J. Snead & H. Newman 1990



Legend

- High priority for treatment
- Medium priority for treatment
- Low priority for treatment
- Indeterminate (unable to be assessed due to location or safety issues)
- N/A (see *Note)

*Note: In 1990, the Bandelier Archaeological Survey identified 77 units in Group F and 13 units in the tent rocks below the group (the units within the tent rocks do not appear in this map, although they do appear on the plan of this group). In 2004, architectural documentation and condition assessment was completed by the Frijoles Canyon Cavate Conservation Project, and at that time 1 unit that was identified during the intial mapping campaign in 1990 was determined to be a natural feature. The area in which this unit was reported to be exhibits no evidence of human modification. It has been given a "N/A" designation for both structure type and management priority, but has not been removed from the numbering system in order to retain continuity between projects. In Group F, units are numbered consecutively within defined panels.

Map No. 10

Title of map: Frijoles Canyon Cavates Group F: Management Priorities

Prepared by: L. Meyer 06/2005

Based on: M. Slater 12/1999

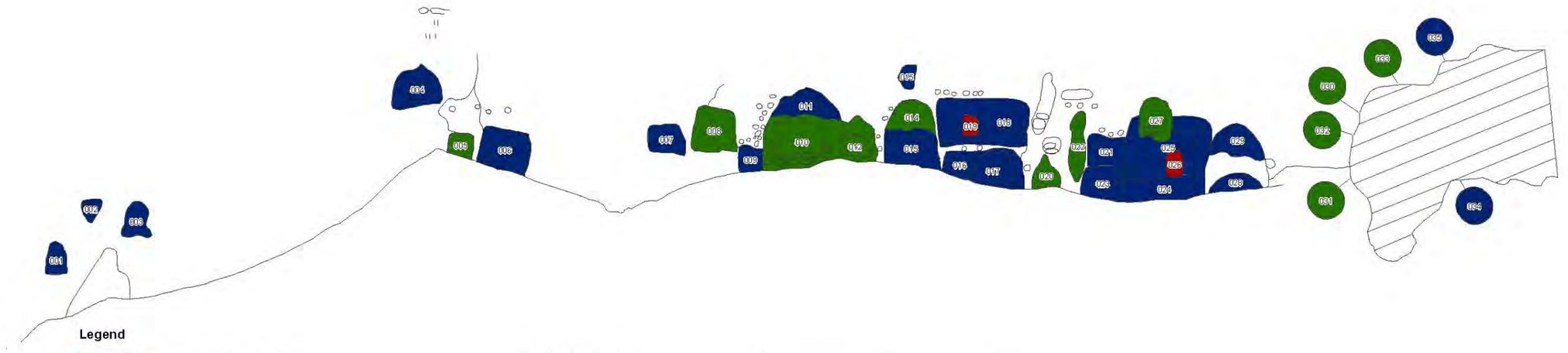
LA 50975

UNITED STATES DEPARTMENT OF THE INTERIOR NATIONAL PARK SERVICE BANDELIER NATIONAL MONUMENT

LA 50974
Frijoles Canyon Cavates

Group I: Management Priorities

L. Meyer 2005 Based on M. Slater 1999, G. Head & A. Prieto 1990



Legend

- High priority for treatment
- Medium priority for treatment
- Low priority for treatment

0 5 10 15 20

Meters

0 10 20 30 40 50 60

Feet

*Note: 35 units have been identified by the Frijoles Canyon Cavate Conservation Project in Group I. Units 30 through 35 are behind a large rock fall which obscures them from view. The units in Group I are numbered consecutively and there are no panels.

Map No. 13

Title of map: Frijoles Canyon Cavates Group I: Management Priorities

Prepared by: L Meyer 06/2005

Based on: M. Slater 12/1999

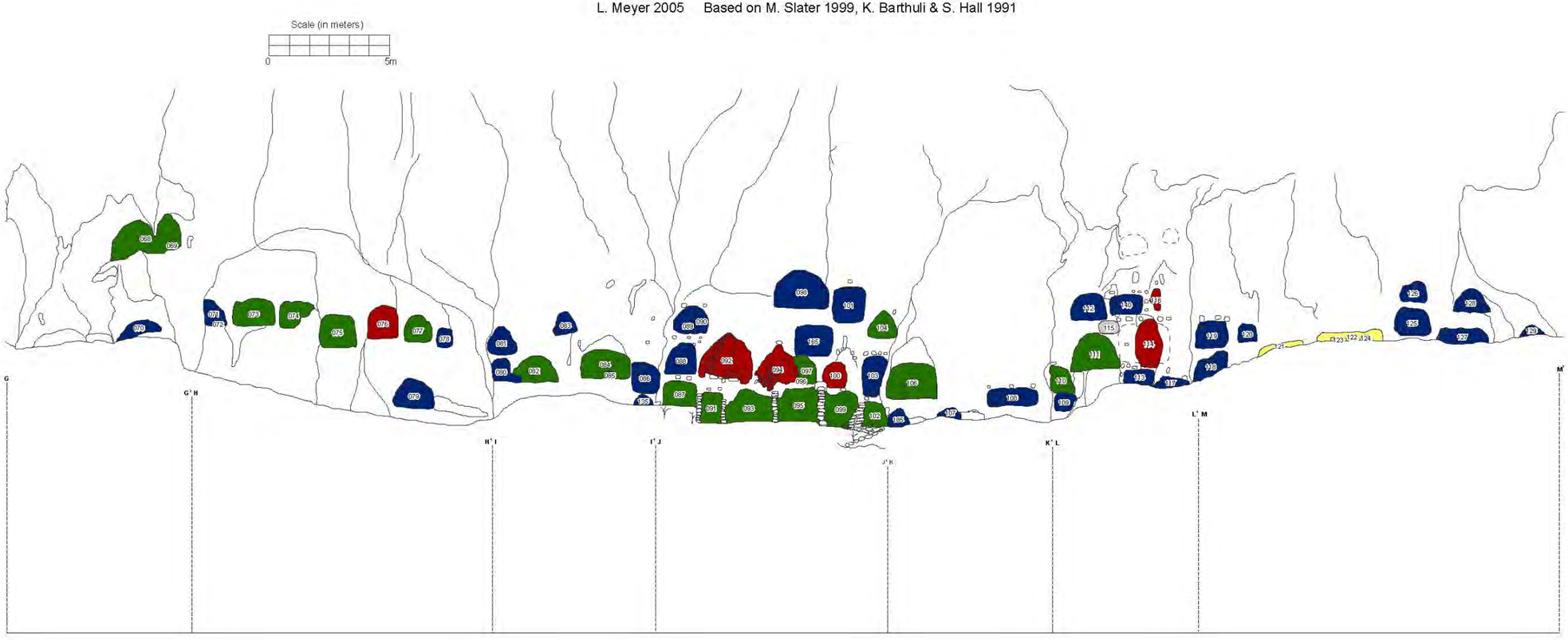
LA 50974

UNITED STATES DEPARTMENT OF THE INTERIOR NATIONAL PARK SERVICE BANDELIER NATIONAL MONUMENT

LA 50972
Frijoles Canyon Cavates

Group M Center: Management Priorities

L. Meyer 2005 Based on M. Slater 1999, K. Barthuli & S. Hall 1991



Legend

- High priority for treatment
- Medium priority for treatment
- Low priority for treatment
- Indeterminate (unable to be assessed due to location or safety issues)
- N/A (see *Note)

*Note: In 1991, the Bandelier Archaeological Survey identified 165 units in Group M, Frijoles Canyon. Architectural and condition assessments for the group were completed in 2004, and at that time 8 of these were determined to be natural features. The areas in which these units were reported to be exhibit no evidence of human modification. They have been given a "N/A" designation for both structure type and management priority, but were not removed from the numbering system in order to retain continuity between projects. Also as a result of this 2004 documentation, 2 additional units were identified. 159 units have been identified by the Frijoles Canyon Cavate Conservation Project in Group M. They are numbered consecutively; no numbers repeat.

Map No. 18

Title of map: Frijoles Canyon Cavates Group M Center: Management Priorities

Prepared by: L. Meyer 06/2005

Based on: M. Slater 12/1999

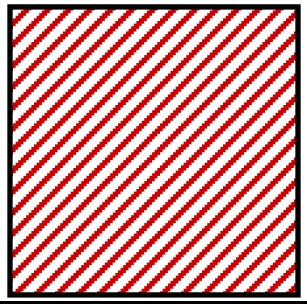
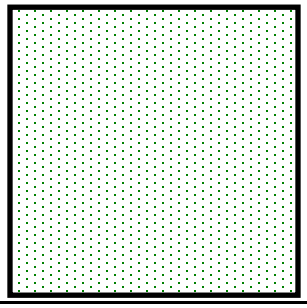
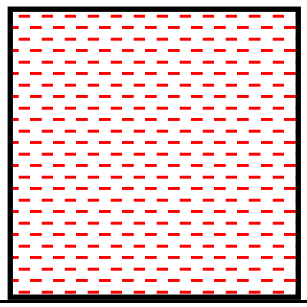
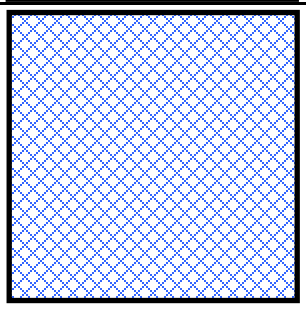
LA 50974

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
BANDELIER NATIONAL MONUMENT

Appendix C:

Illustrated Glossary of Conditions and Features

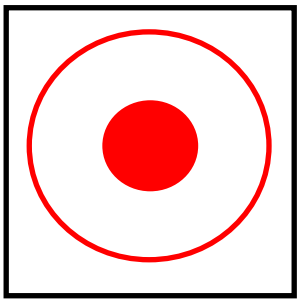
BAND Cavate Documentation and Condition Assessment
Key to Graphic Condition Assessment

Loss of total original: Complete absence of surface finish from substrate based on total original extent.		
Friability: Active granular disaggregation of the rock or finishes resulting in a coarse texture.		
Detachment (can refer to plaster or rock): Separation of or voids at the rock/plaster interface or within the rock.		
Delamination / flaking: The separation and lifting of discreet layers of finishes from each other.		

BAND Cavate Documentation and Condition Assessment
Key to Graphic Condition Assessment

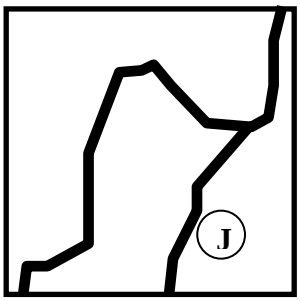
Blistering:

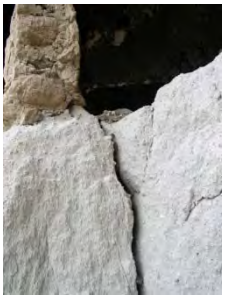
Localized, small scale swelling and/or rupturing of the finish layer.



Structural cracking:

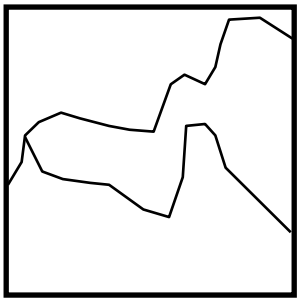
Major linear discontinuities in the rock or masonry, including geologic joints.





Non-structural cracking:

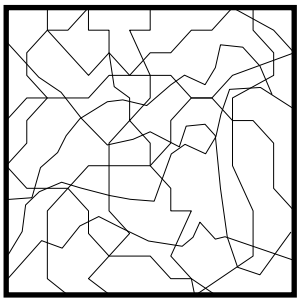
Fractures of variable length and orientation in the rock or masonry, not the result of structural settlement or movement.





Map cracking:

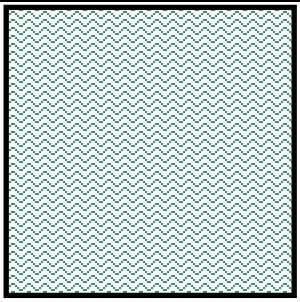
Fine pattern cracking over an area of the finishes.





Mud flow:

Discoloration of the rock or finishes caused by the flow of water and mud over surfaces.

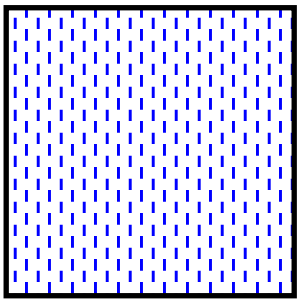




BAND Cavate Documentation and Condition Assessment
Key to Graphic Condition Assessment

Accretions:

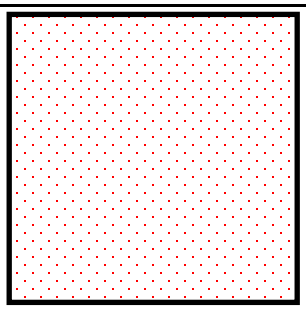
Discoloration of the rock or finishes caused by the deposition of a foreign substance such as animal excrement; does not apply to oxidation or soot.





Mechanical damage:

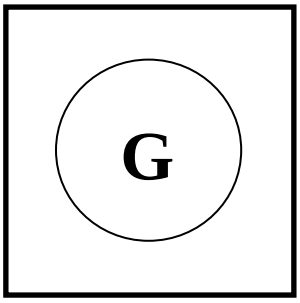
Discrete areas of damage or loss caused by a clearly discernable external impact or force, such as visitor abrasion or pull out.





Graffiti / vandalism:

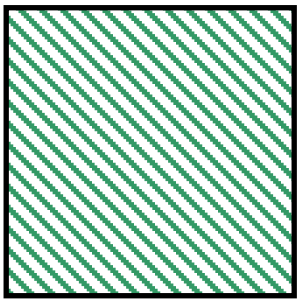
Modern, intentially inscribed or applied markings on the rock or finishes such as names or dates.





Rock undercutting:

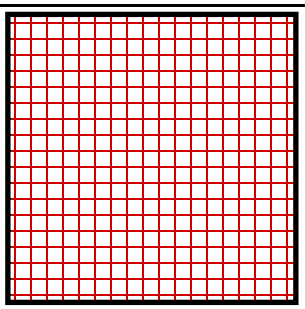
The undermining of rock resulting in an overhanging portion in relief; usually occurs on the ceiling near the entrance, around openings or at the cavate base, interior or exterior.





Surface weathering (of the tuff):

The dimensional loss of surface material of the tuff due to active and severe weathering.

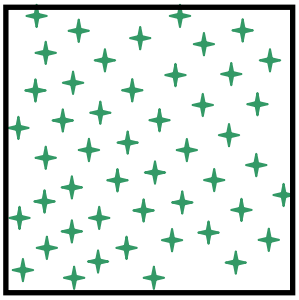




BAND Cavate Documentation and Condition Assessment
Key to Graphic Condition Assessment

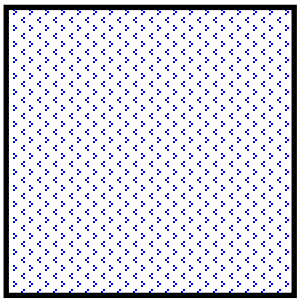
Efflorescence:

White crystalline deposits composed of insoluble and soluble salts (includes leaching deposits). Not a common condition in the cavates.



Biological growth:

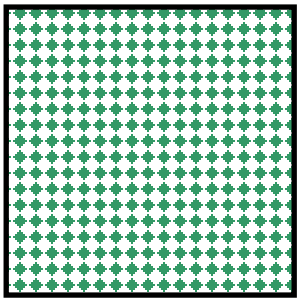
The presence of microflora (algae, fungi, and/or lichen) on the surface that is visible as green, brown, orange or black areas.





Vegetation:

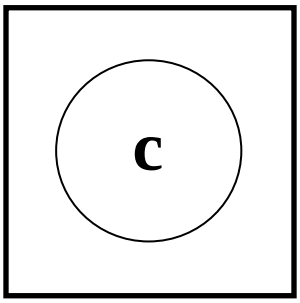
The presence of higher plant forms or the roots thereof.





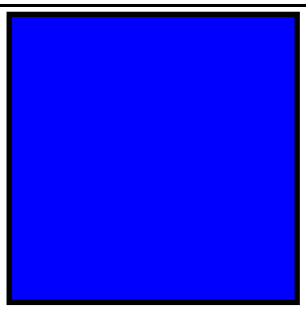
Condition – Unique:

Any condition that does not fall into above categories (describe in a notation).



Modern treatment:

Deteriorated area has been treated (indicate type of treatment as a note and see treatment documentation for detailed information).





BAND Cavate Documentation and Condition Assessment

Feature Types

Doorway / entrance:
Intentionally shaped opening to the outside; mostly rectangular with some oval and trapezoidal variants; some show evidence of having had lintels and / or slots in the jambs



Interior doorway:
Doorway leading from one chamber into another.



Firepit / hearth:
Pit, generally in the center of a room, which shows evidence of burning.



Floor box:
Plaster lined box built into and up from the floor of a cavate. There exists no evidence of burning in or around feature.



Floor level niche:
Niche at floor level with substantial volume. Most are plastered and / or smoked on the interior, and have rectilinear or curvilinear openings. These niches were likely used for storage functions.



Wall niche:
Small niche, usually some distance from the floor. Most are plastered and / or smoked on the interior and are round or rectilinear in shape.



Floor pit complex:
Grouping of concave depressions excavated through the plaster and into the tuff floor of a cavate for which a function has yet to be determined.



Metate rest:
Feature related to grinding and catching meal. Most remain as an inclined adobe line rising from floor level. Related features might include worn areas in the wall from abrasion, and slots related to storage areas.



Slot:
Excavated vertical or horizontal elongated ovals, often found at or near floor level. Slots are often associated with other features such as metate rests or floor ridges.



Floor ridge:
Raised floor feature usually running across the width (short dimension) of a cavate and constructed of built up plaster layers. The function of these ridges is unknown.



BAND Cavate Documentation and Condition Assessment

Feature Types

Loom anchors:
Wooden loops cemented into cavate floor which may have served as basal anchors for a loom. Usually occur in a straight line and in a series of four or more.




Upper loom support:
Large, deep beam holes found at or near ceiling level which are angled towards the floor. Usually found in association with loom anchors.



Smokehole:
Round openings in the closure wall of a chamber which are usually found above doorways. Usually quite large in diameter and angle upward as they pass to the outside.



Vent:
Small hole which passes through a wall that is not either a door or a smokehole. Includes holes which pass between rooms and those which pass to the outside.



Viga hole:
Round or square beam supports, often found in the cliff face, which would have provided roof / floor support to former masonry constructions. Viga holes tend to be large and deep, and appear in rows.



Indeterminate hole:
Any hole for which a function can not be assigned.



Bench: A bench appears as an unexcavated rectilinear platform that rises from the floor and has sharp edges and a smooth, flat top.

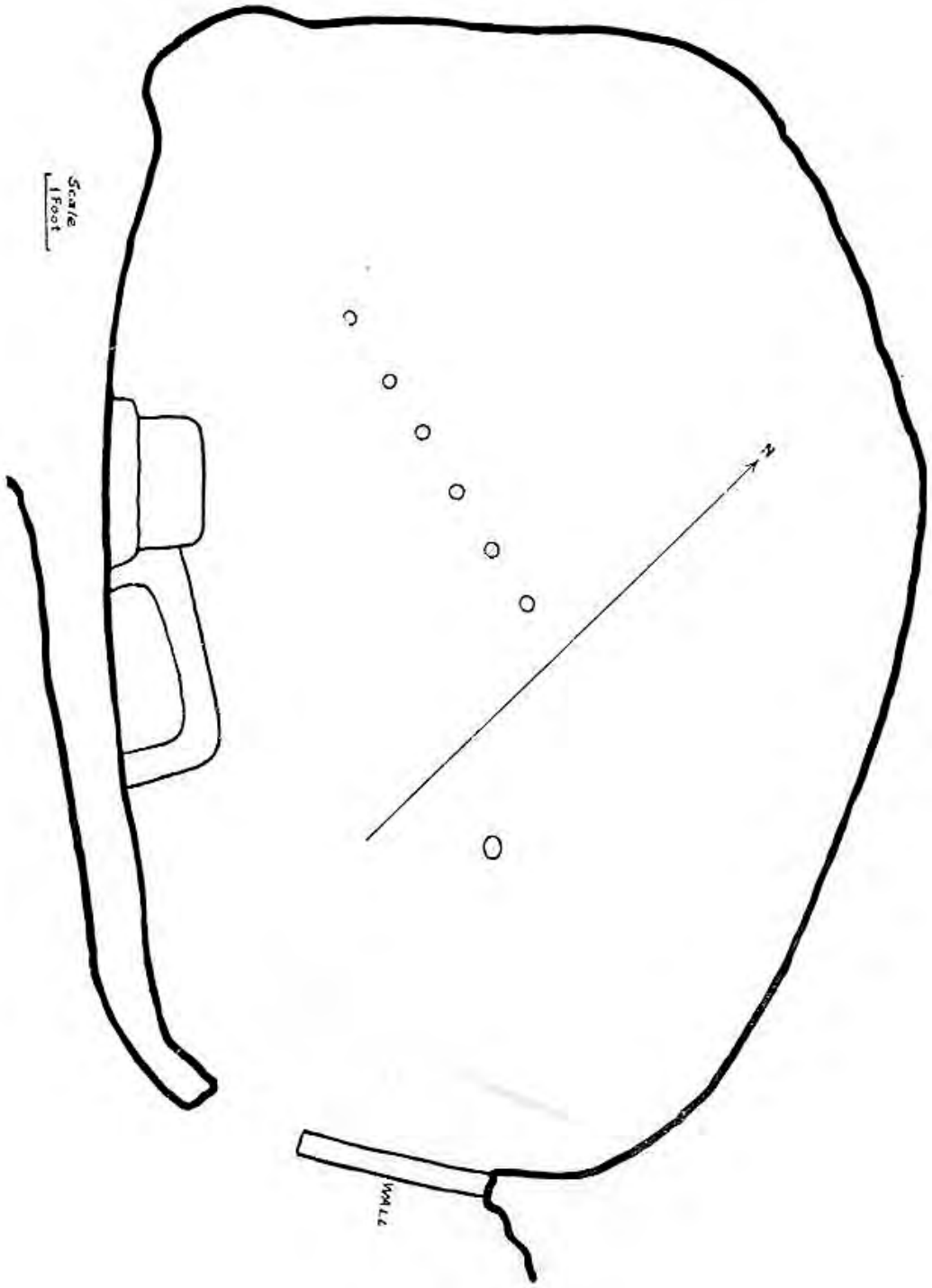


Socket: Round or square beam support that appears on the interior wall of a cavate. These holes often have a matching hole on the parallel wall. They tend to be large and deep.

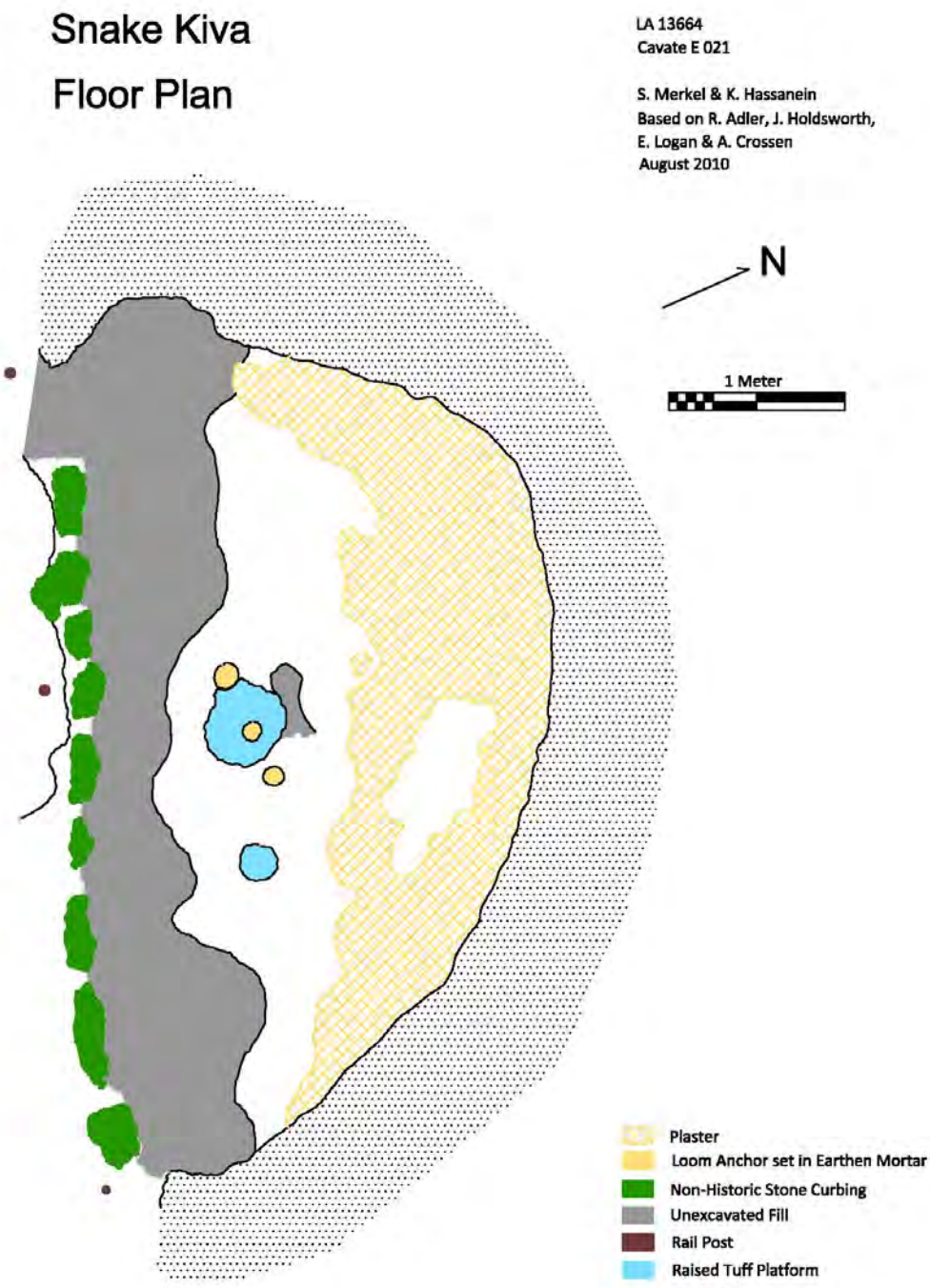


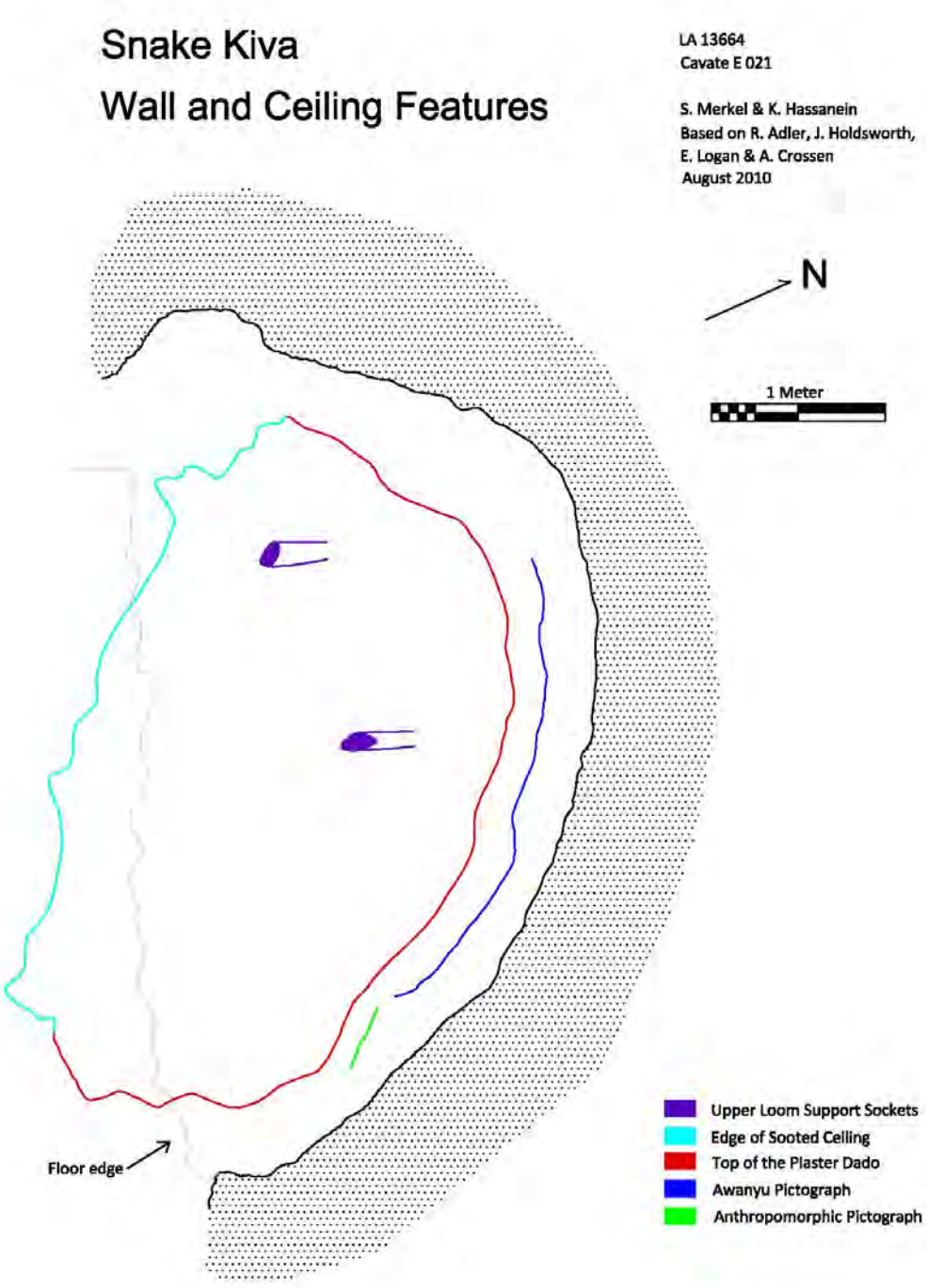
Appendix D:

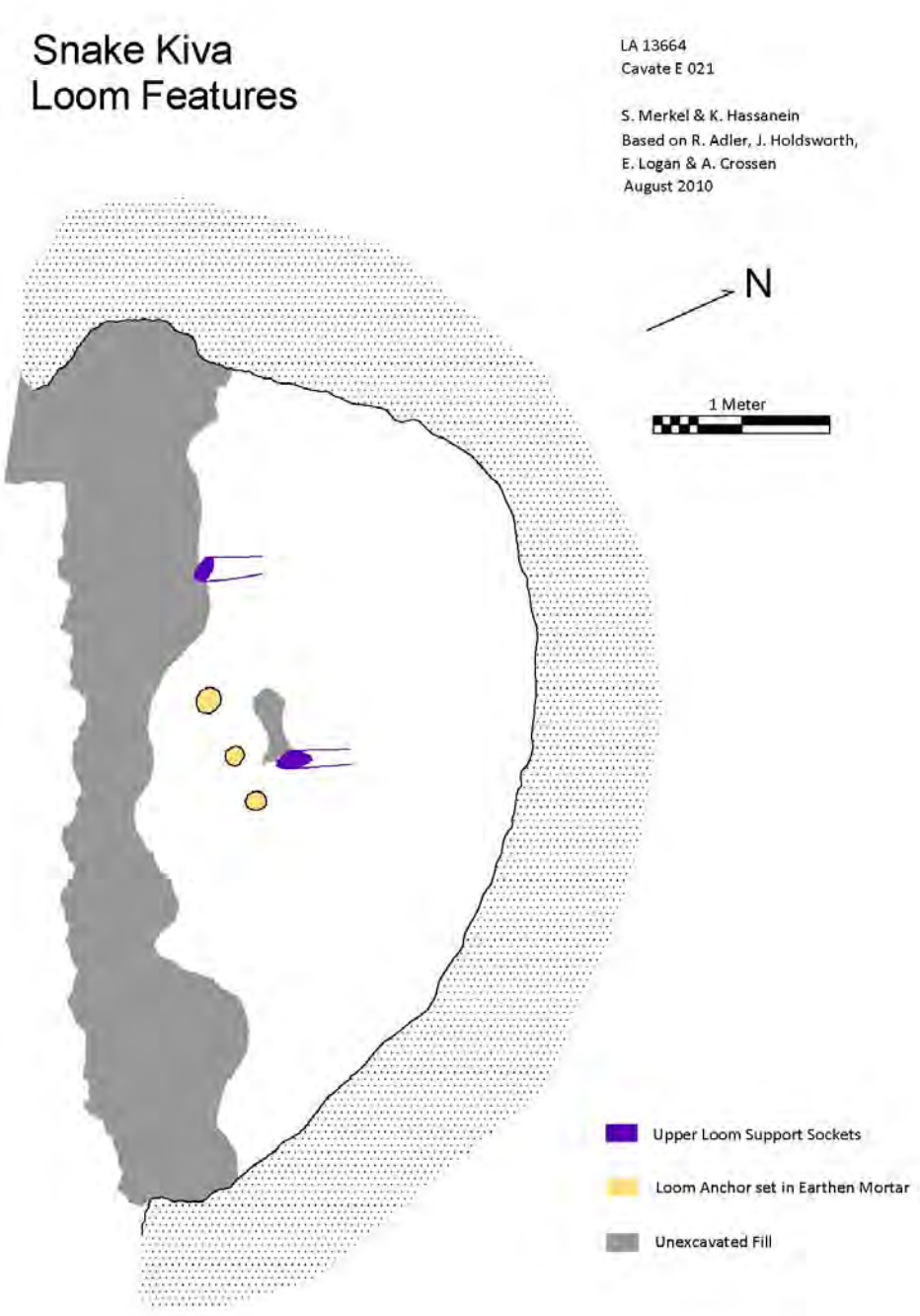
Floor Maps of Snake Kiva
Cavate E 021, LA 13664

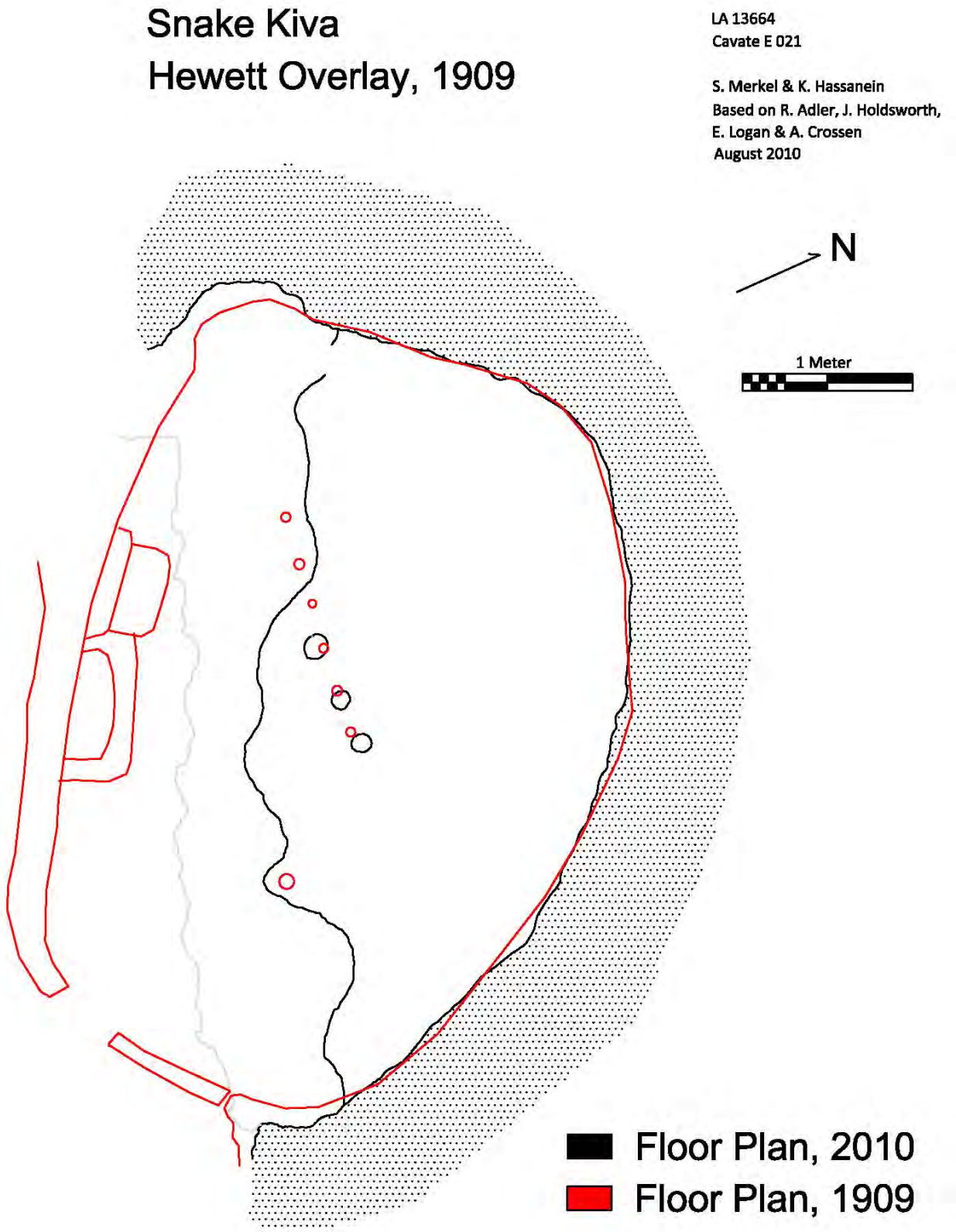


Snake Kiva plan as excavated in 1909 from Hewett's The Pajarito Plateau and Its' Ancient People, 1938


Snake Kiva
Floor Plan
LA 13664
Cavate E 021
S. Merkel & K. Hassanein
Based on R. Adler, J. Holdsworth,
E. Logan & A. Crossen
August 2010
N
1 Meter
Plaster
Loom Anchor set in Earthen Mortar
Non-Historic Stone Curbing
Unexcavated Fill
Rail Post
Raised Tuff Platform


Snake Kiva
Wall and Ceiling Features
LA 13664
Cavate E 021
S. Merkel & K. Hassanein
Based on R. Adler, J. Holdsworth,
E. Logan & A. Crossen
August 2010
N
1 Meter
Floor edge
Upper Loom Support Sockets
Edge of Sooted Ceiling
Top of the Plaster Dado
Awanyu Pictograph
Anthropomorphic Pictograph


Snake Kiva
Loom Features
LA 13664
Cavate E 021
S. Merkel & K. Hassanein
Based on R. Adler, J. Holdsworth,
E. Logan & A. Crossen
August 2010
N
1 Meter
Upper Loom Support Sockets
Loom Anchor set in Earthen Mortar
Unexcavated Fill


Snake Kiva
Hewett Overlay, 1909
LA 13664
Cavate E 021
S. Merkel & K. Hassanein
Based on R. Adler, J. Holdsworth,
E. Logan & A. Crossen
August 2010
N
1 Meter
Floor Plan, 2010
Floor Plan, 1909

Appendix E:

Snake Kiva Floor Description and Photography

Snake Kiva Floor Description – 2010

Johnny Holdsworth

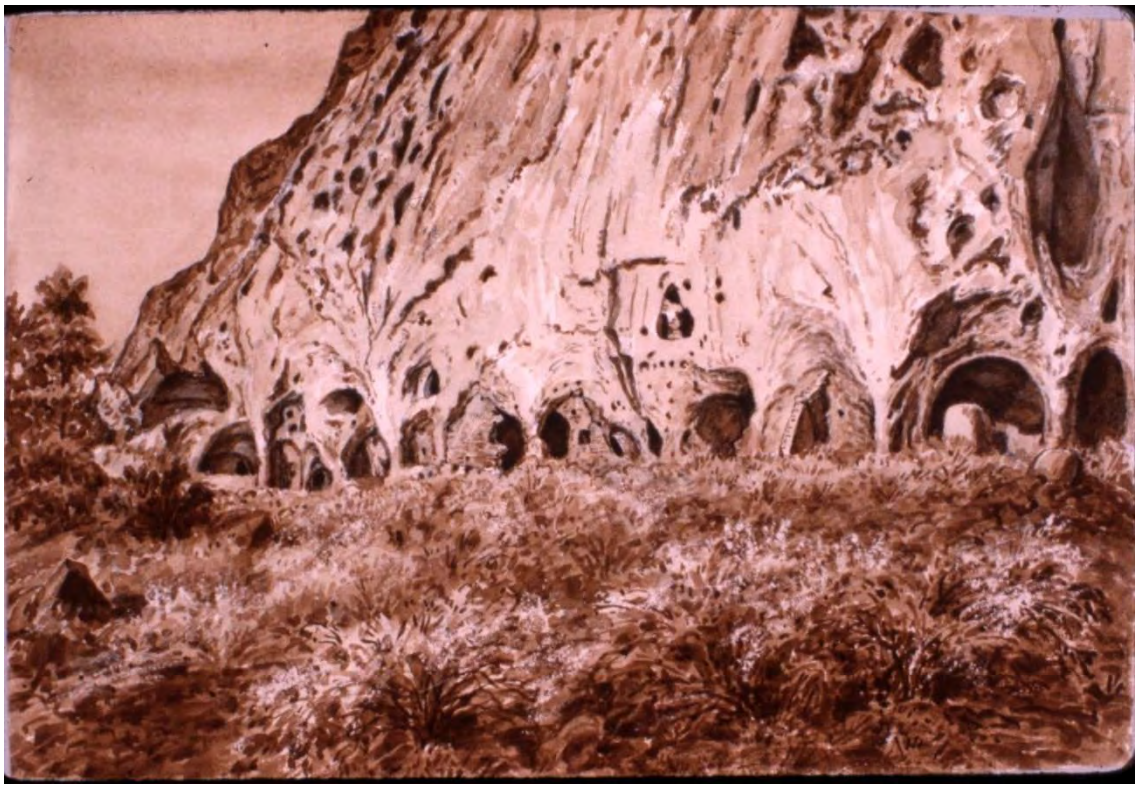
The plastered floor is in places still 7 layers thick. Despite the thickness, the floor is fragile and susceptible to breakage under even slight pressure. The plaster itself is a mixture of clay and sand, and at the edges, where deterioration had set in, it has turned to a fine powder. The color was tan and matched the color and consistency/finish of the intact wall surfaces.
At the edges where the plaster remained and the tuff was exposed, the floor depth increased gradually as you move south towards the opening, and the floor is punctuated only by a few features. The tuff that is exposed is friable and loose, making uncovering the surfaces difficult. The closer to the retaining wall, the more difficult it was to brush down to an intact surface, and for this reason, the floor was only partially cleared. In the deeper areas, which also happen to be the more exposed areas on the south side of the cavate, the fill was left in place.

In the middle of the cavate floor, 3 loom anchors were located in the floor. The anchors were little more than plaster plugs set into the tuff with only partial wooden loops remaining to secure the lower loom beam. The wooden loops had at some point broken off down to the floor level but were still visible in the plaster plugs. The 3 sockets were distanced evenly apart and had the remnants of wooden loops all aligning in a linear pattern.

Two circular sections of tuff remain where the level surface of the tuff is even with the surface level of the finished plaster floor. The “plateaus” of tuff are raised above the deteriorated exposed tuff surface anywhere from 1 to 2 inches (roughly). Adjacent to one of these tuff “plateaus” is a shaped depression with a circular shape and a raked surface angling upwards to the level of the exposed tuff floor. The depth is roughly 2.5 inches.

Appendix F:

Supplementary Archival Images of Cavate Masonry

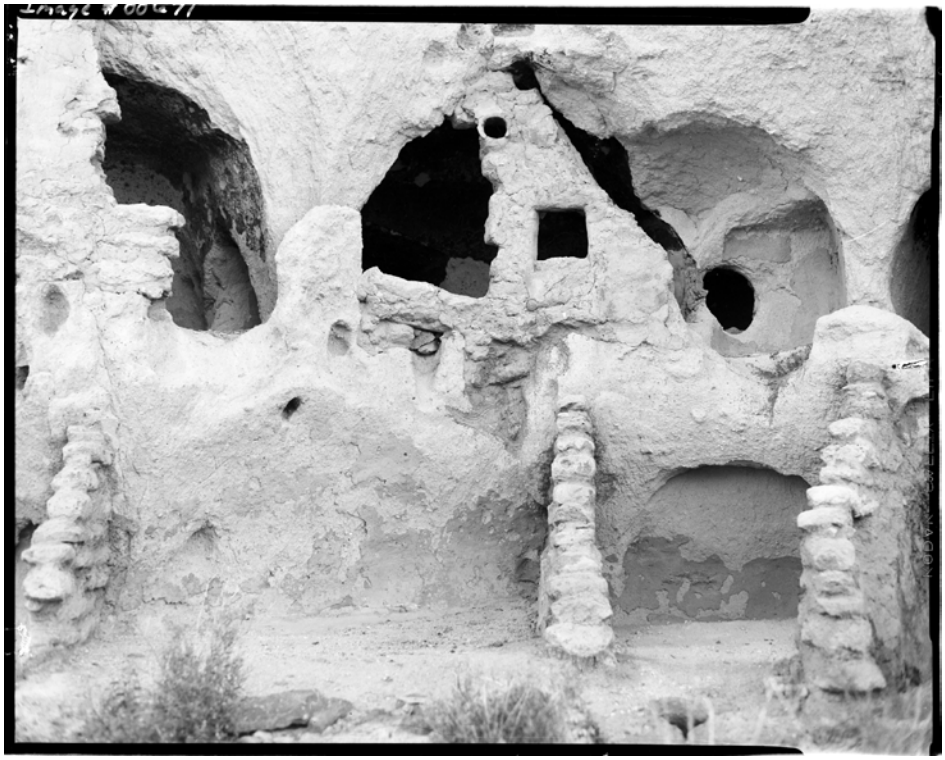




Matilda Coxe-Stevenson watercolors of the M 100 Group from 1882, National Archive



Photograph of Hendron's stabilization crew during the treatment of the M 100 Group, 1943. Bandelier NM on file



Photograph showing the Jim Maxon's stabilization of the M 100 Group, June 1965. Bandelier NM on file



Photograph showing the Jim Maxon's stabilization of the M 100 Group, June 1965. Bandelier NM on file



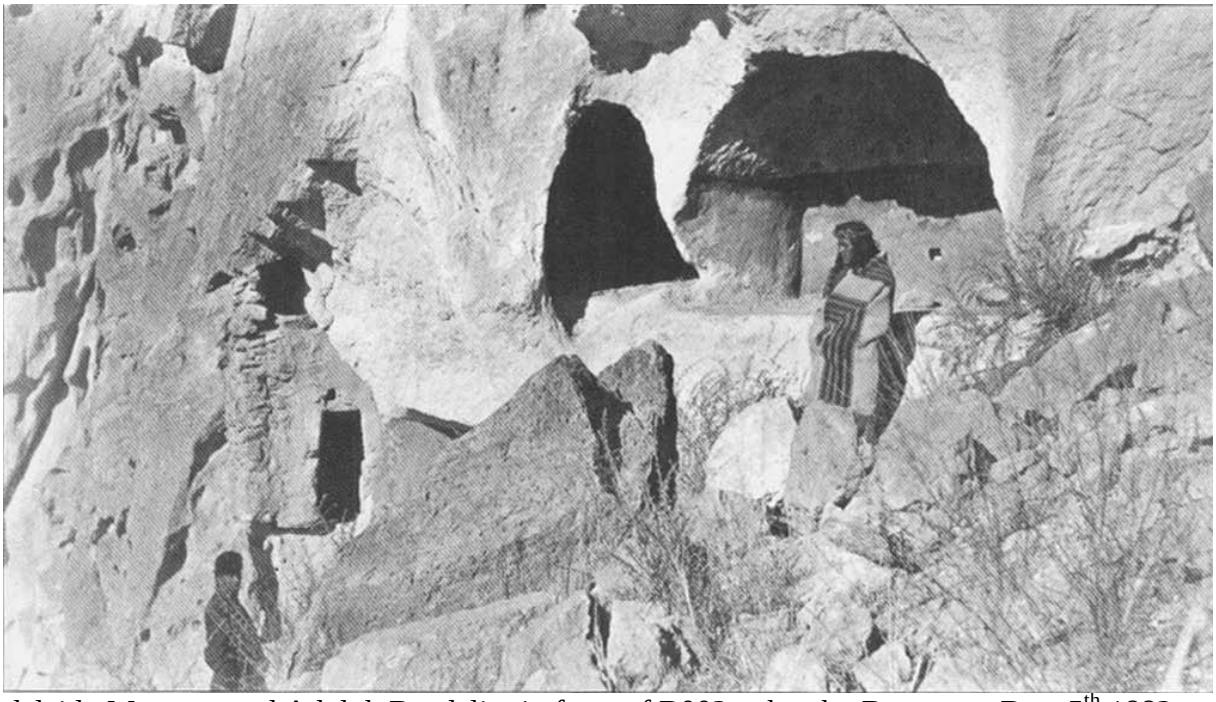
Stabilization of the M 100 Group in August 1964. Bandelier NM on file



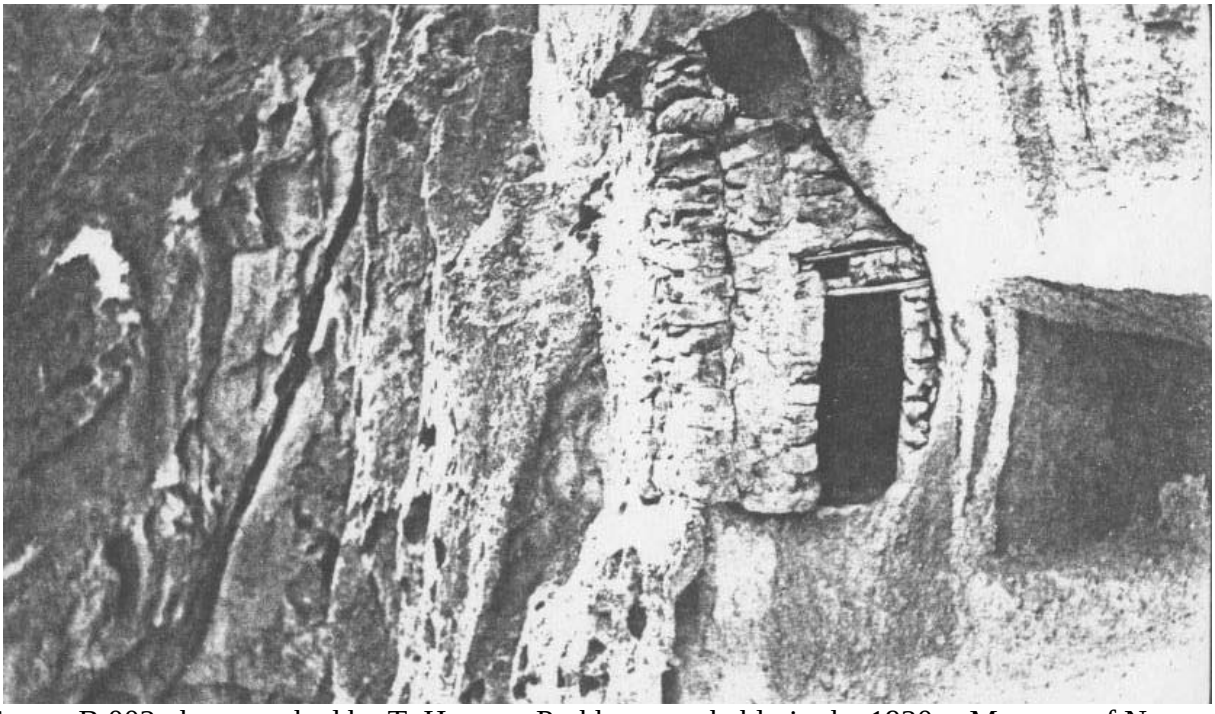
Tim Kohler excavation of M 122 and M 123, 1988. Bandelier NM on file.



