

# **ANALYSIS OF ARCHITECTURAL MORTAR SAMPLES FROM WEST RUIN AT AZTEC RUINS NATIONAL MONUMENT**

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## **INTRODUCTION**

Installation of a water drainage system at the West Ruin at Aztec Ruins National Monument required five penetrations through prehistoric masonry walls (Figure A1). The drainage system was installed as part of the Aztec West backfilling project during Fiscal Year 2000. This project is part of a long-term preservation program oriented toward backfilling some parts of the ancient Puebloan ruin that were excavated many years ago for research and display. Natural precipitation within the excavated rooms in the pueblo had no means of external drainage; the resulting water was a major cause of deterioration of the ancient masonry. In conjunction with backfilling, the drainage system was designed to collect water and transport it through PVC drain pipes to locations outside the pueblo. Most of the pipes were routed through prehistoric doorways, but wall perforations were made in five instances where no architectural passage existed.

The wall perforations resulted in unavoidable impacts to small sections of the ancient masonry, but they also provided an opportunity to collect in-situ architectural mortar samples and to describe construction details that are not normally exposed. The work was done by backfilling personnel and monitored by the FY00 AZRU Archeologist. Samples were collected from each perforation as the work proceeded and placed in plastic ziplock bags (Table A1). Samples are of three types: the first sample number listed in the left-hand column refers to large bulk samples categorized for flotation processing (macrobotanical analysis); the second number refers to pollen samples (microbotanical analysis); the third is a reference sample that was collected for basic description and subsampling, if needed, for additional specialized analyses.

This report describes and interprets the results of wall perforation monitoring and sample analyses. Field recording forms, photodocumentation, and specialist reports are integrated into the summaries provided in the current report, while the full attachments are appended at the end. The report begins with a discussion of recording and analysis procedures, followed by summaries of the results. This information is used to devise and evaluate a provisional typology of aboriginal mortars. Individual wall perforations then are compared. The report concludes with a comprehensive discussion of archeological implications, as well as recommendations for further research and preservation strategies.



Figure A1. Location of wall perforations in FY00 backfill area.

### Analysis Procedures

Samples of mortar were subjected to basic description and various specialized analyses. Descriptions include color classification, identification of visible inclusions, and other essential observations. Specialized analyses include physical (texture, hardness, particle size, etc.) and biological analyses (flotation and pollen). Very little in the way of previous investigations of this sort have been conducted at Aztec Ruins, so the study was oriented toward recovering baseline data. Still, an attempt was made to collect information relevant to preliminary exploration of some research issues of relevance to the pre-backfilling architectural documentation program at Aztec's West Ruin.

Mortar samples were assigned in the field to veneers or the core of the wall. Generally, samples were collected from mortar joints in each veneer and the more prolific mortar joints in the core masonry. Field observations suggest that core masonry and veneers on either side of the wall were normally laid more or less simultaneously, though several courses in one area may have preceded coursing in the next. Consequently, separate batches of mud may have been used within the cross-section of a wall, even at the same elevation. It was expected, however, that cross-sectional variation within a wall would be less than between walls in the same room or between different rooms.

Table A1. Mortar Samples Collected from FY00 Wall Perforations at Aztec's West Ruin.

Sample Nos.	Perforation No.	Location	Context
SA-00-021, 22, 23	2000-04	East Wing, Wall 64/84 (64/84 Core)	Semicoursed masonry core in solid core/veneer wall
SA-00-024, 25, 26	2000-04	East Wing, Wall 64/84 (64W)	McElmo style veneer masonry mortar joints in solid core/veneer wall interior courses on west side of Room 64
SA-00-027, 28, 29	2000-05	East Wing, Wall 70/Exterior (70X)	McElmo style veneer masonry mortar joints in filled core/veneer wall exterior courses
SA-00-030, 31, 32	2000-05	East Wing, Wall 70/Exterior (70/X Core)	Semicoursed masonry core in filled core/veneer wall
SA-00-033, 34, 35	2000-05	East Wing, Wall 70/Exterior (70E)	McElmo style veneer masonry mortar joints in filled core/veneer wall interior courses on east side of Room 70
SA-00-036, 37, 38	2000-02	East Wing, Wall 63/72 (72W)	McElmo style veneer masonry mortar joints in semicoursed solid core/veneer wall interior courses on west side of Room 72
SA-00-039, 40, 41	2000-02	East Wing, Wall 63/72 (63E)	McElmo style veneer masonry mortar joints in semicoursed solid core/veneer wall interior courses on east side of Room 63
SA-00-042, 43, 44	2000-03	East Wing, Wall 63/64 (63/64 Core)	Semicoursed masonry core in solid core/veneer wall
SA-00-044, 46, 47	2000-03	East Wing, Wall 63/64 (63W)	Type II style veneer masonry mortar joints in solid core/veneer wall on west side of Room 63
SA-00-048, 49, 50	2000-03	East Wing, Wall 63/64 (64E)	Type II style veneer masonry mortar joints in solid core/veneer wall on east side of Room 64
SA-00-051, 52, 53	2000-01	East Wing, Wall 70/71 (70/71 Core)	Uncoursed masonry core in filled core/veneer wall
SA-00-054, 55, 56	2000-01	East Wing, Wall 70/71 (70W)	McElmo style veneer masonry mortar joints in reveneered Type III filled core/veneer wall on west side of Room 70
SA-00-057, 58, 59	2000-01	East Wing, Wall 70/71 (71E)	Stabilized McElmo style veneer mortar joints in filled core/veneer wall on east side of Room 71. Original wall face was probably Type III coursed-pattern style.
SA-00-060	2000-04	East Wing, Wall 64/84 (84E)	McElmo style veneer masonry mortar joints in solid core/veneer wall interior courses on east side of Room 84

The two botanical studies produced interesting data on mortar resource provenance and mud preparation for prehistoric masonry construction. Nine samples were selected from three wall perforations for each analysis; samples were selected from each veneer and from the core of each perforation. The pollen and flotation reports are attached as appendixes, and the results are summarized in this report. The pollen analysis was conducted by the Laboratory of Paleoecology at Northern Arizona University, Flagstaff. Flotation processing was done by the Navajo Nation Archaeology Department in Farmington; sorting and macrofossil identifications were performed by the Cultural Resources Management Program at San Juan College, Farmington. The laboratory procedures employed in the botanical studies are fully described in the specialist reports.

The same nine sample proveniences were also included in a grain-size analysis conducted by the AZRU Archeologist. This initial grain-size sorting entailed a series of graduated sieves in a hand-manipulated shaker cylinder. The amounts collected within each sieve size were recorded in milliliters and used to calculate the quantity and percentage passing each sieve. Sieve size ranged from U.S. standard sieve #4 (consistently absent) to #270. These sieve sizes retain fine gravel, sand, and most silt-sized particles. Samples were crushed by hand and screened through ¼-inch hardware cloth before further processing. Most of the mortars were extremely hard and dense, requiring further pulverization, which was done carefully between sheets of clean paper using an ordinary rolling pin.

The in-house evaluation of mortar samples also included a series of basic tests to describe their physical characteristics. A drop of hydrochloric acid on a small subsample taken from the reference samples served to determine their alkalinity. Reaction to the acid was evaluated visually and effervescence was classified as strong, moderate, or none. Most of the mortars are very hard, as described as one of the basic physical characteristics, along with their density and cohesion. Fracture characteristics were evaluated by taking a chunk of mortar and hitting it with moderate force using a small sledge hammer; the fresh break was then described in terms of how clean and regular it appeared to the unaided eye.

A 10-power hand lens was used to examine the specimen for inclusions and voids in the mortar matrix. Voids were characterized as either cracks or interstices; their abundance (porosity) was measured as a percentage of total surface area through comparison with charts for estimating proportions of mottles and fragments in the Munsell soil color book. Any distinctive inclusions other than typical sediment particles were noted and identified, if possible. Quartz sands were a distinctive inclusion that appeared as a frequent but minor particle in the ambient mortar matrix. Other minerals were rather rare. Botanical and faunal inclusions were also noted as a preliminary supplement to the specialized botanical work. Artifacts and bone were collected during both the laboratory inspection and during field monitoring.

An additional specialized soil study was performed by an outside laboratory on all 15 mortar samples. This study consisted of a texture analysis of subsamples removed from the larger reference samples. The work was done by Inter Ag Services (IAS Laboratories) in Phoenix, Arizona, using hydrometer tests to separate sand, silt, and clay fractions based on the amount of time that it took for particles to settle out of suspension after mixing with fluids. IAS also used these percentages to classify soil texture into standard USDA Soil Conservation Service textural units based on tripartite placement of the sand, silt, and clay fractions. All samples were classified as some type of loam (i.e., soil with moderate fractions of all three texture categories).

## Results

The results of individual analyses are briefly presented below. Supporting data and specialist reports are attached at the end of this report. Rather than present all of the raw data or repeat the specialists' discussions, the results are summarized. The intent with the botanical reports, especially, is to synthesize the pollen and flotation results in terms of complementary information on past environmental and resource distributions, and to discuss archeological implications of the two botanical analyses.

### *Descriptive Analysis*

All samples were examined during excavation and subsequently under controlled conditions. Subsampling for pollen extraction was done by AZRU volunteer Glynn Brashear in a clean environment at the Aztec Ruins Visitor Center using sanitary tools and proper procedures to avoid contamination with modern ambient pollen. All of the samples of varying types were catalogued into the AZRU master soil/sediment log; inventory lists of samples to be analyzed were provided to the respective specialists along with the samples. The reference samples were used for the basic descriptive analysis (Table A2).