Kohler excavation of M 122 showing the entrance to M 123, 1988. Bandelier NM on file.



Adelaido Montoya and Adolph Bandelier in front of B002, taken by Bennet on Dec. 5th 1882. Museum of New Mexico Photo Archives.



Cavate B 002 photographed by T. Harmon Parkhurst probably in the 1920s. Museum of New Mexico #89970.

Appendix G:

Graphic Documentation for Cavate Masonry Stabilization

Existing Conditions Before Stabilization

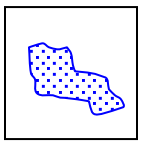
Pre-Treatment Graphic Documentation for Masonry Stabilization



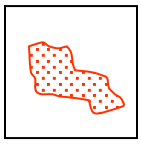
Cement Mortar



CCC Earthen Mortar



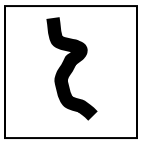
CCC Cement



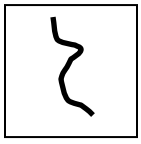
Pre-Historic Mortar



Pre-Historic Plaster

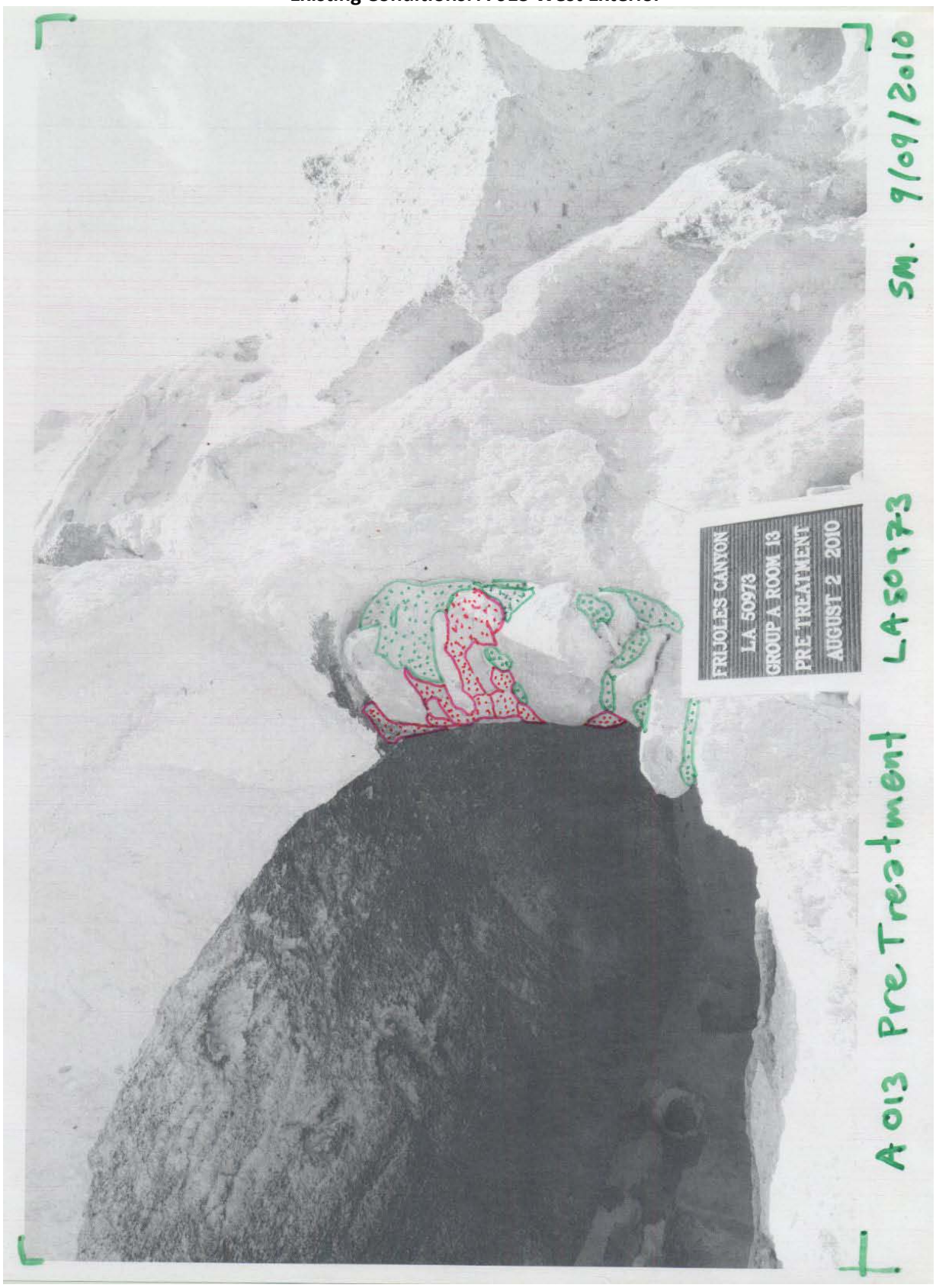


Large Cracks (Structural)

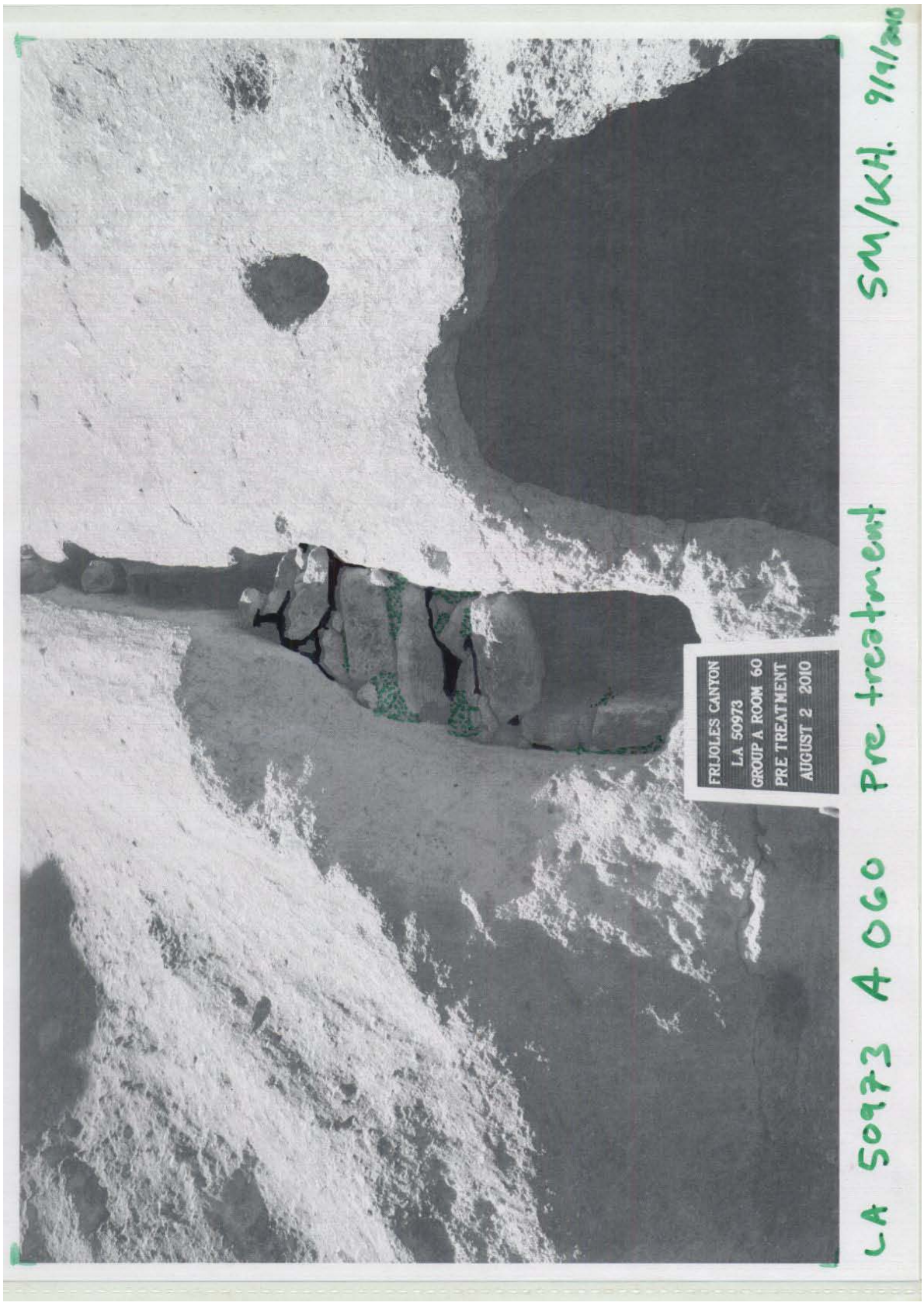


Small Cracks

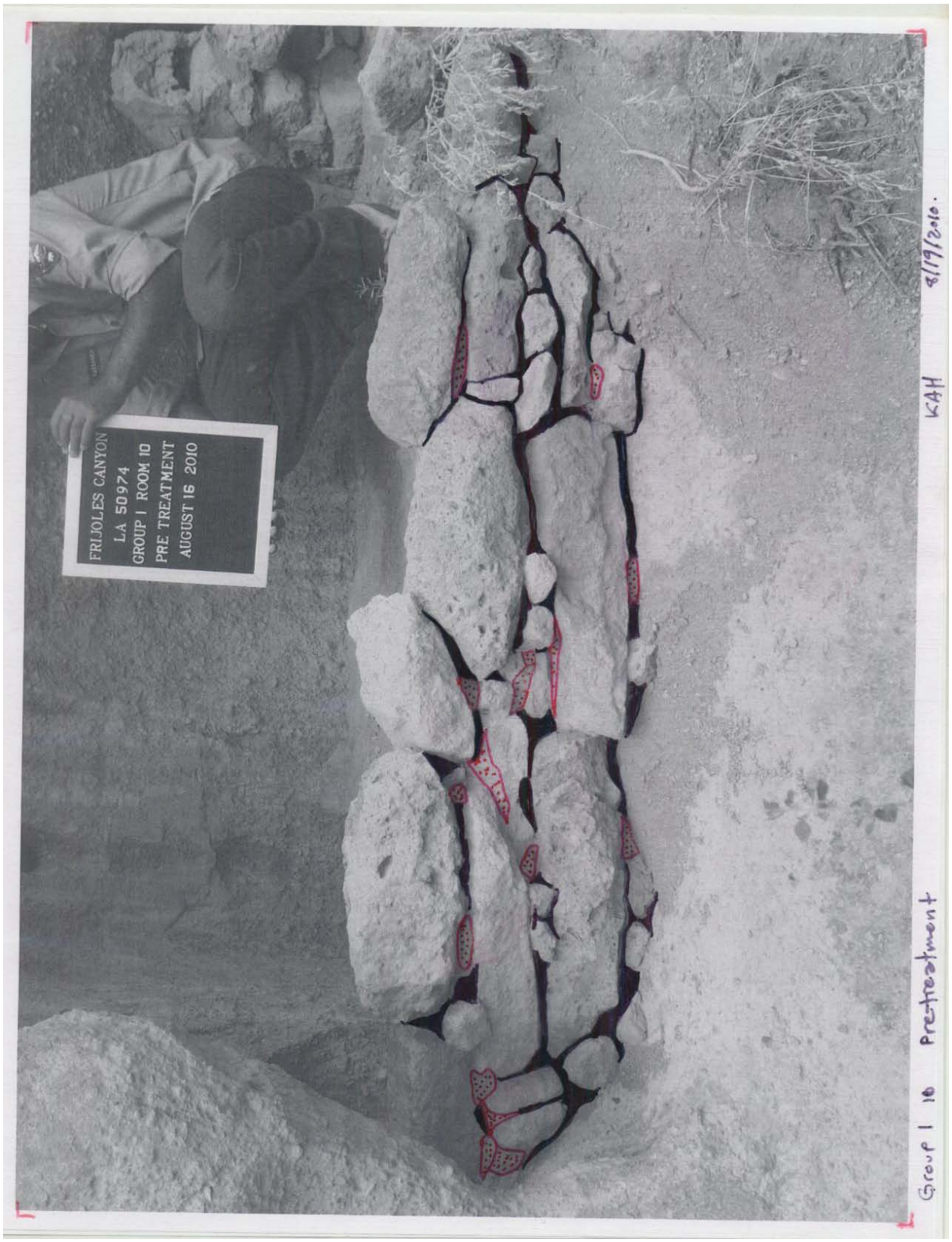
Existing Conditions: A 013 West Exterior



Existing Conditions: A 060 South Exterior



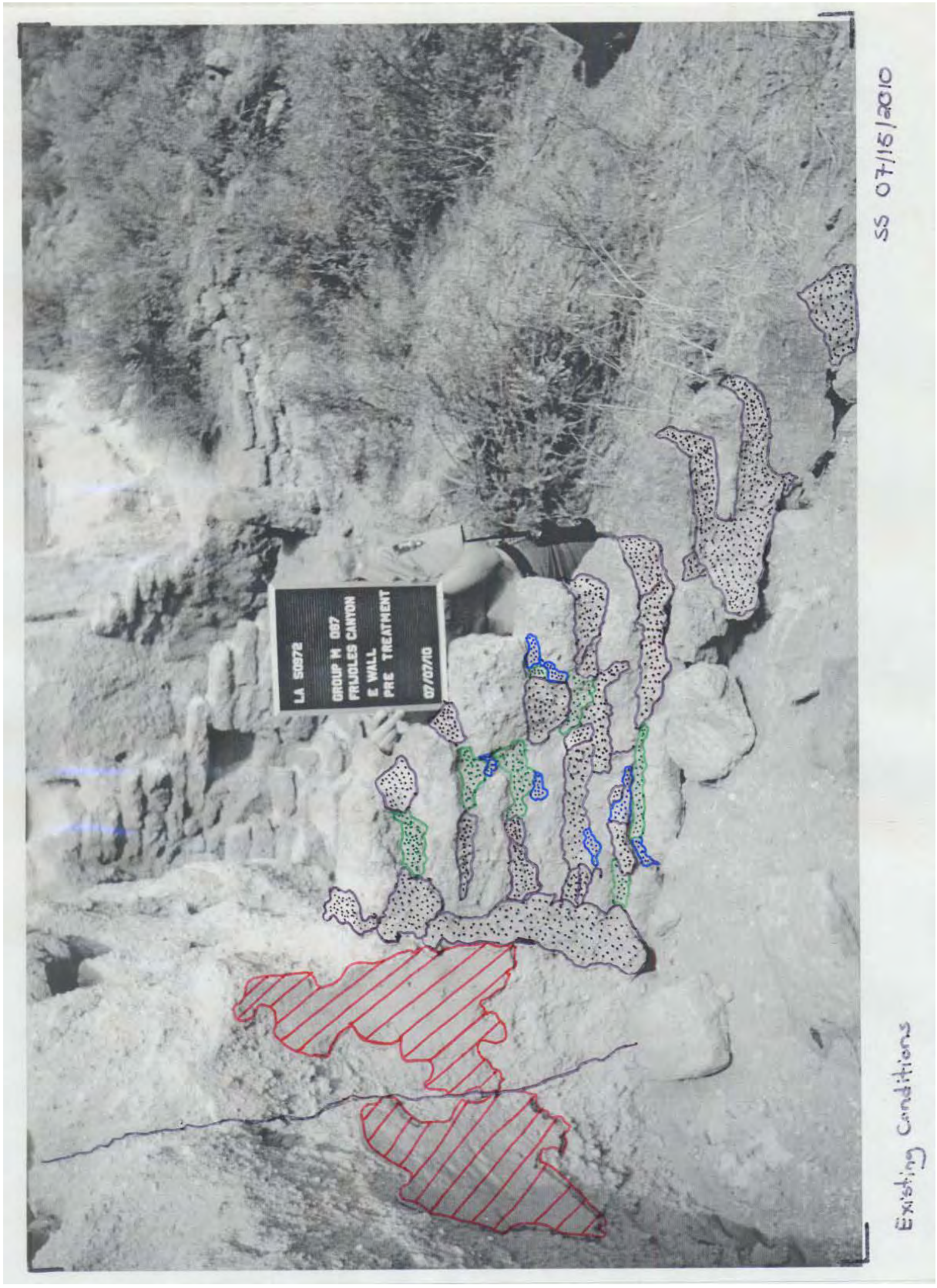
Existing Conditions: I 010 South Exterior



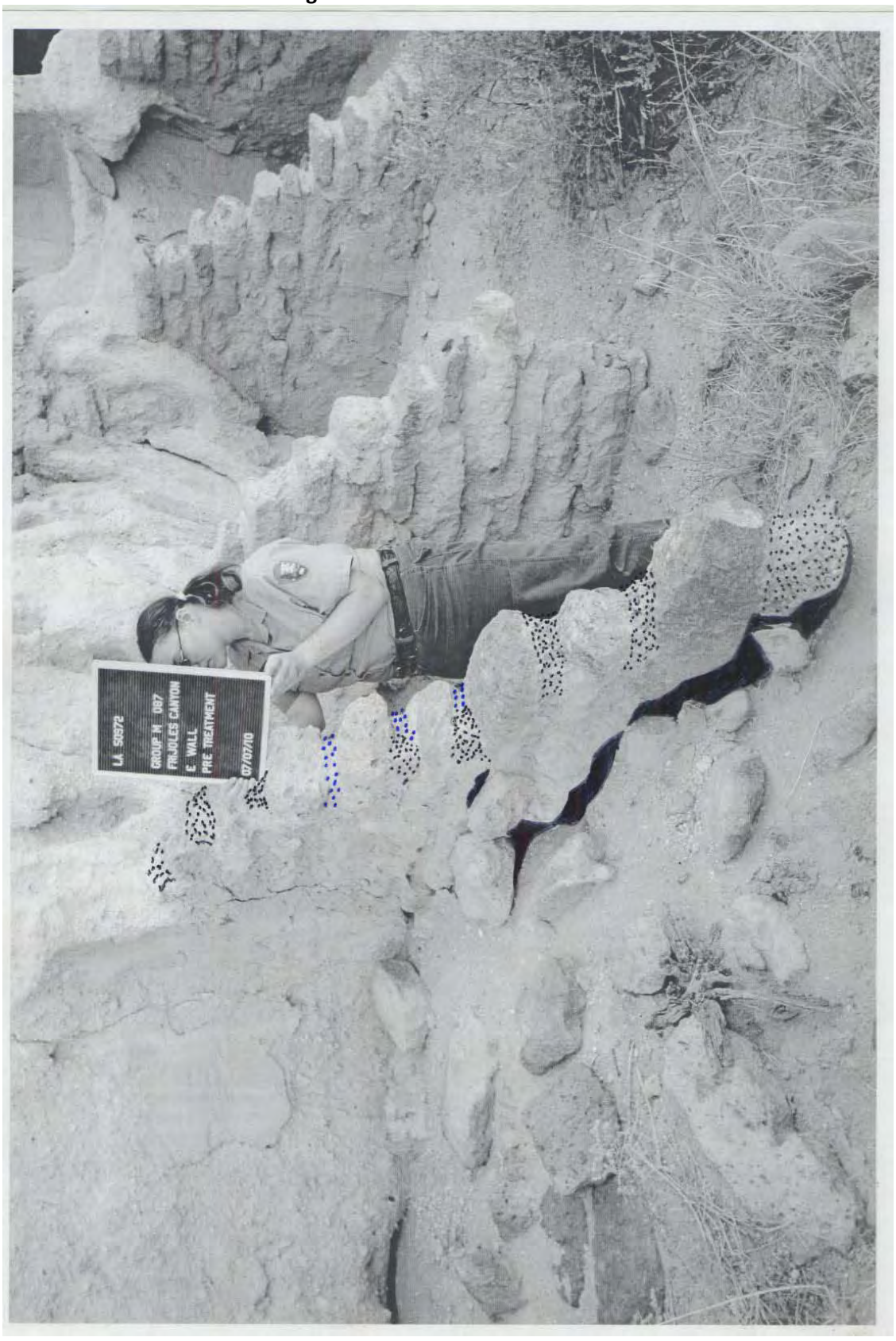
Existing Conditions: I 022 South Exterior



Existing Conditions: M 087 East Interior #1



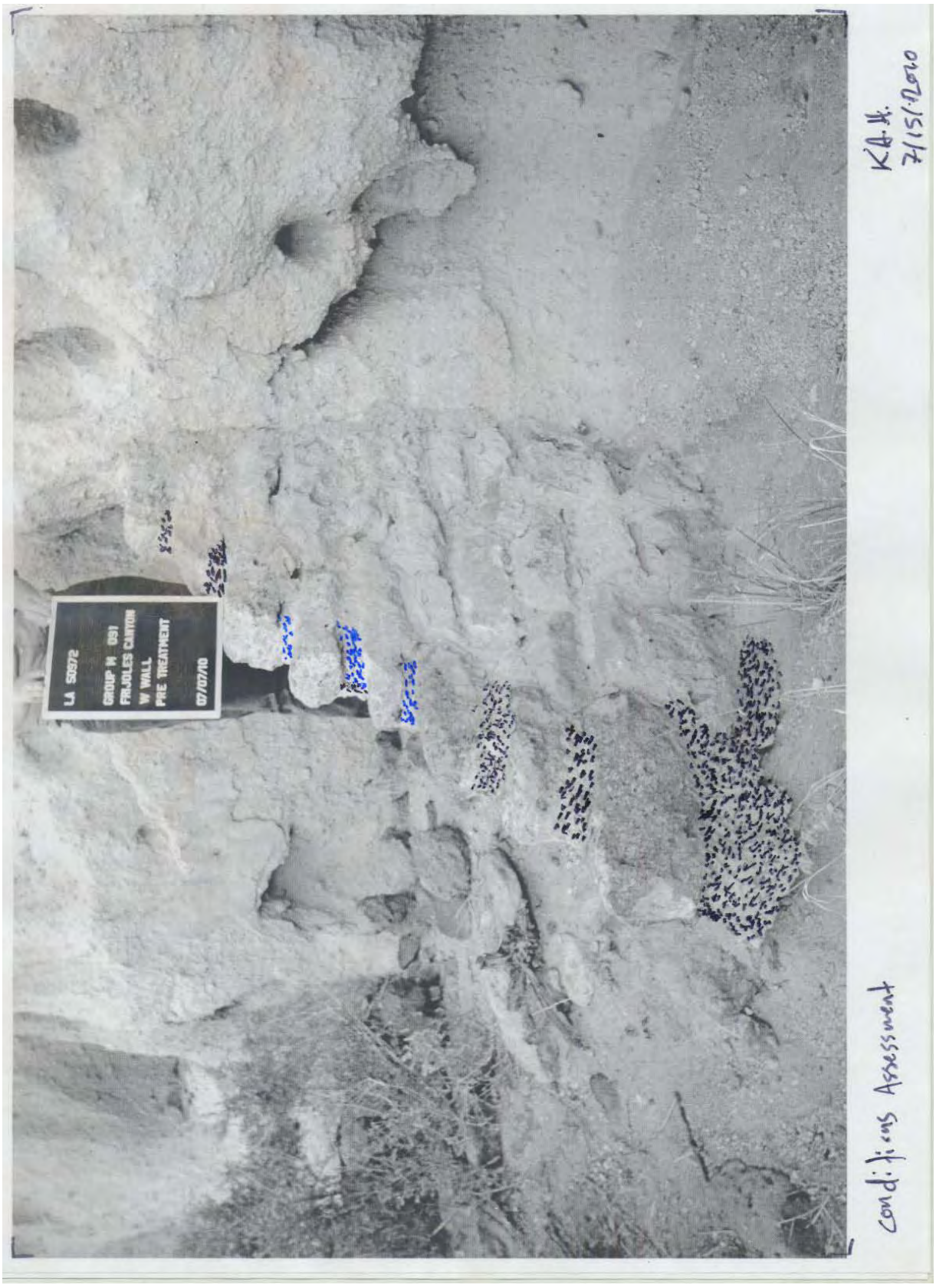
Existing Conditions: M 087 East Interior #2



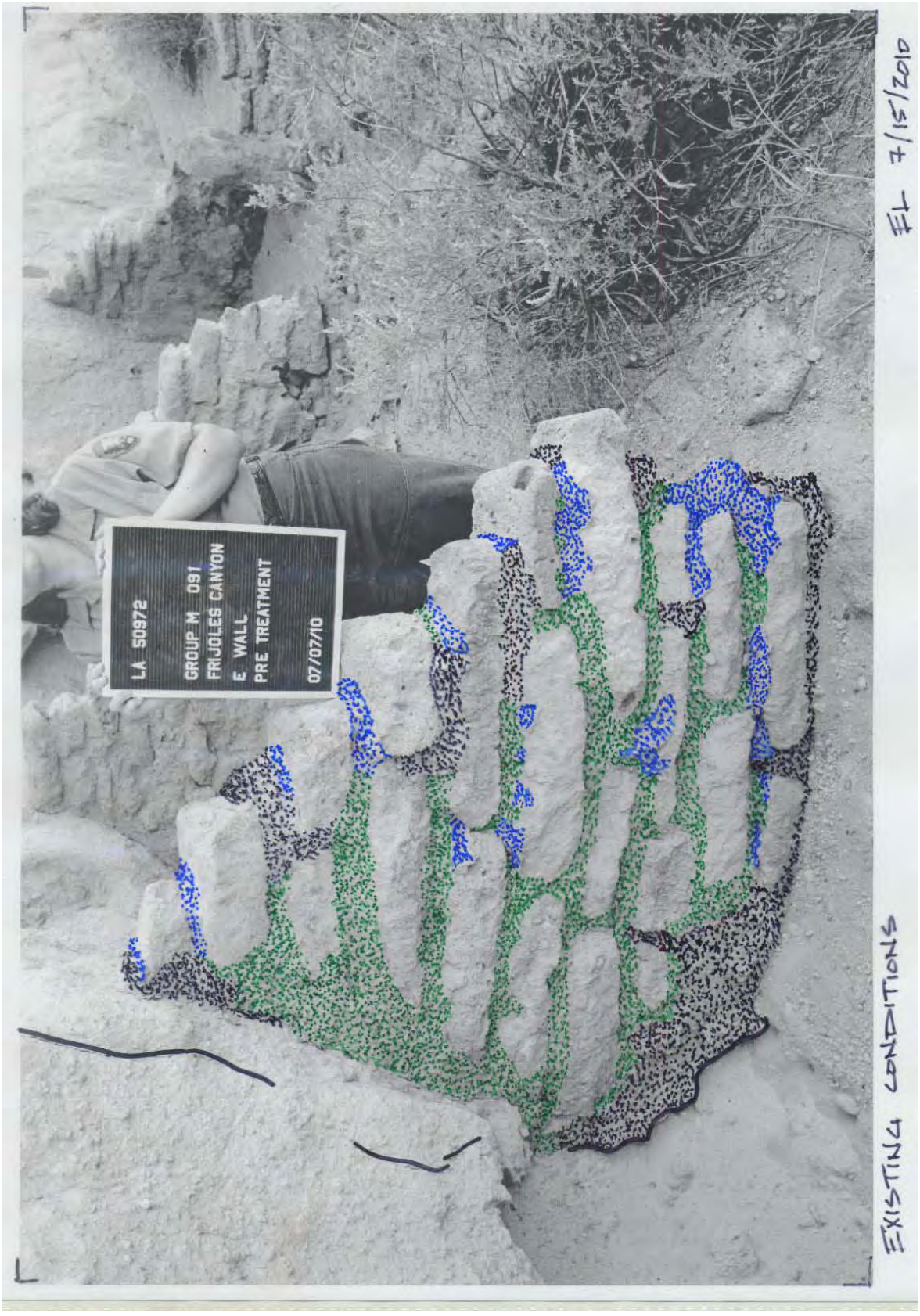
Existing Conditions: M 091 West Interior #1



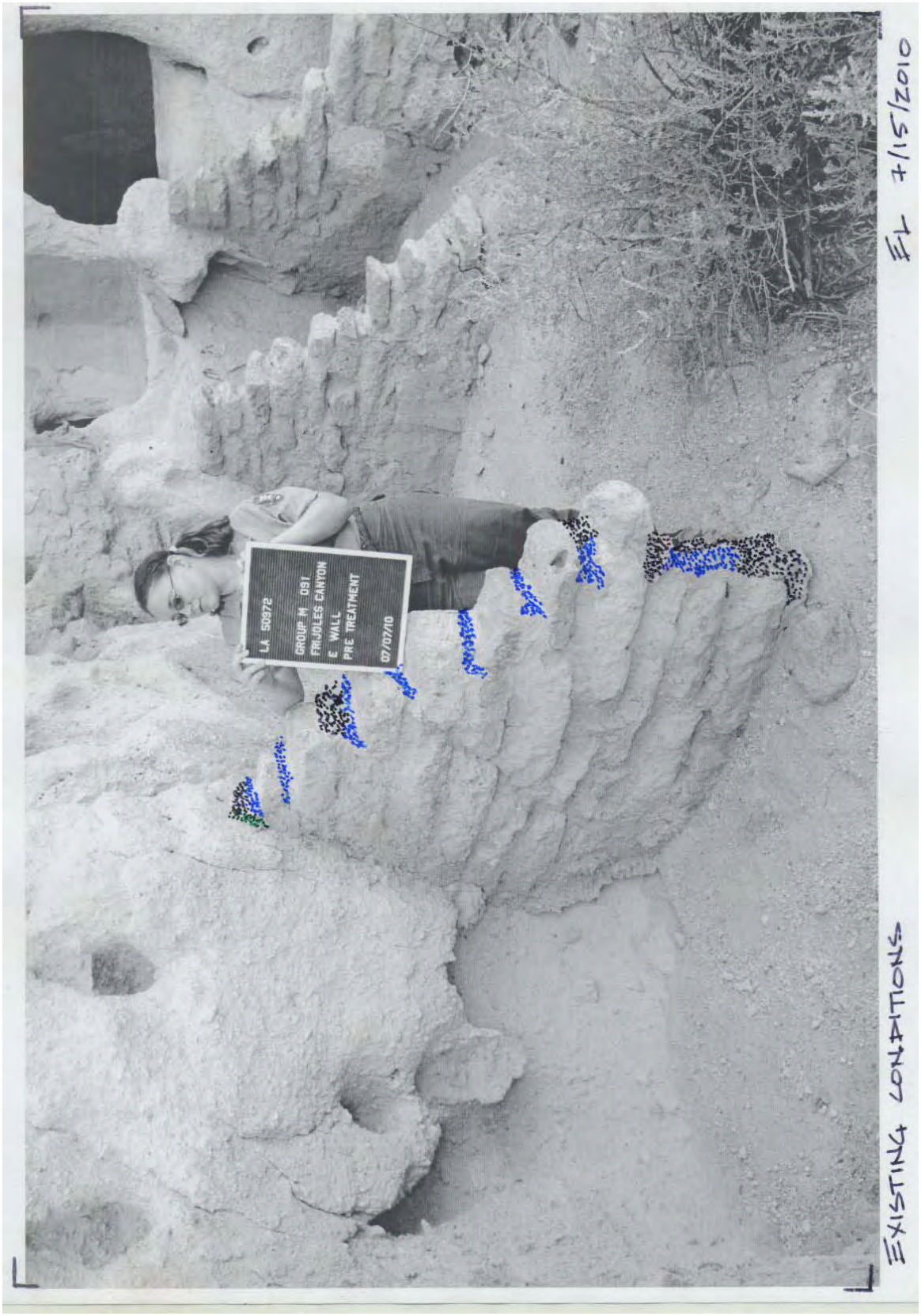
Existing Conditions: M 091 West Interior #2



Existing Conditions: M 091 East Interior #1



Existing Conditions: M 091 East Interior #2



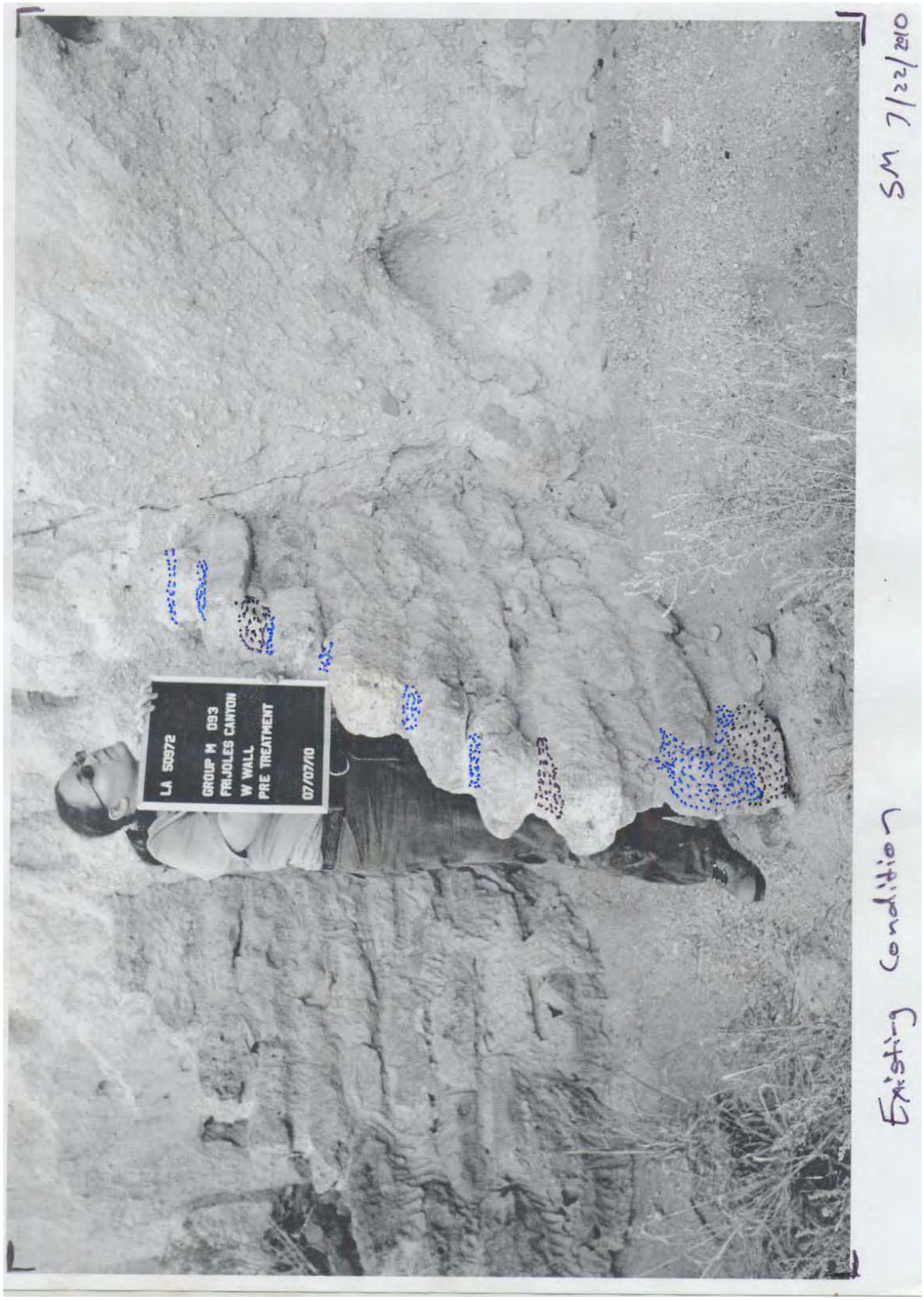
Existing Conditions: M 092 South Exterior (not treated)



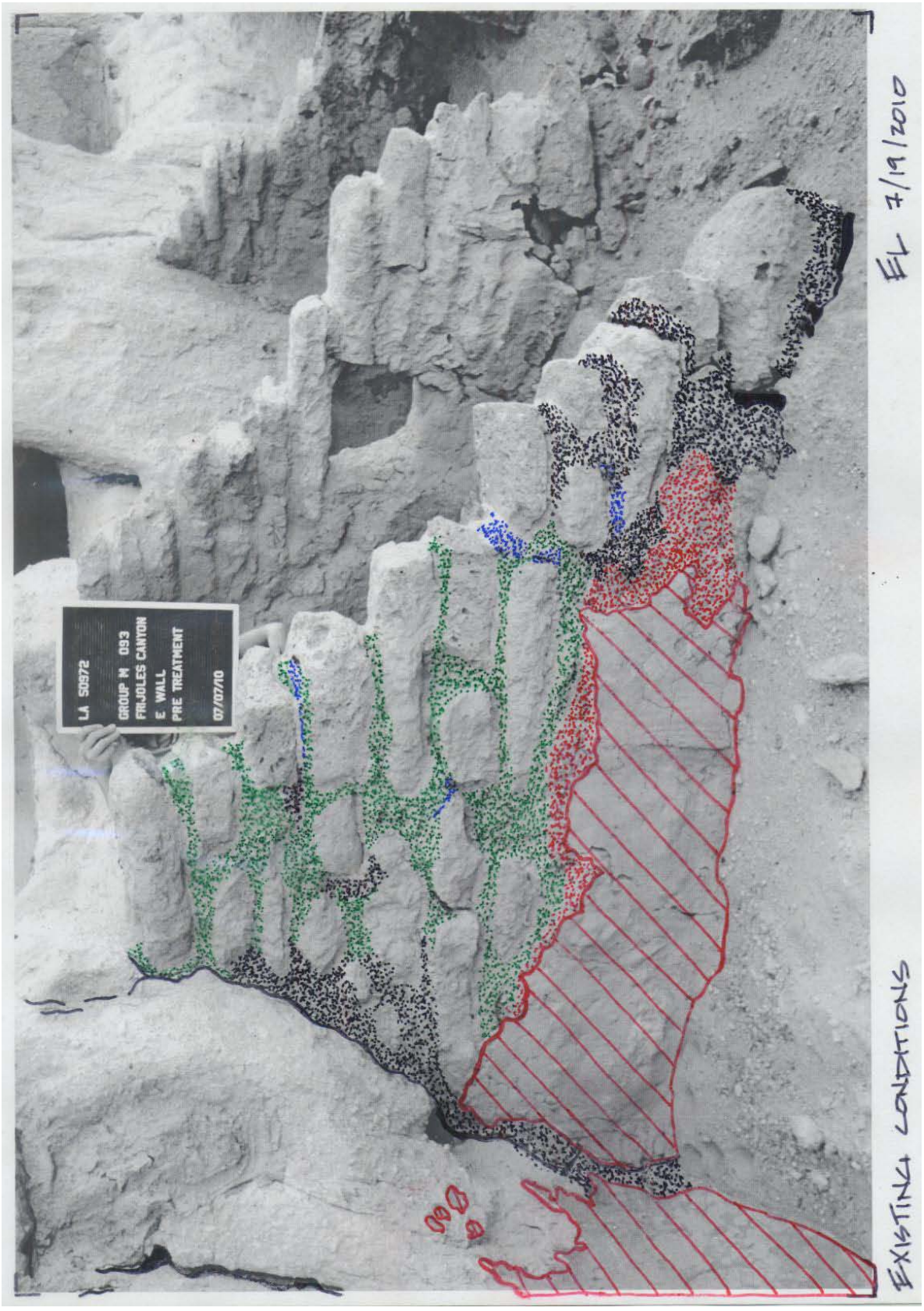
Existing Conditions: M 093 West Interior #1



Existing Conditions: M 093 West Interior #2



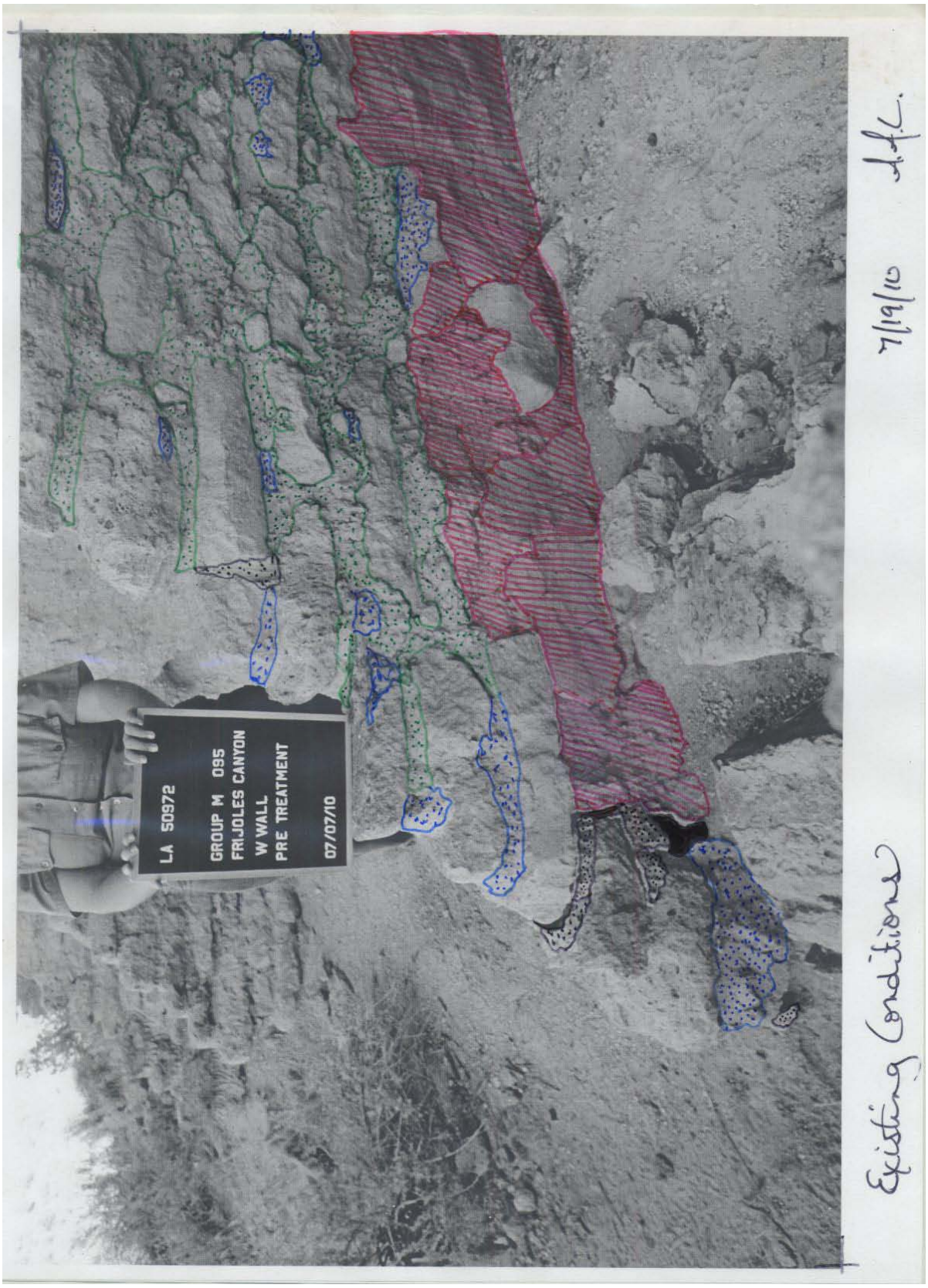
Existing Conditions: M 093 East Interior #1



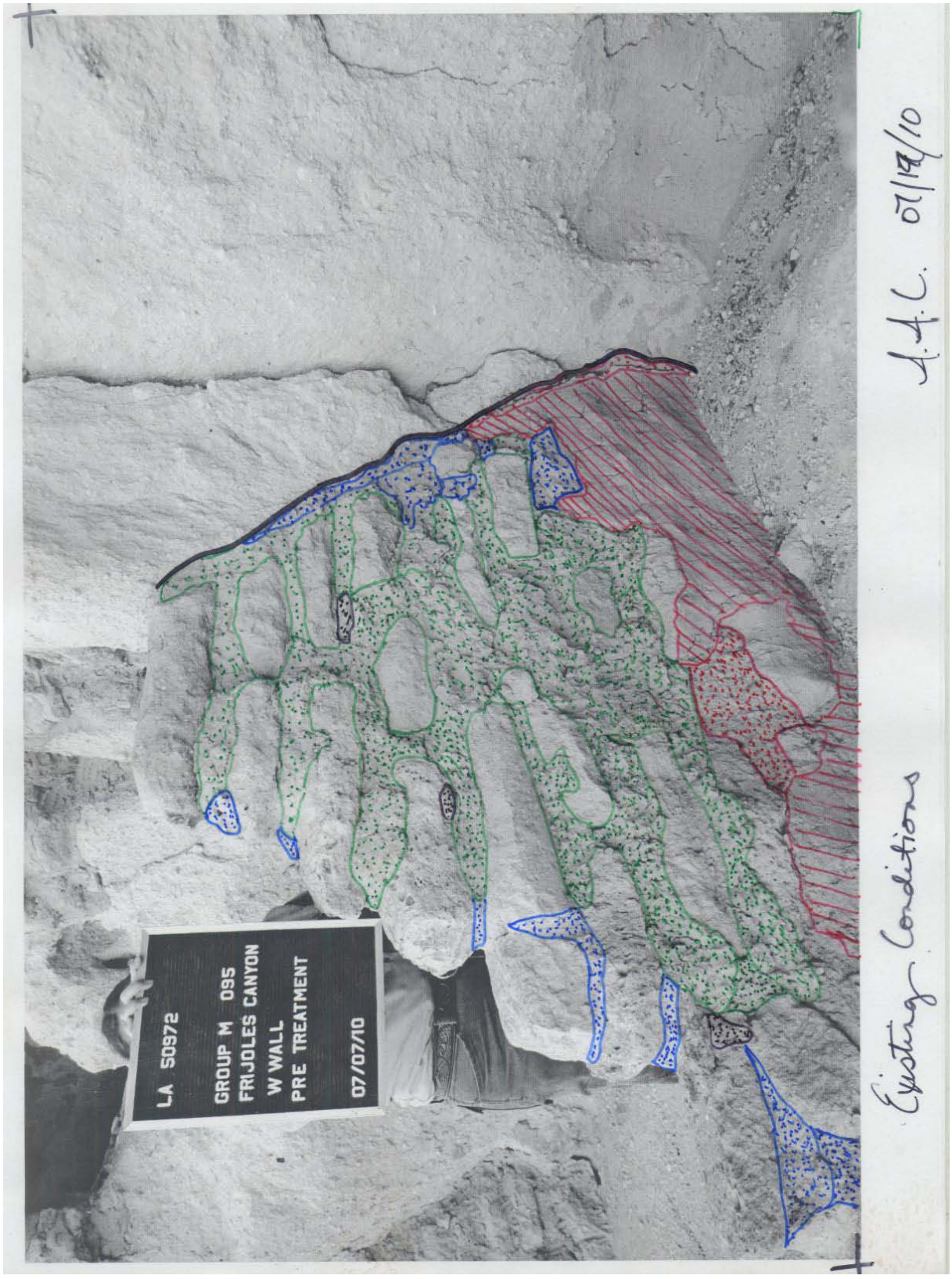
Existing Conditions: M 093 East Interior #2



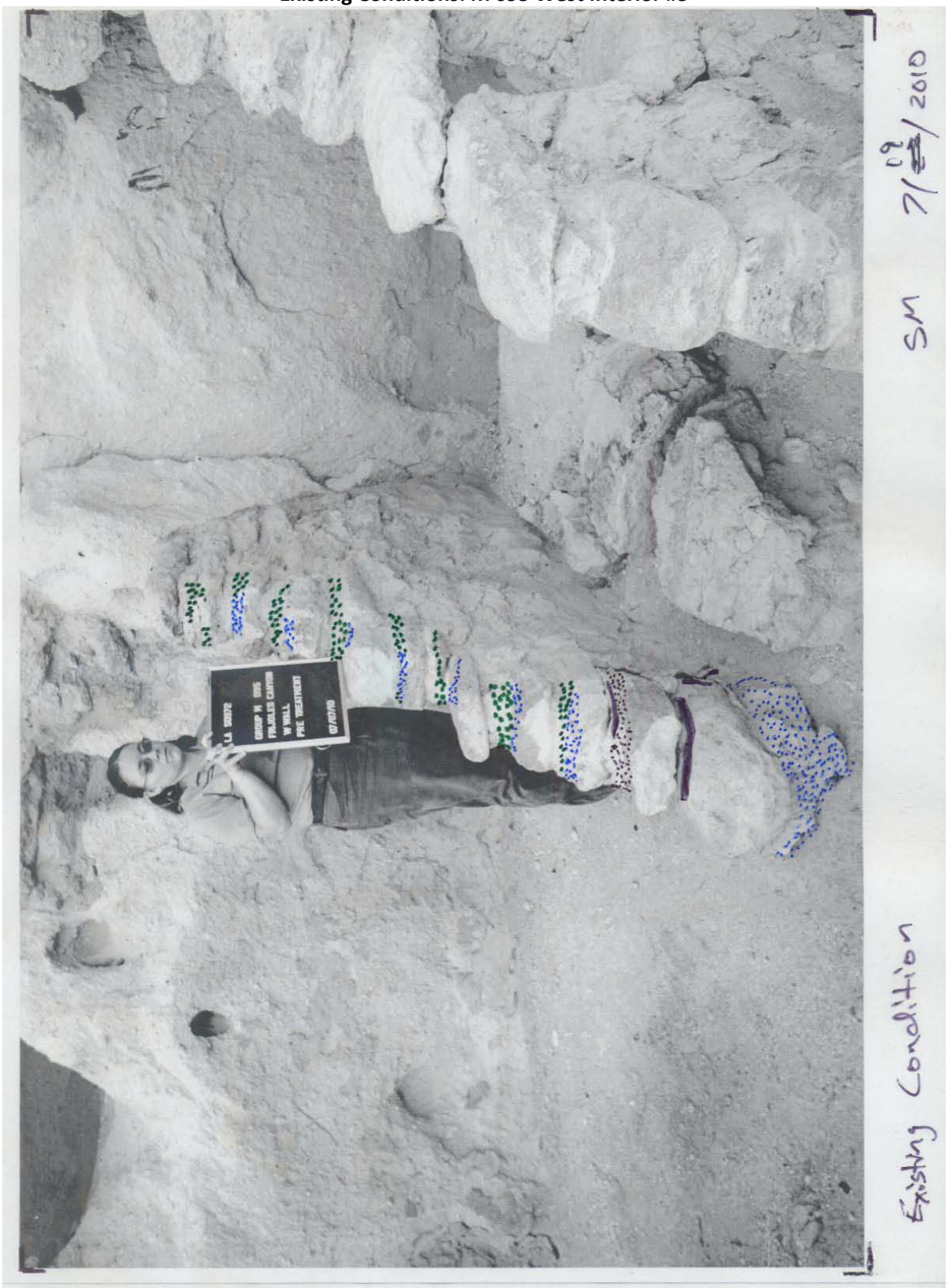
Existing Conditions: M 095 West Interior #1



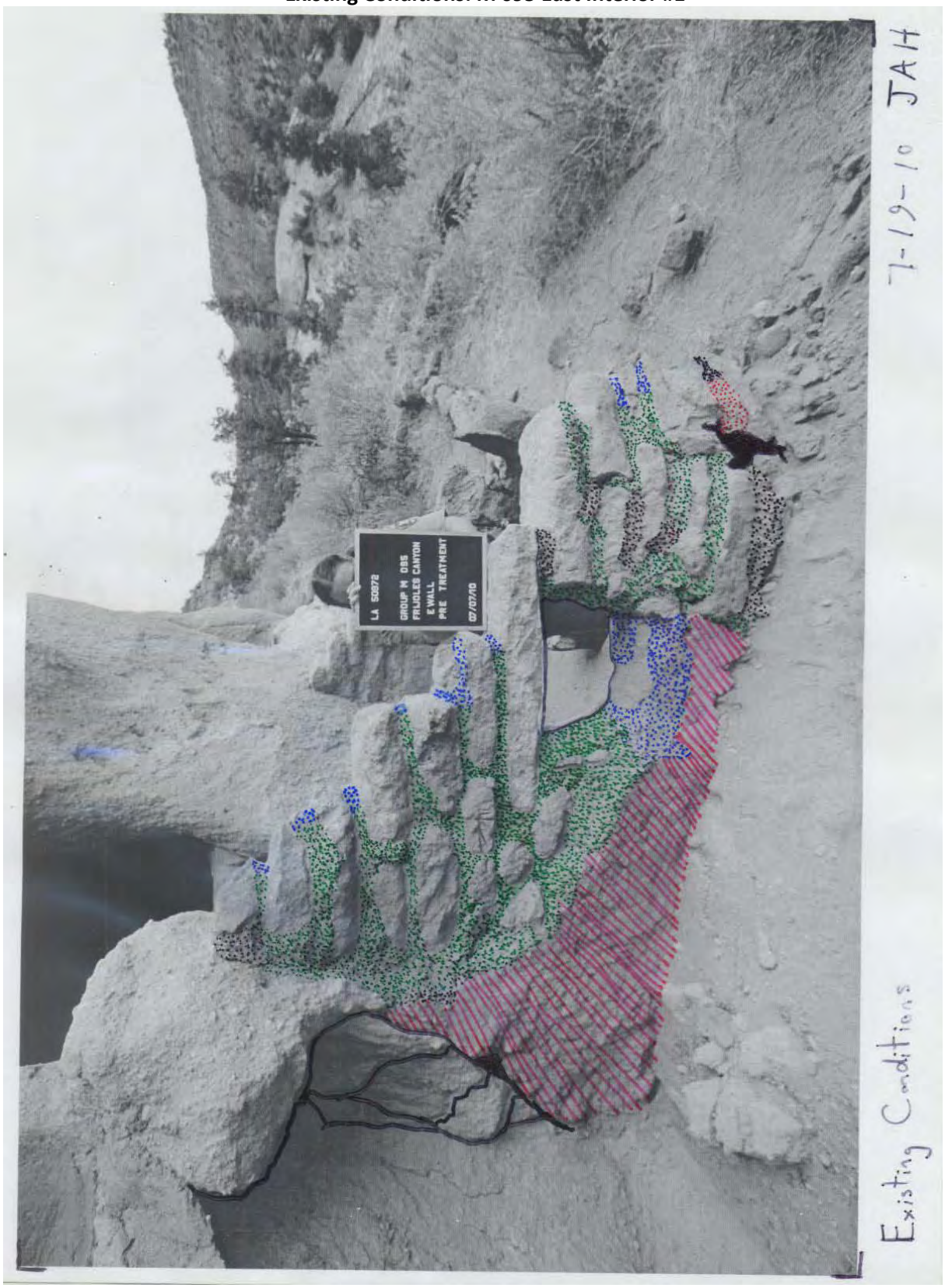
Existing Conditions: M 095 West Interior #2



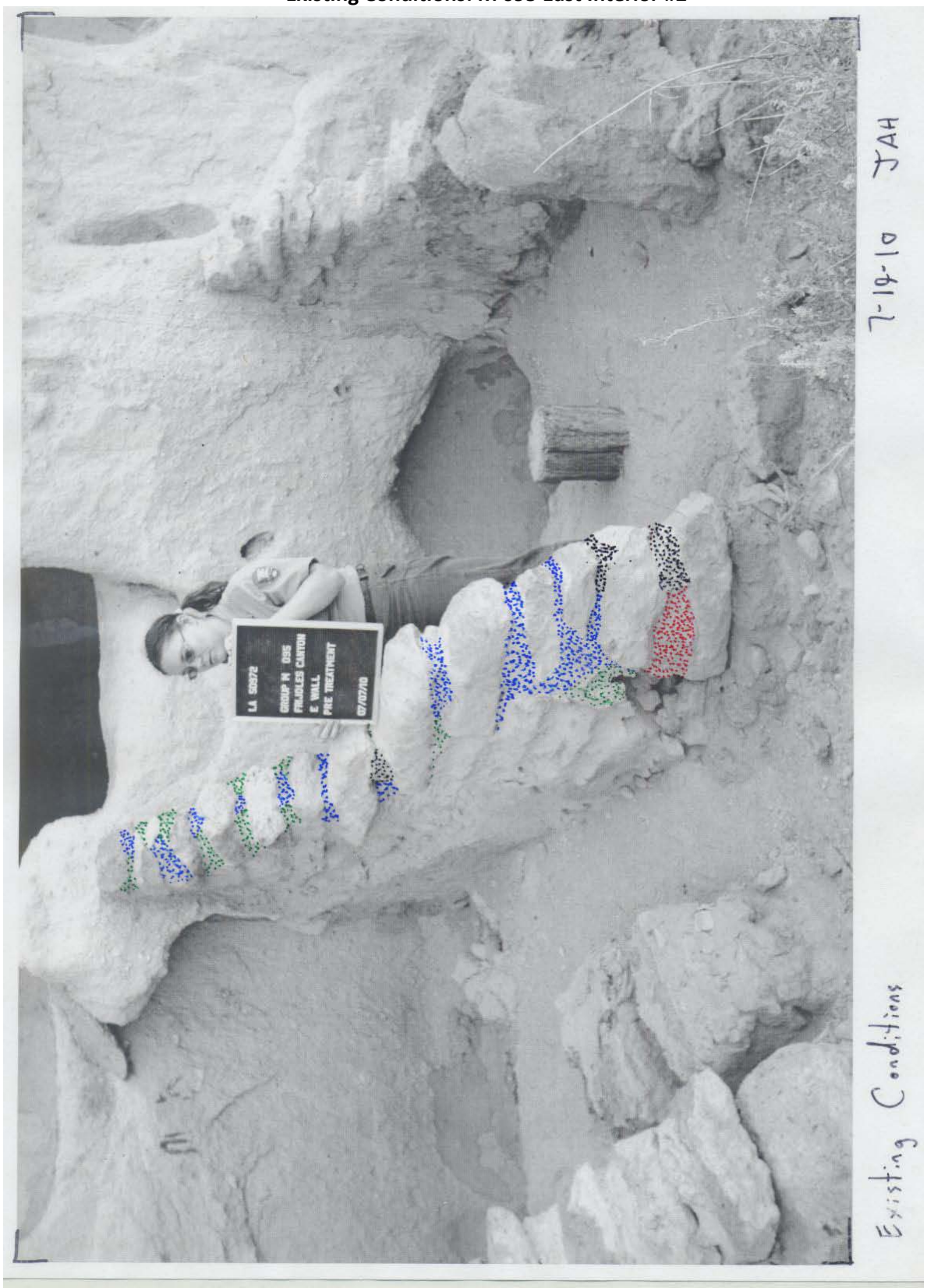
Existing Conditions: M 095 West Interior #3



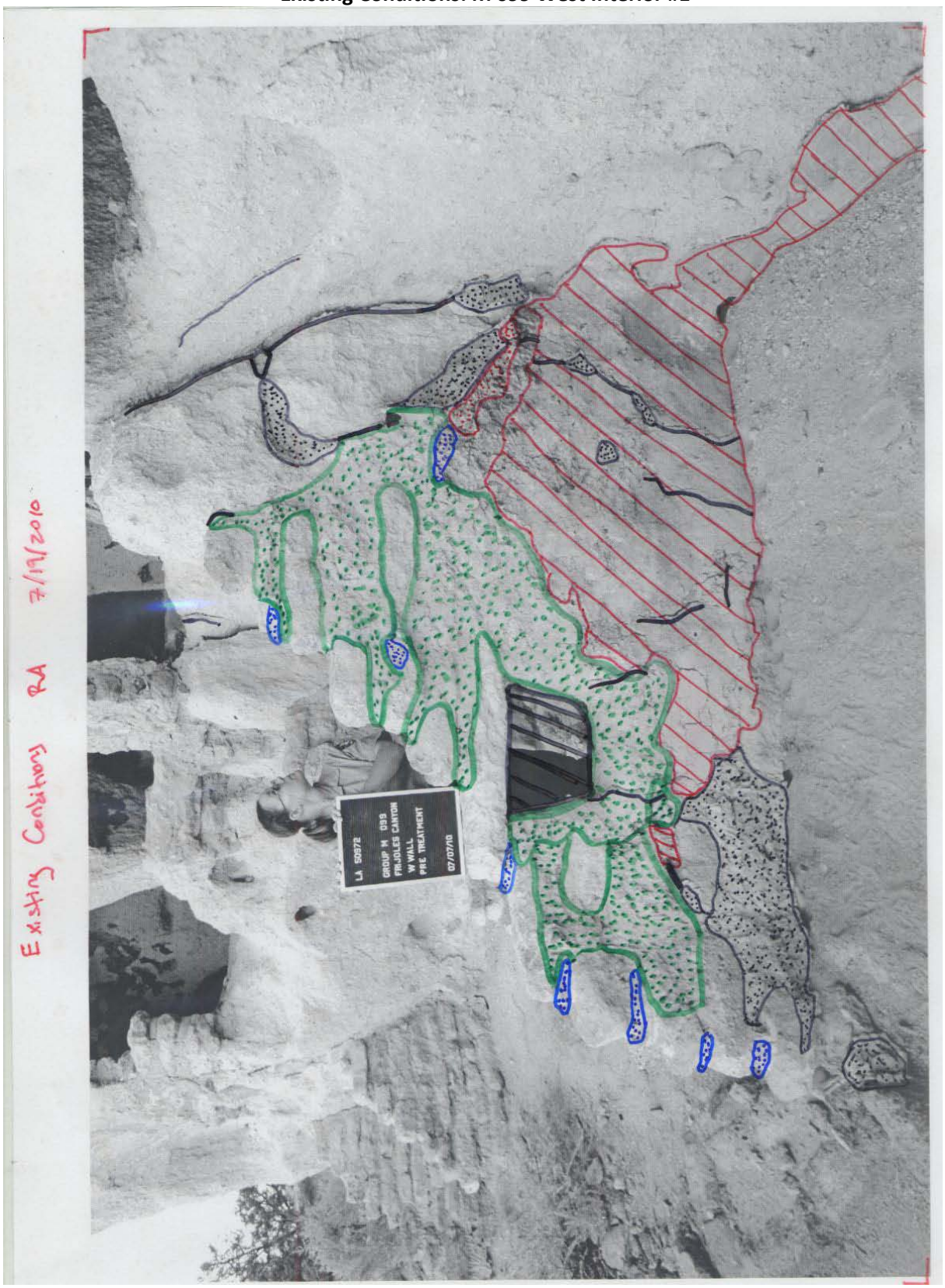
Existing Conditions: M 095 East Interior #1



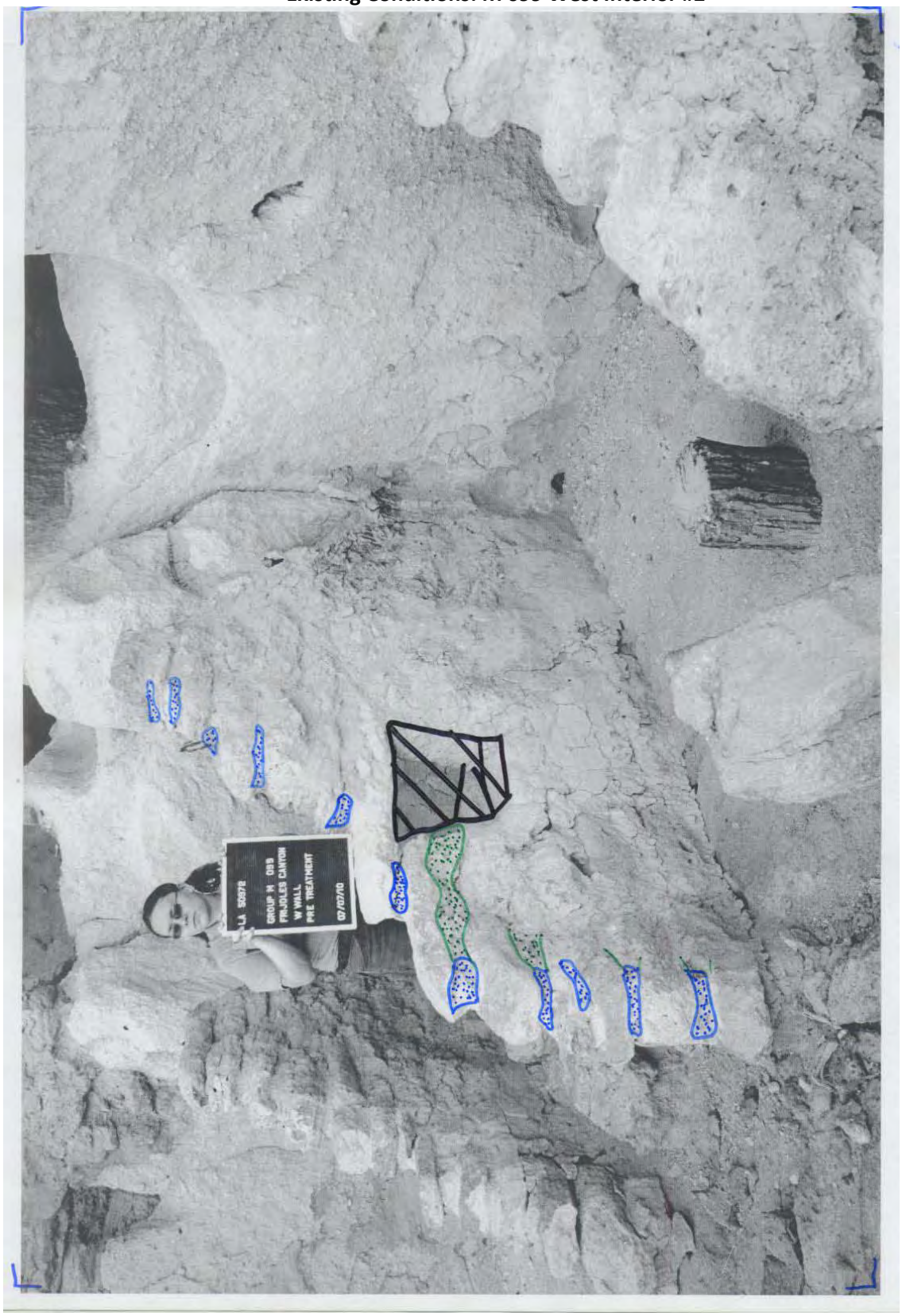
Existing Conditions: M 095 East Interior #2



Existing Conditions: M 099 West Interior #1



Existing Conditions: M 099 West Interior #2



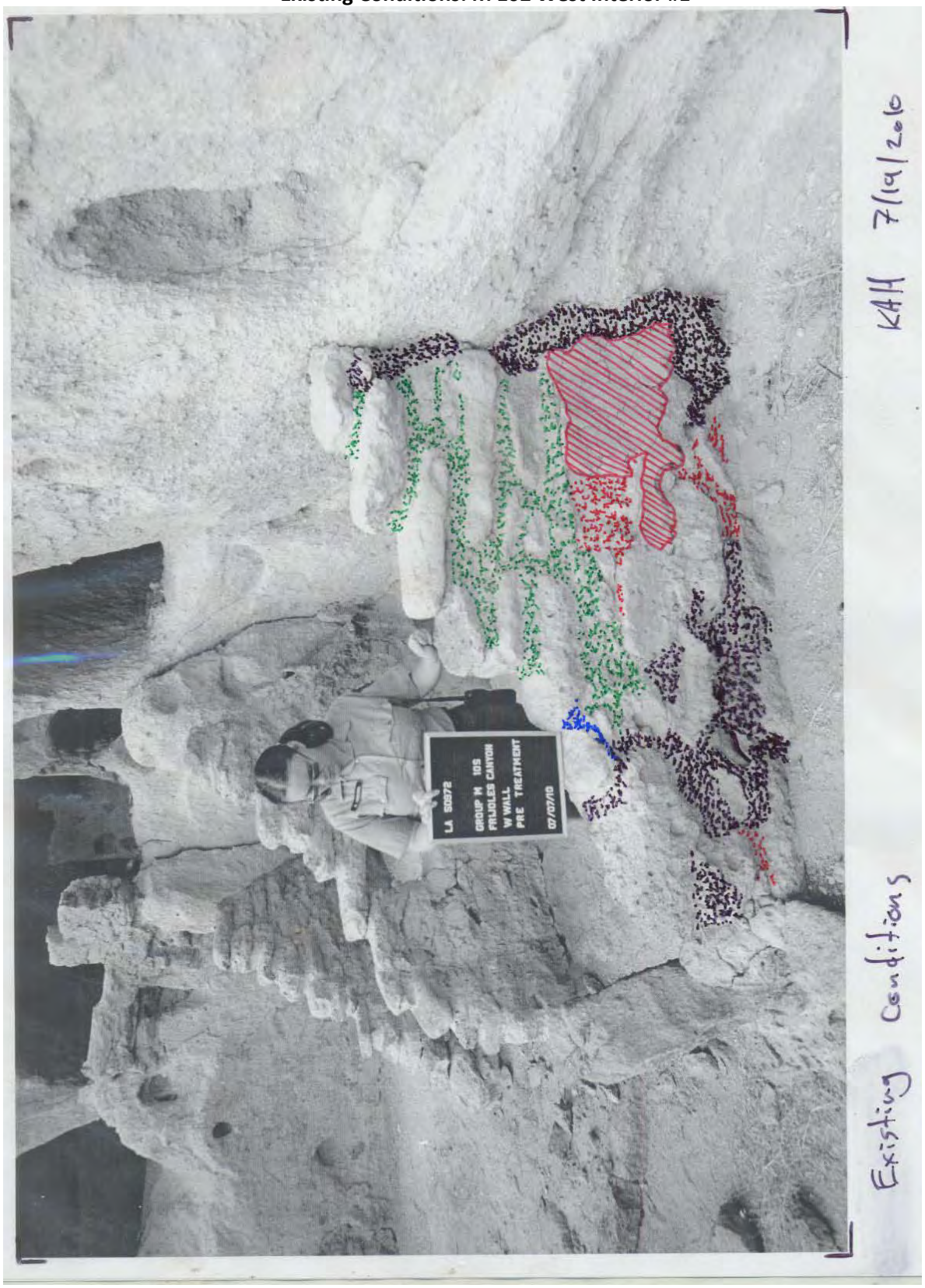
Existing Conditions: M 099 East Interior #1



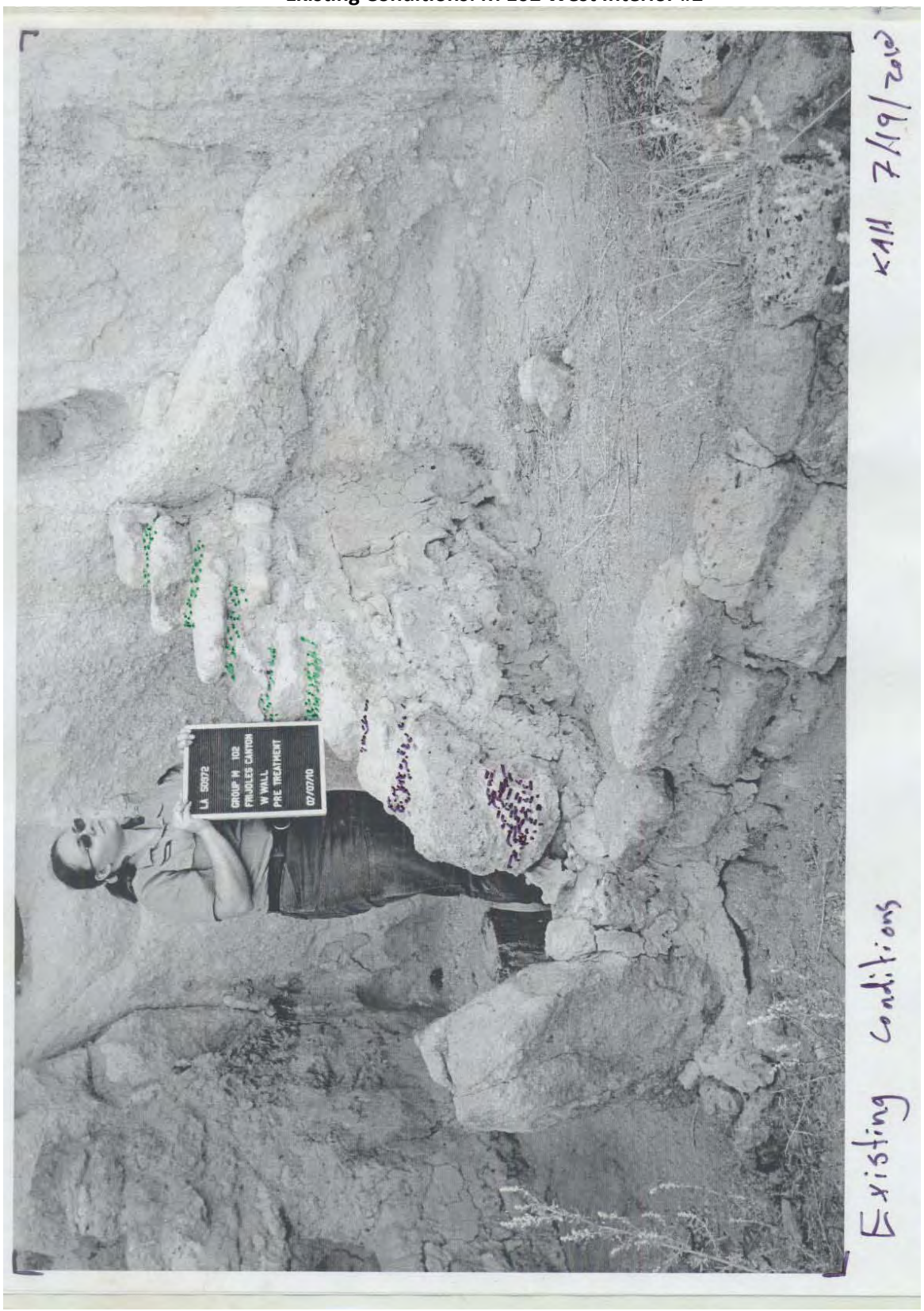
Existing Conditions: M 099 East Interior #2



Existing Conditions: M 102 West Interior #1



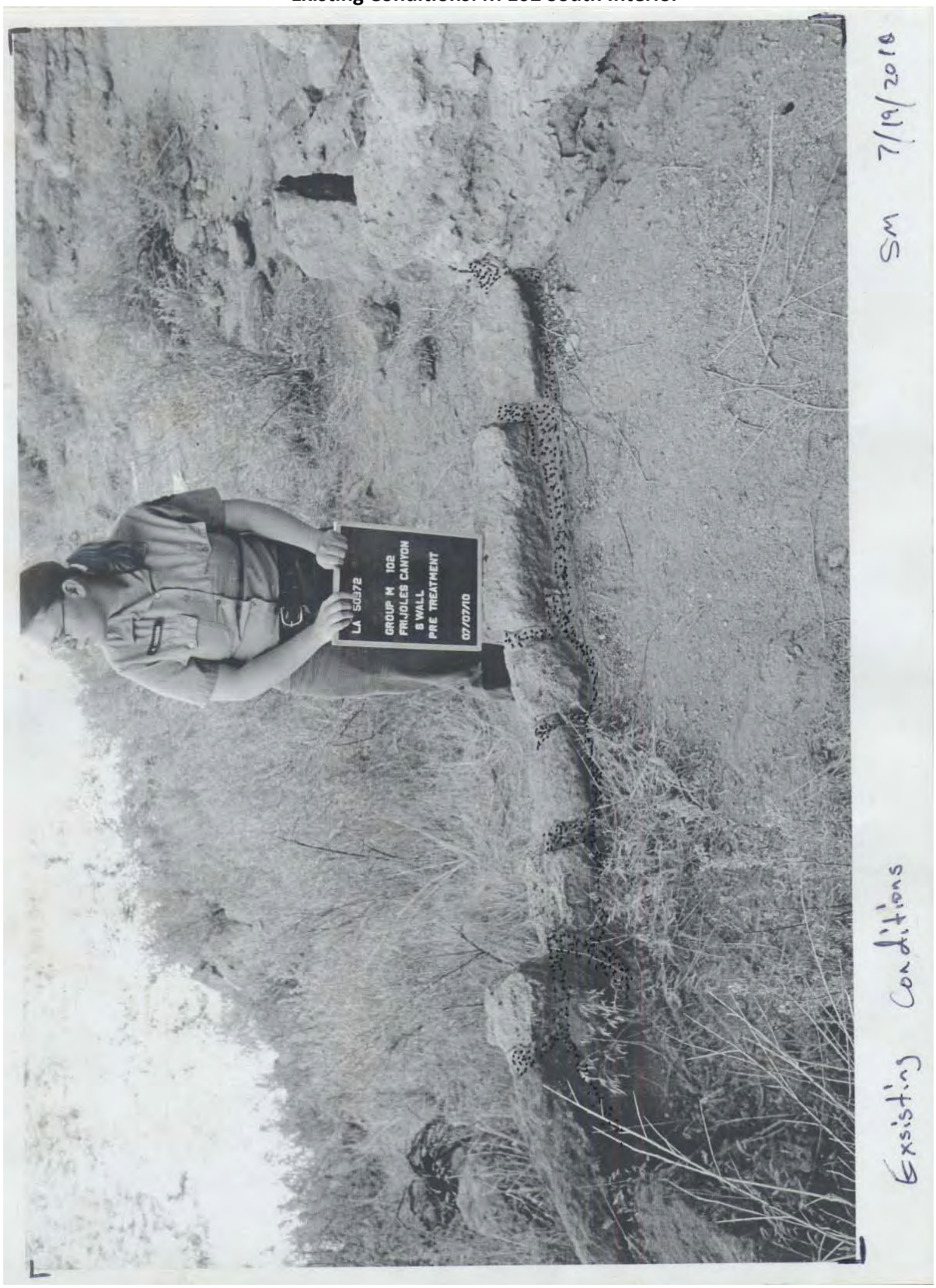
Existing Conditions: M 102 West Interior #2



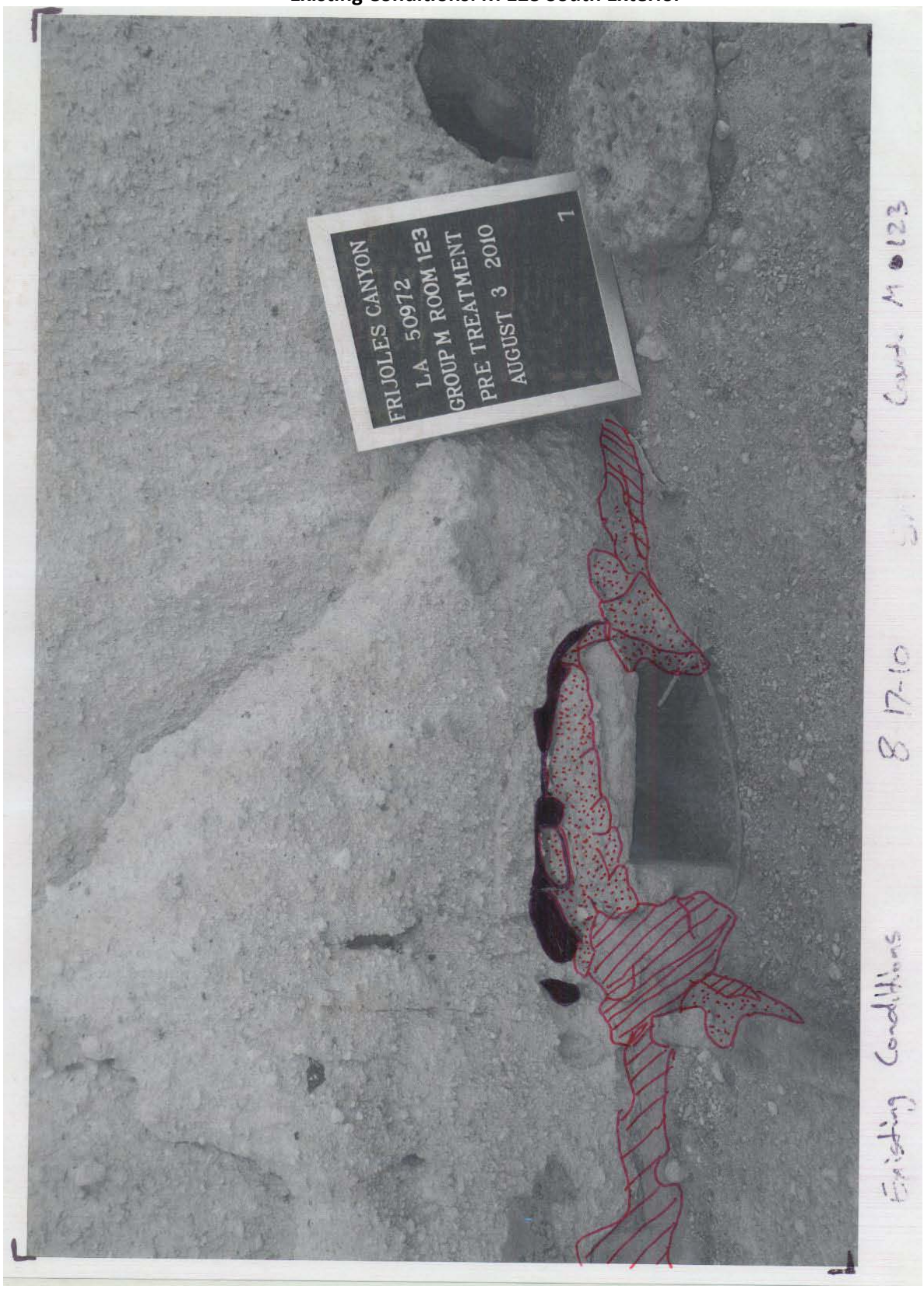
Existing Conditions: M 102 South Exterior



Existing Conditions: M 102 South Interior



Existing Conditions: M 123 South Exterior

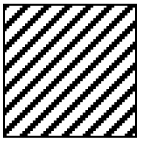


Appendix H:

Graphic Documentation for Cavate Masonry Stabilization

After Stabilization

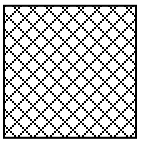
Post Treatment Graphic Documentation for Masonry Stabilization



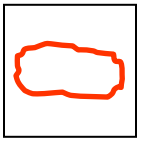
Repointed with Earthen Mortar



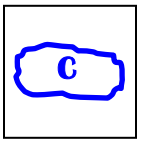
Repointed with Amended Mortar



Rebedded with Earthen Mortar



Stone Rebedded in New Mortar



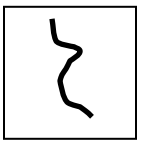
Chinking Stones



Chinking Stones covered by Mortar

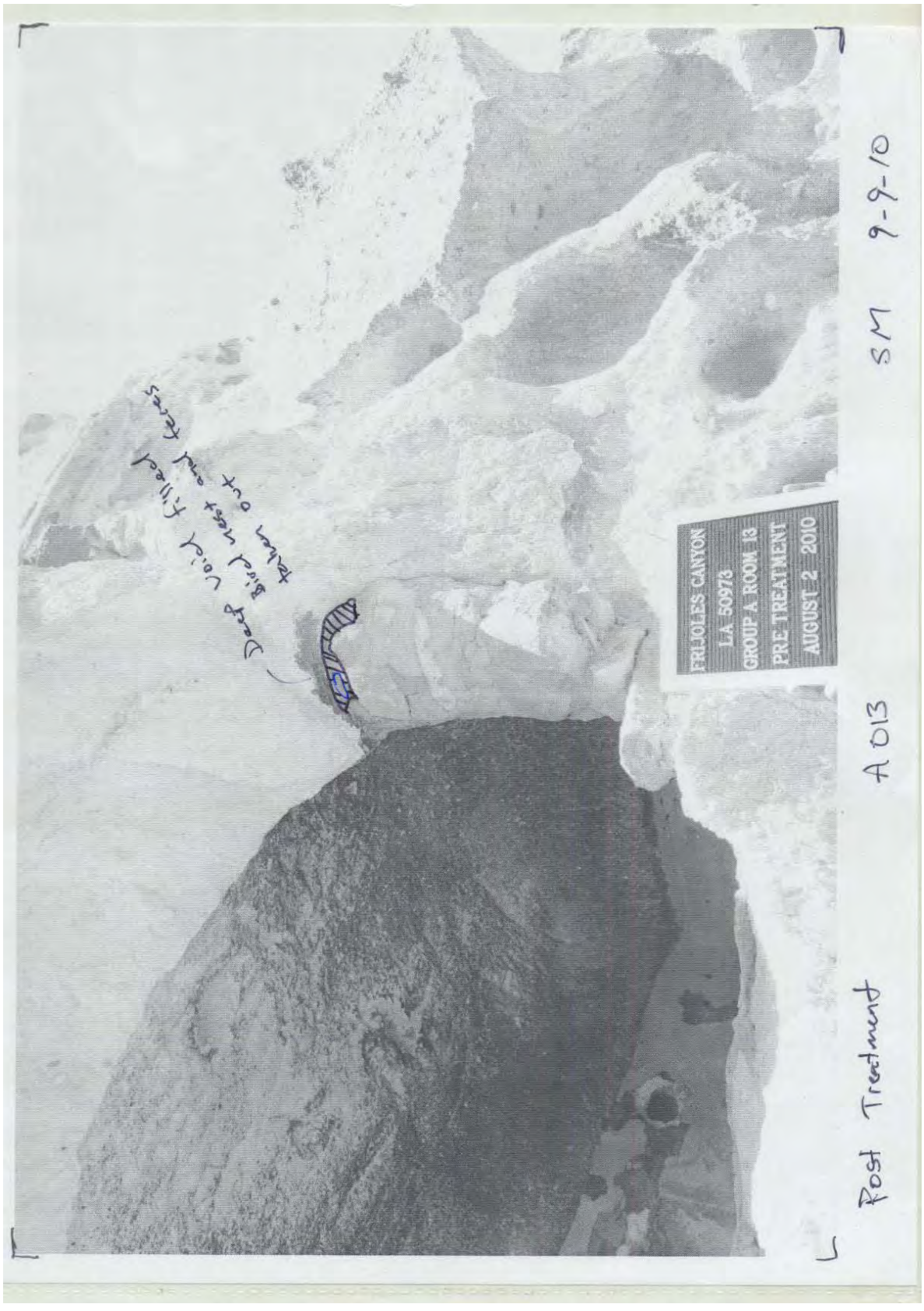


Cement

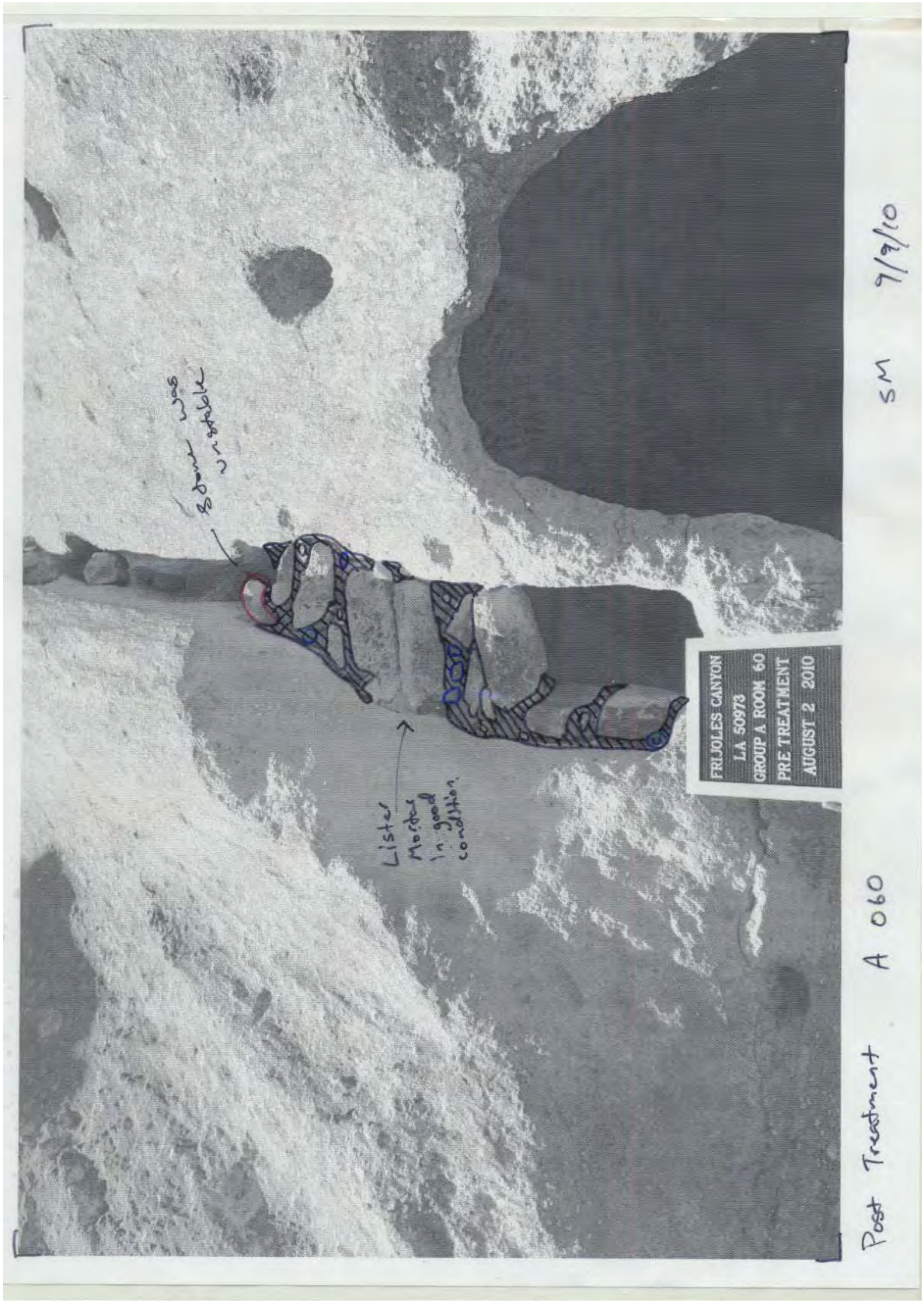


Crack in the Stone

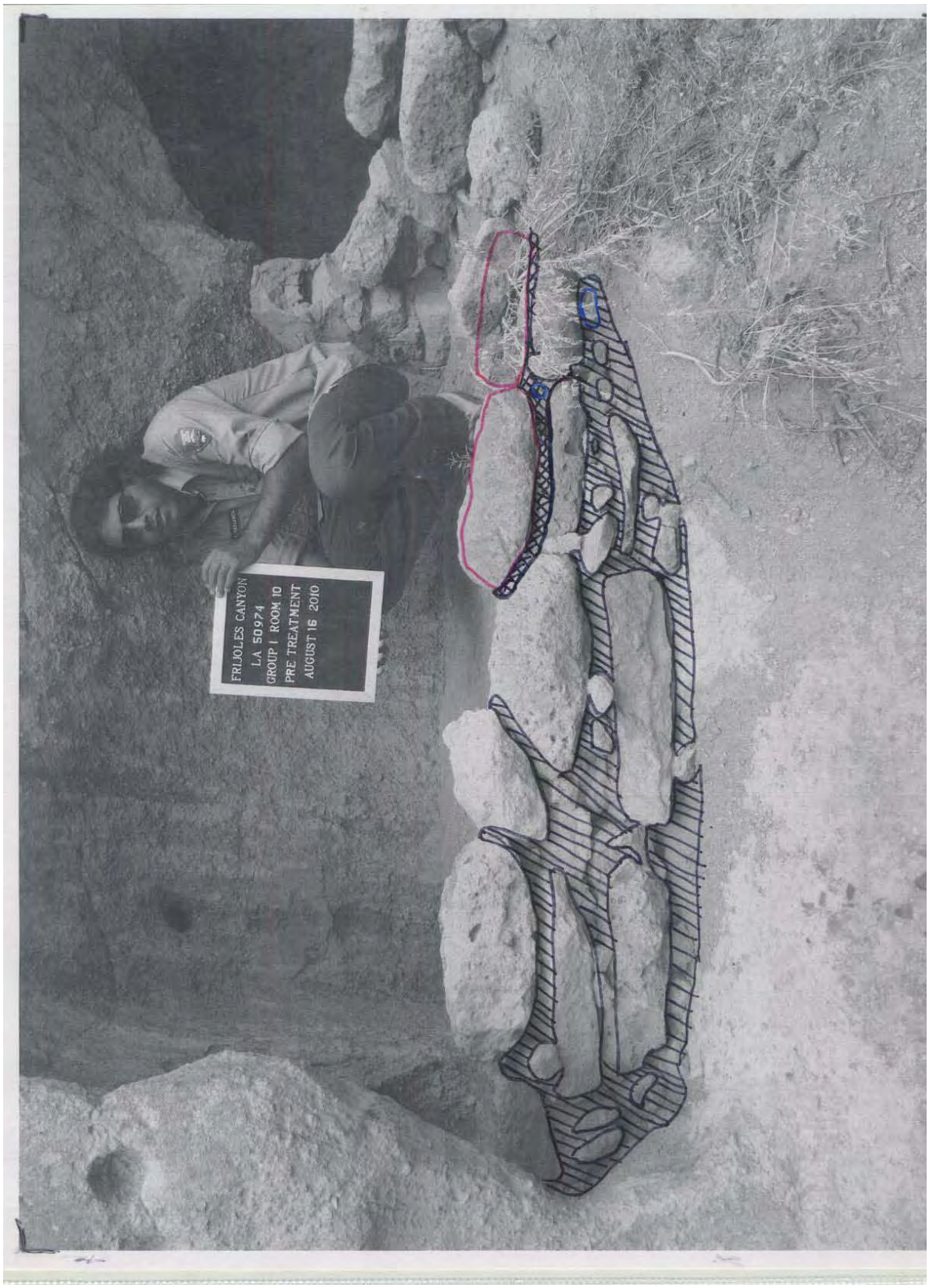
After Treatment: A 013 West Exterior



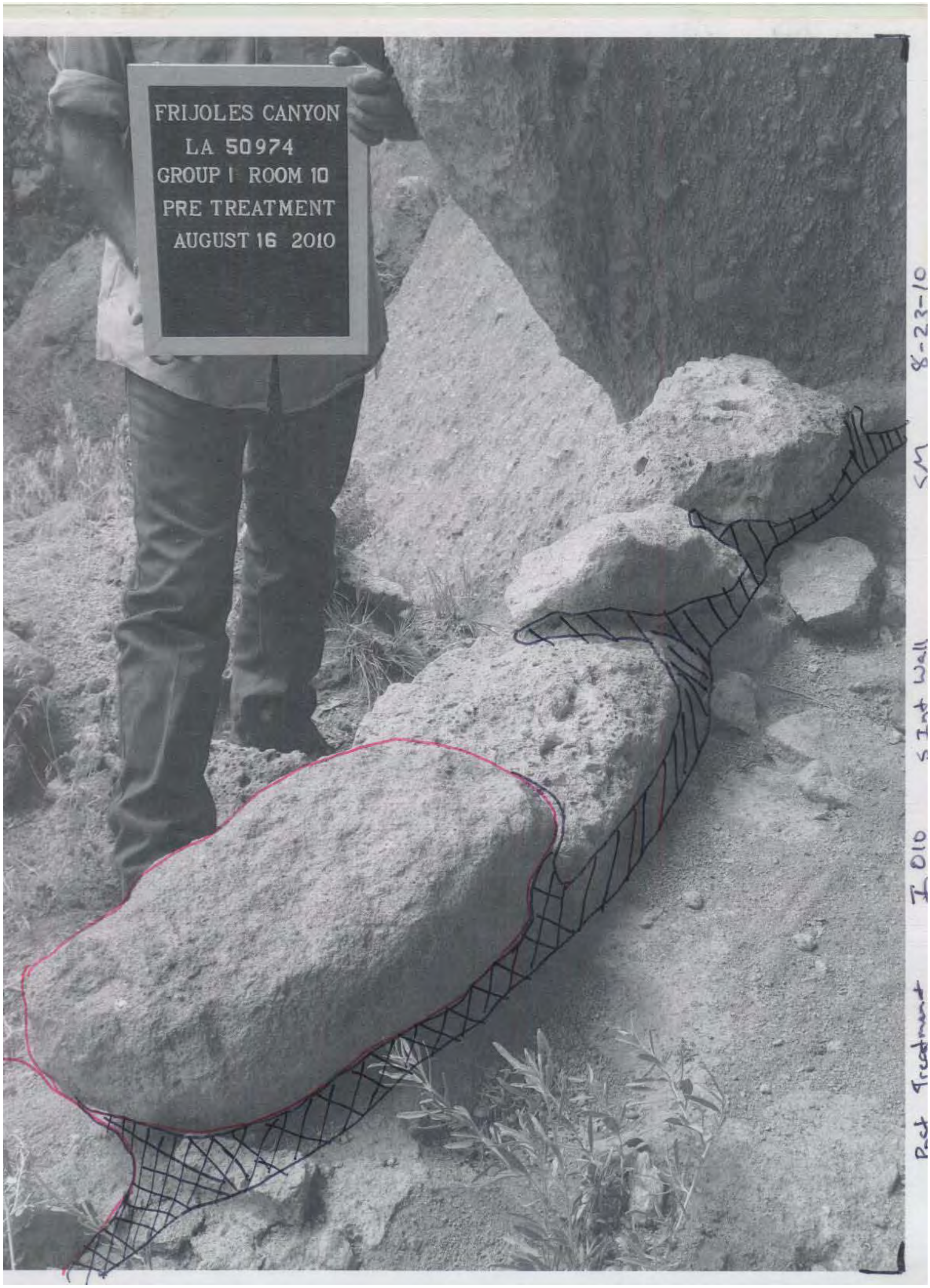
After Treatment: A 060 South Exterior



After Treatment: I 010 South Exterior



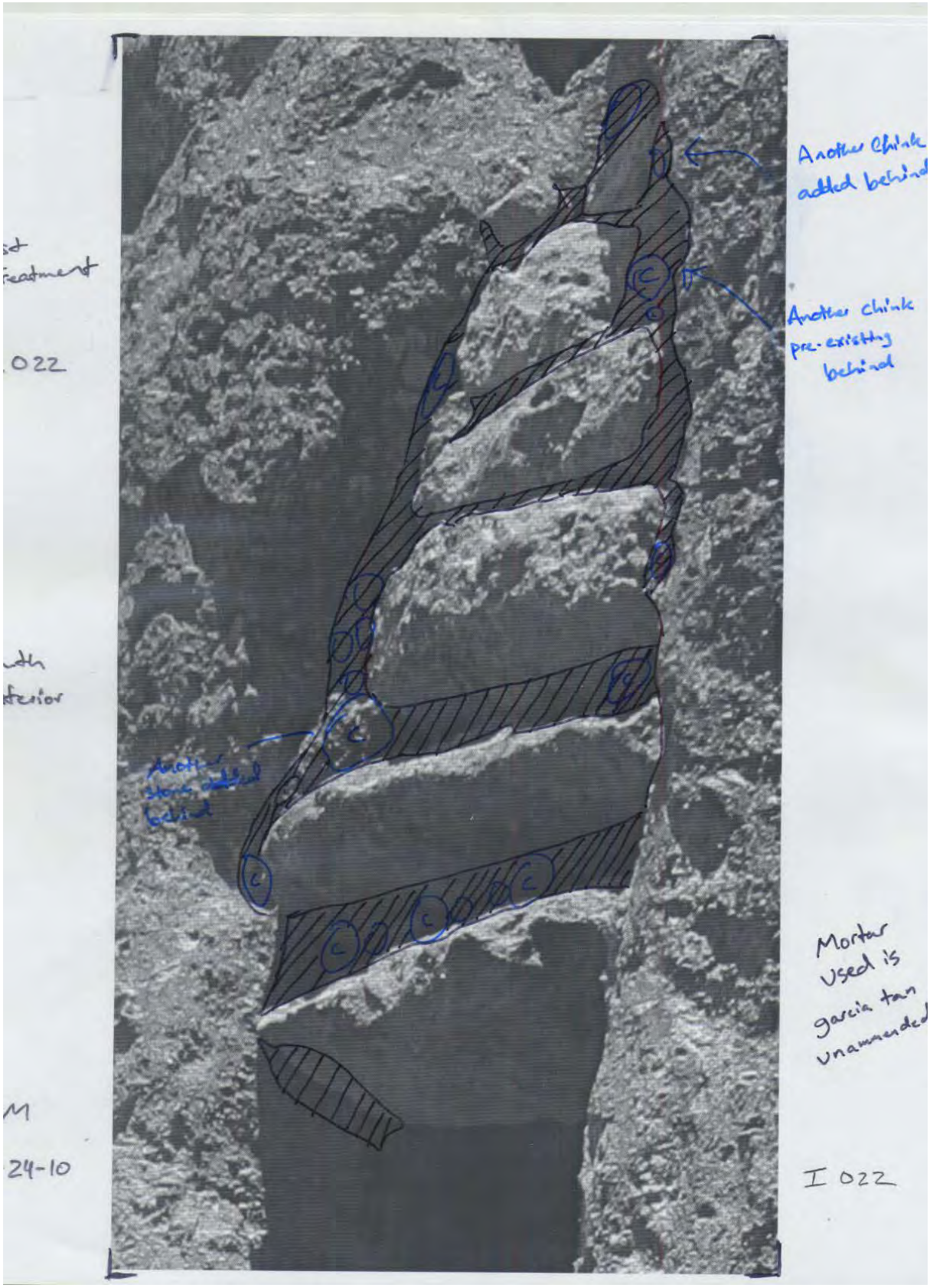
After Treatment: I 010 South Interior



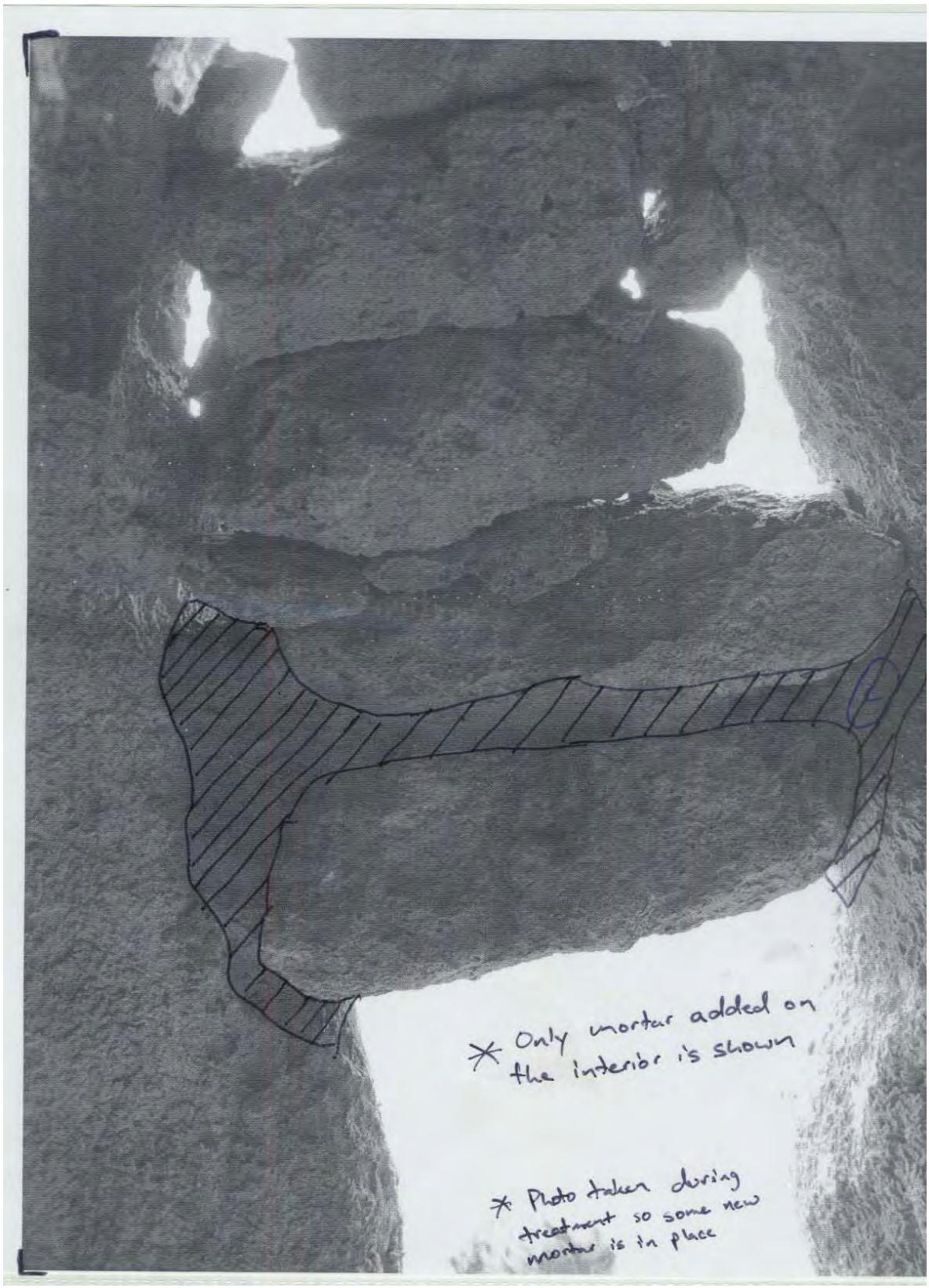
After Treatment: I 022 South Exterior #1