Each mortar sample was compared to the Munsell soil color chart for classification of hue, value, and chroma. All samples are of the same hue (10YR in the Munsell nomenclature). This hue is typical of most local soils and all mortars that have been examined during the course of the pre-backfilling architectural program at West Ruin. Colors were fairly consistent, ranging in value from 5 to 6 and in chroma from 3 to 4. The descriptive range is between pale brown and yellowish-brown. Such colors typically are low in humic content and, assuming that mortars were derived from soil, would probably represent B-horizon or possibly C-horizon deposits. Clayey soils in this range are abundant around the main ruins at Aztec, though colors of these cultural deposits may be influenced by decomposition of the pueblo itself. In buried deposits south of the main ruins, where such factors are less significant, cultural deposits tend to be darker and typically fall within the range of A-horizon soils (10YR, values 3 to 4), while values identical to the mortar samples (5 to 6) are abundant at greater depth in sterile, underlying clayey soil deposits (Moore and Nathan 2000).

Darker, organic mortars are more typical of recent stabilization work at Aztec Ruins. This probably reflects the use of topsoils and especially silts dug up from local irrigation ditches at the monument as a major constituent of mortar currently used for stabilization repair work (James D. Brown, personal communication). The color of these amended mortars can frequently be distinguished from aboriginal mortars, though their colors do overlap. Samples of stabilization mortar have been identified within the 10YR5/4 (yellowish-brown) range, but the lighter colors (value 6) that are most common in the prehistoric samples have not been observed in stabilization mortars. Due to the overlap, however, color itself does not seem to be a reliable means of discriminating between the original and recent mortars.

Table A2. Descriptive Characteristics of Mortar Samples from FY00 Wall Perforations.

Perf. No.	Sample	Color Name	Munsell Color	Texture Type	Hcl Reaction	Fracture	Porosity	Other Characteristics	Unusual Mineral Inclusions	Cultural Inclusions
2000-01	SA-053	Brown	10YR5/3	Loam	Strong	Rough, angular	5%	Hard, dense, cohesive	White specks, some fine quartz sand	Obsidian flake; charcoal; uncharred splinters and juniper bark; uncharred seeds; three unburned mammal bone fragments
2000-01	SA-056	Pale Brown	10YR6/3	Sandy Loam	Strong	Rough, angular	5%	Hard, dense, cohesive	White specks, some fine quartz sand, angular lithic detritus	Charcoal; uncharred splinters and juniper bark; uncharred seeds; one small burned bone fragment
2000-01	SA-059	Brown	10YR5/3	Sandy Clay Loam	Strong	Rough, angular	3%	Hard, dense, cohesive	White specks, some fine quartz sand, angular lithic detritus	Charcoal; uncharred wood fragments and juniper bark
2000-02	SA-038	Pale Brown	10YR6/3	Sandy Loam	Strong	Rough, angular	4%	Hard, dense, fair cohesion	Very sparse quartz sand, angular lithic detritus, mica(?) flecks	Charcoal; uncharred wood fragments and juniper bark; one unburned small mammal bone
2000-02	SA-041	Pale Brown	10YR6/3	Sandy Loam	Strong	Rough, angular	3%	Hard, dense, cohesive	Very sparse quartz sand, angular lithic detritus, mica(?) flecks	Charcoal; unburned wood fragments
2000-03	SA-044	Light Yellowish Brown	10YR6/4	Clay Loam	Strong	Irregular	3%	Hard, dense, cohesive; some contraction cracks	Heterogeneous fine sand particles	Charcoal; uncharred wood fragments, splinters, and juniper bark; uncharred seeds
2000-03	SA-047	Light Yellowish Brown	10YR6/4	Loam	Strong	Irregular	3%	Hard, dense, cohesive	Very sparse quartz sand and angular lithic detritus; breaks up into shale(?) platelets	Very sparse charcoal and uncharred wood fragments and juniper bark; uncharred seeds
2000-03	SA-050	Light Brownish Gray mottled with Pale Brown and Light Yellowish Brown	10YR6/2, 10YR6/3, 10YR6/4	Clay Loam	Moderate	Rough, angular	2%	Friable, fairly dense and cohesive	Patches of quartz sand, sparse mica(?) flecks, blobs of finer sediment; small sandstone granules	Charcoal; uncharred wood fragments, splinters, and juniper bark; uncharred seeds