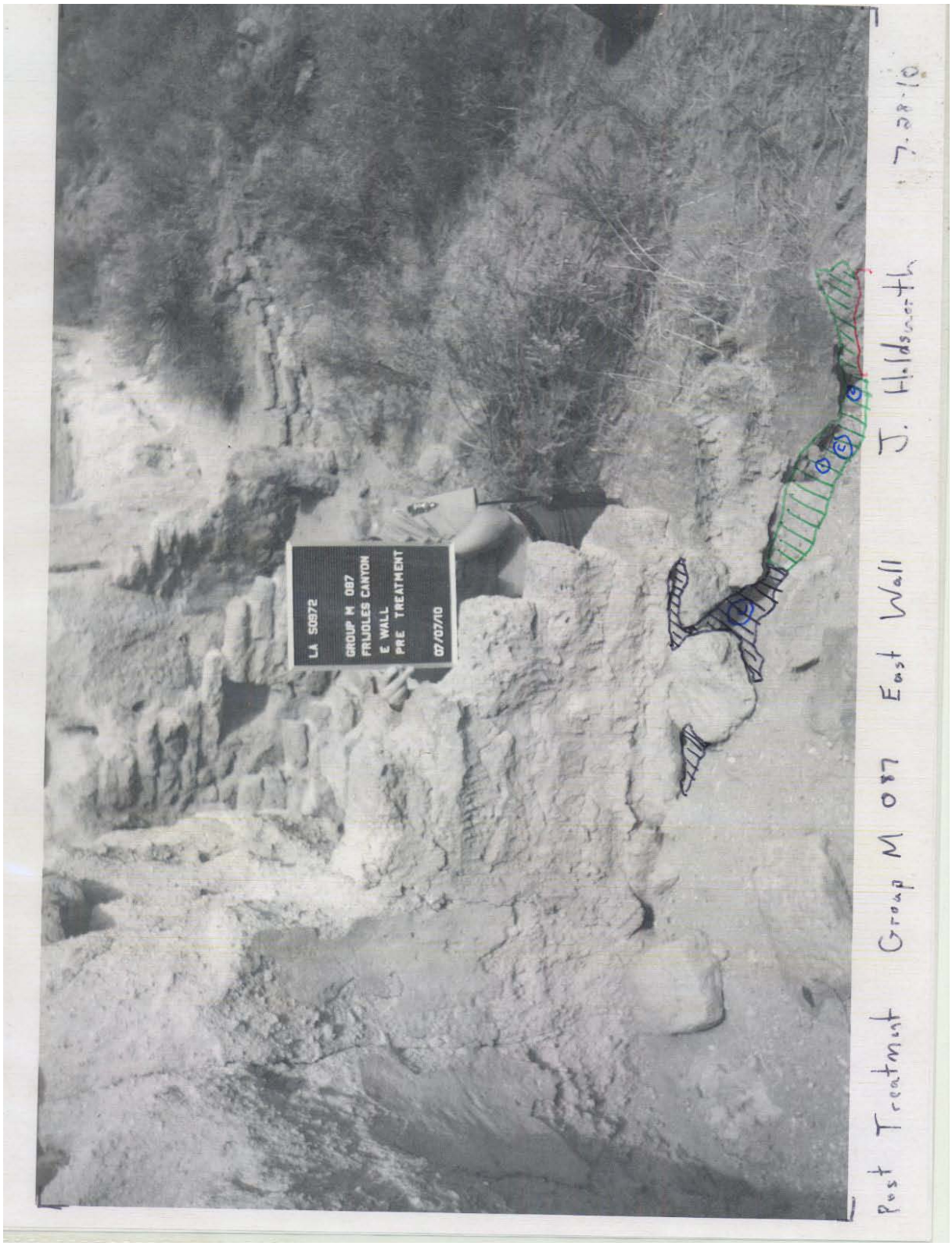
After Treatment: I 022 South Exterior #2



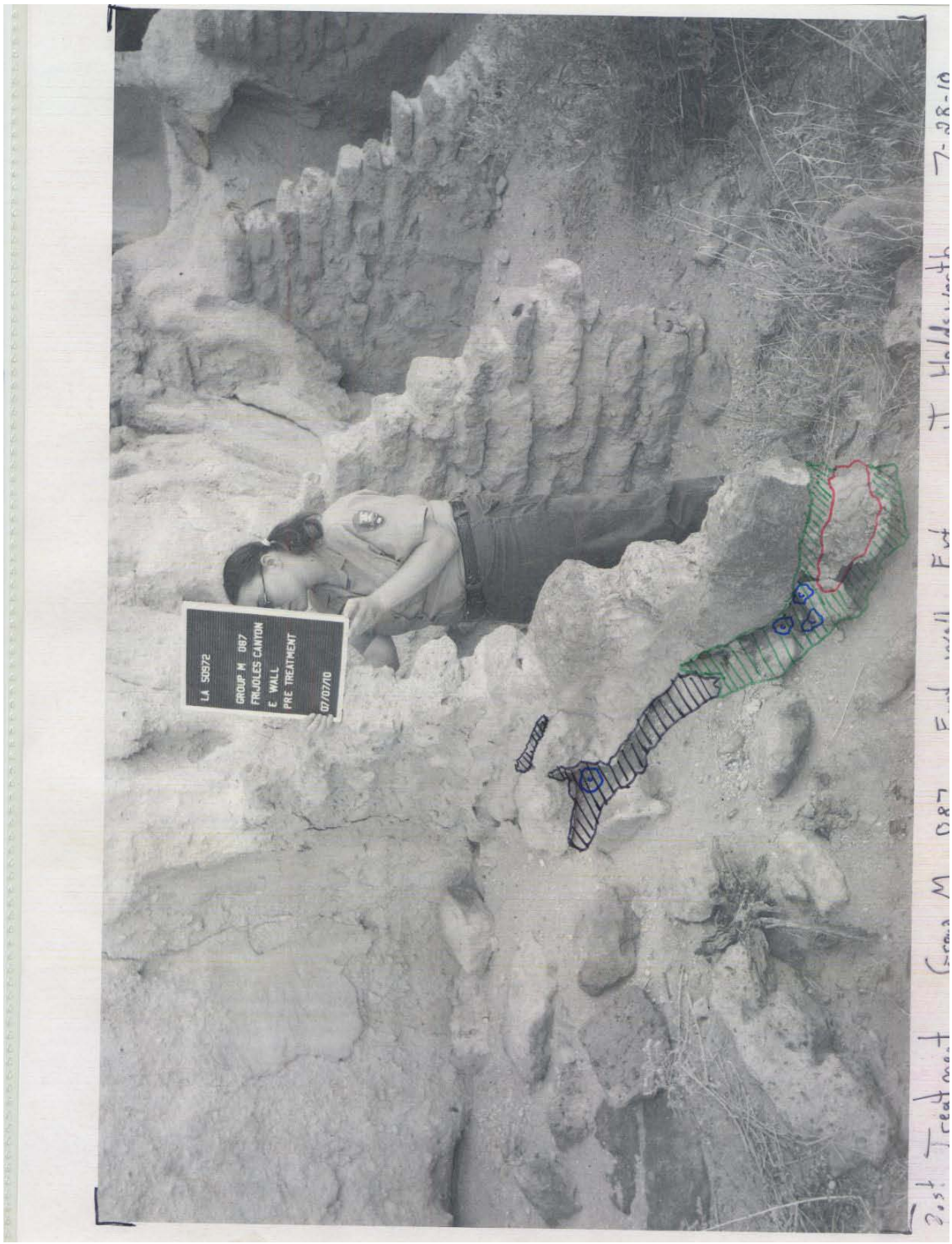
After Treatment: I 022 South Interior



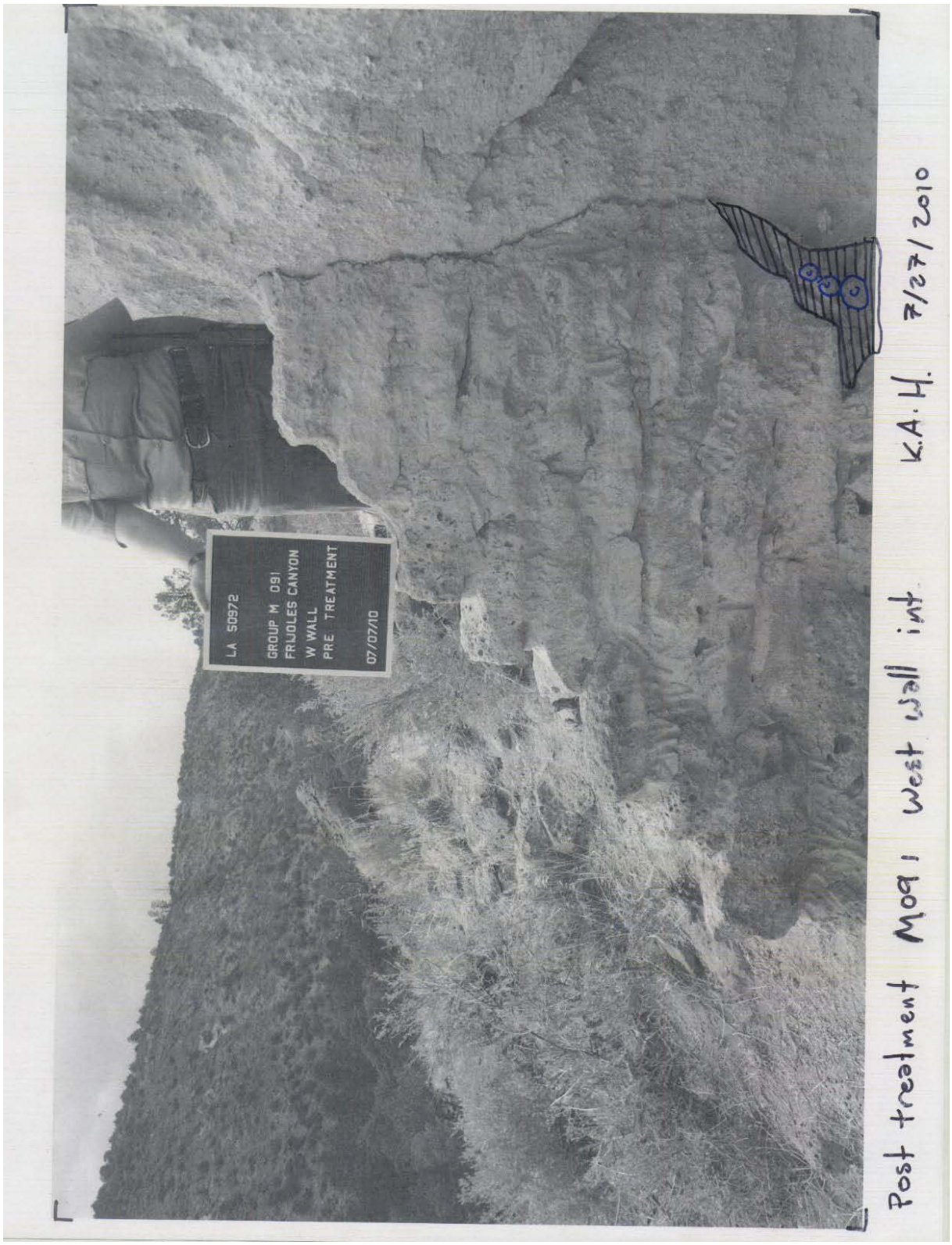
After Treatment: M 087 East Interior #1



After Treatment: M 087 East Interior #2



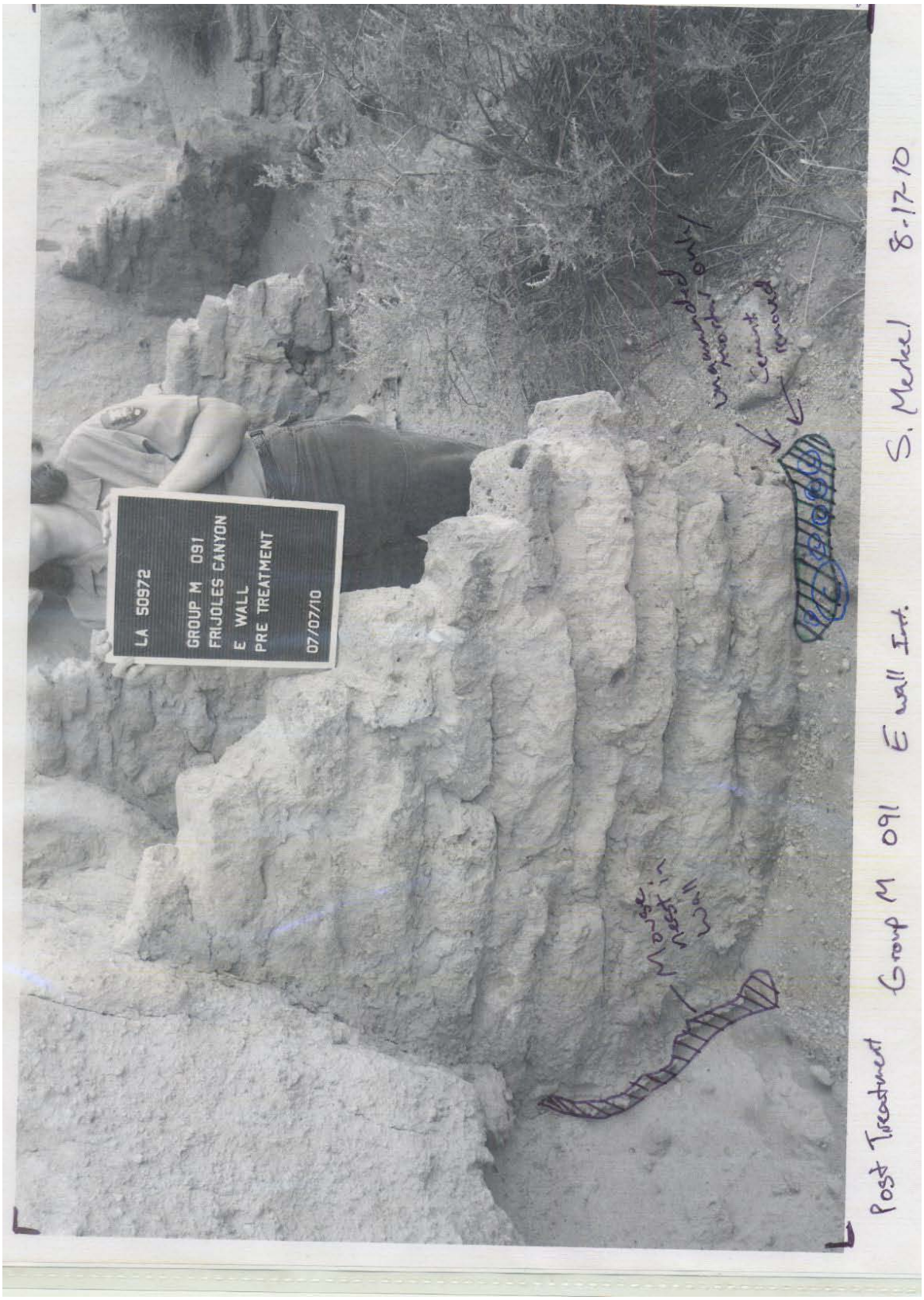
After Treatment: M 091 West Interior #1



After Treatment: M 091 West Interior #2



After Treatment: M 091 East Interior #1



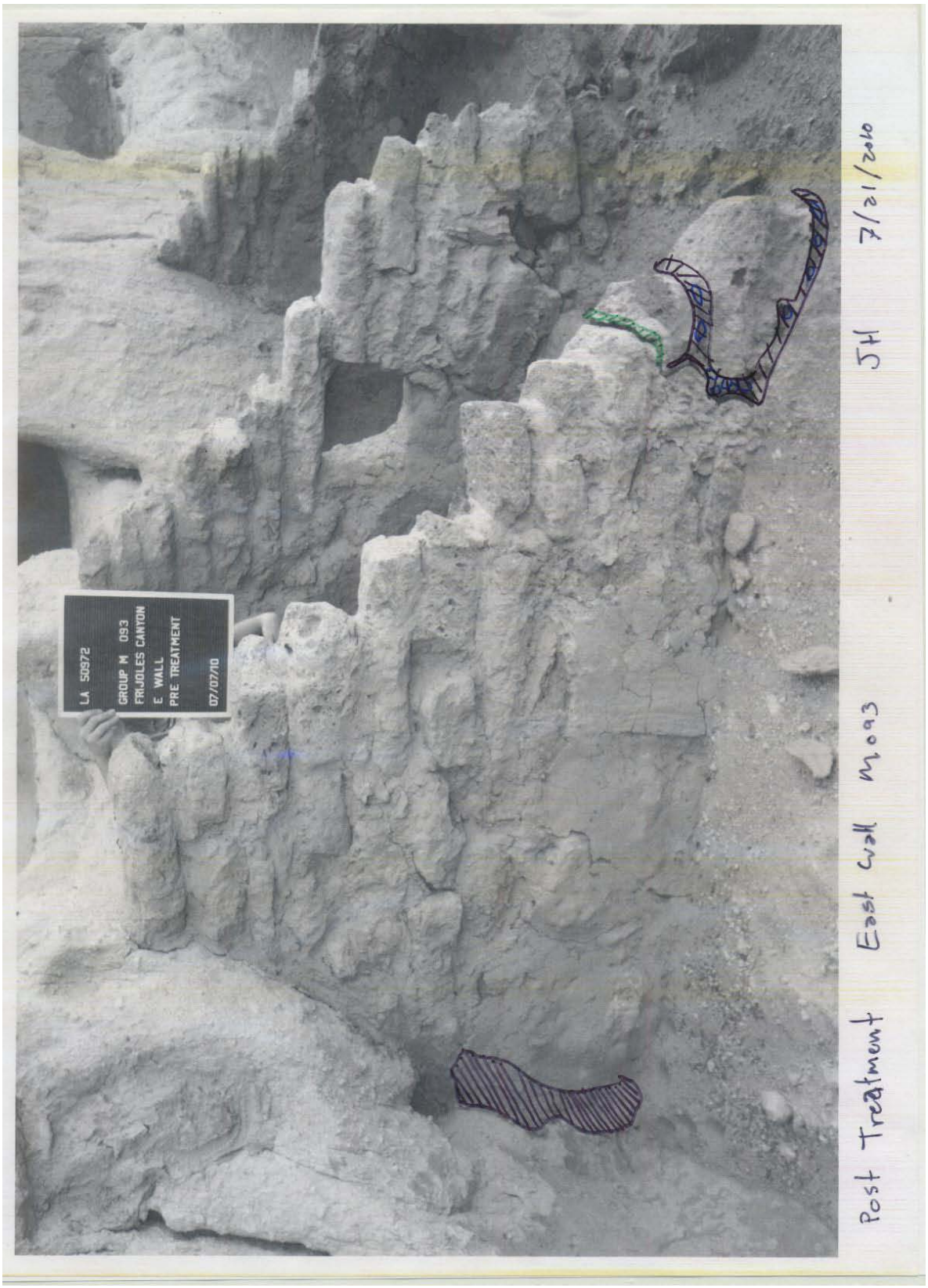
After Treatment: M 093 West Interior #1



After Treatment: M 093 West Interior #2



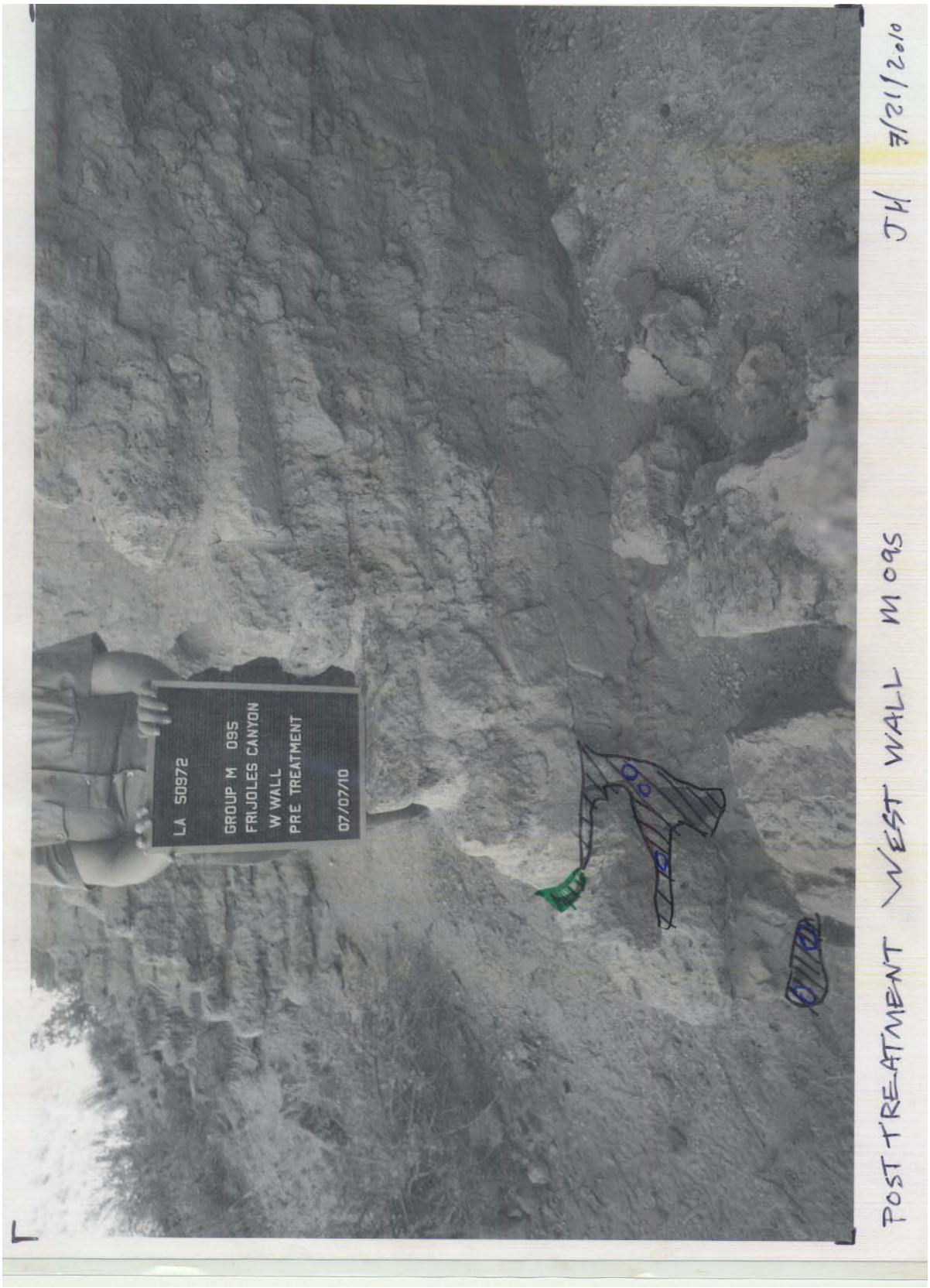
After Treatment: M 093 East Interior #1



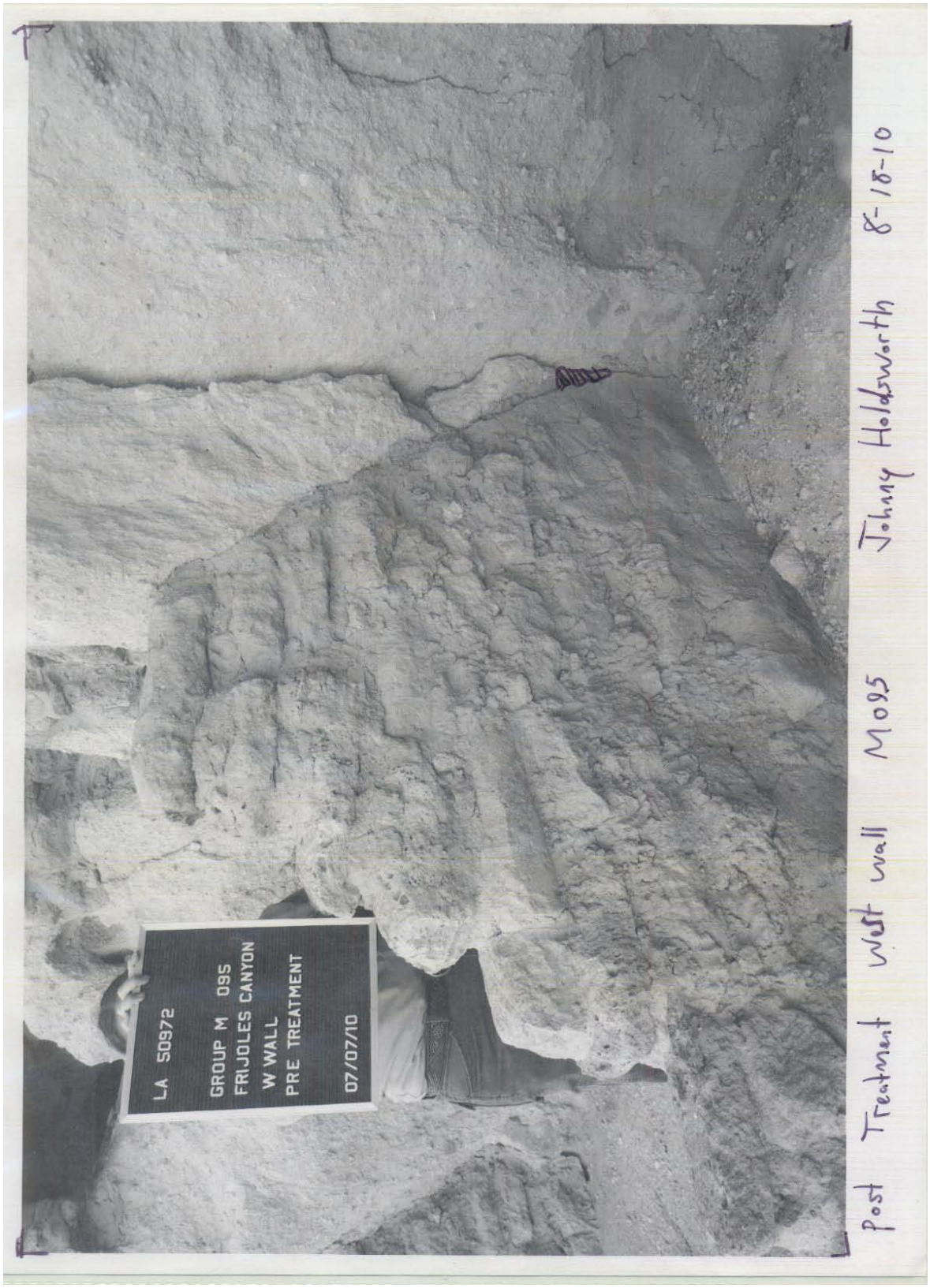
After Treatment: M 093 East Interior #2



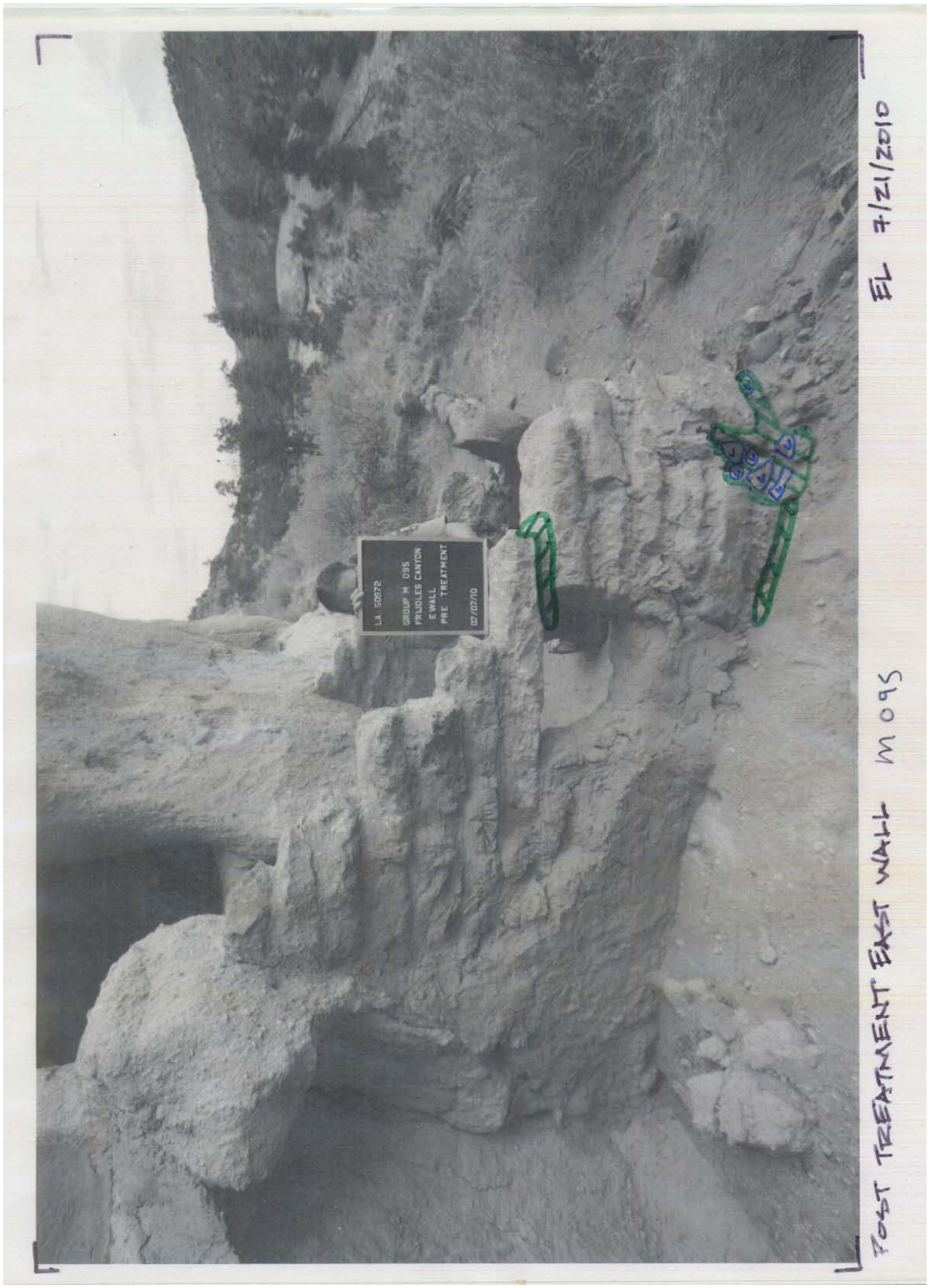
After Treatment: M 095 West Interior #1



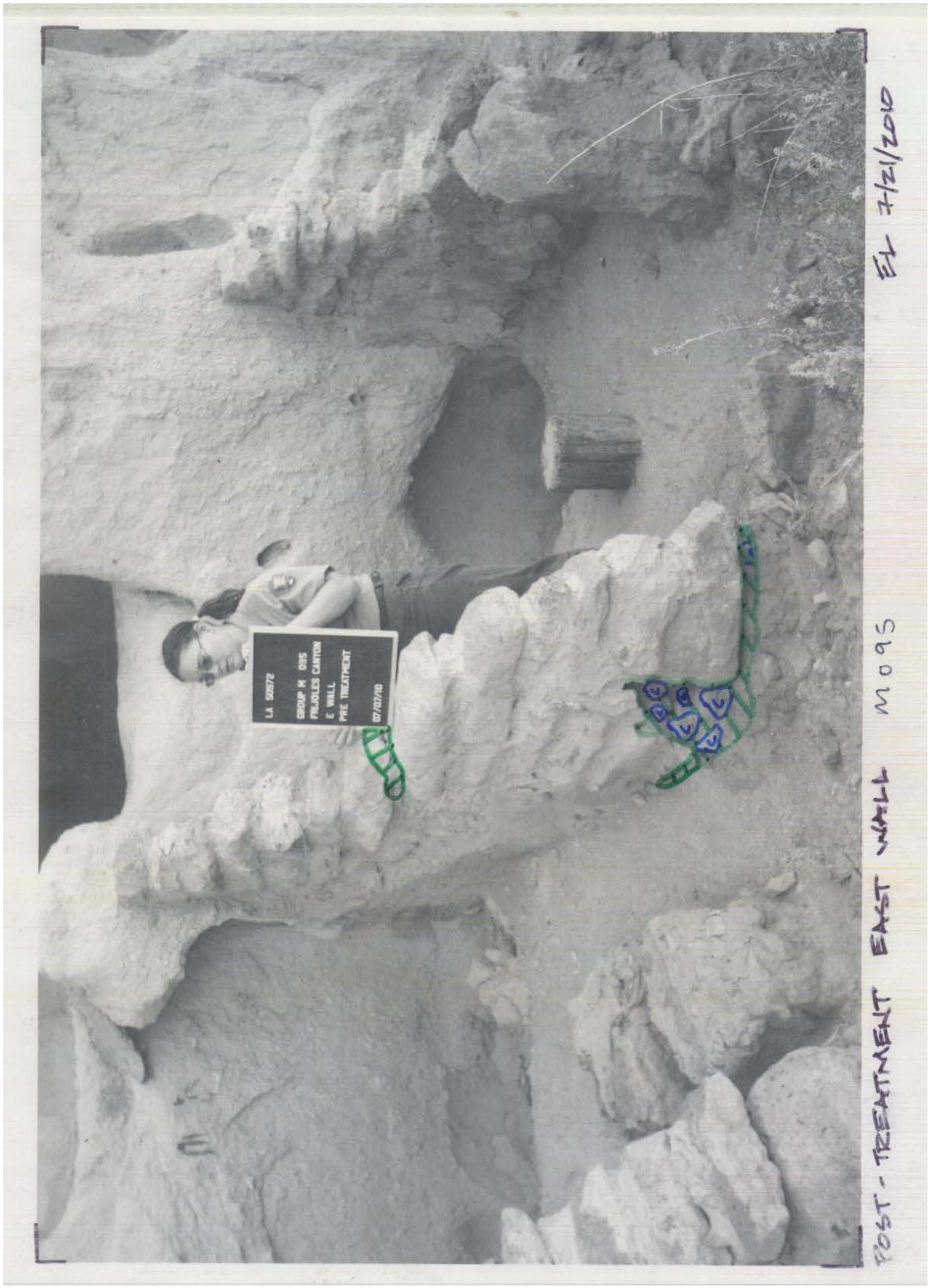
After Treatment: M 095 West Interior #2



After Treatment: M 095 East Interior #1



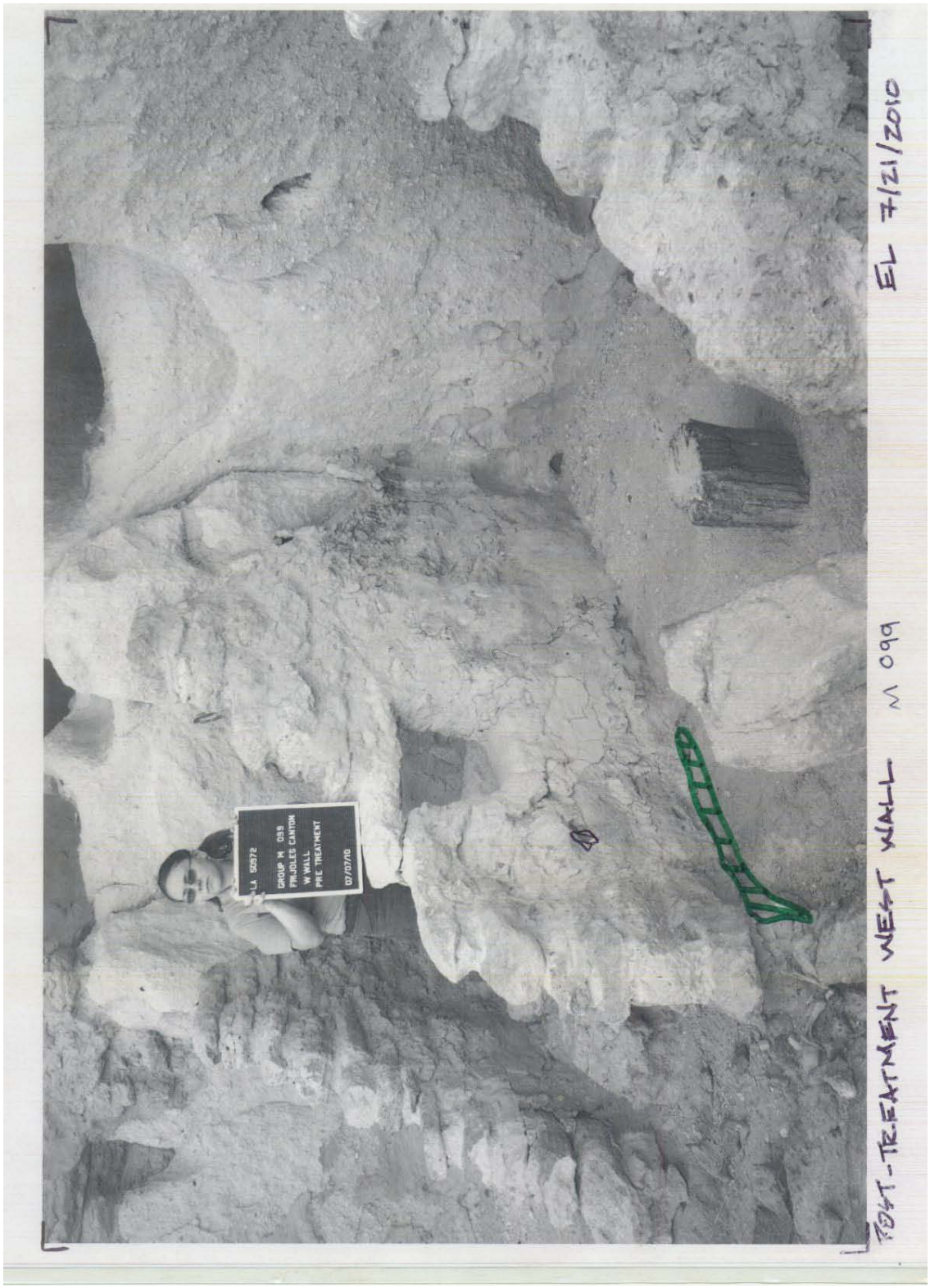
After Treatment: M 095 East Interior #2



After Treatment: M 099 West Interior #1



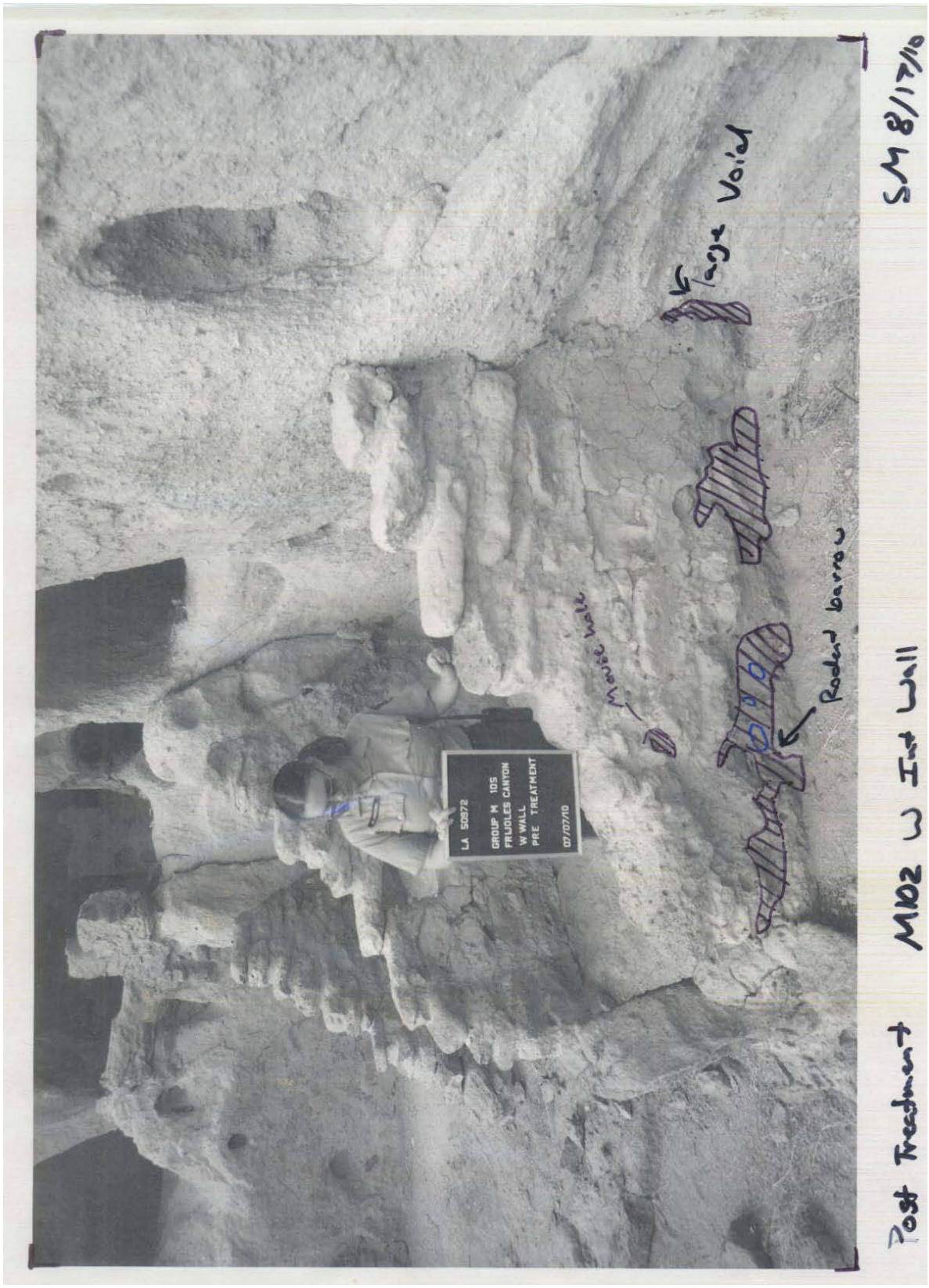
After Treatment: M 099 West Interior #2



After Treatment: M 099 East Interior #1



After Treatment: M 102 West Interior #1



After Treatment: M 102 South Exterior



After Treatment: M 102 South Interior



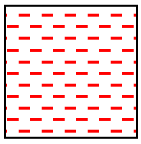
After Treatment: M 123 South Exterior



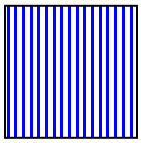
Appendix I:

Graphic Documentation for Finishes Conservation

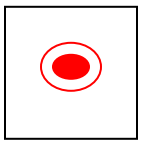
Pre and Post Treatment Graphic Documentation for Finishes Conservation



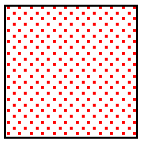
Detachment



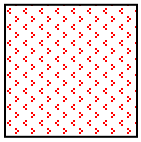
Delamination



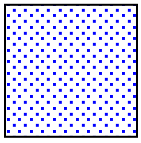
Blister



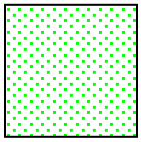
2.5% Gelatin (Hot)



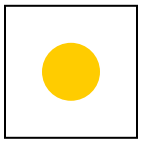
5% Gelatin (Hot)



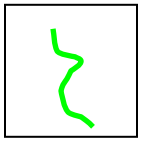
10% Gelatin (Cold)