Perf. No.	Sample	Color Name	Munsell Color	Texture Type	Hcl Reaction	Fracture	Porosity	Other Characteristics	Unusual Mineral Inclusions	Cultural Inclusions
2000-04	SA-023	Yellowish Brown	10YR5/4	Clay Loam	Moderate	Rough, angular	2%	Friable, fairly dense and cohesive	Fine quartz sand and sparse mica(?) flecks; sandstone detritus < 6 mm	Charcoal; uncharred wood fragments and juniper bark; uncharred juniper seed
2000-04	SA-026	Yellowish Brown	10YR5/4	Clay Loam	Moderate	Irregular	1%	Fairly hard, dense, and cohesive	Fine quartz sand, sparse mica(?) flecks and angular lithic detritus	Charcoal; sparse uncharred wood fragments and plant fibers
2000-04	SA-060	Brown	10YR5/3	Sandy Loam	Strong	Irregular	3%	Hard, dense, cohesive	White specks, sparse quartz sand, and subangular lithic detritus; probably some small sandstone detritus	Charcoal; uncharred wood fragments, small twigs, juniper bark, and other organics
2000-05	SA-029	Pale Brown	10YR5.8/3	Sandy Clay Loam	Strong	Rough, curvilinear	2%	Hard, dense, cohesive	Caliche granules, small nodule of white ocher (kaolinite, 10 by 8 by 4 mm), bits of brown and gray shale(?), fine quartz sand, mica(?) flecks; sparse lithic detritus; sandstone detritus < 15 mm	One small black-on-white bowl sherd; charcoal; uncharred wood fragments, splinters, and juniper bark; uncharred seeds and feather fragments; additional organics
2000-05	SA-032	Brown	10YR5/3	Sandy Loam	None	Rough, angular	2%	Hard, dense, fair cohesion	Heterogeneous alluvial(?) sands, hardrock particles, calcite(?) crystals, mica(?) flecks	Charcoal; uncharred juniper bark; uncharred seeds; additional organics
2000-05	SA-035	Yellowish Brown	10YR5/4	Clay Loam	Strong	Rough, angular	2%	Hard, dense, fair cohesion	Sparse quartz sand, angular lithic detritus, and mica(?) flecks	Charcoal; uncharred juniper bark and plant fibers; uncharred seeds; additional organics

The texture types in Table A2 are based on the hydrometer tests discussed in the following section. In-house tests included observation of chemical reactions with exposure to hydrochloric acid. Most mortar samples reacted vigorously with a strong display of effervescence, although three samples had only a moderate reaction, and one sample did not react. The alkaline reactions are probably due primarily to calcium carbonates which occur naturally in many local soils that have been buried for a long time. With one exception, the mortars can be classified as alkaline sediments. White specks observed in most of the samples that produced a strong reaction may be caliche, a naturally occurring calcium carbonate leached from topsoils into more deeply buried deposits.

When struck with a hammer, most of the samples shattered into fragments with rough, angular fracture surfaces which seemed to represent tightly cemented particles and a well-bonded mass; one sample was characterized by rough, curvilinear fractures that probably indicated even greater cementation. Four of the 15 samples displayed irregular fractures that resulted from a mass that was not as tightly cemented.

Other attributes that were monitored include hardness and porosity. All samples were described as hard with the exception of one sample classified as fairly hard and two that were friable. Most samples were very dense and cohesive, though several were only fair in these categories. Porosities were observed in all of the samples, generally occurring as irregular voids that most likely reflect incomplete mixing and compaction of wet mortar, but the volume of these voids did not exceed 5 percent. Cracks attributed to shrinking as the original mortar dried out were observed in only a single sample that had an exceptionally high clay content. Contraction cracks are a common problem with modern stabilization mortars, suggesting that prehistoric mortars may have been superior in some respects.

A variety of mineral inclusions was seen in the mortar samples. Most of them exhibited some amount of visible sands, frequently quartz but also occasionally including heterogeneous light and dark-colored grains. Angular lithic detritus observed in nine instances refers to tiny particles of rock that have been pulverized; in one case they were accompanied by obvious particles of hard rock that may be metamorphic in origin. Such inclusions are not typical of local sedimentary rocks and the soils they produce, but both recent alluvial soils and Quaternary alluvium capping the terraces north of the ruins have abundant cobbles and potentially grains of similar origin derived from long-range transport of metamorphic and igneous rocks upriver toward the San Juan Mountains. Angular lithic detritus was distinguished from occasional irregular-shaped sandstone detritus which likely reflects debris from nonlocal rocks that were transported and shaped into building stones at Aztec Ruins.

Just over half of the samples had tiny glittery particles that may be mica or pyrite, also likely inclusions derived from the San Juans. One specimen had a few crystals of what appears to be calcite, a common occurrence in local shale outcrops. Four samples had white specks of unknown origin, and one sample had larger granules of what

appeared to be some kind of calcium carbonate, presumably caliche. The latter sample also produced a small, soft nodule of white kaolinite which is probably a cultural inclusion; it produced a fine white powder suitable for pigment. Two samples produced tiny platelets derived from laminated sediments which could either be shale or dried-out batches of mortar.