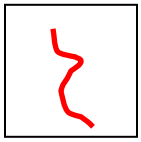
Cyclododecane & 2.5% Gel



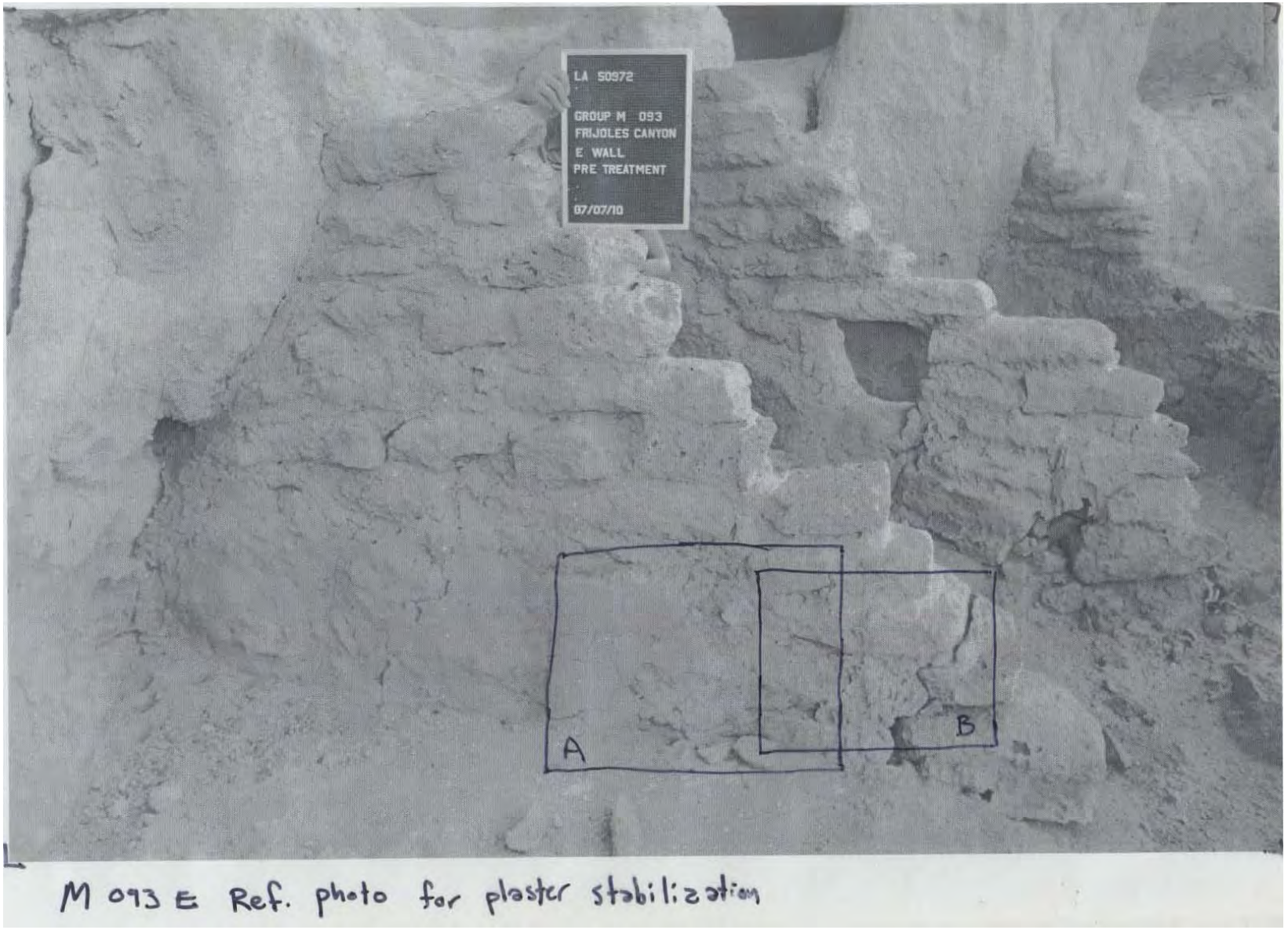
Grout (2HHL: 1 M. Sphere: 1 Sand)



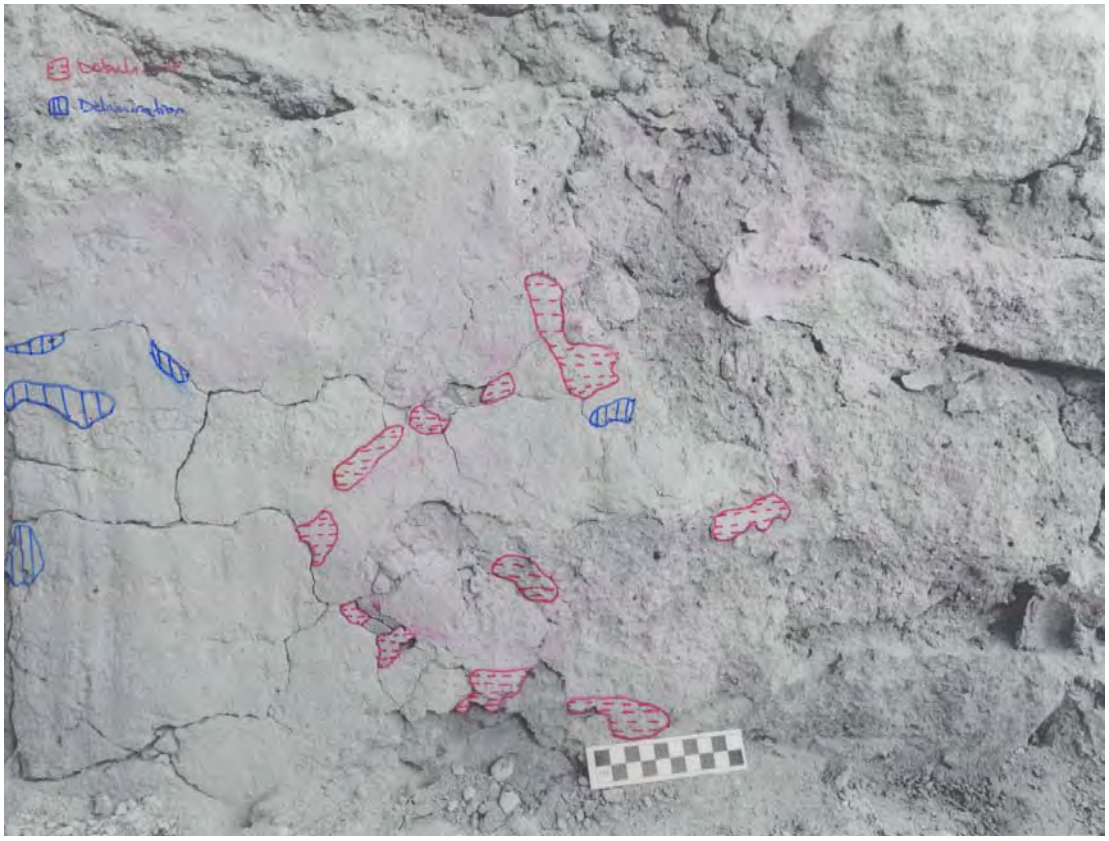
Edging



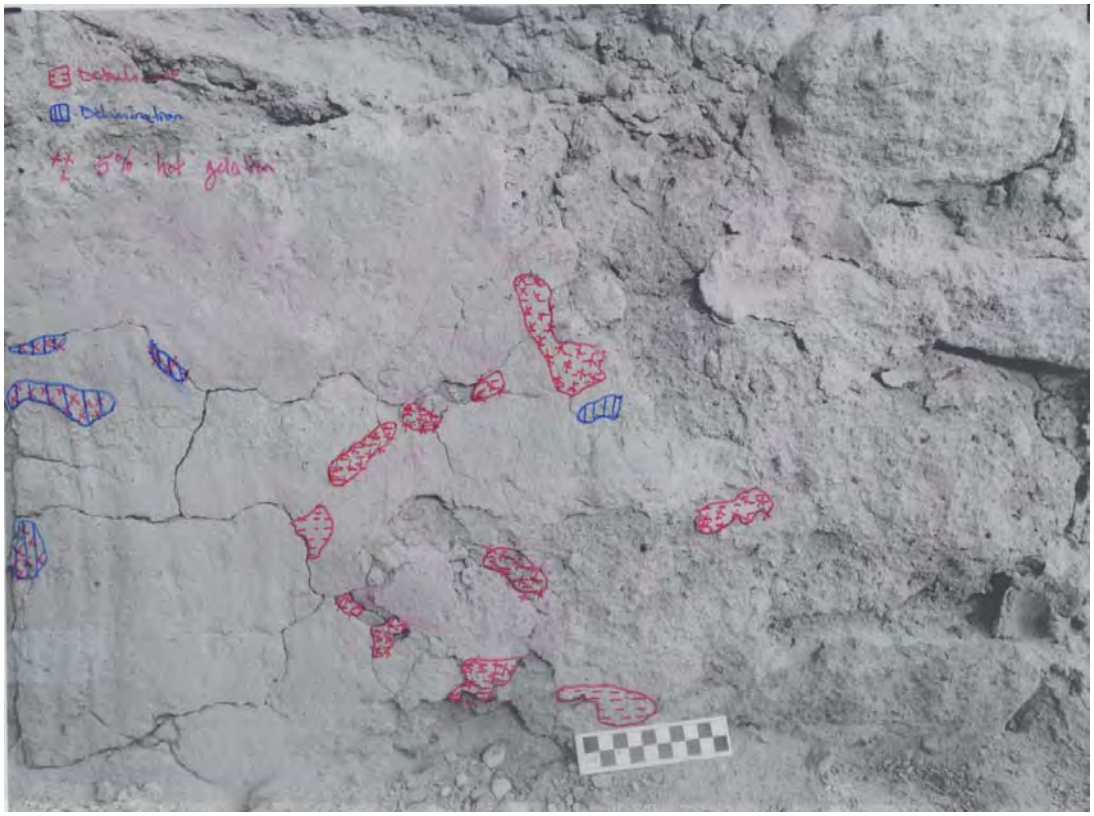
Crack



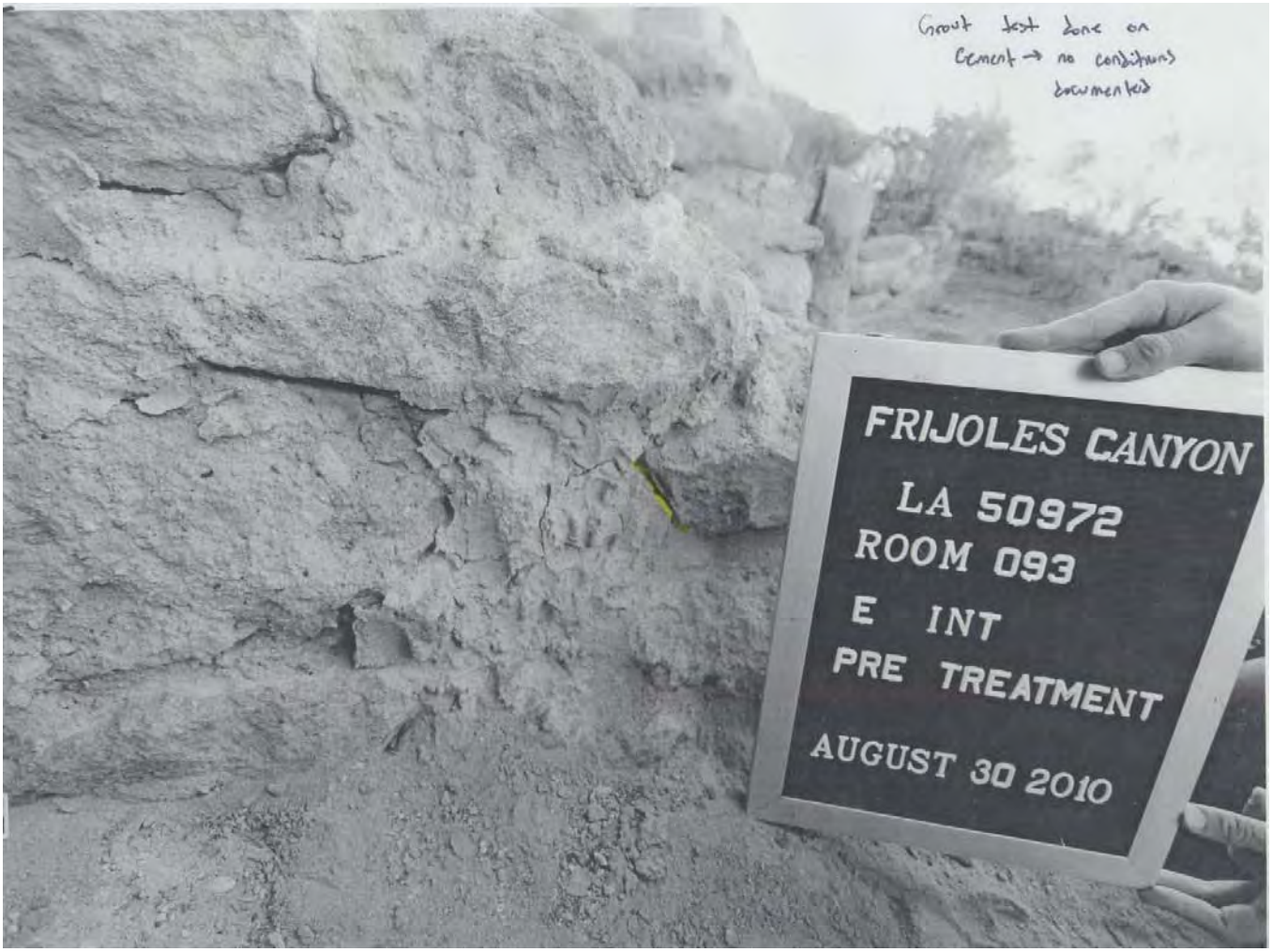
Reference photograph showing location of following photographs from M 093, East Interior Wall



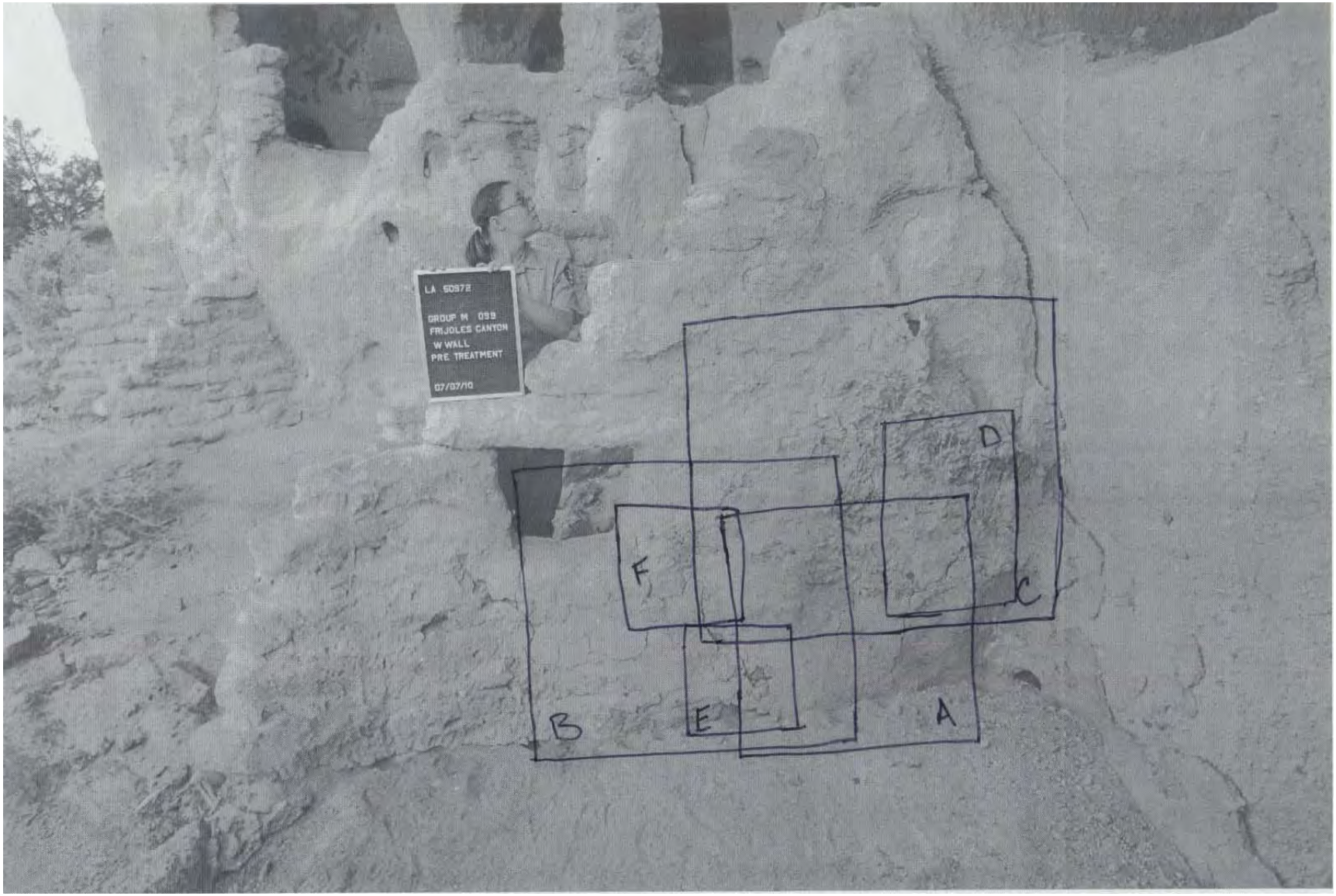
Panel A. M 093 East Interior Wall Conditions



Panel A. M 093 East Interior Wall Treatments



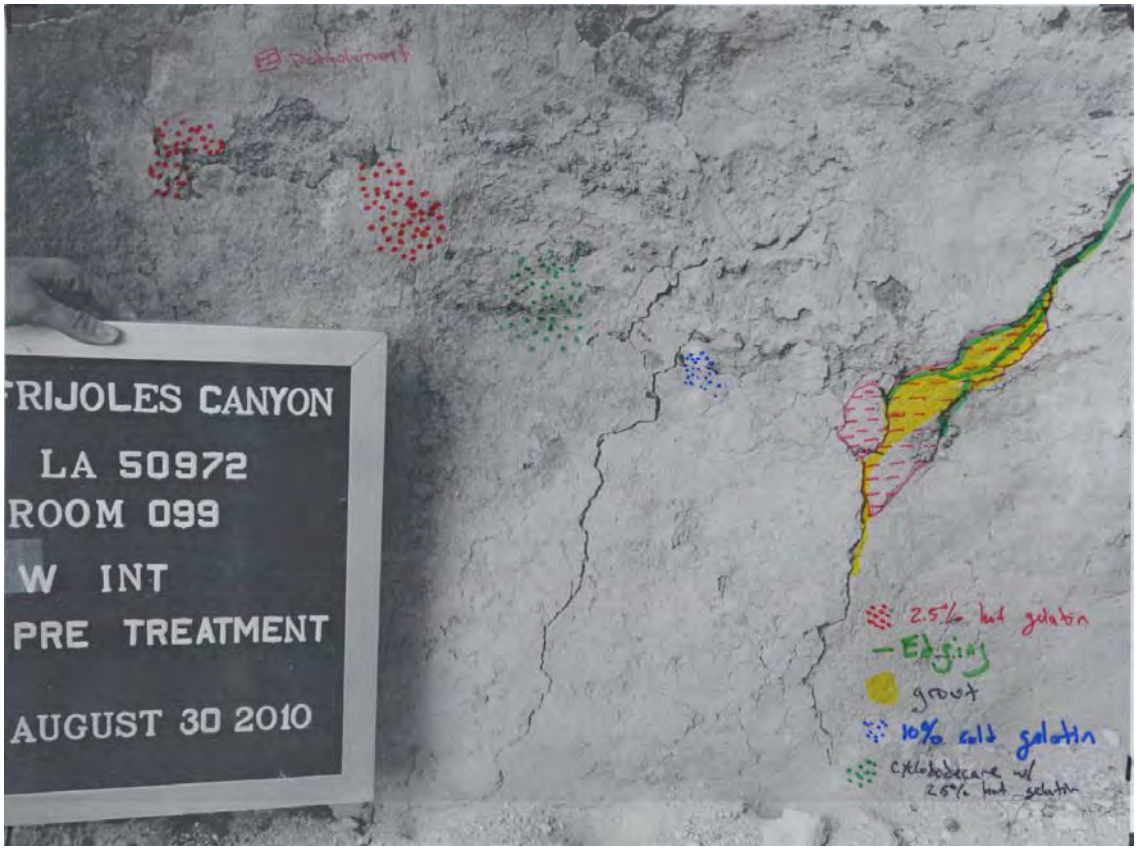
Panel B. Area of grout test on stabilization cement. M 093 East Interior Wall.



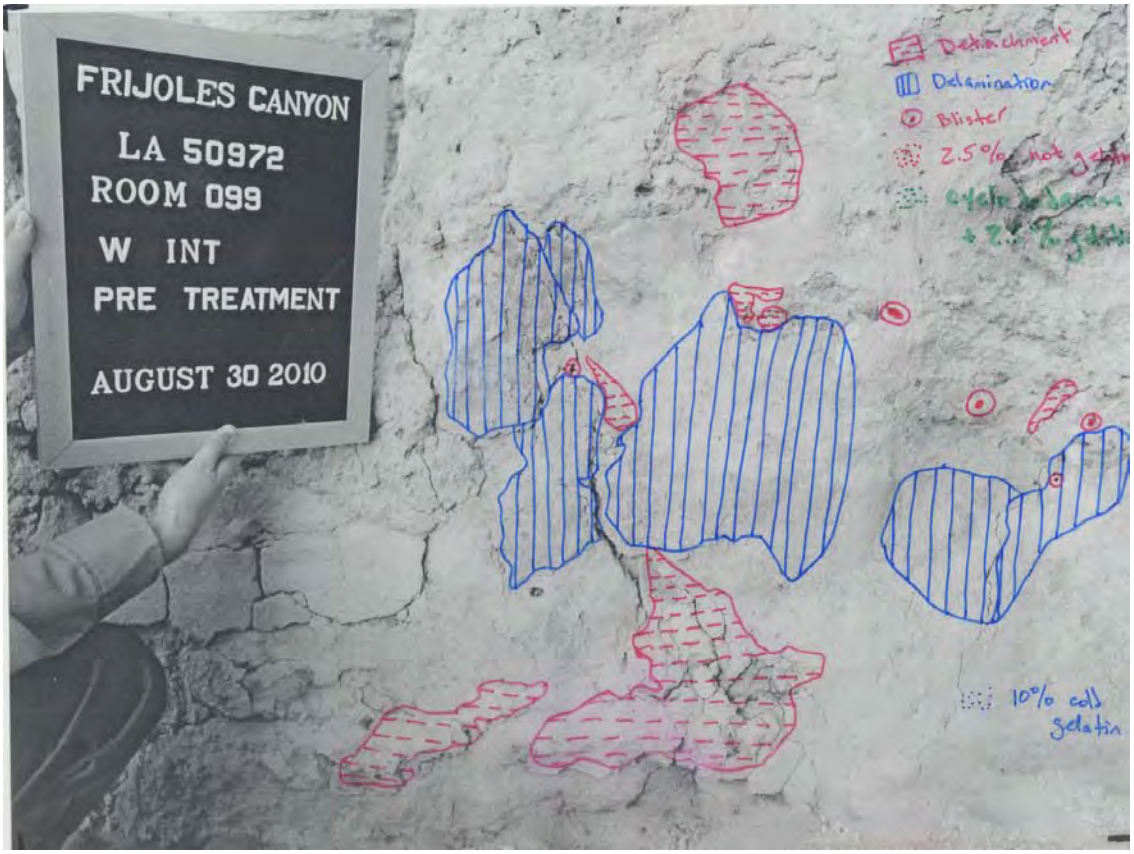
Reference photograph showing location of following photographs from M 099, West Interior Wall



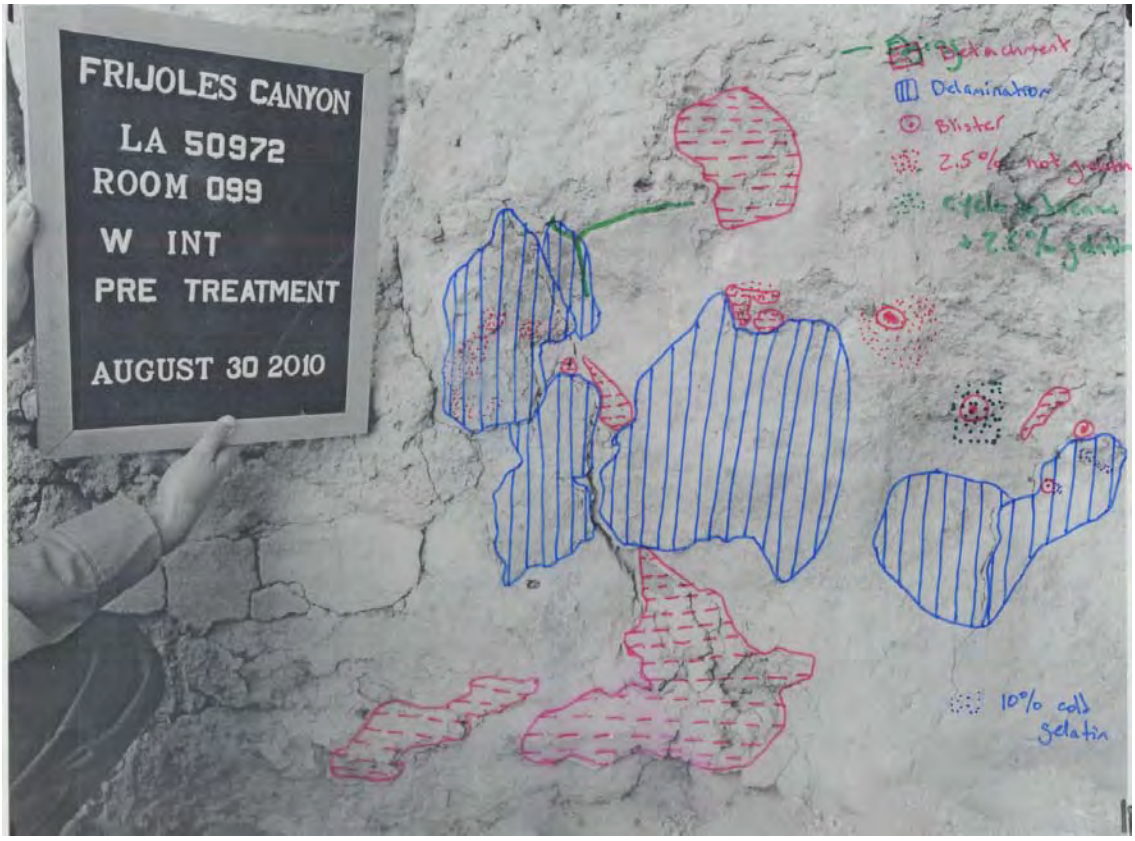
Panel A. M 099 West Interior Wall Conditions



Panel A. M 099 West Interior Wall Treatments



Panel B. M 099 West Interior Wall Conditions



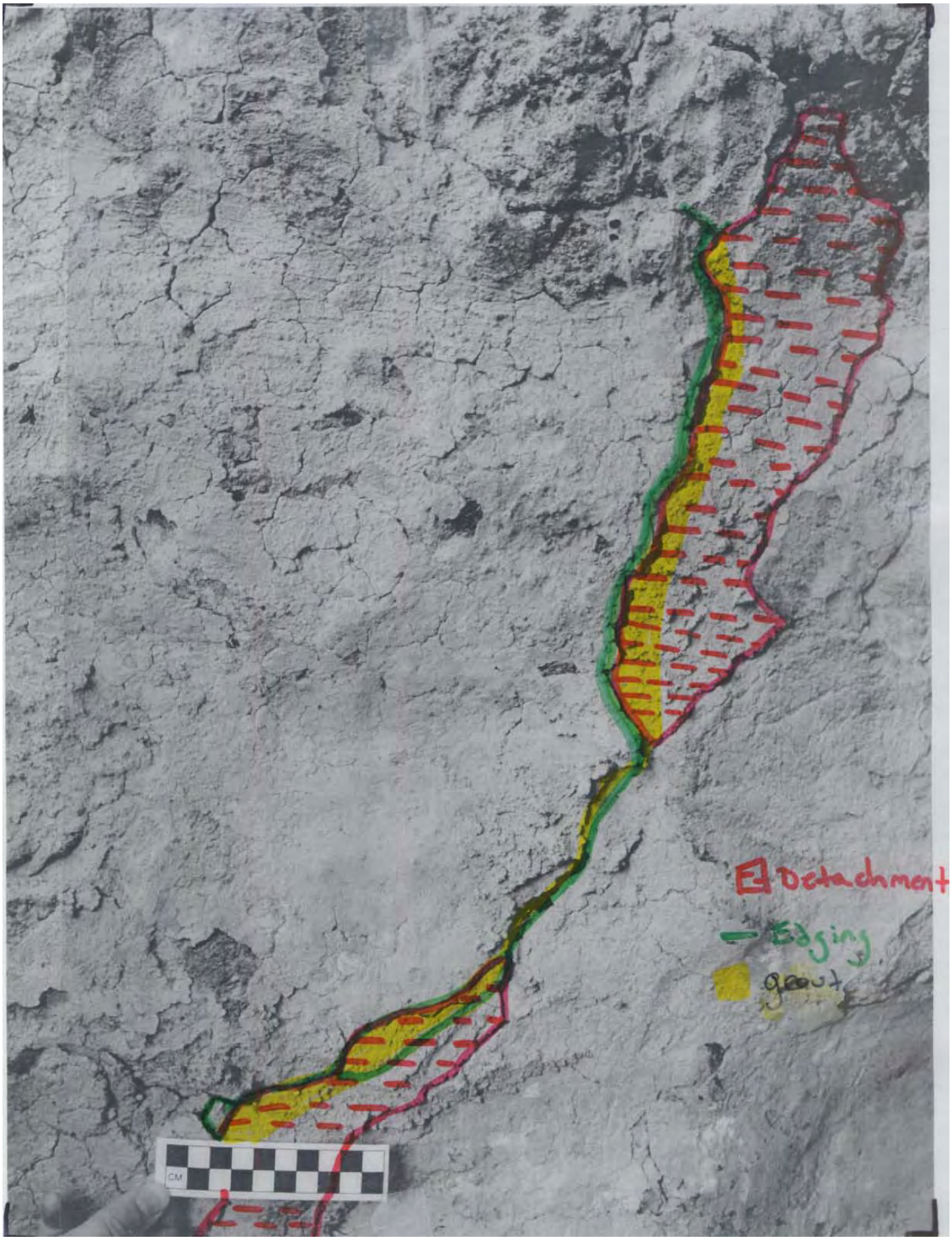
Panel B. M 099 West Interior Wall Conditions



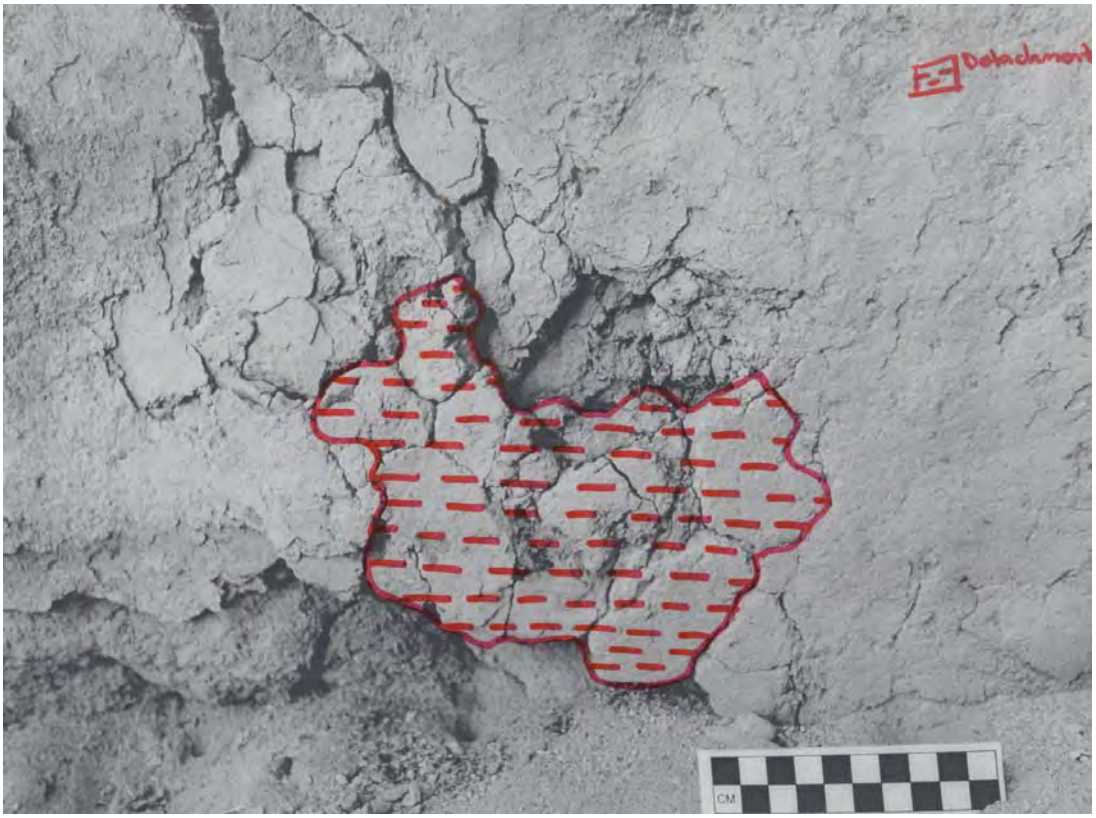
Panel C. M 099 West Interior Wall Conditions. See Panel D for treatments.



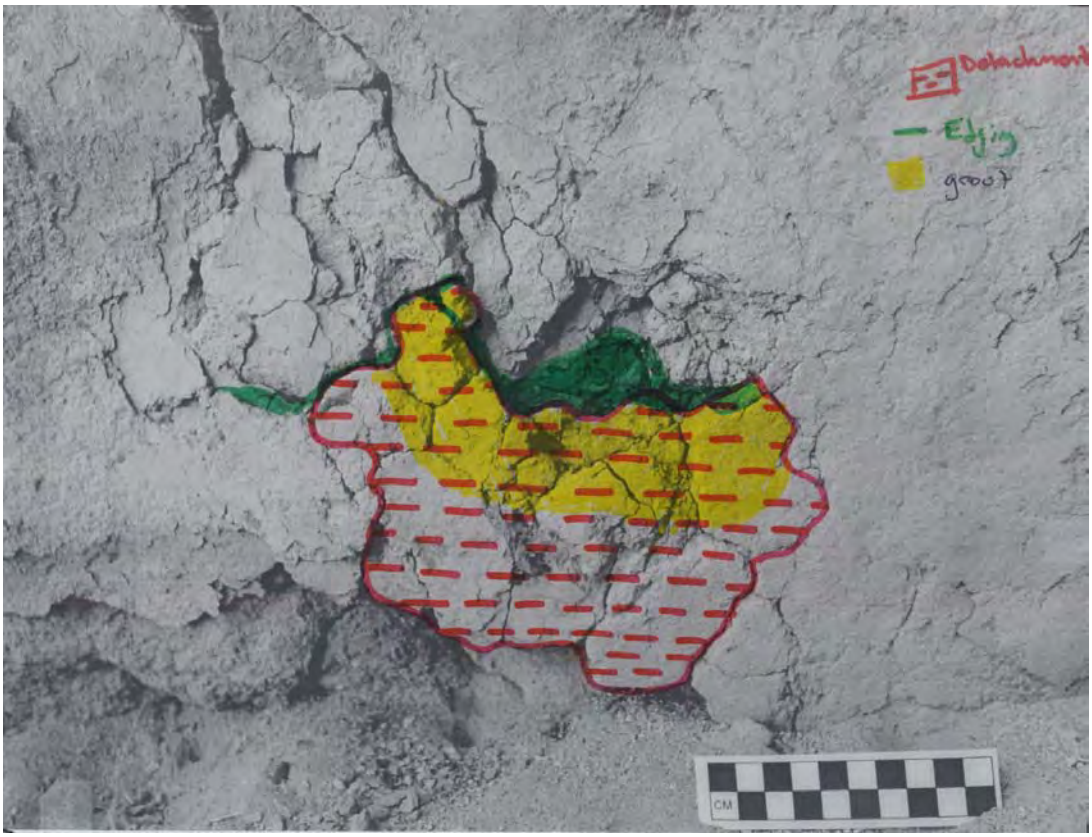
Panel D. M 099 West Interior Wall Conditions



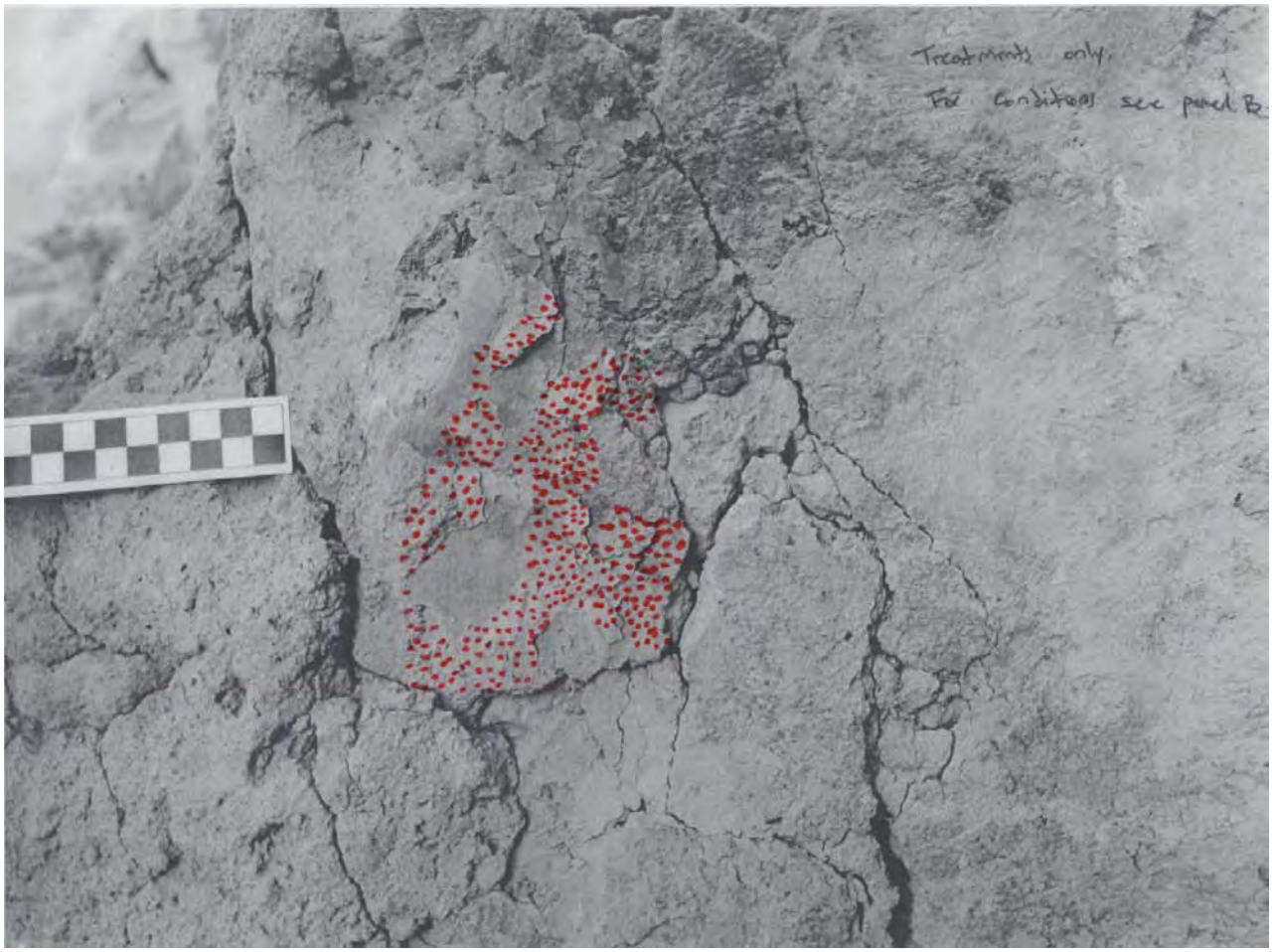
Panel D. M 099 West Interior Wall Treatments



Panel E. M 099 West Interior Wall Conditions



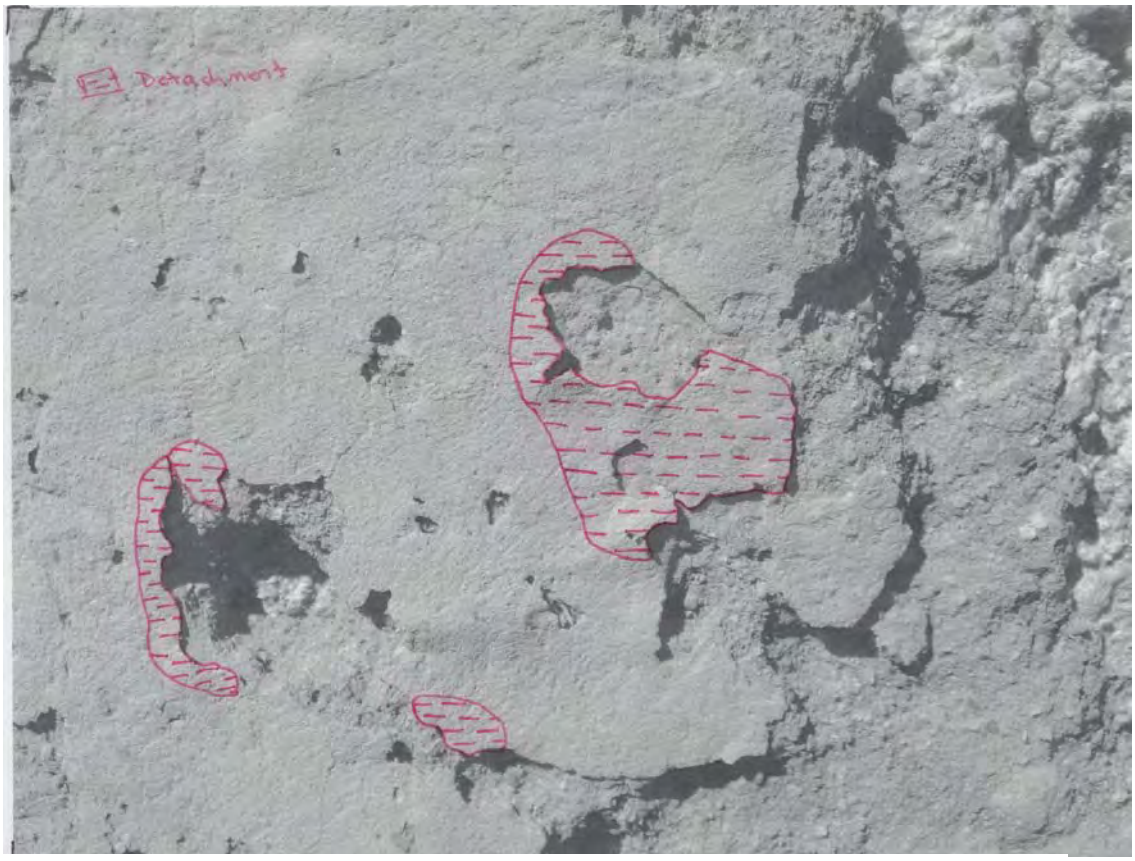
Panel E. M 099 West Interior Wall Treatments



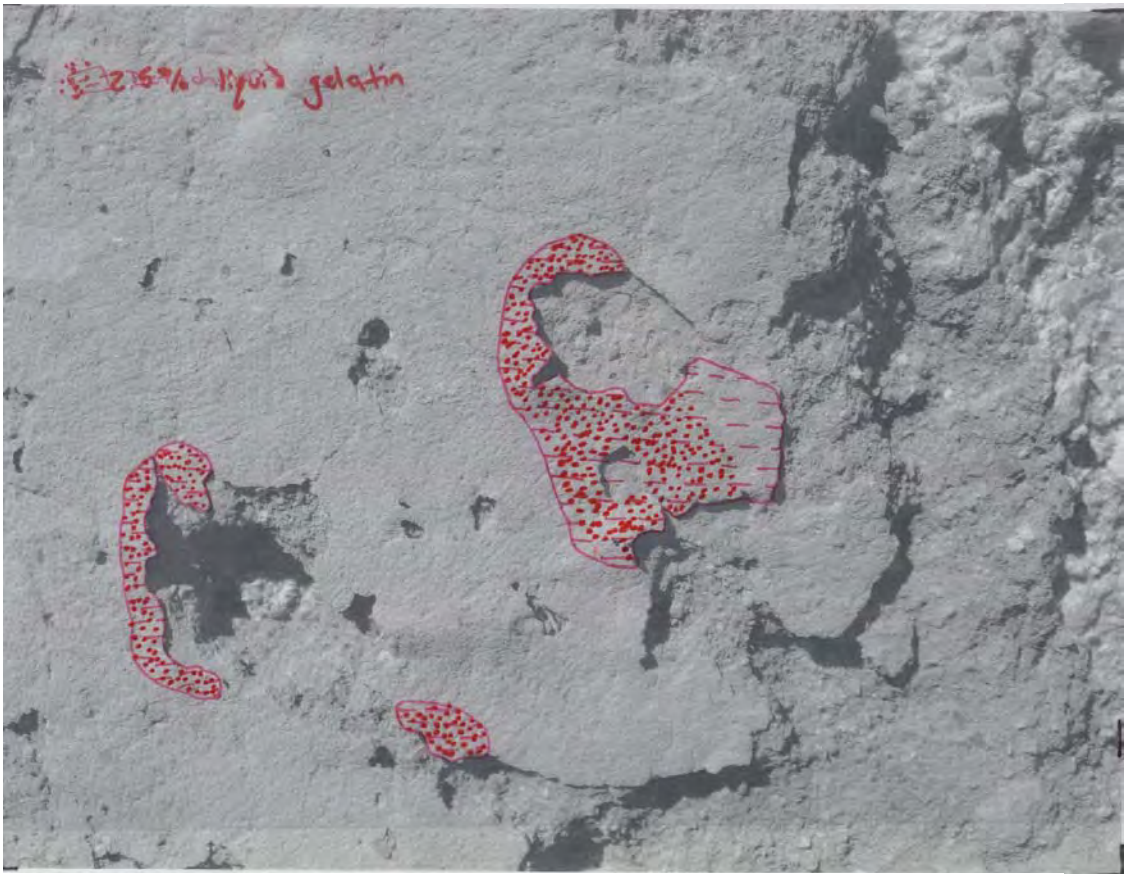
Panel F. M 099 West Interior Wall treatments only. For conditions see Panel B.