The most consistent inclusion of certain cultural origin was charcoal. Although natural burning might result in ambient charcoal within local soils, the macrobotanical analysis discussed below indicated that wood charcoal is dominant and that little in the way of other carbonized organic material that might be expected during natural fires or burning of agricultural fields are present. Small particles of wood charcoal were consistently mixed through all mortar samples. Charcoal was described as very sparse in one instance, but generally tiny fragments occurred in greater abundance. Unburned pieces of wood, commonly occurring as splinters, and shredded juniper bark also were common. Wood, bark, or both are present in all of the samples. Plant seeds and other organic materials are fairly common, generally occurring as unburned inclusions that may have been cultural in origin or simply ambient plant seeds in the source sediment materials.

Artifacts are rare. An obsidian artifact and one small sherd are the only true artifacts. The obsidian specimen is a broken core reduction flake (22 by 23 by 5 mm) with no residual cortex. It has abrupt marginal microflaking that was evidently produced through utilization as some form of expedient tool. The platform is large and the bulb pronounced; it is obviously a hard-hammer flake made through direct freehand percussion. The obsidian is semitranslucent black with a conspicuous phenocryst; it resembles material from Obsidian Ridge or possibly other sources in the Jemez Mountains. The sherd is a whiteware bowl bodysherd with dark gray paste and sand and probably crushed-sherd temper; the interior surface is slipped and shows vivid black organic paint. Although very small, it is identifiable as Chaco-McElmo Black-on-white (Peter J. McKenna, personal communication), a common type in the Chacoan area between A.D. 1100 and 1150.

A total of three butchered and unburned animal bone fragments were recovered in two samples, and one tiny burned bone fragment occurred in another sample. Part of a bird feather was noted in one sample, and additional feathers were observed in the macrobotanical analysis (see below).

### *Physical Analyses*

The first series of physical analyses were performed in-house by the AZRU Archeologist. This pilot study included all samples from three out of five FY00 wall perforations (nine samples total). A grain-size analysis was performed using a graduated series of sieves to quantify sediments within size-sorted categories. Subsamples from the original reference samples were then submitted to IAS Laboratories, a soil analysis lab, to produce data for refining the results. Samples collected from all five wall perforations were included in the second phase of the study. Each perforation had two veneer samples

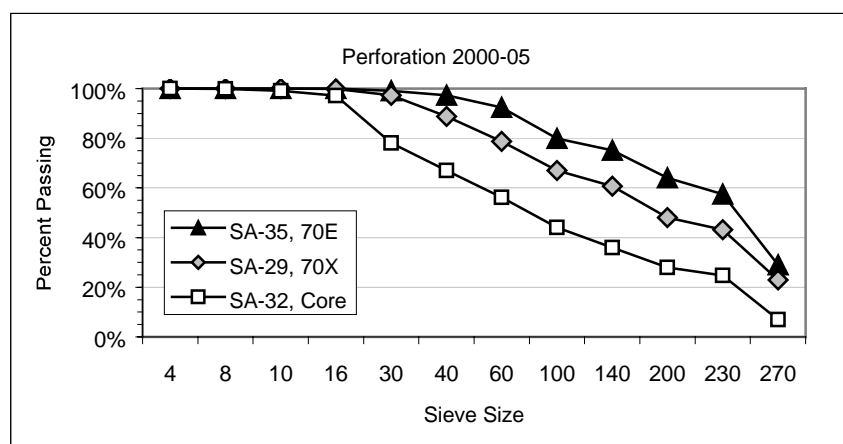
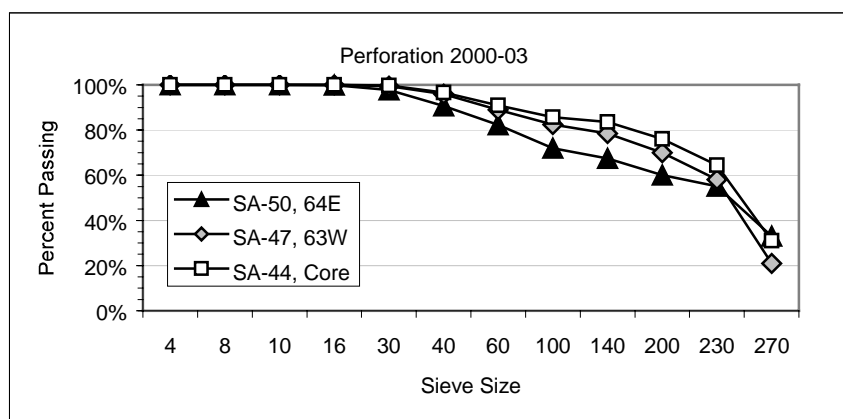
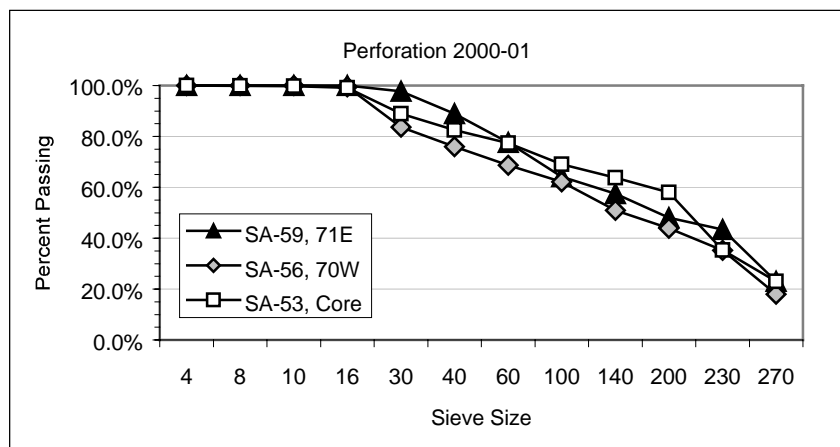
from opposite sides of the wall and one sample from the core, except Perforation 2000-02 which had two veneer samples but none from the core.