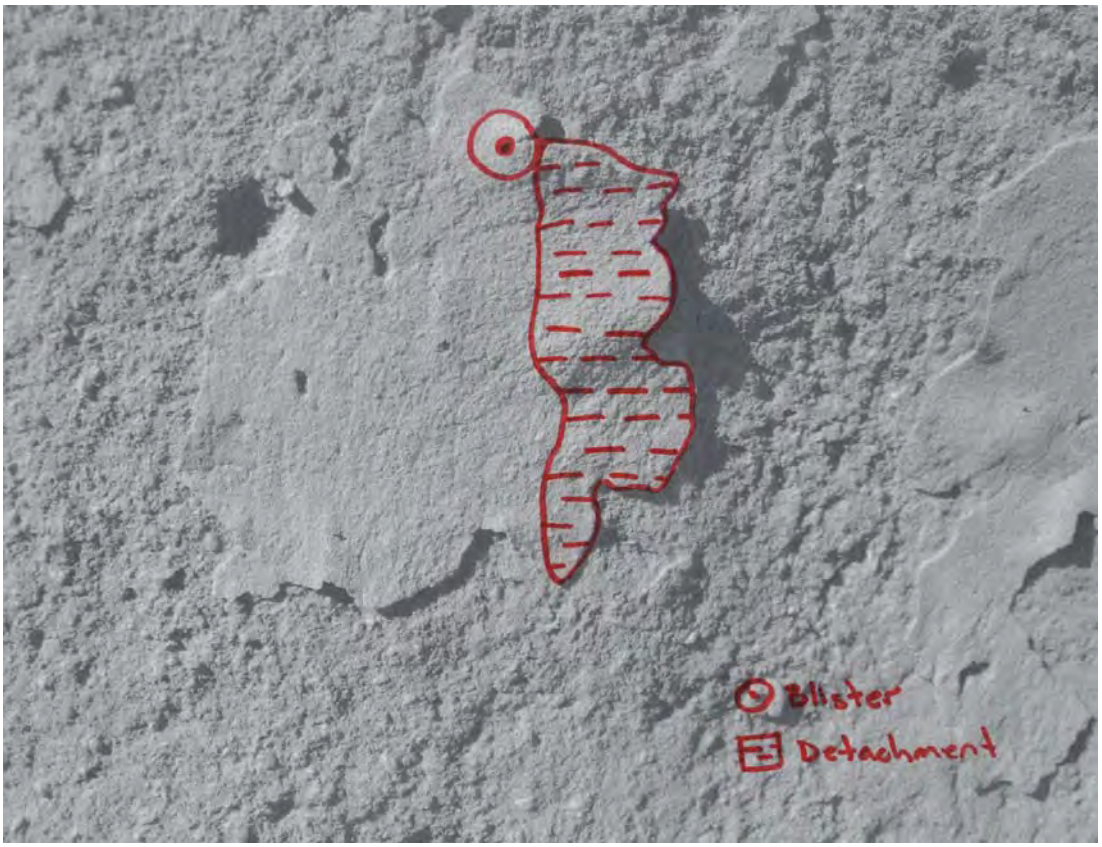
Reference photograph showing location of following photographs from M 093, North Interior Wall



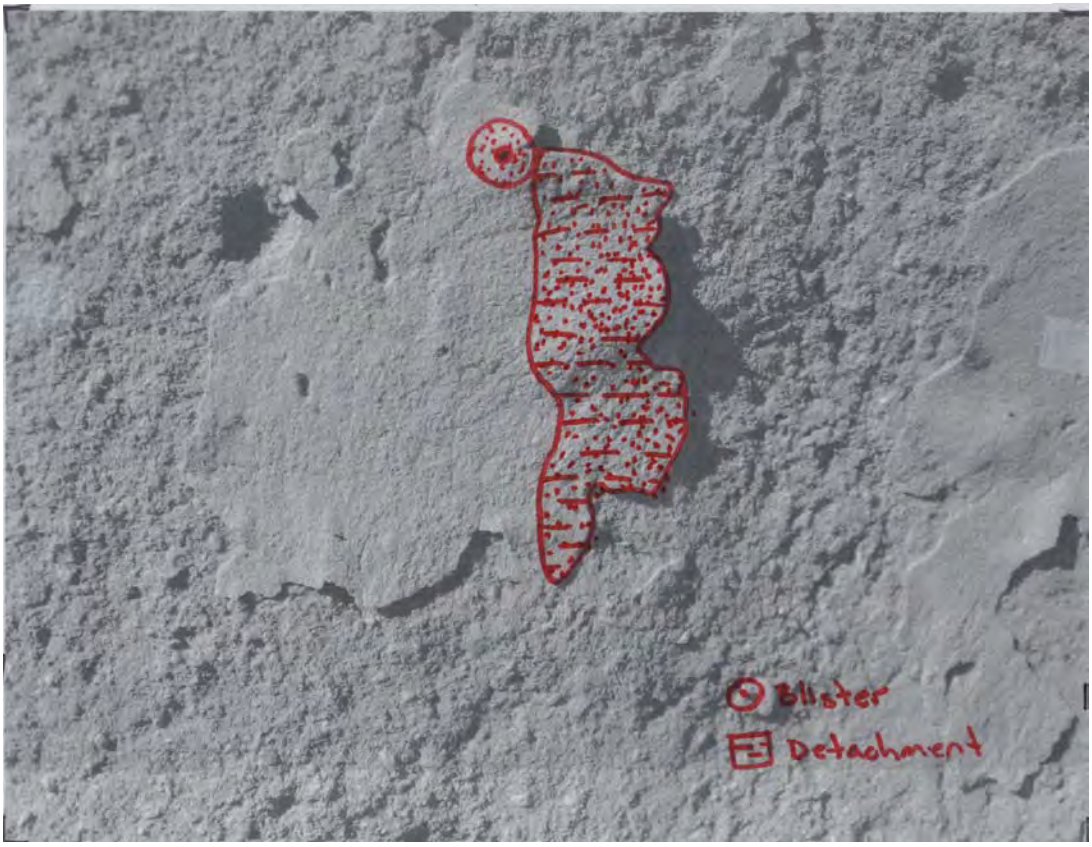
Panel A. M 093 North Interior Wall conditions



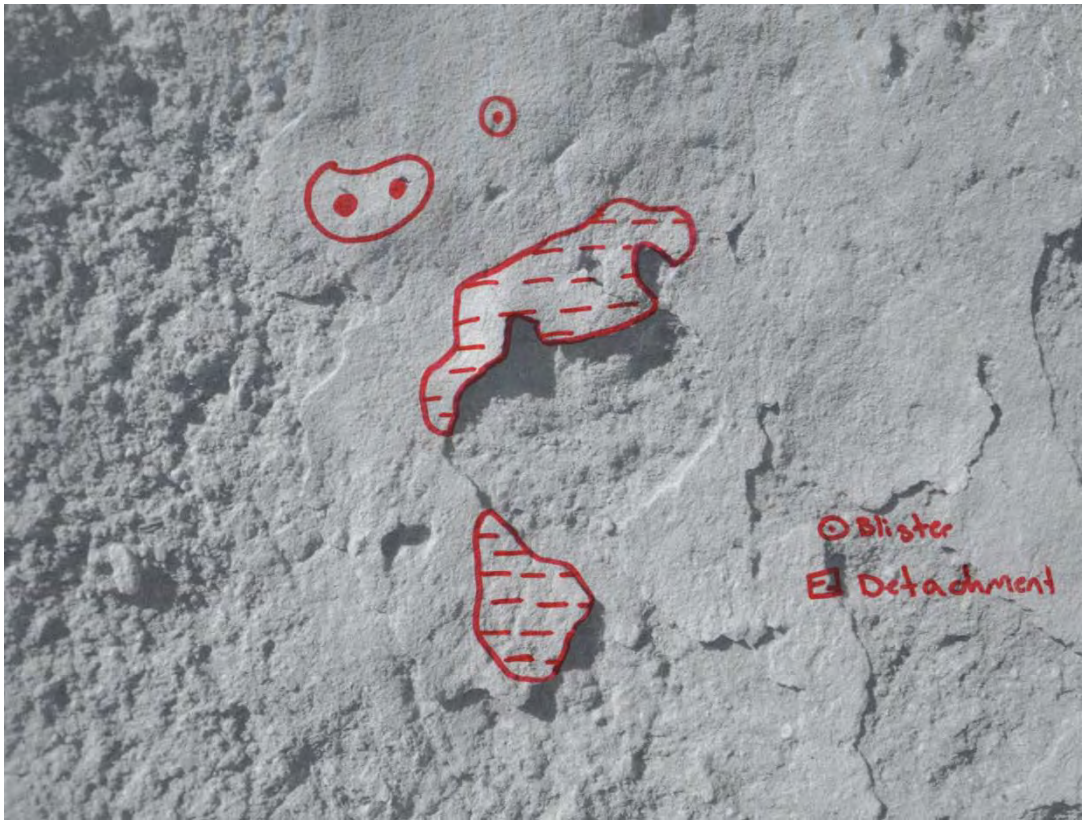
Panel A. M 093 North Interior Wall treatment



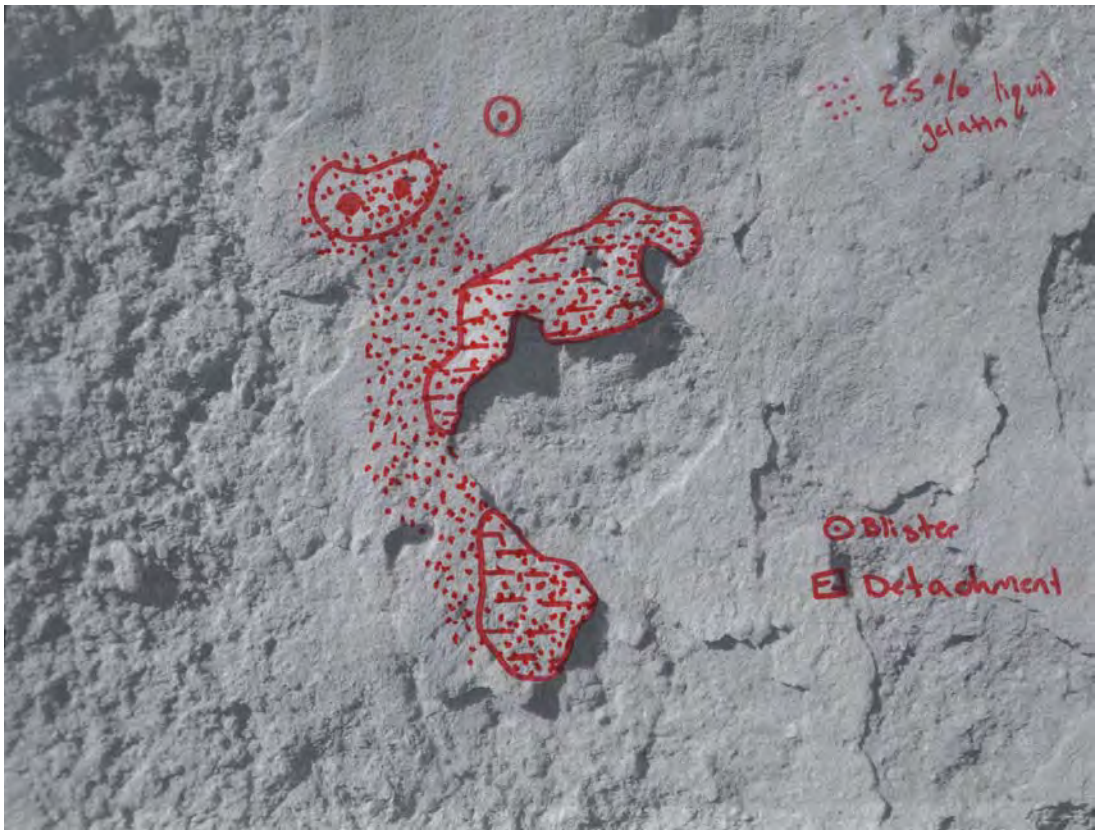
Panel B. M 093 North Interior Wall conditions



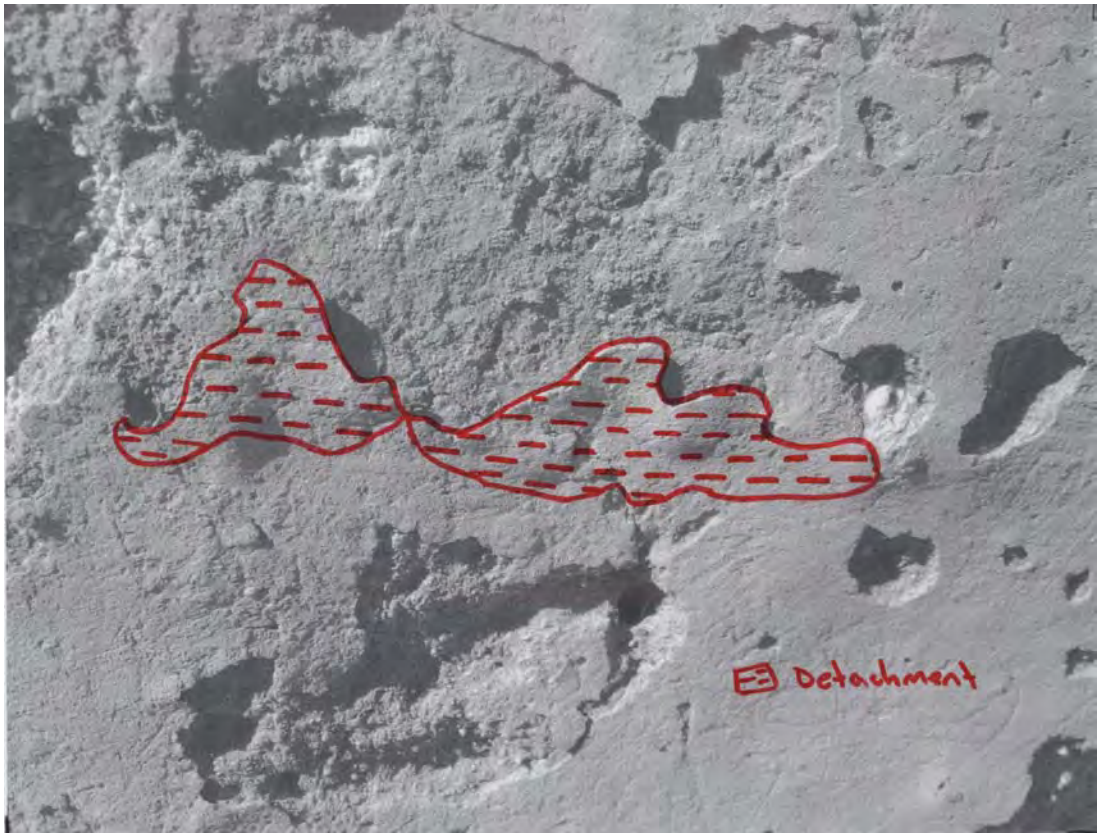
Panel B. M 093 North Interior Wall treatment



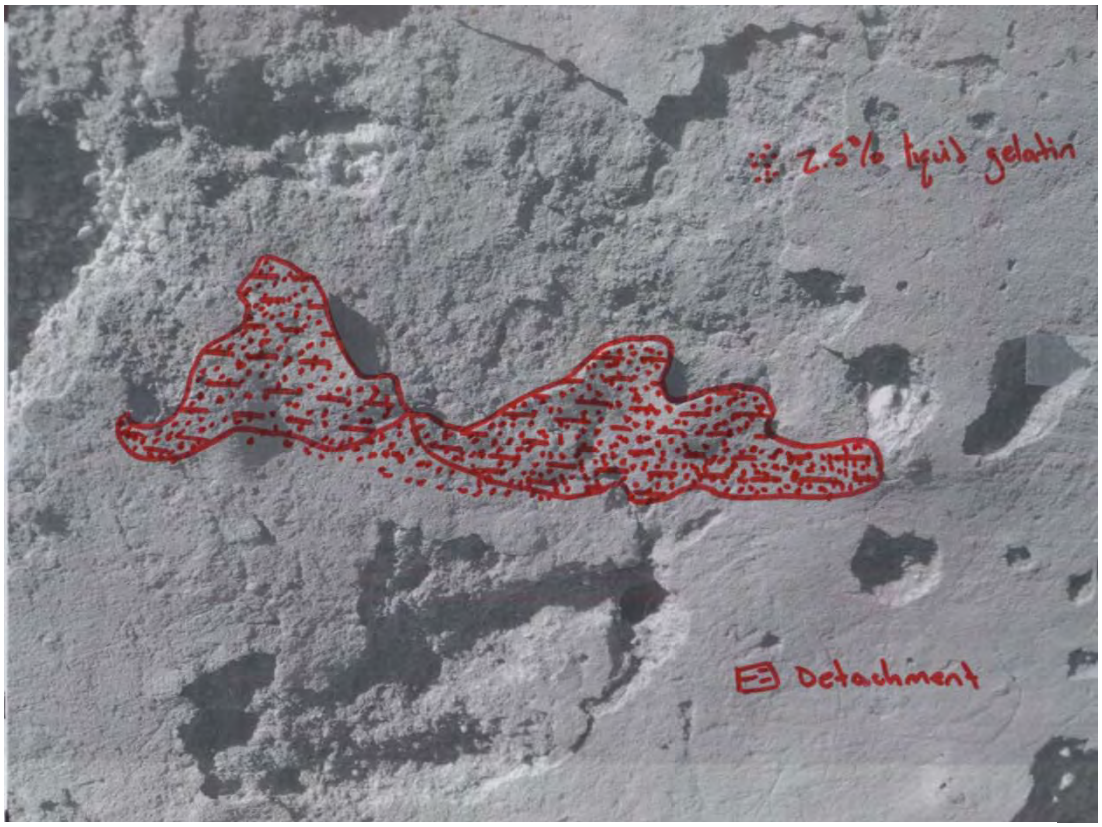
Panel C. M 093 North Interior Wall conditions



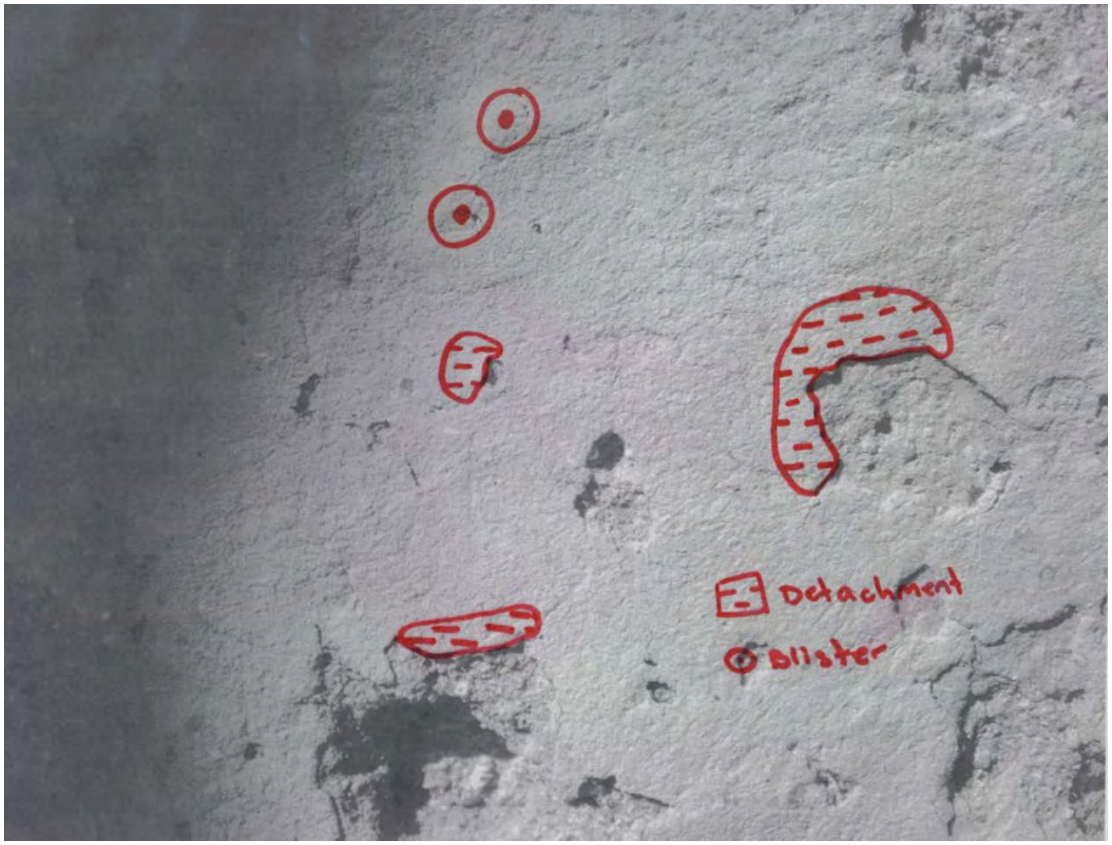
Panel C. M 093 North Interior Wall treatment



Panel D. M 093 North Interior Wall conditions



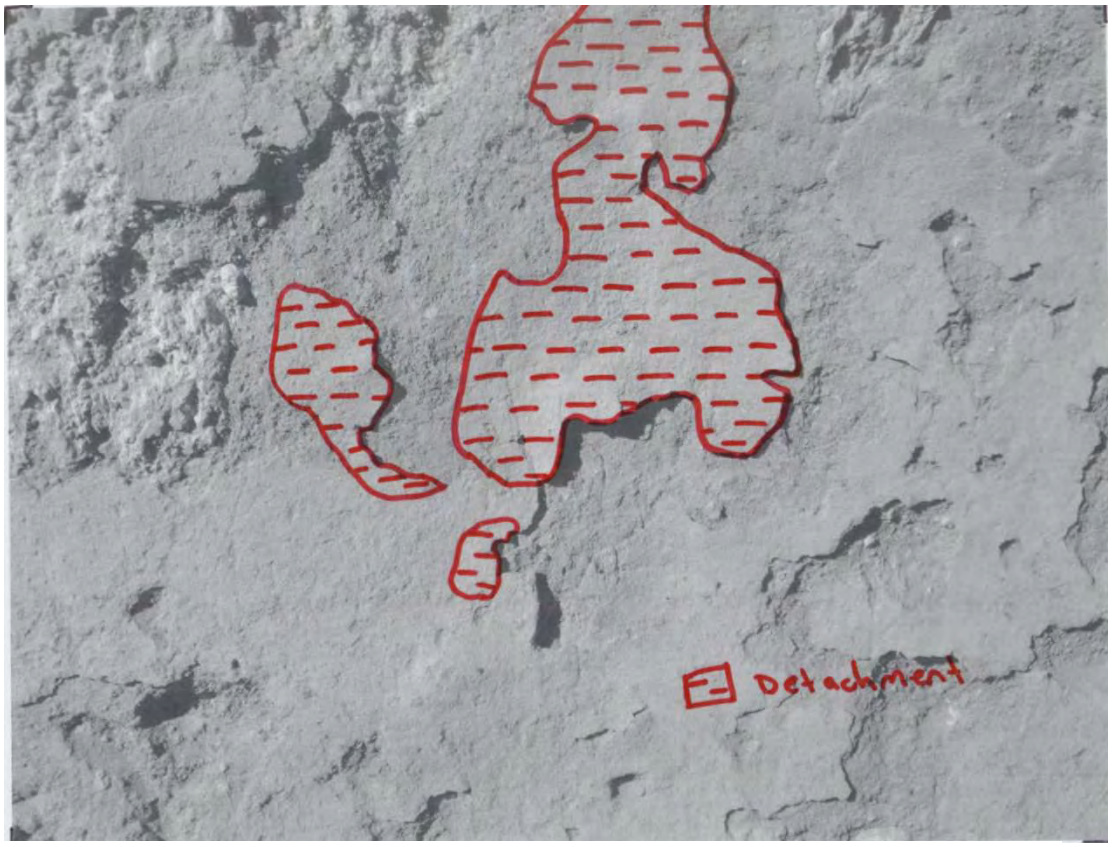
Panel D. M 093 North Interior Wall treatment



Panel E. M 093 North Interior Wall conditions



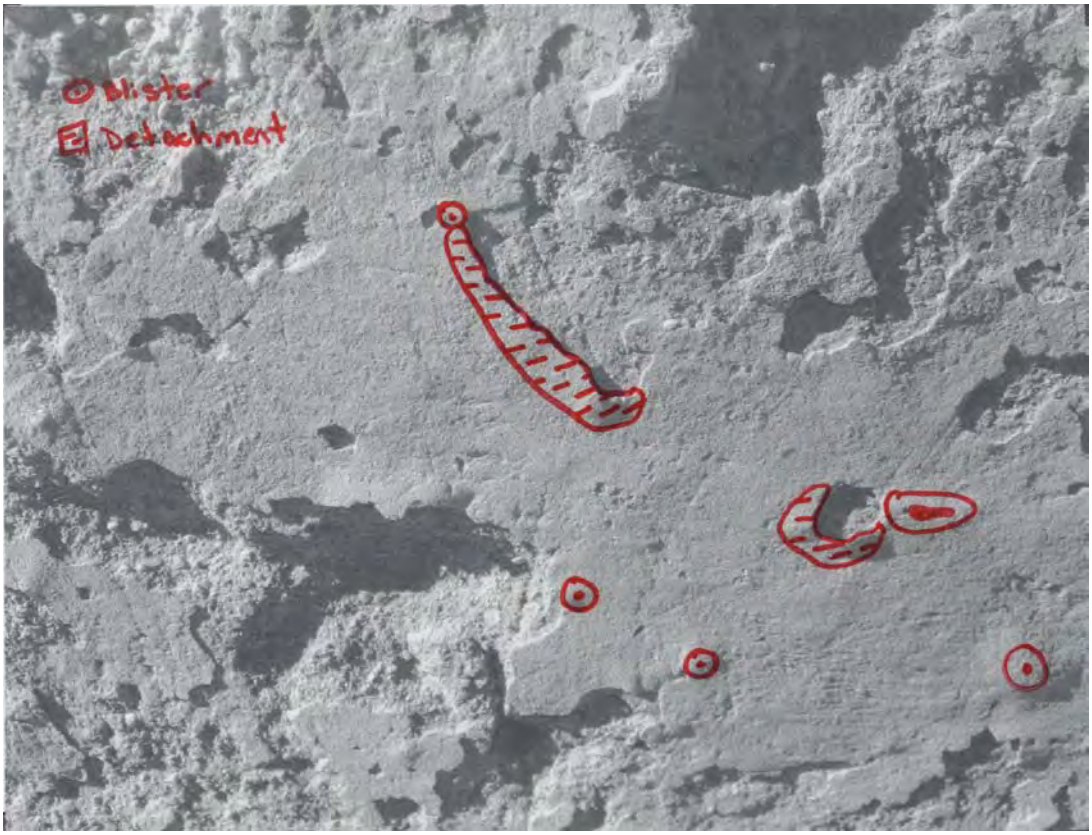
Panel E. M 093 North Interior Wall treatment



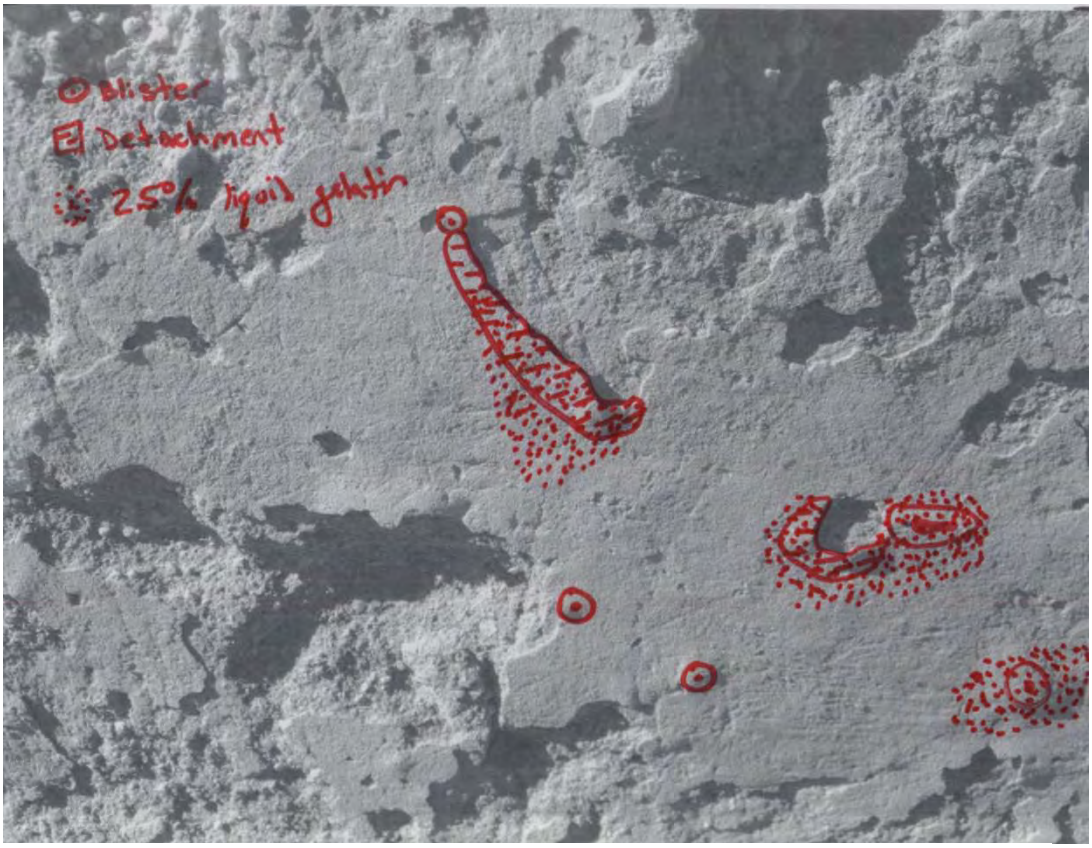
Panel F. M 093 North Interior Wall conditions



Panel F. M 093 North Interior Wall treatment



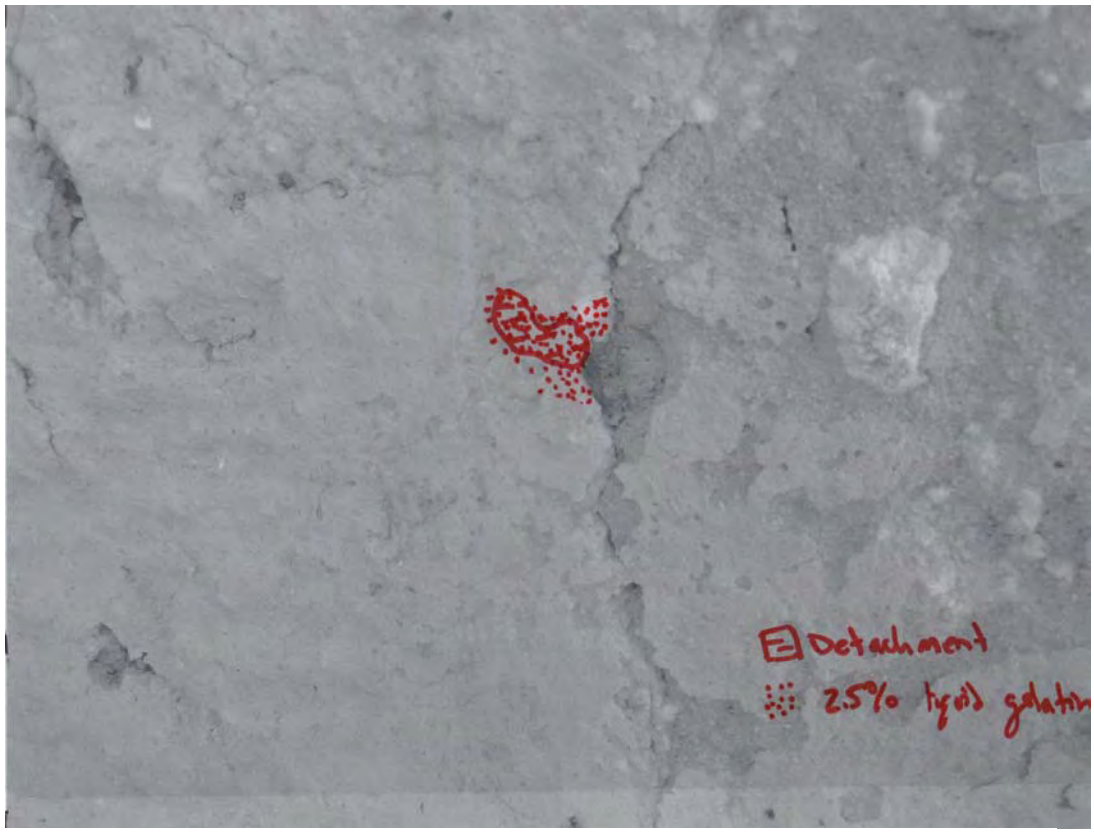
Panel G. M 093 North Interior Wall conditions



Panel G. M 093 North Interior Wall treatment



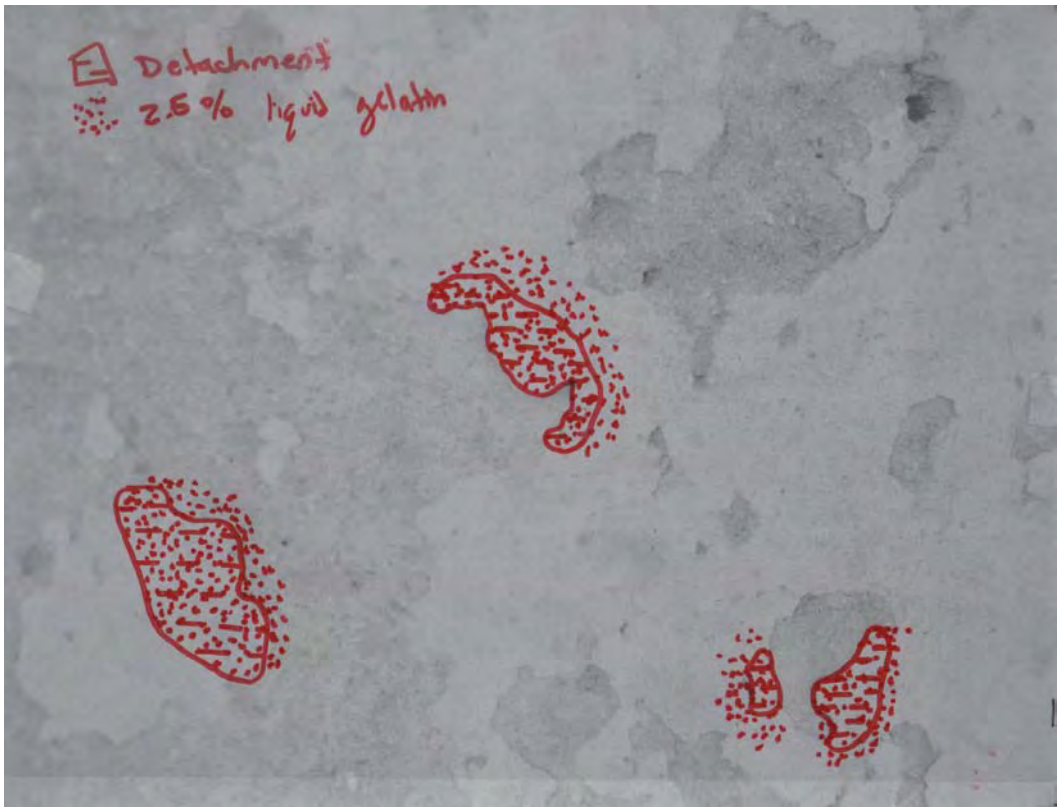
Panel H. M 093 North Interior Wall conditions



Panel H. M 093 North Interior Wall treatment



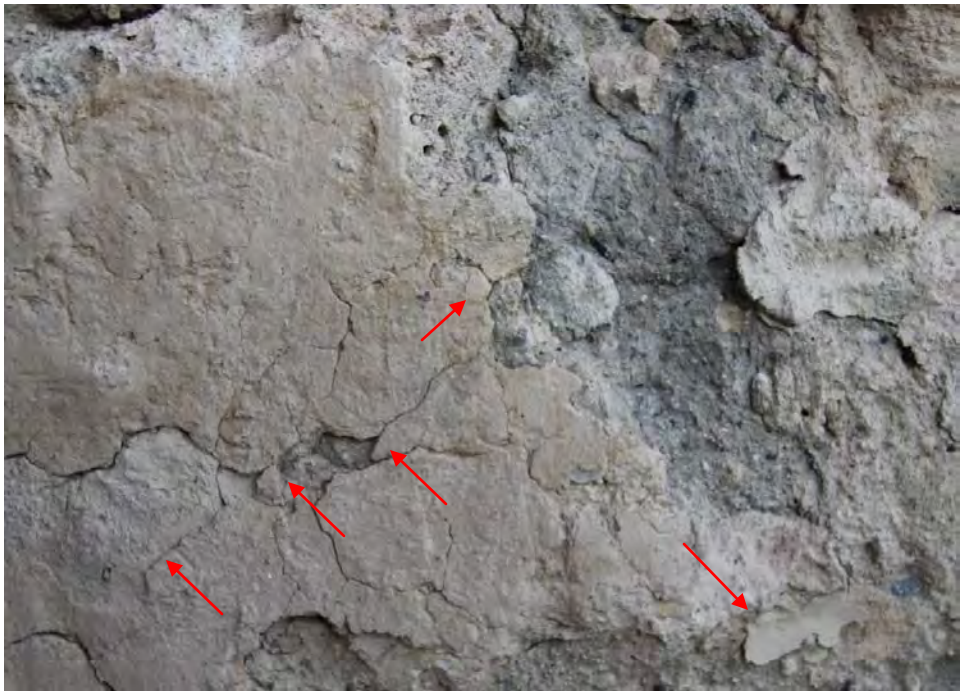
Panel I. M 093 North Interior Wall conditions



Panel I. M 093 North Interior Wall treatment

Appendix J:

Pre – Post Treatment Photography
Plaster Stabilization



M93 East Interior Wall, detail before treatment



M93 East Interior Wall, detail after treatment



M99 West Interior, Wall detail before treatment



M99 West Interior Wall, detail after treatment



M99 West Interior Wall, detail before treatment



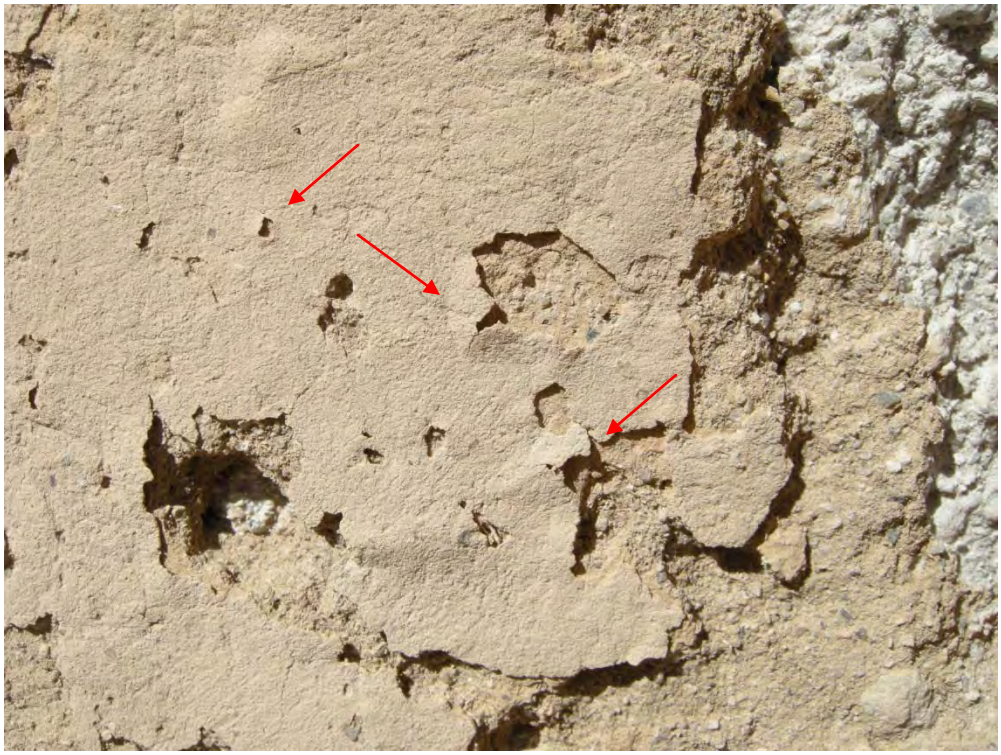
M99 West Interior Wall, detail after treatment



M99 West Interior Wall, detail before treatment



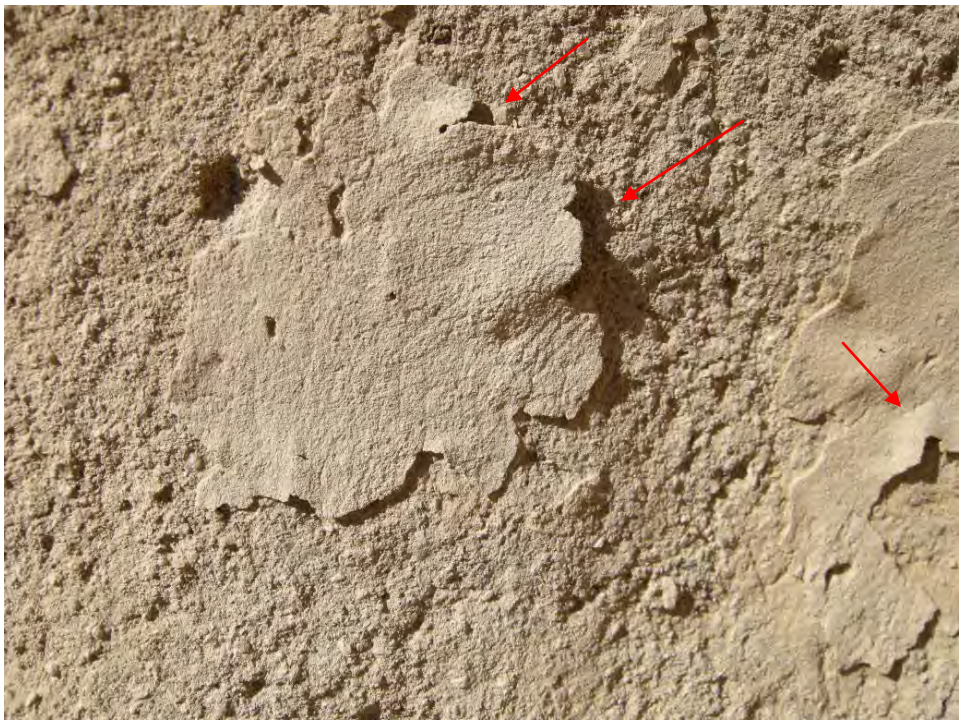
M99 West Interior Wall, detail after treatment



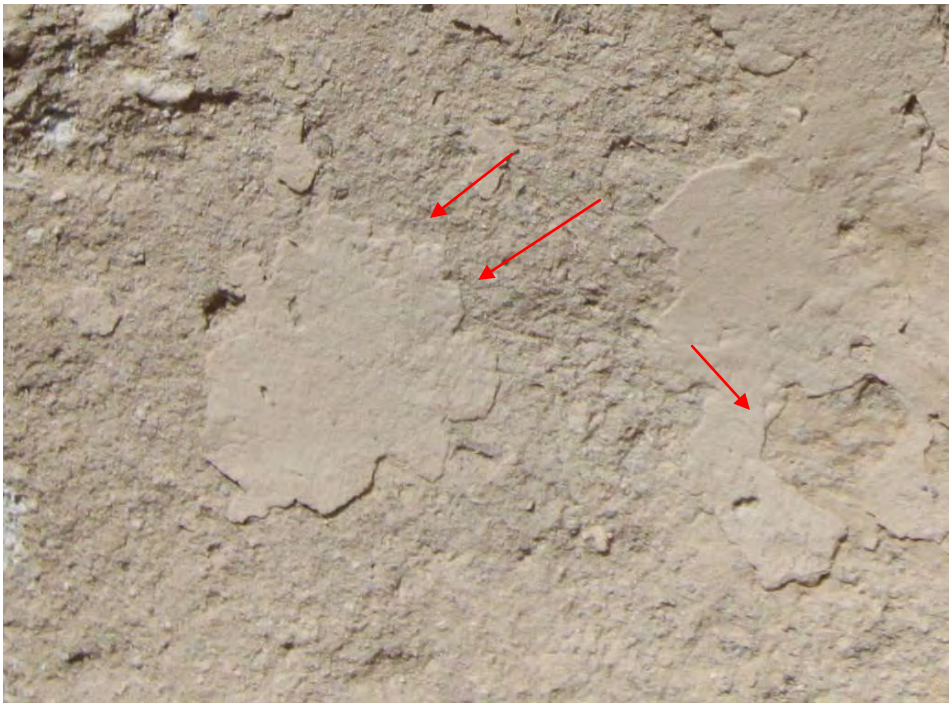
M93 North Interior Wall, detail before treatment



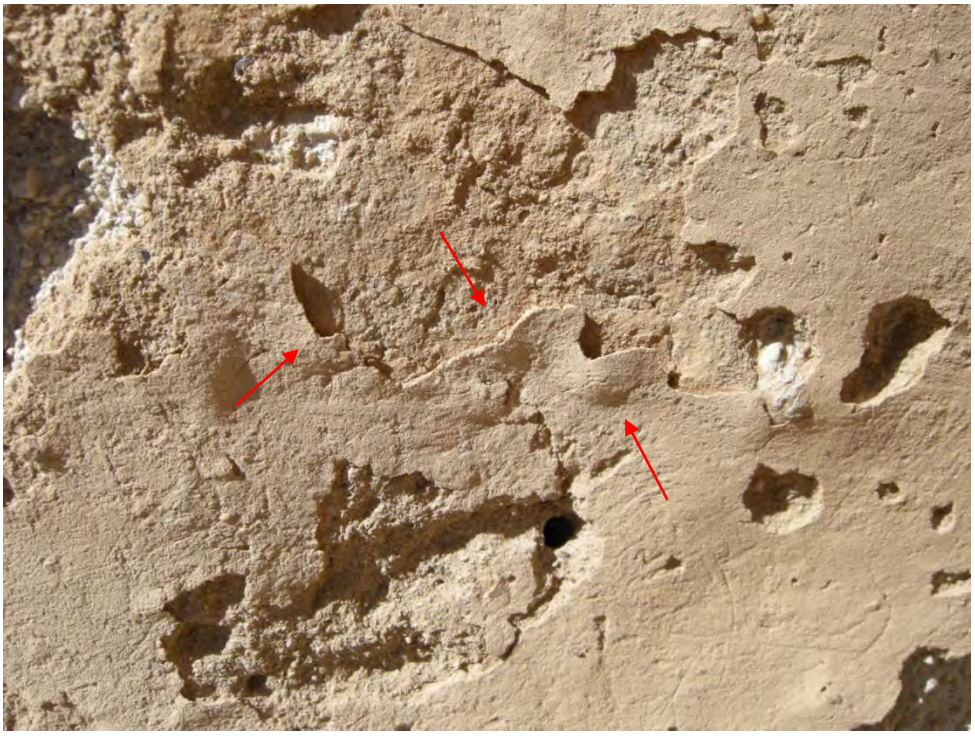
M93 North Interior Wall, detail after treatment



M93 North Interior Wall, detail before treatment



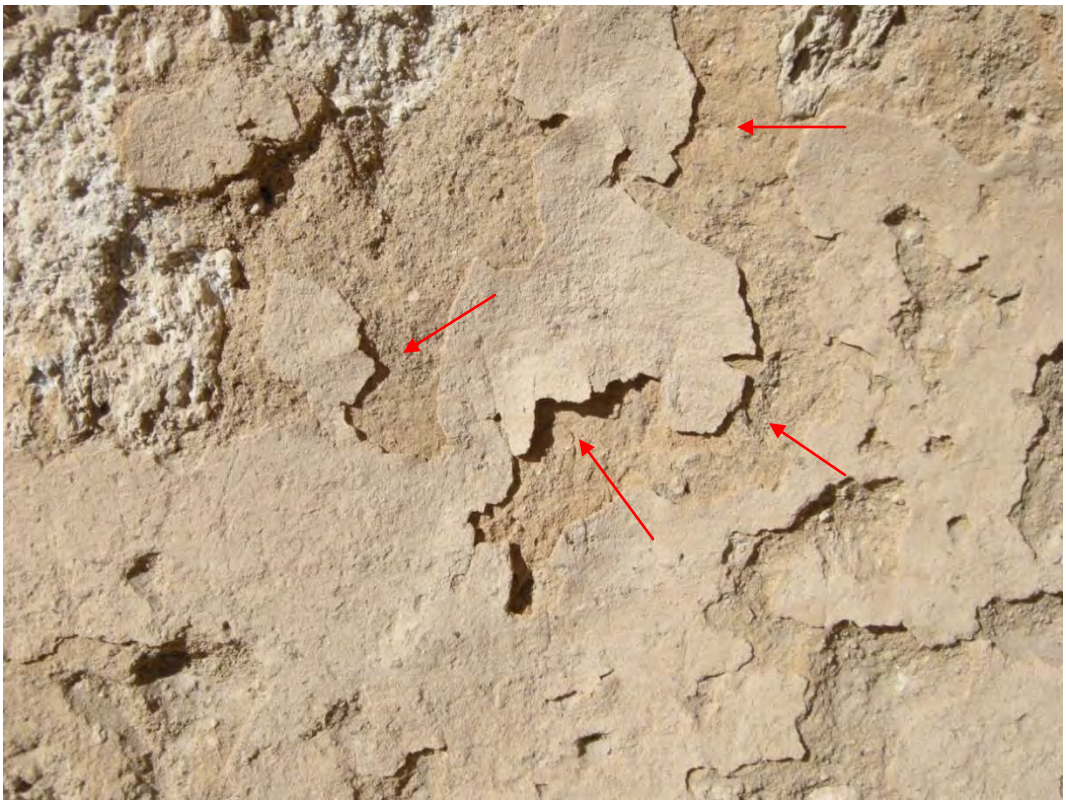
M93 North Interior Wall, detail after treatment



M93 North Interior Wall, detail before treatment



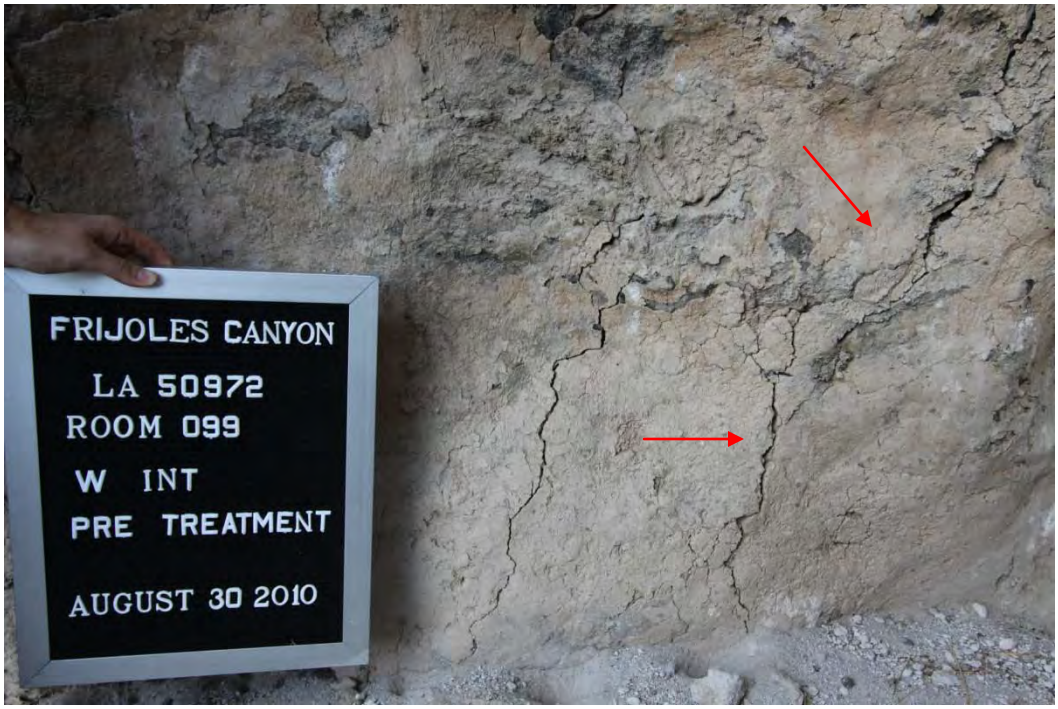
M93 North Interior Wall, detail after treatment



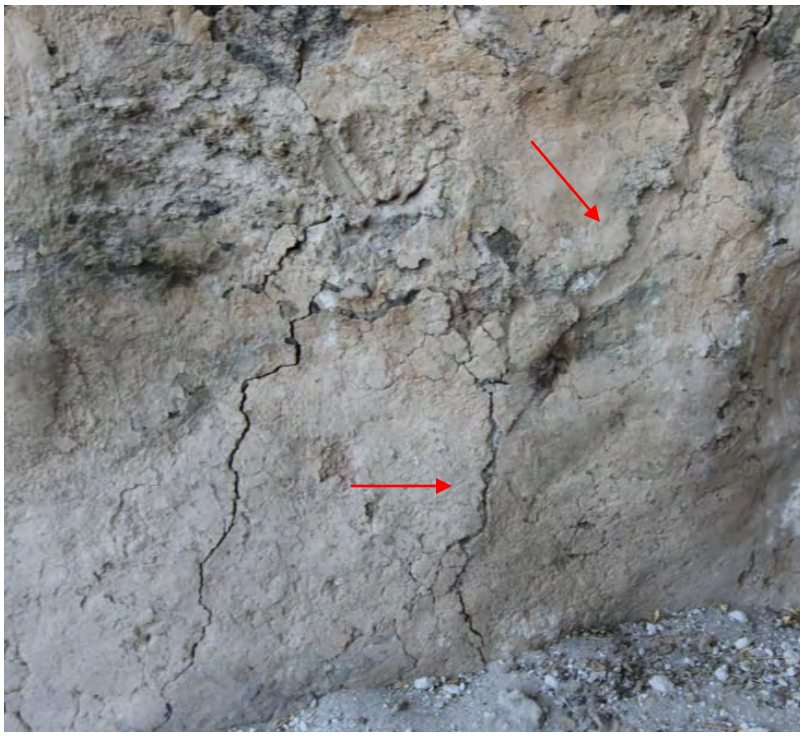
M93 North Interior Wall, detail before treatment



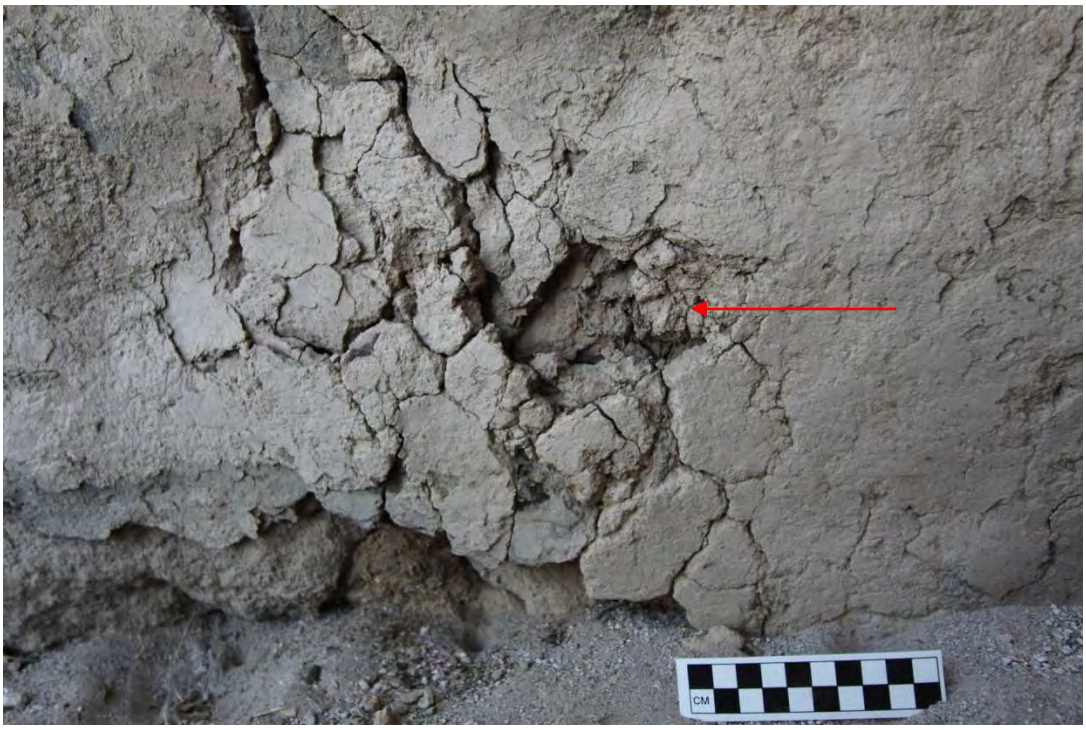
M93 North Interior Wall, detail after treatment



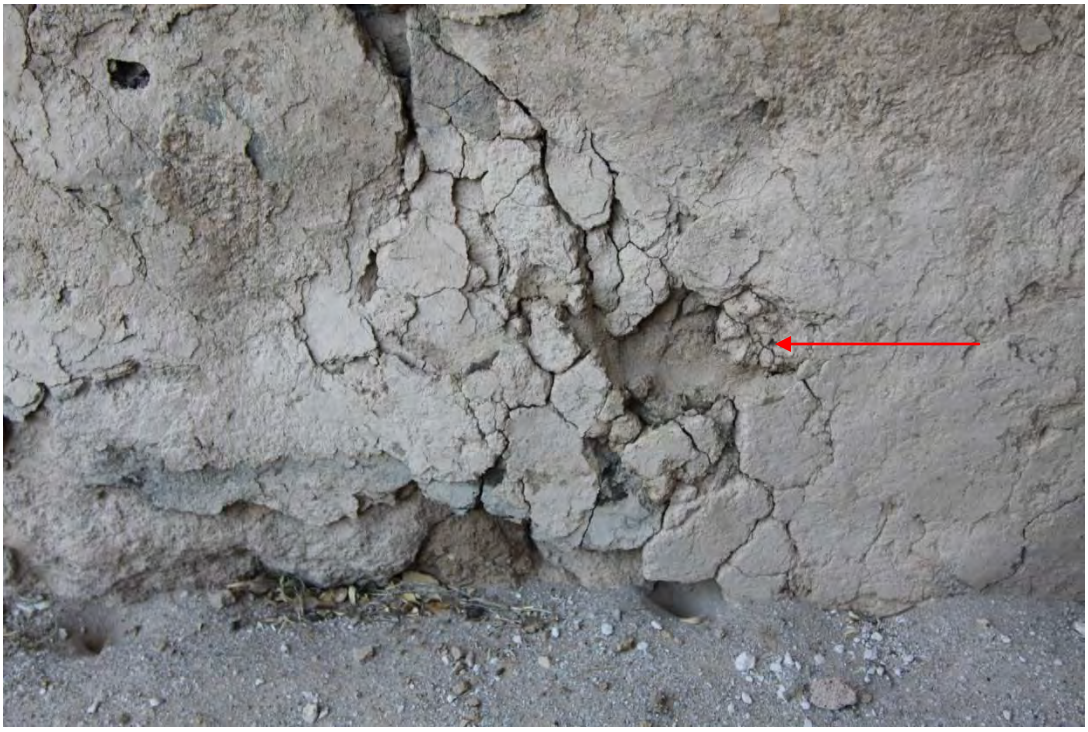
M99 West Interior Wall, before grout and fill treatment



M99 West Interior Wall, after grout and fill treatment



M99 West Interior Wall, detail before grout and fill treatment



M99 West Interior Wall, detail after grout and fill treatment



M99 West Interior Wall, detail before edging treatment



M99 West Interior Wall, detail after edging treatment

Appendix K:

Instructions for Cavate Photography

Instructions for Cavate Photography - 2010

The Vanishing Treasures (VT) group at Bandelier National Monument has undertaken the task of documenting more than 1000 cavates in Frijoles Canyon with photographs and measurements. Previous teams have completed written documentation of the cavates, but photodocumentation remains ongoing.