The grain-size procedure proved to be useful for quantification of varying sand-sized particles, but it was not well suited for separating the sizes of silt and clay particles (i.e., those passing through the #200 sieve). All of the grain-size curves were quite similar except for the core sample (SA-32) from Perforation 2000-05, the east wall of Room 70 which divides it from the exterior of the pueblo (Figure A2). The latter sample was the only one in which “fines” (silt and clay-sized particles) did not compose over 40 percent of the sample. This sample and two from Perforation 2000-01 were the only ones in which the overwhelming majority of the sand-sized particles were not classifiable as fine-grained sands (i.e., sand passing through the #40 sieve). These three samples had moderate quantities of both fine-grained and medium-grained sands.

These results were most informative when synthesized with hydrometer testing conducted by the consulting laboratory to separate sand, silt, and clay fractions. The hydrometer results also made it possible to classify the mortar samples by soil type. The raw lab data are attached at the end of this report; the results are presented in Table A3 along with percentages by textural classes. Although there are four different texture categories within the 15 samples, they all are some type of loam varying primarily in the proportion of sand (especially the amount of medium-grained sand). The percentage of medium-grained sand ranges from 3 to 32 percent, while sand overall ranges from 24 to 72 percent. The proportion of fine-grained sand is the least variable, ranging from 21 to 41 percent. Clay is also fairly consistent; when one obvious outlier (7 percent) is excluded, the range is only from 18 to 36 percent. Silt ranges from 21 to 49 percent.

Table A3. Percentages of Texture Categories for Mortar Samples from All Five Wall Perforations.

Perf. No.	Wall Provenience	Wall Location	Ref. Sample No.	Coarse Lithic Detritus	Fine Gravel	Coarse Sand	Med. Sand	Fine Sand	Total Sand	Silt	Clay	Texture Classification
2000-01	70W	Veneer	SA-056	trace	0%	trace	24%	32%	56%	26%	18%	Sandy Loam
2000-01	71E	Veneer	SA-059	trace	0%	trace	11%	41%	52%	25%	23%	Sandy Clay Loam
2000-01	70-71	Core	SA-053	0%	0%	trace	17%	25%	42%	35%	23%	Loam
2000-02	72W	Veneer	SA-038	trace	0%	N/A	N/A	N/A	56%	26%	18%	Sandy Loam
2000-02	63E	Veneer	SA-041	trace	0%	N/A	N/A	N/A	56%	26%	18%	Sandy Loam
2000-03	63W	Veneer	SA-047	trace	0%	trace	4%	26%	30%	49%	21%	Loam
2000-03	64E	Veneer	SA-050	0%	0%	trace	9%	31%	40%	27%	33%	Clay Loam
2000-03	63-64	Core	SA-044	0%	0%	0%	3%	21%	24%	45%	31%	Clay Loam
2000-04	64W	Veneer	SA-026	trace	0%	N/A	N/A	N/A	36%	35%	29%	Clay Loam
2000-04	84E	Veneer	SA-060	trace	0%	N/A	N/A	N/A	58%	24%	18%	Sandy Loam
2000-04	64-84	Core	SA-023	trace	0%	N/A	N/A	N/A	32%	32%	36%	Clay Loam
2000-05	70X	Veneer	SA-029	trace	trace	trace	11%	41%	52%	25%	23%	Sandy Clay Loam
2000-05	70E	Veneer	SA-035	0%	0%	trace	3%	33%	36%	35%	29%	Clay Loam
2000-05	70-X	Core	SA-032	trace	trace	1%	32%	39%	72%	21%	7%	Sandy Loam