There are several challenges in photographing the cavates in Frijoles Canyon.

1. The cavates are irregularly shaped and often very small;
2. They are often dark, with walls and/or ceilings blackened with soot or pigmented plasters; and
3. They are often difficult to access, and have fragile floors and wall plasters.
4. The environment is dusty and detrimental to camera equipment.

These challenges can be largely met by using equipment and techniques designed for such circumstances, including wide-angle lenses, reflectors, and long exposures.

In addition to standard 35mm black and white photography, high resolution digital photography is also used to provide easily accessible images of the cavates for VT staff. The procedures and methods listed below are designed to facilitate successful photography, and were updated in 2007 by Joshua (Moe) Nadel and Breelyn Van Fleet, based on methodology developed by preceding Vanishing Treasures staff.

Cameras, both conventional film and digital, are increasingly complex, and every manufacturer adds unique features which compounds the complexity. But the basic principles of light and exposure are constant. The instructions for camera use below attempt to provide only basic guidance for the operation of Bandelier's cameras. But these instructions cannot replace the manufacturers' manuals that accompany each camera and flash unit, or hands-on instruction by someone with field experience.

Signboard

Wherever possible, a signboard and scale should be included in each overall shot of the exterior, walls, ceilings, and floors. A photo scale should be included in all close-ups and detail shots. A scale is not required in the context shots of the cavate groups, but should be used, if possible, in the individual

exterior cavate photographs. The most convenient means of including a scale in each photograph is to attach the scale bar to the sign board by slipping it under the edge of the signboard frame. For detail images, the scale can be held next to the subject. Be sure that the sign board and scale do not obscure significant elements of the room, such as niches or embellishments. In the event that the sign board has to cover a feature, two photographs should be taken, moving the signboard between the two images. Double check the signboard frequently for the correct information. The sign board should include the following information:

1. LA #
2. Group, Panel (if applicable), 3-digit room number, and name (if applicable)
3. Direction and subject
4. Date

The sign board should appear as follows:

LA12345
Group X
Room 012
Long House
N Wall

10/11/2007

35 mm Photography

Conventional silver-chemistry black and white film provides the greatest archival stability, and so the VT program uses 400 ASA black and white film for the archival documentation photography. Label each roll of film with a sequential number with a sharpie (record this on the photolog) and take a picture of the roll number identification sign with the first shot on the roll (or later if you forget). The roll identification sign can be a small dry erase board, a blank printout with a space for the roll number and date, or a blank piece of paper with the information written on it if nothing else is available. This information provides identifying information for archival purposes, and taking a photo of the sign ensures that the information will always stay with the negatives. Keep all exposed, unprocessed film in a central location prior to processing.

Bandelier owns a Pentax ZX-5n and a Nikon FM 10. Both are automatic 35mm single lens reflex cameras, with interchangeable lenses. Most photographs of walls, ceilings, and floors should be taken with the 24 mm lens. Photographs of smaller special features should be made with the 28-200 mm zoom lens. In the 2010 season, the primary camera was the Pentax ZX-5n, but the Nikon FM 10 was also used. Based on current protocols, a flash should not be used unless long exposures fail to produce satisfactory results. Longer exposures offer a higher quality photo than using a flash.

An f-stop of f/5.6 or higher should provide adequate depth of field. Each photograph should include an overlap area on both sides and top and bottom, to ensure that all interior surfaces of the cavates are photographed. Whenever there is a doubt about whether a 35 mm photograph was taken correctly - or covered an adequate area, or was in focus or not - take it again. Film is relatively cheap. Bracket exposures if you are unsure of a light meter reading, or of the electronic flash output.

Digital Photography

The park owns six digital cameras, two Canon PowerShot A630s, a Nikon Coolpix P5100, a Pentax Optio E60, and a Canon Rebel XT. The Rebel XT is used for interior cavate photography because it provides higher quality images, the viewfinder looks directly through the lens (rather than above it), and it has a wide angle lens. The digital cameras are more complex than the 35 mm film cameras, however once it they are set up, use is relatively straight forward. Digital versions of the camera manuals are saved in the VT folder at U:\VT\Camera Manuals.

Canon Rebel XT: Use for high quality documentation along with 35mm black and white camera. Make sure the camera is set to ISO 400. The tripod should be used at all times. For general available light, use camera on Program (P) setting. This setting is completely automatic and will give the best working combination of shutter speeds and aperture. For tricky lighting situations, such as cavates that read below “30” on the internal light meter and walls with openings to outside daylight, the photos must be approached with the camera set on manual (M). Be sure to set the camera on self timer as to avoid shaking the camera while depressing the shutter button. The self timer is located on the back of the camera with a “timer” symbol next to it. When the camera is set to manual, *the hand-held light meter must be used*. After reading the hand-held light meter, adjust the aperture and shutter speed appropriately. Longer exposures offer a higher quality photo than a strobe! A flash should never be used.

Because the camera is an SLR, the LCD screen cannot be used as a viewfinder. When camera is on auto focus, each image should be checked on the LCD screen to make sure the image is actually in focus. A useful tool is the zoom setting on the camera. The zoom in and zoom out buttons are located in the upper right corner on the back of the camera with a magnifying glass symbol next to it. the "+" is zoom in and the "-" is zoom out.

For general battery maintenance, daily charging is not necessary. At the end of the field week, charge battery to completion. For general memory card care, download images from card daily. Be sure that card is empty before another day of shooting. The last shot for the day is the digital photo log. The photo log is always photographed in case the hard copy is damaged or lost.

Hand-Held Light Meter

Sekonic Twinmate L-208: Read the light meter's manual. Make sure ISO is set to the correct film speed. While holding the light meter in your hand, face the dome toward the camera. Be sure to have the camera already in place to take a photo so that the light meter reading is most accurate.
For a tricky lighting situation, such as a wall that has extreme highlights and shadows, the light meter must be placed in the average shadow. Under most circumstances highlights will be caused by vent holes, passages, or openings. It is important to prioritize shadow detail over highlights.
It is important to have the dome slid over the light-sensitive eye. This will provide an incident (middle-gray) reading vs. a reflective reading.

Photo Logs

It is important to keep the photologs accurately to ensure proper identification. Photologs should always be recorded in the field as photos are taken (not at the end of the day). Periodically reconcile the photo log and the cameras to make sure that they are in synch.

Film Log:

Make sure the following info is filled in:

1. Names of photographers
2. Date
3. Roll #
4. Type of film (brand and speed)
5. Type/make of camera

When filling out the information in the description use the following format:

group A – panel a – room 001 ext nw

When a photo is taken and the exposure/focus or sign board is incorrect, retake the photo and note in log that image was reshot and what frame # it is.

Digital Log:

Make sure the following info is filled in:

1. Names of photographers
2. Date

When filling out the information in the description use the following format:

group A – panel a – room 001 ext nw

Leave the shot # column blank until you are back in the office and able to fill in the photo image #'s.

Back in the Office

When downloading the images, go through the photo log and assign correct image number to the matching description in the photo log. At the beginning of each new entry for a cavate, go over the group/panel/room # with a black fine-tipped sharpie so that data entry is easier. Allow approximately one hour at the end of the day for going over the photo logs, downloading the digital images, and entering information into the database.

Photolog Abbreviations

N	north
S	south
E	east
W	west

NW northwest

NE northeast

SW southwest

SE southeast

fea feature

nich niche

ext exterior

BT before treatment

AT after treatment

REMINDER…ALWAYS** carry extra charged **batteries, film** and **memory cards** for the cameras, as well as additional **roll identification forms** and **photo logs** when going out into the field and **NEVER** place cameras or parts on the ground. It is very dusty in and around the cavates, and the cameras will break if you are not careful!*

Appendix L:

Photography Forms

BANDELIER NATIONAL MONUMENT
2010 Cavate Documentation — Digital Photography Log

Photographer(s): _____ Date: _____, 2010

Page _____ of _____

Digital File	Shot No.	Description
	1	
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BANDELIER NATIONAL MONUMENT
2010 Cavate Documentation — Film Photography Log

Photographer(s): Date: _____, 2010

Camera: **Pentax ZX-7** **Vivitar**
Film: _____ Roll No.: **BANDCAVATE – 10 – ____**

Neg. No.	Shot No.	LA#:_____ Group:_____ Description:
	1	roll identification sign
	2	
	3	
	4	
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	10	
	11	
	12	
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BANDELIER NM

ROLL: BANDCAVATE-10-_____

DATE: _____, 2010

NOTES:

Appendix M:

Instructions for Archiving Photographs

Instructions for Archiving Photographs

Digital Photography Archive Procedures

Digital photographs should be downloaded to the appropriate folder within the VT folder on the U: drive when the photographer returns from the field. A new folder should be created and labeled with the date that the photographs were taken. The photo log should be added to the photo log binder in the digital photo log section.

The photographs are then opened and manipulated using Adobe Photoshop (see Appendix B for specific instructions). These images are at this time checked against the photo logs and the photo logs are altered so that the information is accurate. This step is particularly important for the digital photo logs because these photographs will not have a detailed identifier label attached to inform a researcher of any mistakes with the photograph.

The manipulated files are saved within the appropriate folder in the Q: drive in the VT/BAND_VT_Archive folder. The cavate photographs are saved within either the cavate folder (Frijoles Canyon cavates) or the Tsankawi folders under the appropriate LA number and cavate number. The photograph is saved with a specific three digit number in order to distinguish it from any other photograph taken of the same cavate. (See Appendix B for specific instructions.)

Tyuonyi photographs are manipulated in the same manner as the cavate photographs but the procedures for saving these photographs are slightly different. Only the after treatment photographs for Tyuonyi and all other masonry stabilization projects get saved within the archive. For Tyuonyi, the photographs are saved in the Q: drive Tyuonyi folder under the Tier

number, room letter, and wall face. Long House masonry stabilization photographs will be saved in the same manner with the exception that they will be in the Long House folder rather than the Tyuonyi folder. The crew has also been working on the masonry stabilization of some of the cavate walls in Frijoles Canyon and at North Mesa. These documentation photographs will be located by cavate number and placed in a folder within the specific cavate folder labeled Masonry Stabilization Photographs.

Traditional Photography Archive Procedures

After the photographs have returned from developer, check them for any problems that need to be corrected; examples may include blurriness, overexposure and under exposure. Any photographs with these problems should be reshot as soon as possible and the photographs should be discarded and noted on the photo log. If it is not possible to immediately reshoot the photograph, it should be kept and archived properly with the expectation that once it has been reshot, the photograph will be removed. In either case, the photo log should be updated to reflect this information.

The next step is to check the negatives against the photo log to ensure that the log is accurate. The negative numbers should be added at this time to the photo log. In addition, the archivist will need to add any photographs that were not recorded to photo log with as much information as possible and in the correct location within the sequence. All discrepancies between the negatives and the photo log should be taken care of at this time. The exact nature of the discrepancy should be noted on the photo log so that later when the photos are put into archival binders, the information can be written up and attached to the photograph.

After the negatives have been checked, labels need to be created that identify the individual photographs. The labels consist of a unique identification number, location information, description, and the date that the photograph was taken. Each photograph is placed in an acetate photograph sleeve after being labeled with an archival (foil-backed) label. These sleeves are placed in an archival binder, which is labeled with a binder number and a description of contents.

Appendix N:

List of Cavates Photographed

Group	Room	Notes on Previous Photodocumentation	Completed
A	044	Only exterior photograph exists, no Interior documentation	06/09/2010
A	077		06/09/2010
A	087		06/09/2010
A	095	Only exterior photograph exists, no Interior documentation	06/09/2010
A	117		06/09/2010
A	119		06/09/2010
A	121	Only exterior photograph exists, no Interior documentation	06/09/2010
A	125		06/09/2010
A	129		06/09/2010
A	132	Only exterior photograph exists, no Interior documentation	06/09/2010
A	140	Only exterior photograph exists, no Interior documentation	06/09/2010
A	144	Only exterior photograph exists, no Interior documentation	06/09/2010
A	148		06/09/2010
B	024	Only exterior photograph exists, no Interior documentation	06/22/2010
B	032	Only exterior photograph exists, no Interior documentation	06/22/2010
B	033	Previous interior and detail photography is incomplete	06/22/2010
B	036	Previous interior and detail photography is incomplete	06/22/2010
B	037	Only exterior photograph exists, no Interior documentation	06/22/2010
B	039	Only exterior photograph exists, no Interior documentation	06/22/2010
B	040		06/22/2010
B	042	Only exterior photograph exists, no Interior documentation	06/22/2010
B	044	Only exterior photograph exists, no Interior documentation	07/12/2010
B	045	Only exterior photograph exists, no Interior documentation	07/12/2010
B	060		07/12/2010
B	062		07/12/2010
Ba	001		07/12/2010
Ba	009		07/12/2010
Ba	019		07/12/2010
Ba	021		07/12/2010
Ba	025		07/12/2010
Ba	035	Previous interior and detail photography is incomplete	07/12/2010
Bc	047	Previous interior and detail photography is incomplete	07/12/2010
Bc	061		07/12/2010
Bd	068		07/12/2010
Bd	071		07/12/2010
Bd	105		07/12/2010
Be	112	Only exterior photograph exists, no Interior documentation	07/12/2010
Be	113		07/12/2010
Bg	151		07/12/2010
C	013-01		06/21/2010
C	017	Previous interior and detail photography is incomplete	06/21/2010
Da	53/3A		06/21/2010

Group	Room	Notes on Previous Photodocumentation	Completed
De	161/3A		06/21/2010
De	166/2A		06/21/2010
De	182/3A		06/21/2010
De	190/3A		06/21/2010
De	208/1		06/21/2010
Ef	017		06/22/2010
Ef	021		06/22/2010
I	026		06/22/2010
Kc	032		06/22/2010
Kd	049	No exterior opening	06/22/2010
Ke	060	Only exterior photograph exists, no Interior documentation	06/22/2010
Ma	001		07/20/2010
Ma	002		07/20/2010
Mb	008		07/20/2010
Mb	009		07/20/2010
Mc	012		07/20/2010
Mc	013		07/20/2010
Mc	015	Only exterior photograph exists, no Interior documentation	07/20/2010
Mc	016	Previous interior and detail photography is incomplete	07/20/2010
Mc	017	Previous interior and detail photography is incomplete	07/20/2010
Mc	018		07/20/2010
Mc	019	Previous interior and detail photography is incomplete	07/20/2010
Mc	020		07/20/2010
Mc	021		07/20/2010
Mc	022		07/20/2010
Md	023	Previous interior and detail photography is incomplete	07/20/2010
Md	024		07/20/2010
Md	025		07/20/2010
Md	026		07/20/2010
Md	027	Only exterior photograph exists, no Interior documentation	07/20/2010
Md	028		07/20/2010
Md	029		07/20/2010
Md	030		07/20/2010
Md	031		07/20/2010
Md	033		07/20/2010
Md	037	Previous interior and detail photography is incomplete	07/20/2010
Md	166	Previous interior and detail photography is incomplete	07/20/2010
Me	035		07/20/2010
Me	036		07/20/2010
Me	038		07/20/2010
Me	040		07/20/2010

Group	Room	Notes on Previous Photodocumentation	Completed
Me	042		07/20/2010
Me	043		07/20/2010
Me	044		07/20/2010
Me	046		07/20/2010
Me	049		07/20/2010
Me	050	Previous interior and detail photography is incomplete	07/20/2010
Me	064	Only exterior photograph exists, no Interior documentation	07/20/2010
Mf	051	Previous interior and detail photography is incomplete	07/27/2010
Mf	052		07/27/2010
Mf	054	Only exterior photograph exists, no Interior documentation	07/27/2010
Mf	055		07/27/2010
Mf	057		07/27/2010
Mf	059		07/27/2010
Mf	060		07/27/2010
Mf	061		07/27/2010
Mg	068		07/27/2010
Mg	069		07/27/2010
Mg	070		07/27/2010
Mh	071		07/27/2010
Mh	072		07/27/2010
Mh	073		07/27/2010
Mh	074		07/27/2010
Mh	075		07/27/2010
Mh	076		07/27/2010
Mh	077		07/27/2010
Mh	078		07/27/2010
Mi	082		07/27/2010
Mi	083		07/27/2010
Mi	084		07/27/2010
Mi	085		07/27/2010
Mi	086	Only exterior photograph exists, no Interior documentation	07/27/2010
Mi	135		07/27/2010
Mj	087		07/27/2010
Mj	088		07/27/2010
Mj	089	Previous interior and detail photography is incomplete	08/02/2010
Mj	091		07/27/2010
Mj	092		07/27/2010
Mj	093		08/02/2010
Mj	094		08/02/2010
Mj	095		08/02/2010
Mj	096		08/02/2010
Mj	097		08/02/2010

Group	Room	Notes on Previous Photodocumentation	Completed
Mj	098		08/02/2010
Mj	099		08/02/2010
Mj	101		08/02/2010
Mj	102		08/02/2010
Mj	103		08/02/2010
Mj	165		08/02/2010
Mk	105		08/02/2010
Mk	106		08/02/2010
Mk	107		08/02/2010
Ml	110	Previous interior and detail photography is incomplete	08/02/2010
Ml	111		08/02/2010
Ml	112		08/02/2010
Ml	113	Previous interior and detail photography is incomplete	08/02/2010
Ml	114		08/02/2010
Ml	115		08/02/2010
Ml	117		08/02/2010
Mm	118		08/02/2010
Mm	119	Previous interior and detail photography is incomplete	08/02/2010
Mm	120		08/02/2010
Mm	121		08/02/2010
Mm	122		08/02/2010
Mm	123	Only exterior photograph exists, no Interior documentation	08/02/2010
Mm	124	Only exterior photograph exists, no Interior documentation	08/02/2010
Mm	125		08/02/2010
Mn	130		08/02/2010
Mn	133		08/02/2010
Mo	136		08/03/2010
Mp	138		08/03/2010
Mp	139		08/03/2010
Mp	141		08/03/2010
Mp	142	Only exterior photograph exists, no Interior documentation	08/03/2010
Mp	143		08/03/2010
Mp	145	Only exterior photograph exists, no Interior documentation	08/03/2010
Mp	146		08/03/2010
Mp	147		08/03/2010
Mq	149		08/03/2010
Mq	151		08/03/2010
Mq	152	Previous interior and detail photography is incomplete	08/03/2010
Mq	153	Previous interior and detail photography is incomplete	08/03/2010
Mq	154	Only exterior photograph exists, no Interior documentation	08/02/2010
Mq	155		08/03/2010
Mq	156	Previous interior and detail photography is incomplete	08/03/2010

Group	Room	Notes on Previous Photodocumentation	Completed
Mq	159	Only exterior photograph exists, no Interior documentation	08/02/2010
Mq	160		08/02/2010
Mq	161		08/02/2010
Mq	162	Only exterior photograph exists, no Interior documentation	08/03/2010
Ms	164		07/07/2010

Appendix O:

Instructions for 360° Photography

Instructions for 360° Photography

360° Tripod Mount:

Panoramic photography requires a tripod and a specialized mount that allows the camera lens to rotate around a single axis or point. The VT program at Bandelier has been using a Nodal Ninja 3 MKII Spherical Tripod Head with RD8 Rotator which is specifically designed for this purpose. This particular tripod mount allows the camera to rotate 360°s on both the vertical and horizontal axis.

The camera is mounted to take portrait shots (as opposed to landscape) and the camera must be mounted so that that the lens is at the point that all objects in the frame of view do not move, relative to each other, as the tripod rotates. The apparent shifting of a foreground object relative to a background object when viewed at different angles or perspectives is known as parallax, and it is important to read the Nodal Ninja 3 User Manual to properly mount the camera so that this distortion does not occur. Once the point at which there is no distortion is identified, the camera and tripod are ready to use.

Capturing the Photographs:

The tripod is set so that as it rotates along the horizontal plane it locks every 45°s, and a photo is taken. Eight photos complete the horizontal axis. Next the camera is rotated up at an angle of 45° and eight photos are taken as the camera is rotated horizontally at intervals of 45°s. The camera is then rotated down 45°s below the horizon and, again eight photos are taken. One photo is taken straight up and one straight down. A total of 26 photos are required to create a spherical panorama.

Dealing with Great Variations in Depth:

Some panoramas require that both the foreground and background are in focus at the same time. To achieve the best results use the highest F-Stop (which means the smallest aperture setting). This usually means that longer exposure times are necessary.

Lighting:

Drastic extremes of lighting pose the most significant barrier to producing a panorama. It is ideal to avoid high-contrast situations entirely by either using the flash or photographing on cloudy days or at other times without direct sunlight. Not only is detail is lost in both overexposure and underexposures,

when high-contrast photos are stitched together in PTGui program problems also arise. Invariably blurry regions develop because of the programs auto-adjustment of contrast as the photos are blended together. In PTGui some manual manipulation of the photo-stitch is possible. By using the MASK tool you can force blurry, sun spotted, or problem areas behind better overlapping photos and excellent results can be achieved.

PTGui:

PTGui is a program designed for producing 360° panoramas in flat, cylindrical and spherical formats. Photographs are loaded into the program, the photos are aligned, control points are automatically selected and the photos are stitched together. Occasionally the control points must be manually inserted. It helps if all the photos are the same orientation prior to loading into the program. It also has problems mixing portrait and landscape orientations. Once the photos are properly aligned and problem areas are masked, a panorama can be saved. Flattened images can be extracted as a JPEG file or interactive 360° spherical models can be produced as a Quicktime (Apple) file. The Quicktime file is automatically set to 70% resolution, but it can be changed to 100% if desired.

Appendix P:

Instructions for Orthorectified Photography

Instructions for Orthorectified Photography

Robert Jensen, Mesa Verde National Park

The purpose of architectural documentation photography is to create high resolution, dimensionally accurate, scaled color photomontage of individual wall elevations. Prints of these images provide a record of the structure that can be used as a substrate for field annotation of architectural details. The general method employed for Arc Doc photography involves creating a grid of small adhesive targets on the wall, recording the dimensions of the grid on vellum graph paper, and photographing the individual blocks formed by the grid. A model of the grid is then generated in AutoCAD and imported into Photoshop where it is used as a guide to fit together the various elements of the photomontage.

The specific techniques of photography, AutoCAD, and Photoshop are as follows:

Photography

A laser level with horizontal and vertical beams is used to establish a base line and verticals to set a grid of small adhesive targets at approximately 50 cm x 75 cm spacing, usually with a vertical orientation. Targets are also placed at the sides, top and bottom of walls on laser lines. Outlying (not on laser) targets are then placed around wall entries and as needed to define extremes of the wall. The layout of targets in kivas should center on pilasters and upper wall spaces between pilasters. The wall and grid are then sketched on graph paper and the measured dimensions recorded. Arbitrary targets must have measurements from two on-laser targets.

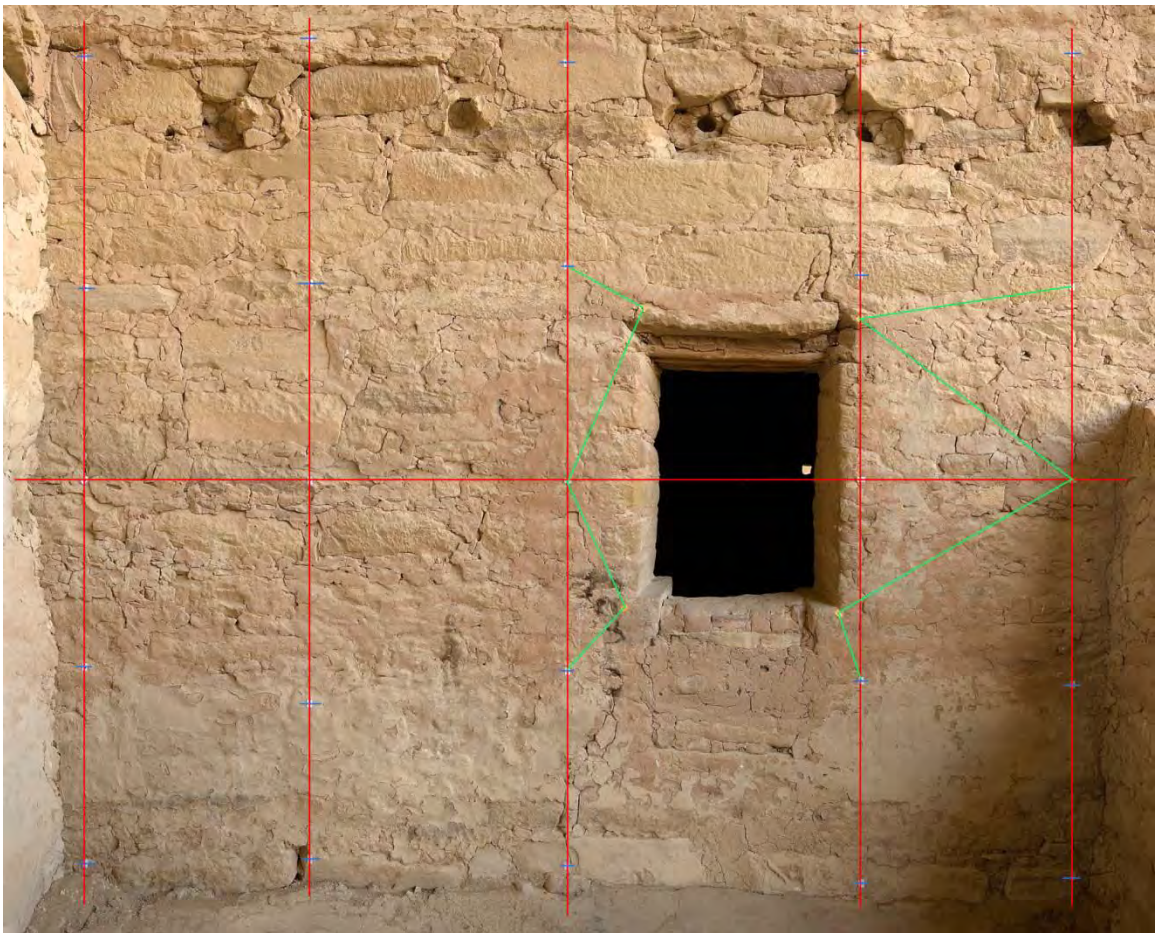


Figure 1: Prehistoric masonry wall at Mesa Verde National Park

A grey card is used to set the camera white balance for each wall. The grey card, ColorChecker, and a label with the unit identification are then photographed for use in color balancing in Photoshop. The best average exposure is determined and photographs of all montage elements are made at the same exposure in Manual mode. All images should be captured in RAW mode. The first photograph should be of the entire wall for reference. A photograph of each block of the grid, with about 10 cm. overlap on all sides, is then captured using the longest practical focal length while maintaining consistent camera-to-subject distance. When using flash the diffusion dome should be used and the orientation should be consistent throughout the series, usually from the upper left. It is best to use Manual mode on the flash unit. Wall entries and openings should be photographed separately for best perspective. Exposure numbers and subject descriptions are recorded on the Image Record Form.

Immediately upon return from the field each memory card should be copied to the D and G drives as outlined above. Grids are then processed in AutoCAD.

AutoCAD Processing

Open: S:\ASCP\CAD_DWGS\MEVE ACAD TEMPLATES\photogrid_template.dwg
(This blank drawing file has one layer: photogrid. Units are set to meters. Object snap is on and is set to endpoints and intersections. F3 toggles Object Snap on and off. Grid interval is set to 50 cm, just for reference, but the grid is not necessary and can be turned off. F7 toggles the grid on and off)

Save As: S:\ASCP\CAD_DWGS\SiteNumber\Photogrids\filename.dwg

Create AutoCAD drawing of the photogrid using field sketch dimensions: ACAD procedural tips: Begin by drawing the horizontal baseline, left to right. Initiate the polyline command and pick a point anywhere on screen to begin the baseline; observe that the command line is requesting that you specify the next point. Refer to the sketch for the distance between the first two points on the baseline, say, for example, 1.5 meters. Type @1.5,0 Enter (the @ symbol tells ACAD that the following point data is to be plotted relative to the previous point, 1.5 meters on the x axis and 0.0 m on the y axis).AutoCAD draws the first segment of the baseline, and is ready to accept distance input for the next point. Continue entering your baseline distances. After entering the last distance in the baseline, hit Enter again to end the polyline command. Now fill in the rest of the grid by working off your baseline points. Start the polyline command and position the cursor above the baseline point where you wish to begin. When a small highlighted box appears, left mouse click to snap to the baseline point to begin drawing the line. The AutoCAD command line is now prompting you to specify the next point. To add a grid point that is 50 cm directly above the baseline point, type @0,.5 Enter. To add a point that is 50 cm directly below the baseline point, type @0,-5 Enter. Continue until all of the vertical reference lines are complete. Then begin plotting outlying grid points that were triangulated from the baseline and/or vertical references lines. Use each triangulation distance as the radius of a circle. Draw the circles centered on the appropriate baseline or vertical reference line points. The intersection of the circles indicates the location of the outlying grid point. Draw a line from any baseline or vertical reference line point to the point of intersection on the circles. Delete the circles. When the grid is completed, you are ready to plot as an Adobe pdf file. Click on File. Then click on Plot to bring up the plot - model dialog window.

Plot settings

Printer/plotter name:	Adobe PDF (Acrobat Distiller)
Paper size	11 x 17
What to Plot:	Window
Plot Scale:	Custom
	1" = .2 Units (Meters)
Plot Offset:	Center the Plot (check box)

Click on the Window button. Using the mouse, d rag a window or box that encompasses the photogrid linework. Click the Preview button. Verify that none of the gridlines have been truncated: if truncated, select smaller scale (for example, 1" = .4) or select a larger paper size from the drop down list. Click the Preview button again to verify that none of the gridlines are truncated. In some cases, it may be necessary to create a custom paper size by clicking the paper/plotter properties button and going through the customization process. When the preview display is acceptable, click on OK. You will be prompted to identify the destination directory for the photogrid pdf file.

Destination Directory: S:\ASCP\CAD_DWGS\SiteNumber\Photogrids\filename

Photoshop Processing

Create a new document at 600 dpi, RGB color mode and bit depth of 16, sized as needed.
Open Grid – 'Import PFD' dialogue box opens.
Set resolution to 600 dpi, Mode to RGB, and bit depth to 16.
Set 'Crop to; to 'Bleed Box', check clearance.
Check anti-aliased checkbox.
Click OK to open.
Drag Grid into the new document, rename layer "Grid", lock layer.
In Bridge, select series for wall beginning with grey card identifier image.
Double click to open series in Camera Raw Plug-In.
Set 'Select All' and 'Synchronize' modes.
Use grey card and ColorChecker in first exposure to optimize images.
Open photos into Photoshop.
Drag first image of grid block into image with grid.

Drag grid layer to the top in the Layers menu.

Select image layer and convert to Smart Object.

Transform photo layer as needed to fit grid using Edit / Transform and Edit / Warp tools.

Convert Smart Object back to Layer.

Drag in next image and fit in the same manner.

Use eraser tool at 100% opacity and 95% hardness to erase overlap of top image near target lines.

Check fit of elements along edges and adjust as necessary.

Continue adding elements until montage is complete.

Change resolution to 300 dpi.

Check scale using Measure tool.

Add a 1" scale and the legend "1 inch = 20 cm" using the Line and Type tools.

(Create a separate file and save for reuse)

Add filename near edge of image using Type tool.

Delete Grid layer and flatten remaining layers.

Optimize image using Levels, Dodge and Burn, etc. as needed.

Sharpen using Unsharp Masking.

Print on Epson R2400 printer using Premium Glossy Paper.

Store in the Arc Doc Print cabinet.

Save in two formats using the appropriate filename. As highest quality JPEG to the site file folder on the server, and as an Uncompressed TIFF on the G drive and on gold DVD.

Appendix Q:

Lime-Tuff Mortar Infill Treatment Evaluation, 2010

Lime-Tuff Mortar Infill Treatment Evaluation – 2010

Introduction to the Condition and its Treatment

Taken from the Field Information Report of the Field School in Site Conservation and Heritage Management, Bandelier National Monument, July 26-August20, 2003:

> Rock undercutting of cavate ceilings and walls has been identified as a serious deterioration problem. Preliminary analysis suggests that this condition is due to a combination of factors including weathering resistance of the tuff and cavate exposure to water and wind-blown particles. Once undercutting begins, it extends along the plane of the surface (wall or ceiling), creating a detached ledge which deforms and eventually collapses from natural forces or vandalism. This phenomenon clearly advances in stages and can be observed at all levels of severity from slight surface erosion to total collapse of cavate ceilings.

In 2003, the Field School in Site Conservation and Heritage Management, a collaboration between Bandelier National Monument and the Graduate Program in Historic Preservation at the University of Pennsylvania, tested a pilot treatment using a lime-tuff mortar infill to stabilize the undercut ceiling of Cavate M148. This treatment consisted of pre-consolidating the tuff inside the undercut area with a range of consolidants and then carefully filling the void with color matched mortars made primarily of lime, sand and crushed tuff. The surface of the fill was then manually textured in order to create visual continuity between the added material and the cavate interior. It was hoped that this infill would not only visually preserve the cavate, but also provide support to the detached tuff ledge, postponing or preventing its eventual collapse. The 2003 treatment appeared to be successful, and so a number of other cavates were treated in a similar manner during the 2007 and 2008 field seasons. The materials varied slightly from those used in 2003, mostly to provide better color and texture matches to original tuff surfaces, and to avoid the use of toxic materials. This appendix includes a summary of treated cavates as well as observations made during the 2010 field season on how the treatments appear to be performing. Suggestions for future testing and concerns about previous treatments are also discussed.

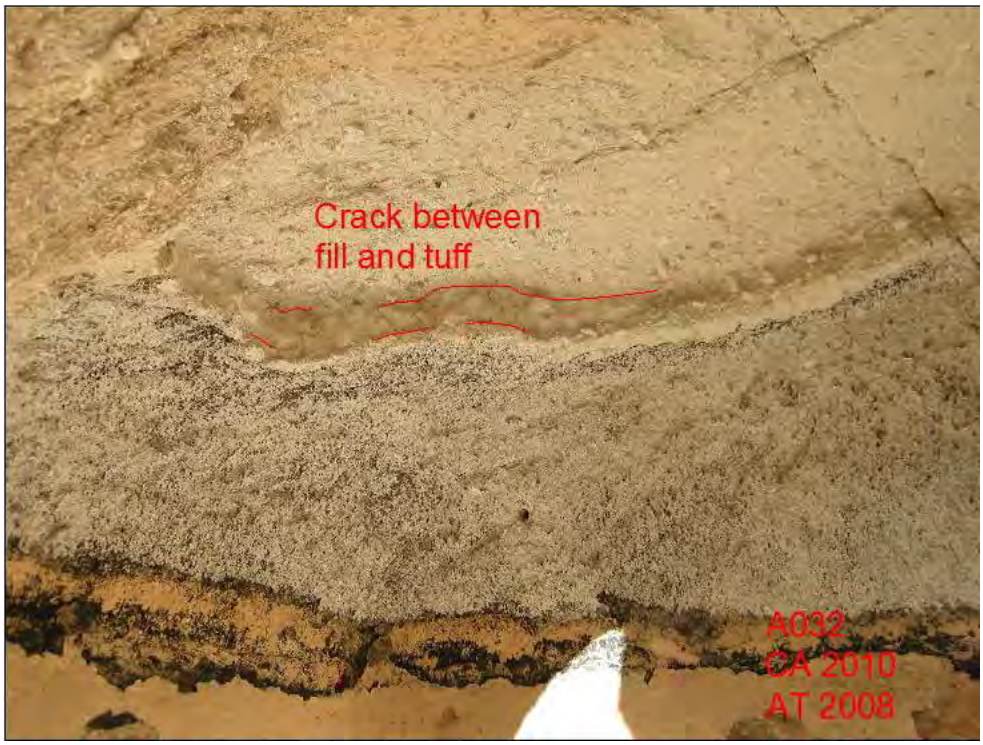
Cavate Number	Year Treated	Mortar Mixture Used	Tuff or Aggregate Used	Notes
A032	2008	2:1 tuff to HHL	Group A Tshirege Tuff	The overall condition of the fill is good. On the left side of the cavate cracks are present between the fill and the tuff on both sides of the fill. It appears that this crack was present in the after treatment photo and likely occurred during drying. Birds are still able to perch on the ledge and there is bird feces on the right side of the ceiling overhang.
A060	2007	2:1 aggregate to HHL	25% ceramic microspheres, 75% Group A Tshirege Tuff	Fill is in excellent shape with no sign of wear, undercutting or other damage. The erosion of the ceiling and south interior wall appears to come from two sources: the smoke hole above the cavate entrance and a water flow that originates in the cupola-type space located directly above the cavate. Both areas of damage are not caused by direct water flow over the surface (the mud flows are a distance away from the affected area), but by moisture moving laterally through the rock causing disintegration and flaking.
A076	2008	2:1 tuff to HHL	Brown Group A/B Cerro Toledo Tuff	The fill is in good condition, and there is no visible evidence of erosion or damage.
A137	2007	2:1 Microspheres to HHL	Group A Tshirege tuff used on facing to match color and texture of surrounding tuff	This cavate is in a precarious situation. It was constructed primarily in the tan Cerro Toledo tuff and its ceiling is the pumice fall under the Tshirege tuff. It appears that a good seal was not obtained with the course and highly friable pumice in the ceiling because a crack between the fill and the tuff appears in the 2007 after treatment photo. It seems to have gotten worse and the undercutting is continuing, but this trend must be confirmed in a few years.

Cavate Number	Year Treated	Mortar Mixture Used	Tuff or Aggregate Used	Notes
K023	2008	2.5:1 tuff to HHL	25% Group K tuff, 75% sieved Group A/B Cerro Toledo tuff	On the left side of the north wall, just below the ceiling, there is a gap between the tuff ceiling and the infill. This gap cannot be explained as a shrinkage crack because the gap is a few millimeters thick. It appears to be evidence of continued erosion above and behind the fill. On the west wall of the cavate there appears to be a small amount of tuff loss below the infill treatment. The tuff is extremely friable and is disintegrating.
K024	2008	2.5:1 tuff to HHL	25% Group K tuff and 75% sieved Group A/B Cerro Toledo tuff	Many of the filled areas have a fine crack between the tuff and the fill. There may be a little undercutting in areas around the entrance as noted on the graphic documentation. The area of undercutting is about 4cm long and one mm deep or so. The problem with separation in some cases was a result of a poor seal being made during application, but it does appear that some cracks have formed since, like on the west wall. On the east wall a crack has formed between the tuff and the infill leaving a section of wall and plaster next to a petroglyph in danger of falling. This section was fragile to begin with, which is why it was treated.
K062	2008	2.5:1 tuff to HHL	25% Group K tuff and 75% sieved Group A/B Cerro Toledo tuff	This cavate was not accessed because it would require a tall ladder to be set up, but much of the treated area can be seen from the ground. The visible fill appears to be in good shape.
K073	2008	2.5:1 tuff to HHL	Brown Group A/B Cerro Toledo tuff	The fill is in good condition. There is some minor separation between the substrate and the infill at the top of the fill, but this may have occurred during drying. Some loss of tuff occurred on the left side, but this is unrelated to the fill.

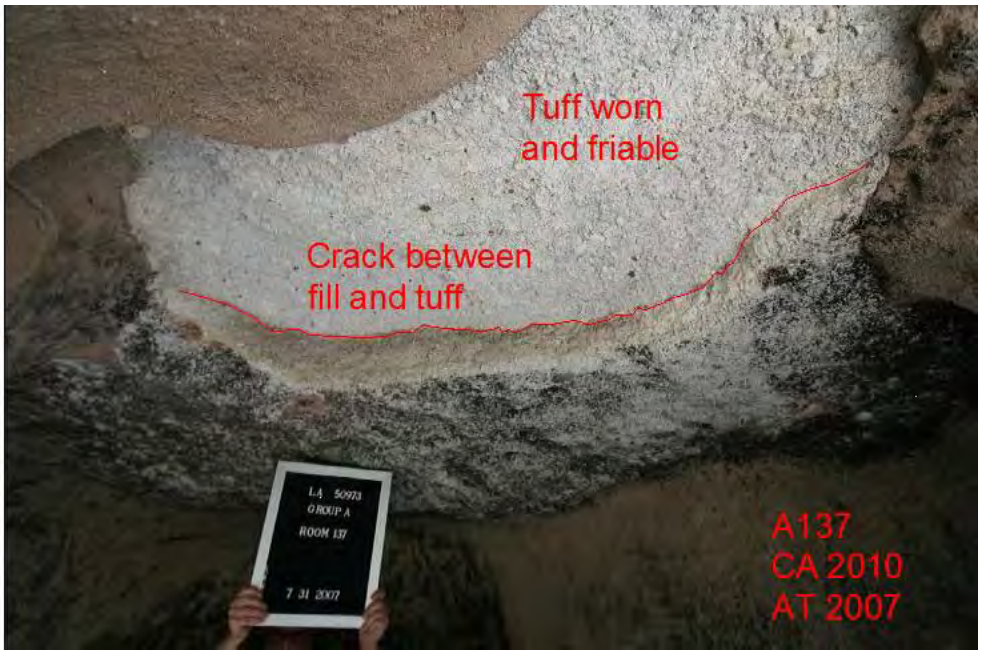
Cavate Number	Year Treated	Mortar Mixture Used	Tuff or Aggregate Used	Notes
M018	2008	3:1 aggregate to HHL	2 parts off-white Group M tuff and 1 part red clay used at Tyuonyi	There are two areas of highly friable tuff that are related to the undercutting problem in this cavate, but are uninfluenced by the infill treatments. One area is east of the ceiling infill, abutting it. This is the eastern edge of the undercut area which was not treated or consolidated and appears to be disintegrating. A similar process is occurring above the fill on the west wall. The tuff is extremely friable and is disintegrating.
M020	2008	3:1 aggregate to HHL	Equal parts A/B Cerro Toledo tuff, red clay, wash silt and 5% burnt umber pigment #1	The fill is good condition, and there is no visible evidence of erosion or damage.
M033	2007	3:1 aggregate to HHL	Local sieved pumice and rocks with 12% by volume clay#2	Active deterioration can be seen in this cavate. A water flow on the right side of the cavate is causing severe plaster detachment, peeling away individual layers from each other and the substrate. The instillation of a drip-line above may alleviate this problem. The shelf above the filled area appears to be eroding away. Perhaps a centimeter of rock has crumbled away in some places. This wear is probably caused by moisture freezing and thawing. It appears to be no damage directly caused by the infill treatment, but the treatment does not seem to mitigate the erosion problems in the cavate.
M139	2008	3:1 aggregate to HHL	2 parts unsieved wash-silt to 1 part Group M tuff	There is a small crack to the right of fill between it and the wall. Fill looks good otherwise. Crack is about 30cm long. The crack is in the 2008 AT photo, which means that it was not caused by erosion, but shrinkage during drying.

Cavate Number	Year Treated	Mortar Mixture Used	Tuff or Aggregate Used	Notes
M146	2007	2:1 tuff to HHL	unsieved crushed pink tuff from Group M	Infill appears to cause no damage. There is a hairline crack separating some of the fill from the tuff below on the N side of the ceiling. This crack may have happened during drying. Flaking of the ceiling has caused loss, but only a small amount. A visit to this cavate in 2011 showed that the cracking is getting worse. Monitor this ceiling closely.
M148	2003	2:1 aggregate to lime	Aggregate= 50:50 sand and microspheres, lime=50:50 Type S HL and Riverton HHL	After seven years the treatment appears as though it is working successfully. There is a good seal still where the mortar abuts the original tuff surface. No damage appears to have occurred as a result of the treatment. The mudflow on the N wall has not worsened in the last seven years, and there is no evidence that the mudflow went over the infilled area. The mudflow is, or has recently been inactive. The mud material used to disguise the infill is washing away primarily over the large niche in the west wall. On close inspection the tuff at the upper-most point of the infilled area is eroding behind the fill material.