**Figure A2. Percentage of Sediments Passing through Graduated Sieves for Three Wall Perforations.**

The typical texture of these mortars is well suited to masonry work. Clay is essential for its plasticity and ability to bond with building stones, resistance to deformation when wet, and tendency to dry into a hard, cohesive mass. However, clay expands and contracts with changes in moisture, cracking as wet mortar becomes dry. This characteristic can be counteracted with the inclusion of aplastic particles of temper. Large amounts of sand tend to decrease the cohesion of mortar, though fine-grained sands in moderate proportions can temper it without great sacrifices in cohesion and plasticity. Silts lack significant plasticity, yet they are too fine to adequately temper mortar against cracking, especially because their “dilatancy” results in changes in volume with changes in shape (USDI 1974:13). As a result, silts are poorly suited to masonry work. The behavior of silt is also very difficult to control while wet, a characteristic that is especially problematical for masons trying to build straight walls of uniform thickness.

The presence of moderate proportions and clays and fine sands in the prehistoric mortar samples, thus, appears to provide a suitable mix of plastic and aplastic particles. The significant proportions of silts may be fortuitous, reflecting the use of available soils with adequate quantities of sands and clays, rather than mixing of sands and clays derived from separate sources. The hardness and good cohesion observed on most of the samples shows that silt in moderate amounts did not adversely affect the properties of the mortar. In fact, the two samples classified as “friable” have fairly typical silt fractions; what distinguishes them is the highest clay fractions encountered in this analysis (33 and 36 percent), suggesting that shrinkage upon drying may have affected their integrity more than dilatancy or lack of good tempering particles. These two samples were both clay loams; another clay loam in this analysis suffered from cracks that are also attributable to shrinkage, and the other two clay loams also had less than ideal hardness and/or cohesion properties.

The clay loams, then, were less than ideal mortars, their relatively high clay content (29 percent and over) causing shrinkage that weakened their integrity. The other samples had less than 25 percent clay and were consistently hard and cohesive. These samples and the rest are plotted in Figure A3. This graph shows clearly that clay loams have the highest clay content revealed by the analysis and they mark the maximum extent of the range in an otherwise clustered distribution of texture composition. The opposite extreme in the observed distribution is the outlier mentioned previously, a sandy loam with only 7 percent clay and the lowest silt fraction (21 percent) in the analysis. Even this small amount of clay was sufficient to form a hard and fairly cohesive mass in a sample that is characterized by a relatively high fraction of fine-grained sand (39 percent) and the highest medium-grained sand fraction (32 percent) in the entire analysis. Some of the sands in this sample were quite rounded and appear to be alluvial in origin.

Most of the remaining samples form a tight cluster near the three-way separation point between loam, sandy loam, and sandy clay loam. Despite the number of terms used to describe them, all of these samples are characterized by a relatively high sand content (over 50 percent) and moderate quantities of clay and silt. The fineness of the sands in all of the samples insured that its abundance did not decrease integrity as long as a moderate quantity of clay was included. The hard, cohesive properties of most samples indicates