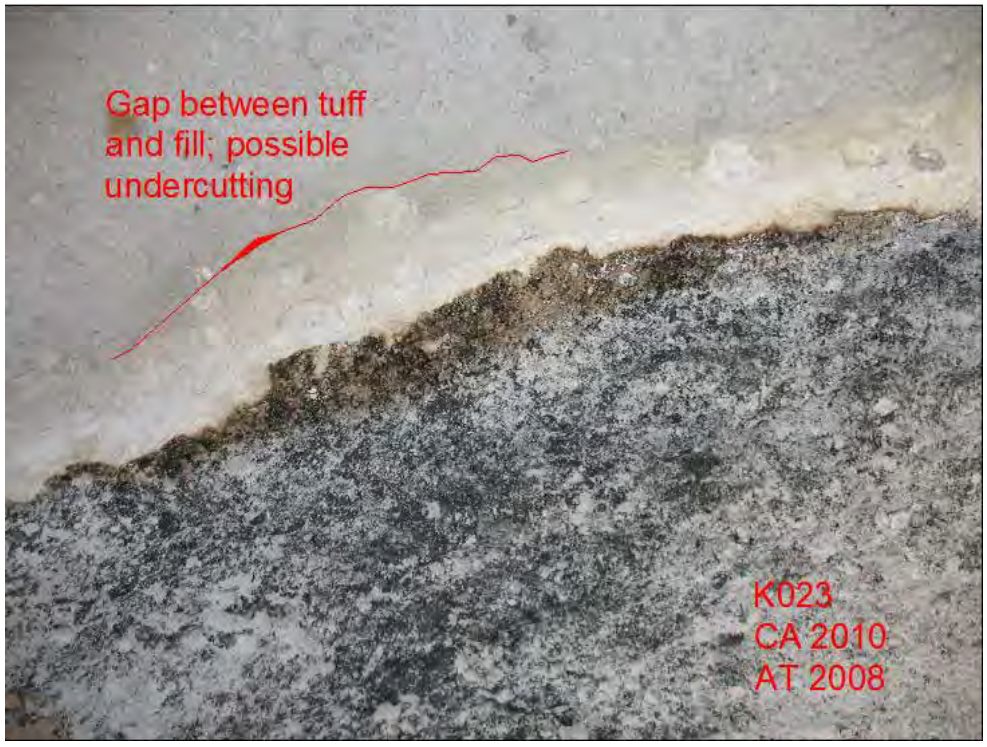
Annotated Photographs of Treated Cavates



A032



A137

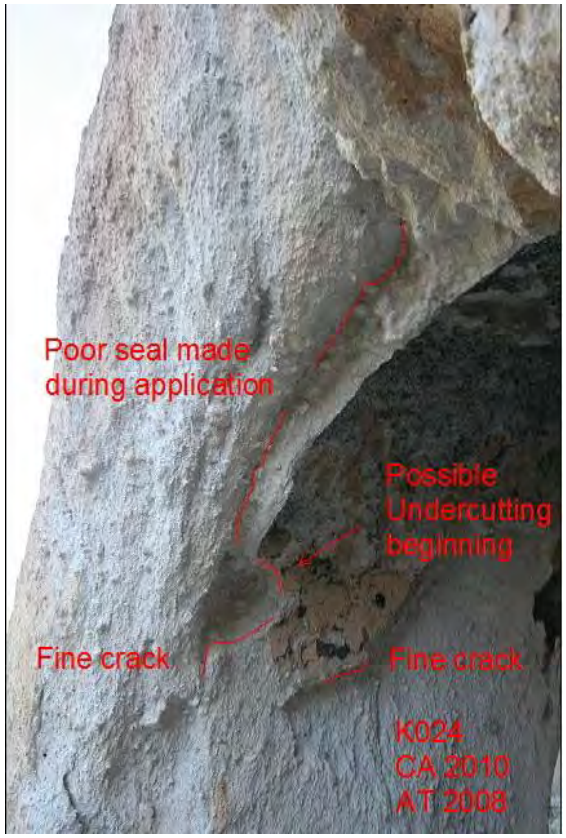

Gap between tuff
and fill; possible
undercutting
K023
CA 2010
AT 2008

K023


Small amount of
disintegration of the
stone (far side of fill)
K023
CA 2010
AT 2008

K023

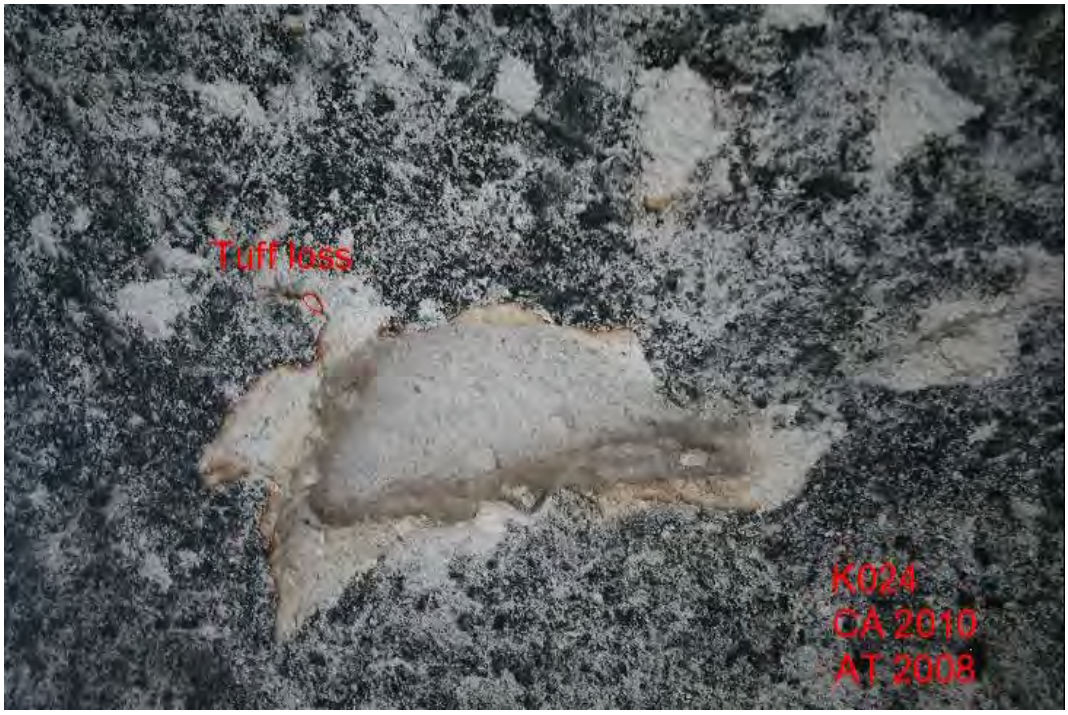
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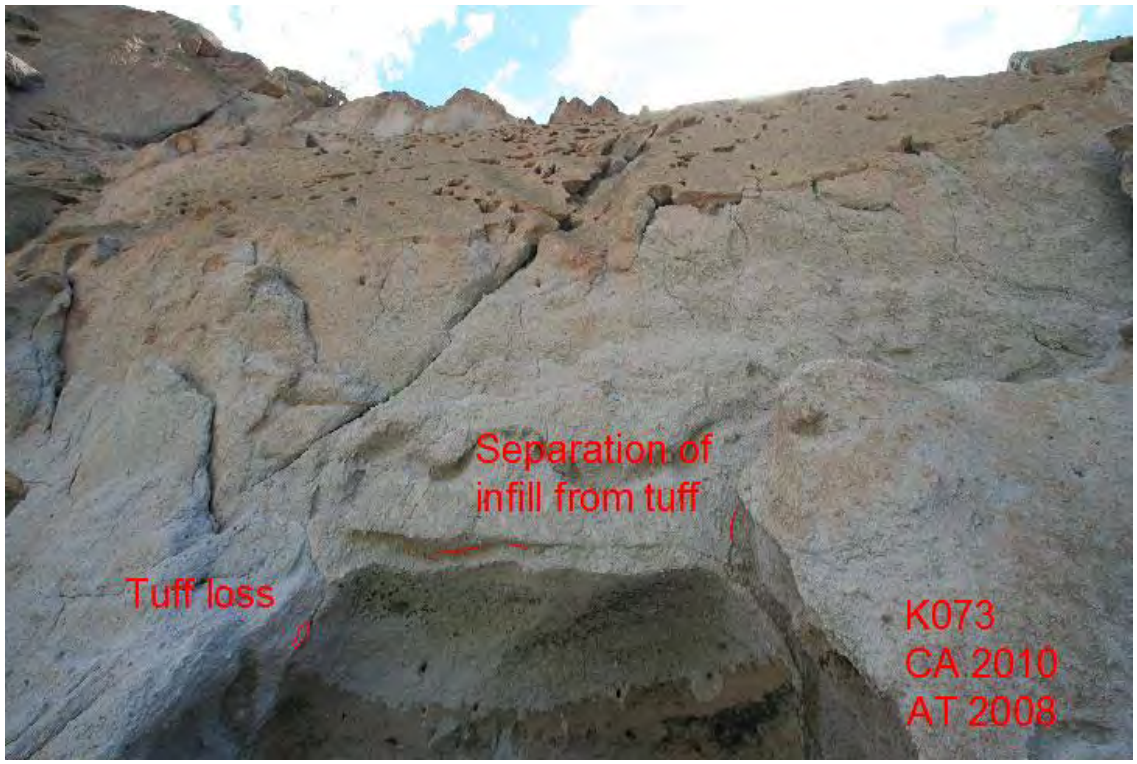
K024



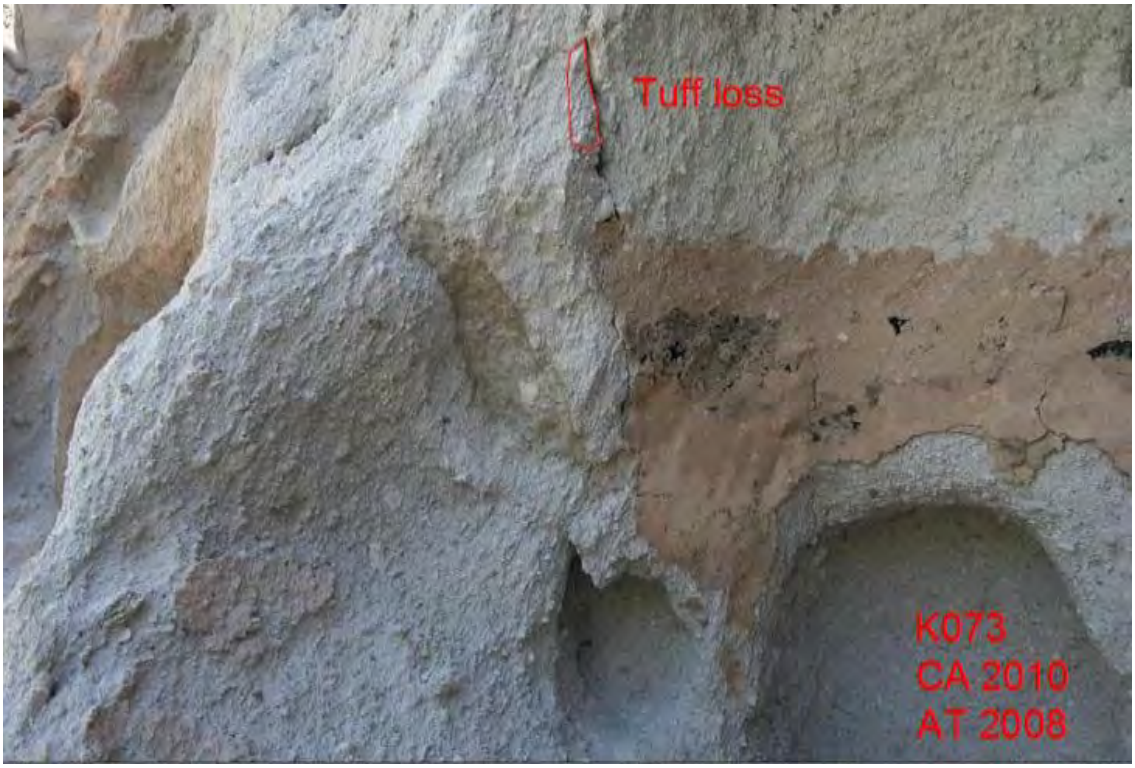
K024



K024


Separation of
infill from tuff
Tuff loss
K073
CA 2010
AT 2008

K073


Tuff loss
K073
CA 2010
AT 2008

K073



M018



M018


Fine crack between tuff and fill
LA 50972
GROUP M
PANEL V
RM 139
AFTER
TREATMENT
11 04 08
M139
CA 2010
AT 2008

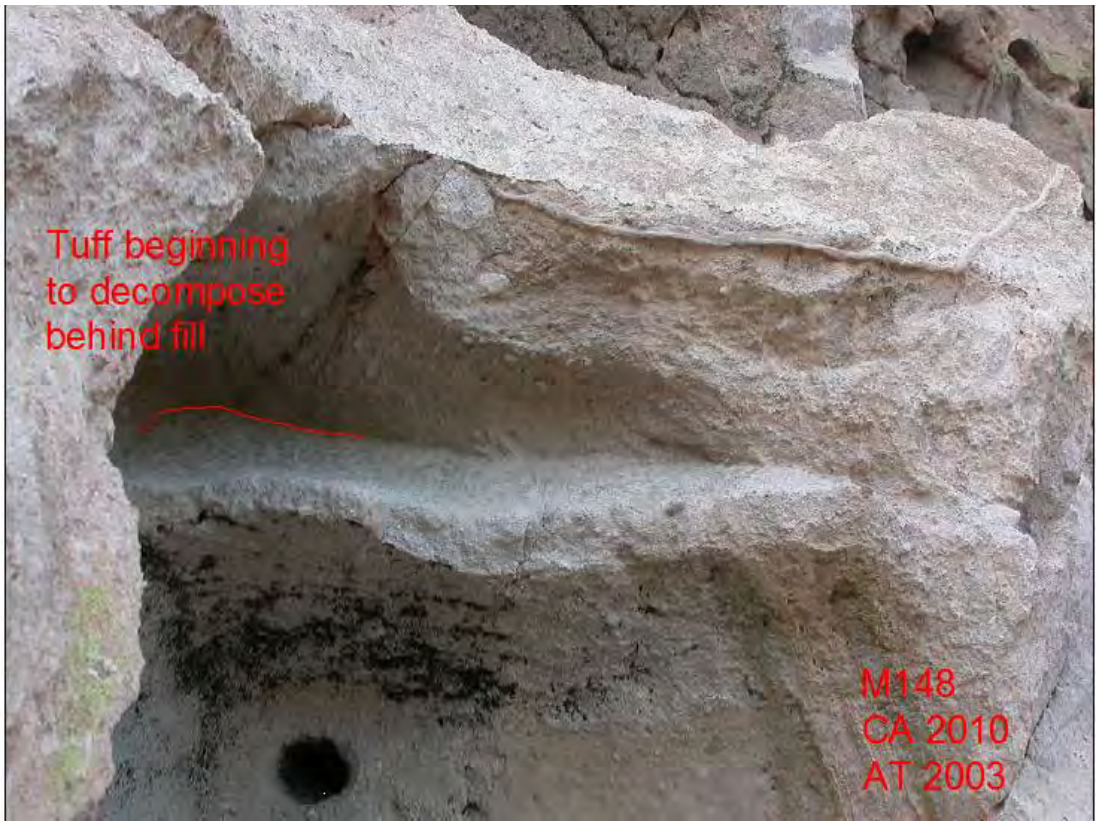
M139


Tuff Loss
Plaster Loss
Undercutting of fill
M146
CA 2010
AT 2007

M146


Tuff Loss
Fine crack
between
tuff and fill
LA 50972
GROUP M
ROOM 146
W WALL
AT
10 24 2007
M146
CA 2010
AT 2007

M146


Tuff beginning
to decompose
behind fill
M148
CA 2010
AT 2003

M148

Discussion

The infill treatments described in this report were carried out in the 2003 and 2007-2008 field seasons. The brief evaluation summarized here has provided us with some idea of how the treatments age and whether or not they are a useful intervention. However, more standardized testing should be done to quantify the benefits of this treatment versus the possible detrimental effects it could have on the soft tuff with which it comes into contact.

Treatment Application Methods

One issue that readily became apparent in this survey is that shrinkage of the infill commonly occurred shortly after treatment, causing it to detach from the tuff. If cracks around the infill are apparent in the after treatment photograph they are most likely due to shrinkage or poor application; in such cases it is difficult to evaluate the success of the treatment because there is no way to tell if there has been a change in the area since the time it was treated. It is also possible that cracks which may have formed shortly after treatment are not visible in the photographs taken shortly after treatment. These may subsequently be attributed to changing conditions where they do not in fact exist. Had more effort been made to ensure a tight seal between the fill and the tuff, both the longevity and effectiveness of the treatment would have increased and questions about how the treatment is aging might be easier to answer.

Pozzolanic Reaction

A possible concern about this infill treatment is that the material used, crushed tuff added to hydrated hydraulic lime, may create a natural soil cement. While the infill material appears to be relatively soft when first mixed, and for several months afterwards, it may gradually become harder over time. This is due to a well-documented chemical reaction that can occur between the lime and volcanic ash, called a pozzolanic reaction.

A pozzolan is defined by ASTM standards as “a siliceous or siliceous and aluminous material which, in itself, possesses no cementitious value, but which will, in finely divided form in the presence of moisture, react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties.” Pozzolanic materials are most often those that contain some amount of clays and have also been fired or subjected to high heat. The volcanic tuffs and pumice found at Bandelier both fall into this category. The addition of pozzolanic material to any lime mortar will

change its characteristics, often making it denser, less porous and more durable than mortar without pozzolans.

The addition of crushed tuff to the infill material used at Bandelier may have inadvertently changed the characteristics of the intended material into something that is harder and therefore less compatible with the soft tuff of the cavates. The test patties that were made in 2003 as part of the pilot infill treatment program were tested to some extent for strength and hardness, however these tests were performed after the patties had only cured for a minimum of a few weeks. Current research shows that some lime mortars, particularly those containing pozzolanic materials can take up to two years to cure completely, meaning that the infill materials may have seemed compatible upon application, but may have become incompatible in the time since they were first used.

If infill treatments are to continue at Bandelier, a more thorough understanding of the long term characteristics of the infill material needs to be obtained. A long term testing program of infill mortar samples is one way of attaining this information. Such a program should take place over a number of years to ensure that the information provided is complete. In addition, other methods of mortar mixing should be tested, including the use of tuff aggregate greater than 70 microns in size, or greater than silt. These particles are too large to be reactive with the lime and could therefore be used as a colorant without changing the chemical structure of the material. Infill of undercut cavate areas has the potential to be a successful treatment, but more documentation and research is needed before its use is continued.

Conclusions and Future Recommendations

This treatment was designed to be sacrificial, meaning that the infill area is meant to erode before the tuff around it, thereby decreasing the rate of undercutting. Unfortunately, this does not appear to be the case. The hardness of the infill instead encourages the softer tuff around it to erode first. A limited understanding of the causes and morphology of undercutting in cavate walls and ceilings has also limited the success of the treatment. Undercutting is a symptom of water infiltration, either by rising damp or moisture from above. Infilling of undercut areas should be done in conjunction with thorough analysis and potential modification of drainage patterns. If nothing can be done to control the drainage, infilling of undercut areas may be the only option. In this case, the infill must truly be a sacrificial layer

that is softer than the tuff it is meant to protect. More work is needed to develop a fill material that is both visually and physically compatible with the stone before this treatment should be performed again.

Appendix R:

Scopes of Work for Active CESU Agreements, FY2010

Scopes of Work for Active CESU Agreements, FY2010

Sampling, testing and analysis of the anthropogenically altered portions of the Tshirege Member of the Bandelier Tuff, Bandelier National Monument

CPCESU Partner Organization: New Mexico State University
Principle Investigator: Dr. N. Mcmillan
Start Date: September 1, 2009
End Date: August 31, 2011

Project Objectives

The goal of this project is to characterize the geology and composition of the tuff and to determine the deterioration phenomena causing cavate disintegration. Cavates are Ancestral Pueblo period dwellings that were hand-excavated into the lower portion of the Bandelier tuff in Frijoles Canyon, Bandelier National Monument and throughout the Pajarito Plateau. Ultimately the data will be used to design appropriate conservation treatments for the cavates. Specific objectives of this first phase of work are to sample and analyze the composition of the tuff in areas that have been anthropogenically disturbed and then compare the results to tuff samples in unmodified, less weathered areas. Subsequent research phases may involve accelerated weathering to determine prevalent weathering trends and effects, and then testing of select stone consolidation treatments. This project contributes to the strategic goals established for the park, specifically the goal of maintaining prehistoric and historic resources in current or better condition to preserve cultural integrity and information potential. It falls under the following parkwide objectives (from Bandelier Foundation Document):

1. *To preserve, protect, and interpret archeological resources associated with the ancestral Pueblo people and the extensive collection of Works Progress Administration (WPA) resources and associated cultural values;*
2. *To develop and implement research that contributes to the stewardship of cultural resources and integrated management of natural resources in the monument, with broader public education and resource management application; and*
3. *To foster and develop partnerships with communities and neighbors in support and protection of Bandelier's cultural and natural resources.*

Statement of Work

The Department of Geological Studies at New Mexico State University will work in conjunction with the Vanishing Treasures Program at Bandelier National Monument to study deterioration and weathering phenomena associated with the Bandelier tuff in Frijoles Canyon, specifically in the lower portion Tshirege member where the cavates (hand-excavated Ancestral Pueblo period dwellings) are located. The goal of the project is to characterize the geology and composition of the tuff and to determine the deterioration phenomena causing cavate disintegration.

Research goals:

1. To determine whether anthropogenic alteration of the tuff has changed its chemical and physical nature (anthropogenic alteration includes carving, sooting and use over time). This will be done by comparing altered samples to unaltered samples taken from the same general area.

2. To understand the weathering phenomena that causes tuff deterioration. This will be achieved through a comparison of the chemical and physical properties of cavate tuff at different stages in weathering.

3. To investigate the roll of lichen in protecting or accelerating the deterioration of the tuff. This will be achieved by mineralogic and chemical analysis of tuff with and without lichen overgrowths.

Tasks associated with research goals:

1. Review of scientific literature available related to the Tshirege Member of the Bandelier tuff and summarize relevance of materials.
2. Sampling of tuff
    a. Anthropogenically altered areas as well as unaltered areas
    b. Competent tuff and tuff in various stages of weathering -- include surfaces with natural and human applied (sooting) case hardening, as well as those for which the case hardening has been lost
    c. Core samples to determine extent and depth of weathering
    d. Lichen-coated and lichen-free samples
    e. Samples will be keyed to maps developed by the concurrent OCA/UNM documentation project.
3. Instrumental analysis
    a. Mineralogy of fresh and altered tuffs, using thin sections, X-Ray Diffraction (XRD)
    b. Physical characteristics – compressive strength, shape, size and density of the pores (important for freeze-thaw and salt crystallization and deliquescence), shape and size of particles that comprise the tuff (texture), absorption capability of competent and incompetent tuff, abrasion resistance, using epoxy-impregnated thin sections and Scanning Electron Microscopy Imaging (SEM)
    c. Chemical composition of fresh and altered tuffs, including soluble salts, clays, zeolites, and other alteration products, using X-Ray Fluorescence (XRF), Scanning Electron Microscopy Imaging (SEM), Electron Microprobe Analysis (EMPA). Some analyses will be done in the field with Portable XRF and LIBS, two portable and minimally-destructive chemical analysis techniques.
    d. Compressive strength and changes of pore characteristics with pressure, using the 20-ton hydraulic press in the Department of Geological Sciences, and thin section analysis.
4. Project report
    a. Review of literature and summary of relevant materials
    b. Sampling methodology, location descriptions
    c. Testing protocols, summary of actions and interpretation of instrumental analyses (including written descriptions, graphics and datasets)
    d. Results of testing
    e. Recommendations for further work

Graffiti Mitigation in the Frijoles Canyon Cavates

CPCESU Partner Institution: The University of New Mexico School of Architecture and Planning
Principal Investigator: Douglas Porter, Associate Professor
Start Date: September 1, 2009
End Date: June 30, 2011

Project description

Many of the cavates in Frijoles Canyon retain original applied earthen plaster and soot finishes over the volcanic tuff substrate. Some cavates have modern graffiti carved into or applied onto their interior walls and ceilings. The highest concentration of graffiti appears to be in cavates that are open to the public, as well as those that are easily accessible from the visitor trail (even though they may be closed to public access). To help prevent further damage and vandalism, the Vanishing Treasures Program is mitigating some of the modern graffiti.

The principal goals of graffiti mitigation are to obscure modern graffiti and reduce the rate of its recurrence. Graffiti is mitigated by infilling and inpainting incised areas with physically and visually compatible materials, primarily earthen mortars and pigments. Infilling also helps prevent additional disintegration and loss of the plaster and the tuff, which easily erodes once the surface has been broken.

The current cooperative project, 'Graffiti Mitigation in the Frijoles Canyon Cavates,' is an outgrowth of the more comprehensive cavate conservation program that began in 2000. The project will involve hands-on graffiti mitigation treatments, and will provide a platform for refinement of existing treatment protocols. Project participants from the School of Architecture and Engineering at the University of New Mexico will work with staff of the Vanishing Treasures Program at Bandelier National Monument and conservators from the Museum of New Mexico Conservation Division to document and treat (through infilling and inpainting) cavate features that have been vandalized through the application of graffiti. Project participants will also assist in the development of a treatment matrix for graffiti in the cavates, which will become part of a management document for the archaeological resources in the park.

Structural Assessment and Monitoring of Cavate B002, Bandelier National Monument, Phase I: Development of Project Methodology

CPCESU Partner Institution: University of New Mexico [School of Architecture and Planning]
Principal Investigator: Douglas Porter, Associate Professor
Start Date: September 1, 2009
End Date: August 30, 2011

Project description:

The School of Architecture at the University of New Mexico (UNM) proposes to participate with staff from Bandelier National Monument (BAND) and professional partners in a program of assessment, research, and structural monitoring of cavate B002 in Frijoles Canyon. The B002 cavate is unique in that one of the stone walls enclosing the rock chamber survives. The University of New Mexico proposes to

evaluate the structural stability of the wall and develop options for long-term structural monitoring. A monitoring program may be implemented to the extent feasible based on the available options and the needs of the park. The park and staff of UNM will jointly participate in the work.

It is anticipated that this project will include educational and training components, and that university students, NPS staff, and practicing professionals will be directly involved in portions of the work that may include: participation in the field assessment work; collection and collation of existing information pertaining to site geology and conservation history; and participation in the collection of data pertaining to structural stability and its analysis. The program will serve as a pilot to determine techniques and equipment necessary to monitor the structural stability of the wall; the project is expected to yield results that will be applicable to similar sites within the Monument.

Structural Assessment and Monitoring of Cavate B002, Bandelier National Monument, Phase II: Tuff Testing and Analysis

CPCESU Partner Institution: University of New Mexico [School of Architecture and Planning]
Principal Investigator: Douglas Porter, Associate Professor
Start Date: June 20, 2010
End Date: August 30, 2011

Project description:

The mineralogy and alteration states of the Bandelier Tuff vary widely making it highly vulnerable to deterioration. Variability in tuff character ranges from large-scale, based on such factors as depositional strata, geographic location, and exposure, to small-scale variations based on mineralogical composition, biological growth, and localized decomposition. This project seeks to examine the pore structure and permeability of tuff immediately adjacent to cavate B002 in order to better understand the structural properties of the cavate and predict erosion rates that may lead to catastrophic collapse of the masonry enclosure wall.

Porosity and permeability have a strong correlation and susceptibility to weather, and are altered by weathering processes (erosion, disaggregation, deposition of deterioration products). Stone heterogeneity also plays a principal role in the types and distribution of stone weathering. The spatial distribution of permeability, considered along with porosity and other inherited characteristics of the stone, can result in a fuller understanding of variations in durability and types/distribution of different weathering forms.

To facilitate characterization of the tuff, samples representing the competent and weathered states of the tuff will be collected from the vicinity of cavate B002. The samples will be collected using a chisel and/or a battery-powered core drill and transported to a laboratory for analysis. The pore structure and permeability properties of the tuff will be determined and mapped using a combination of technologies including gas permeability, wicking tests, and microscopy with image analysis. This analysis should provide (a) useful predictors of the susceptibility to weather of the tuff in its several forms and (b) quantitative descriptions of the weathering profiles encountered at Bandelier.

By collating test results on volume porosity, pore area, pore size distribution, and water transport properties for each of the tuff compositions and weathering states, investigators will gain a basic understanding of their susceptibility to environmental deterioration. Profiles based on these

measurements will provide powerful tools in the interpretation of weathering processes directly relating to cavate B002. These will play a critical role in subsequent research, including accelerated weathering, modeling of tuff hydrology, determination of erosion rates, and development of preservation strategies.

Appendix S:

B 002 Laser Scanning and Structural Analysis
Progress Reports #1 and #2

STRUCTURAL ASSESSMENT AND MONITORING OF CAVATE B002
BANDELIER NATIONAL MONUMENT

PROGRESS REPORT 03/16/10

BACKGROUND AND OBJECTIVES

Under Cooperative Agreement # H1200-09-0005 (Colorado Plateau Cooperative Ecosystem Studies Unit), Bandelier National Monument (BAND) and the School of Architecture and Planning at the University of New Mexico (UNM), along with its professional partners, are participating in a program of assessment, research, and structural monitoring of cavate B002 in Frijoles Canyon. The University of New Mexico is evaluating the structural stability of the wall and developing options for long-term structural monitoring. The park and staff of UNM are jointly participating in the work.

This project includes educational and training components for university students and NPS staff. In addition, practicing professionals are directly involved in portions of the work including: field assessment; collection and collation of existing information pertaining to site geology and conservation history, and; and structural stability assessments and analysis. The program will serve as a pilot to determine techniques and equipment necessary to monitor the structural stability of the wall. The project is expected to yield results that will be applicable to similar sites within the Monument.

PROJECT DESCRIPTION

Cavate B002 is unusual in that two of its original walls were built of masonry. Both walls were intact in the 1920s. One of the walls has since collapsed; the surviving wall, which is the largest masonry enclosure left in situ in Frijoles Canyon, is extremely fragile due to extensive mortar loss between the masonry units and severe cracking in the cliff face just above it. Its structural stability is in question, and this project focuses on structural assessment and development of recommendations for structural monitoring. The project will be conducted in phases. Phase 1, covered by this agreement, includes:

1. A site visit to assess the condition of the wall and the surrounding tuff, and to determine the current level of weather exposure.

2. Laser scanning to record the wall geometry and produce a highly accurate TIN (triangulated irregular network) model
3. Development of a computer model simulating the structural stability of the wall, using custom software appropriate for historic masonry structures.
4. Assessment of the current structural condition of the wall based on modeling results, and evaluation of the potential impacts of additional material deterioration.
5. Recommendations for ongoing monitoring of the wall and possibly for tuff associated with the wall. UNM will outline the merits of monitoring options and can assist with developing a phased plan for implementation on the basis of this information.
6. Preparation of a completion report based on the results of the investigation. The report will include a narrative description of the project goals, methodology, results of analysis, and recommendations for ongoing monitoring. The completion report will be made available to project cooperators in digital (pdf) and paper formats.

WORK COMPLETED TO DATE

Site Visit

Cooperators inspected surviving masonry structures in cavate groups B, M, and the North Mesa. The goal of the inspection was to characterize construction methods as they relate to the wall at B002, focusing on masonry that has undergone minimal interventions. As a result of the inspection, cooperators determined that the masonry at B002 is typical of tuff masonry construction elsewhere in Frijoles Canyon in many respects: tuff masonry units show slight evidence of hewing or deliberate shaping, and are roughly brick-like in shape, with their depth exceeding their thickness, and their length exceeding their depth. In instances where the coursing was visible, stones were bedded against other stones, and both mud mortar and stone chinks were used to fill irregular voids between the rough stone surfaces. Walls are one wythe deep, and coursing is random, though stonework appears to form nearly vertical columns at corners and jambs. Mud mortar was used for pointing bedding and head joints, and as a plaster on some wall surfaces.

There are two major areas of concern in cavate B002. First, a large portion of the overhanging cliff is detaching from the rock face and is supported on the masonry wall. Water flowing down the cliff face seeps into the fracture and is progressively eroding the rock. Second, the surviving wall is unsupported along the corner and at its base and the mortar in this area is depleted.

Laser Scanning

The masonry wall at B002 and portions of the surrounding cliff face were laser scanned by Western Mapping Company on September 25, 2009 under the supervision of project staff. A 5mm TIN model was developed from the raw point cloud. Because of shadows created by scanner placement and the contour of the cliff face, it was necessary to fill several small holes using 'intelligent' algorithms; the corrected TIN model was checked against photographs taken at the time of scanning. The corrected model has been delivered to John Ochsendorf of MIT, who will supervise construction of the computer model that will be used to determine the structural stability of the wall and provide a theoretical basis for establishing stability/failure thresholds. The computer model is currently under construction.

Literature Search

A literature search is underway to collect and summarize relevant and current research on stone deterioration; tuff characterization, geotechnical properties and weathering mechanisms; and in situ conservation. Conservation (AATA, BCIN) and geological science (GeoRef) databases were searched. The literature review provides crucial background information for understanding both the methodology and results of assessing and treating volcanic tuff, and has allowed us to establish the state of research and determine how our new work might be useful to both Bandelier and the larger field of conservation. The literature search results have been entered into an EndNote bibliographic database that will be provided to the park upon completion of the project.

Research Plan Development

Additional research is needed to complete characterization of the tuff, record deterioration, and develop methods for erosion monitoring. The project team is developing a research plan focused on the following components:

1. *Tuff characterization*

The mineralogy and alteration states of the Bandelier Tuff vary widely making it highly vulnerable to deterioration. Porosity and permeability have a strong correlation to susceptibility to weather, and are altered by weathering processes (erosion, disaggregation, deposition of deterioration products). Furthermore, stone heterogeneity plays a principal role in the types and distribution of stone weathering. The spatial distribution of permeability, considered along with porosity and other inherited

characteristics of the stone, can result in a fuller understanding of variations in durability and types/distribution of different weathering forms (McKinley, et al. 2007)

The pore structure and permeability properties of the tuff can be determined and mapped using a combination of technologies including gas permeability, wicking tests, and microscopy with image analysis. This analysis should provide (a) useful predictors of the susceptibility to weather of the tuff in its several forms and (b) quantitative descriptions of the weathering profiles encountered at Bandelier. An engineering student at the University of Vermont has obtained a Barrett Scholarship to support research on tuff permeability. The research will take place during summer 2010 and will focus on measurement of surface gas permeability of tuff samples to produce 3D graphical representations of permeability throughout the sample depth, wicking tests, and determination of pore size distribution and shape using fluorescent confocal microscopy.

By collating test results on volume porosity, pore area, pore size distribution, and water transport properties for each of the tuff compositions and weathering states, investigators will gain a basic understanding of their susceptibility to environmental deterioration. Profiles based on these measurements will provide powerful tools in the interpretation of weathering processes. These will play a critical role in subsequent research, including accelerated weathering, modeling of tuff hydrology, determination of erosion rates, and development of preservation strategies.

2. Weathering forms and profile mapping

Classification of weathering forms (or profiles) combines field data with lithological/petrographical characterization, accelerated weathering studies, and porosity/permeability measurements and other stone properties taken of samples for each profile. In this way, weathering profiles are understood in terms of their relationship to rock structure and mineralogy, and quantitative data is collected for each weathering state. To some extent, classification of weathering profiles has been standardized (Fitzner and Heinrichs, 2002). Weathering profile information can be plotted on deterioration maps that also capture deterioration intensities; intensity classifications are particular to a site or structure (Fitzner, 2004). These maps are useful in capturing deterioration distributions and establishing relationships between damage and site-specific factors including orientation, exposure, profile, etc. The maps help with quantification of damage, determination of erosion/loss rates, development of preservation strategies and priorities.

3. Accelerated weathering testing

One of the goals of accelerated weathering is to characterize damage profiles that may appear in a progression from 'fresh' to 'failed' stone. Standards for accelerated weathering are sometimes designed to produce failure as quickly as possible, minimizing the testing required for comparative durability ranking of a range of candidates for replacement stone. This can be through the application of excessive heat, concentrated salt solutions, saturation of small samples for freeze-thaw testing, etc. These tests are sometimes more reflective of the experimental conditions than of intrinsic structural and mineralogical properties of the stone, and tests that more accurately replicate real exposure conditions result in significantly different durability rankings, particularly for stones with lower rankings (Warke, et al. 2007). If the subtleties of various weathering profiles are to be captured in accelerated weathering testing, tests must replicate 'real-world' conditions in a way that illustrates/elicits the periods of apparent quiescence in the development of weathered states and allows for change of structural and mineralogical properties in response to weather.

4. Erosion monitoring/isotope measurement

Recent technological developments related to the measurement of isotopes associated with river sediment have improved our ability to identify sediment sources. The isotopes (principally Meteoric ^{10}Be, ^{137}Cs, and ^{210}Pb) have different depth and decay profiles and, when coupled with data related to basin topography, climate, geology, and land use, can be used to identify sediment sources. This technique provides the potential for 'fingerprinting' river sediment sources and may be useful in quantifying erosion rates of the cliffs along Frijoles Creek by allowing us to determine where on the landscape the sediment originated.

References

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Report submitted by Douglas Porter and Angelyn Bass Rivera, March 16, 2010

STRUCTURAL ASSESSMENT AND MONITORING OF CAVATE B002
BANDELIER NATIONAL MONUMENT

PROGRESS REPORT #2

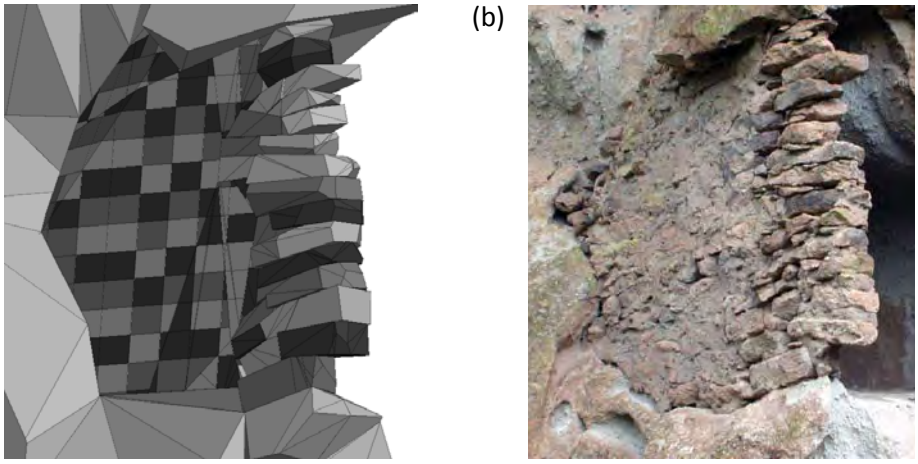
05/31/10

Since our March meeting and first progress report, we've assembled a working computer model of the masonry wall at cavate B002, have begun to query the model, and are preparing for our lab work at UVM, scheduled to start June 21, 2010. Following are descriptions of each aspect of the work.

Structural Model

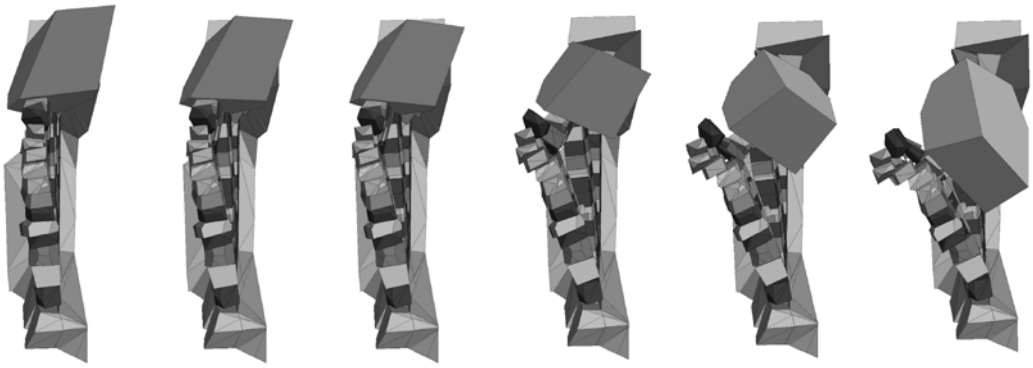
The laser scan TIN model was transformed into discrete block CAD models and imported into a discrete element modeling program. Since the end wall nearest the cavate opening was assumed to be critical in determining stability and the individual blocks are easier to distinguish, this portion of the wall was reproduced on an individual block basis. The rest of the wall is covered with an extruded plaster, so individual blocks were difficult to locate. Partly for this reason, and since the plastered portion of the wall appears to be more stable, it was modeled with a uniform grid of non-interlocking blocks. As expected, analyses of the wall under these assumptions confirm that the wall is stable. Even assuming that the large rock above the wall is not fixed but bears directly on the masonry, the compressive stresses in the wall remain small (<100 psi). To investigate the types of collapse that could potentially occur, joint material properties were reduced below expected values and the analyses were repeated; reducing joint material properties is one method of simulating material degradation. For a joint friction angle of 20 degrees, collapse resulted. The model will be used to explore the fragility of the 'column' of blocks nearest the cavate opening, and the impacts of erosion at the base of the wall and where the wall abuts the cliff face. Results are expected in July 2010.

(a) (b)

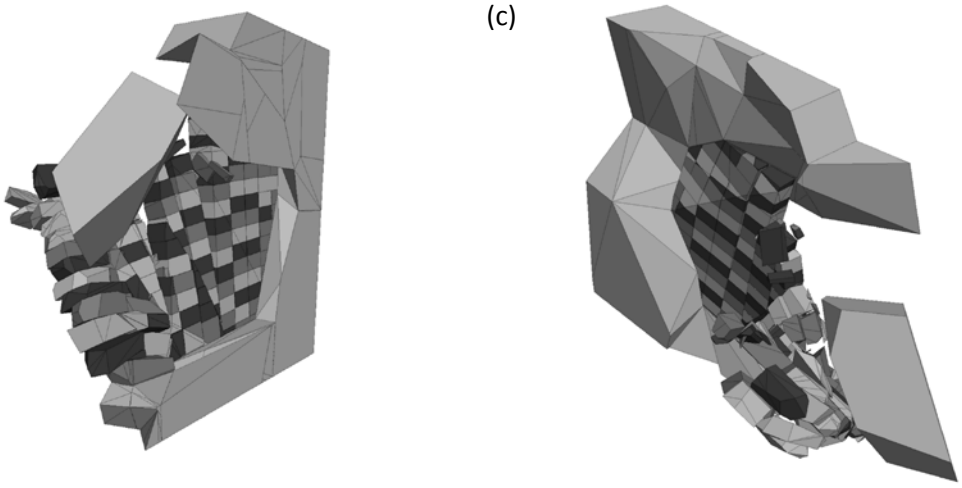


Comparison of (a) the three-dimensional model created from the laser-scan point cloud and (b) an actual wall image.

(a)



(b) (c)



Collapse mechanism for wall with unrealistically soft joints and low frictional capacity: (a) side view of progressive collapse, (b) inside view of collapse, (c) outside view of collapse from above.

Tuff Characterization

In summer 2010, laboratory research will take place at the University of Vermont to determine the pore structure and permeability properties of the Qbt1g layer of the Bandelier tuff in the area of B002[1]. Porosity and permeability have a strong correlation to susceptibility to weather, and are also altered by weathering processes (disaggregation, erosion, deposition of deterioration products, etc). Pore structure and permeability properties will be determined and mapped for each sample using a combination of techniques including surface gas permeability, wicking tests, and determination of pore size distribution and shape using fluorescent confocal microscopy. The results are expected to provide (a) useful predictors of the susceptibility to weather of the tuff in its several forms and (b) quantitative descriptions of the weathering profiles encountered at Bandelier, and will play a critical role in subsequent research, including accelerated weathering, modeling of tuff hydrology, determination of erosion rates, and development of preservation strategies. The School of Engineering at the University of Vermont has awarded a Barrett Scholarship (in excess of $10,000) to conduct this research. This, in addition to partial match funds from Bandelier National Monument, will support a research stipend, lab fees, and faculty supervision.

[1] Shannon Dennison completed NPS compliance for sampling, which will be conducted in June by the Barrett Scholarship intern and members of the project team.

Appendix T:

List of Treated Cavates

Treated Cavates in Frijoles Canyon - 2010

Stabilization of Associated Masonry

	Group	LA #	RM #	Treatment Priority	Treated
1	M	50972	087	Medium	July, 2010
2	M	50972	091	Medium	July, 2010
3	M	50972	093	Medium	July, 2010
4	M	50972	095	Medium	July, 2010
5	M	50972	099	Medium	July, 2010
6	M	50972	102	Medium	August, 2010
7	M	50972	123	Indeterminate	August, 2010
8	I	50974	010	Medium	August, 2010
9	I	50974	022	Medium	August, 2010
10	A	50973	060	High	September, 2010
11	A	50973	013	High	September, 2010

Floor Mapping

	Group	LA #	RM #	Treatment Priority	Dates Mapped
1	E	13664	022	High	6/30/10,7/1/10

Cavates Treated to Control Drainage and Erosion

	Group	LA #	RM #	Treatment Priority	Dates Treated
1	M	50972	087	Medium	July, 2010
2	M	50972	102	Medium	July, 2010
3	I	50974	026	High	August, 2010

360 Photography

	Group	LA #	RM #	Treatment Priority	Photographed
1	D	13665	156 2/A	High	8/5/2010
2	F	50975	Panel B	All	10/6/2010

Finishes Conservation

	Group	LA #	RM #	Treatment Priority	Dates Treated
1	M	50972	093	Medium	8/30/10, 9/20/10
2	M	50972	099	Medium	9/14-20/10
3	F	50975	013	Medium	10/07/2010

Graffiti Mitigation

	Group	LA #	RM #	Treatment Priority	Dates Treated
1	B	140939	009	Low	6/14-25/10
2	B	140939	012	High	6/14-25/10
3	B	140939	083	High	6/14-25/10
4	B	140939	132	Low	6/14-25/10
5	B	140939	148	Medium	6/14-25/10
6	B	140939	151	Low	6/14-25/10

Appendix U:

List of Participants

List of Participants - 2010

Shannon Dennison	Program Manager/Architectural Conservator
Stephen Merkel	Project Manager/Field Supervisor
Rachel Adler	Field Lead
Marty Davenport	Mason Lead
Jonathan Holdsworth	Archaeological Technician
Ashley Crossen	Archaeological Technician
Karim Hassanein	Archaeological Technician
Eli Logan	SCA Intern
Micah Ben-Haim	Photography Assistant

Appendix V:

Materials and Suppliers

Materials and Suppliers - 2010

MATERIALS FOR MASONRY STABILIZATION

- Tyounyi mortar mix and pure Garcia Tan Soil
- Dusting brush or canned air
- Rags
- Water Jugs, two gallons
- Small spray bottle
- Dash brush
- Trowels
- Chisels
- El Rey 200 acrylic additive
- Nitrile gloves
- Palm coated masonry gloves
- Four five-gallon buckets
- External frame packs
- Rubber bungee cords, 22" and 30"
- Extension ladder
- Acetate sleeves and binder for graphic documentation
- Permanent markers, red, blue, green and black

MATERIALS FOR FLOOR MAPPING

- 22" x 22" metric graph paper
- 22" x 28" masonite board 3/16" thick
- Graphite pencils and colored pencils
- Drafting dots
- Two measuring tapes (ribbon)
- Two self-retracting pocket tape measures
- Plumb-bob
- Scotch tape
- Artists tape (for tracing curves)
- Compass w/ vertical needle or wire for easy alignment
- Soft paint brush (for investigating features)
- Canned air

MATERIALS FOR FLOOR CLEARING AND BACKFILLING

- Two 1' wide brushes
- Two dust pans
- Full-face or half-face respirator w/ safety goggles
- Nitrile gloves

- 4 five gallon buckets

MATERIALS FOR DRAINAGE CONTROL TREATMENT

- Crushed tuff (collected near site and from Group A-B)
- Hydrated Hydraulic Lime (St. Austier)
- Trowels
- Bucket
- Spray Bottle
- Acetate sleeves and binder for graphic documentation
- Permanent markers, red, blue, green and black

MATERIALS FOR FINISHES CONSERVATION

- #60 Sieve
- Ceramic microspheres
- Fine sand (60 mesh)
- Hydrated Hydraulic Lime (St. Austier)
- Syringes, 10 ml
- Needles, 12 gauge and 16 gauge
- Gelatin packets
- Glycerin
- Insulated container for carrying hot water
- Glass mason jars for storing gelatin mixes and grout
- Microspatulas
- Cordless drill with bit for stirring grout
- Canned air
- Tweezers
- Cosmetic sponge
- Graduated cylinder for measuring gelatin mixes
- 50ml and 250ml plastic measuring beakers
- Acetate sleeves and binder for graphic documentation
- Permanent markers, red, blue, green and black

MATERIALS FOR FIELD PHOTOGRAPHY

- Digital SLR camera with memory card and battery
- B&W film SLR camera
- 2 rolls of extra B&W film
- Tripod
- Light meter
- Long lens
- Sign board and letter case
- Scale bar and arrow
- Pencil and sharpie

- Camera cleaning supplies
- Clipboard
- Film and digital photo logs
- Roll identification sheets
- Black permanent marker
- Compass
- Maps
- Cavate database list

SUPPLIERS

Archival Labels
University Products, Archival Supplies
University Products Inc.
517 Main Street
Holyoke, MA 01040
1.800-628-1912
http://www.universityproducts.com/

Ceramic Microspheres
3M
3M Corporate Headquarters
3M Center
St. Paul, MN 55144-1000
1-888-364-3577
http://www.3m.com/

Conservation Supplies
Artisan
2601 Cerrillos Road
Santa Fe, NM 87505
1-505-954-4179
http://www.artisan-santafe.com/

El Rey Superior Additive 200
El Rey Stucco Company, Inc.
Corporate Office Parex Lahabra, Inc.
4125 E. La Palma, Suite 250
Anaheim, CA 92807
1-714-778-2266

Field Supplies
Home Depot
952 Richards Ave
Santa Fe, NM 87507
1-505-424-9463

Mapping Supplies
Forestry Suppliers Inc.
205 West Rankin Street
P.O. Box 8397
Jackson, MA 39284-8397
1-800-647-5368
http://www.forestry-suppliers.com/

Metal Cannulae
McMaster-Carr
9630 Norwalk Blvd.
Santa Fe Springs, CA 90670-2932
1-562-692-5911
http://www.mcmaster.com

Microspatula
Talas
213 W 35th St
New York, NY 10001-1996
1-212-736-7744

Photography supplies and film processing
Camera and Darkroom
Penn Road Shopping Center
Santa Fe, NM 87505
1-505-988-2043

St. Austier Hydrated Hydraulic lime
Transmineral USA
201 Purrington Rd.
Petaluma, CA 94952
1-707-769-0661
info@transmineralusa.com

Soils
Garcia Landscape Materials
County Road 0046
Los Luceros, NM 87511
1-505-852-2569

Syringes and Needles
BD
1 Becton Drive
Franklin Lakes, NJ USA 07417
201.847.6800
http://www.bd.com/

Appendix W:

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