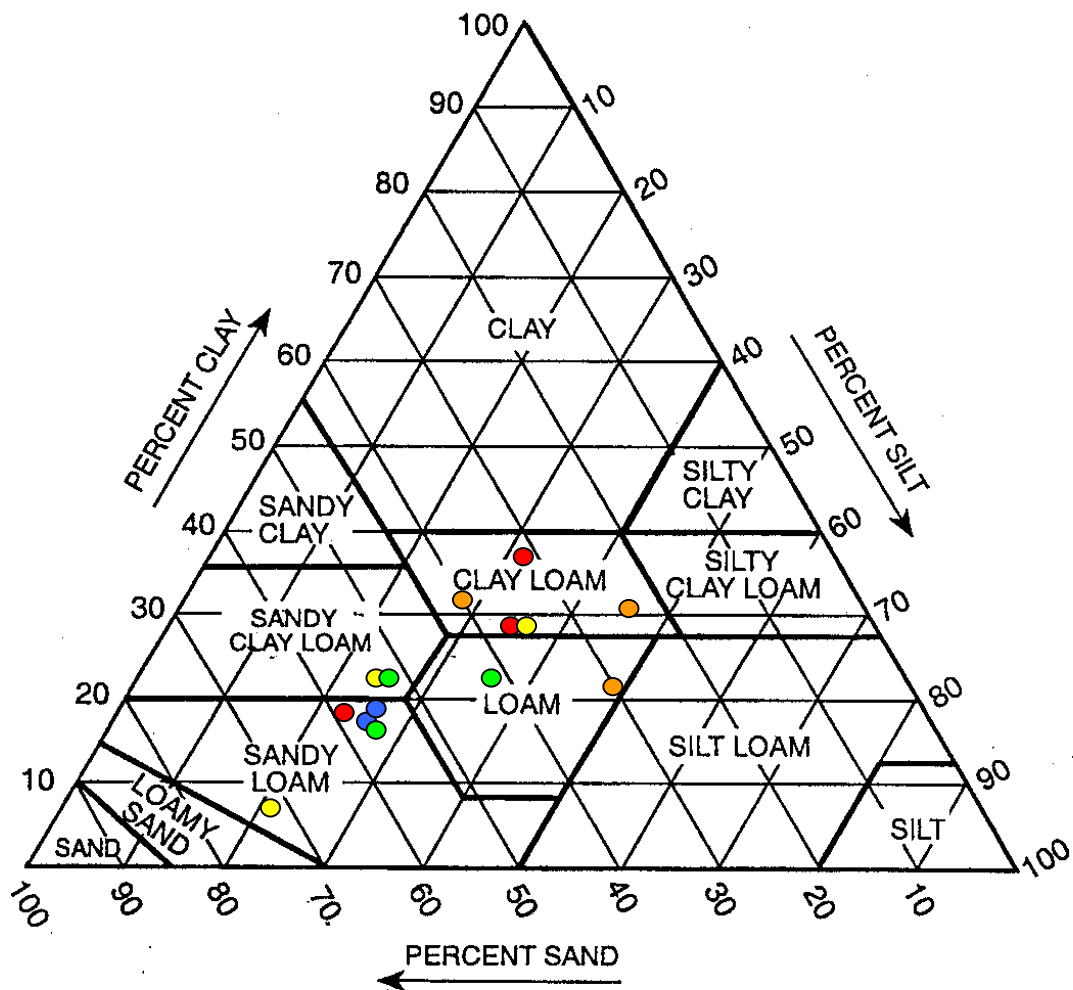


Figure A3. Three-Way Classification of Sand, Silt, and Clay Percentages within 14 Mortar Samples. Perforation 2000-01 = Green; 2000-02 = Blue; 2000-03 = Orange; 2000-04 = Red; 2000-05 = Yellow.

that clay fractions, while relatively low, were high in “fat” clays (i.e., those with high to very high dry strength and high toughness) that counteracted the silts, with just the opposite physical characteristics (USDI 1974:Figure 7). Clays of this type are highly plastic and compressible. The color values discussed in the previous section indicate further that these are inorganic sediments, which would tend to have less dry strength and toughness characteristics.

As expected, samples within walls have a slight tendency to cluster more closely together than samples from other wall perforations (see Figure A3). However, the obvious sandy loam outlier differs from both its associated veneer mortars and the rest of the samples, even though it appeared in the field to simply represent a separate (slightly darker) batch of mortar used during simultaneous construction of this wall. Interestingly,

this exceptionally diverse suite of samples represents the only exterior wall of the pueblo represented in this analysis. The samples from Perforation 2000-01, in contrast, are quite homogeneous in texture even though one of the veneers appeared to have been rebuilt well after the initial construction of this wall.

### *Botanical Results*

Nine mortar samples were processed for specialized archeobotanical analyses. They represent all three samples (the core and both veneers) from three of the five wall perforations. Samples were selected to help assess variation within the wall cross sections that would contribute to characterization of the mortars discussed above. Based on the field results and preliminary inspection of the mortar samples, each sample was rated in terms of mortar sample integrity, observed potential to yield botanical remains, and interpretive potential. Bulk samples were also measured in liters to determine how close they would come to the two liters desirable for flotation processing. Some samples were quite small due to limitations in the amount of aboriginal mortar that had to be removed for a wall perforation, post-construction disturbance from burrowing animals, erosion, and the desire to avoid removing original masonry fabric beyond that needed for installation of the PVC drainage system. Sample size was also considered in ranking the samples and assigning overall priorities to each one. This individual priorities were then averaged for each wall perforation since complete groups of three samples from each perforation (core and veneers) were wanted to maximize internal comparisons and analytical potential.

Wall Perforations 2000-01, 2000-03, and 2000-05 received the highest scores and were included in the botanical analyses. They also were the same three suites of samples subjected to grain-size analysis (see above). The bulk sediment samples from these perforations and the smaller pollen samples were submitted to NNAD and NAU, respectively, for processing. NNAD prepared light and heavy fractions through flotation processing of the bulk samples and delivered the fractions to Meredith Matthews at San Juan College for microscopic scanning and macrobotanical identifications. The pollen samples were processed at NAU and slides prepared for microscopic scanning and counting of pollen grains by Susan Smith. Both studies were very informative.

The macrobotanical analysis made it possible to greatly refine the description of organic inclusions in the original mortars. The specialist report is attached at the end of this report, and Table A4 presents a summary of the results, along with ubiquity values (i.e., percentage of samples with each type of macrofossil). Juniper bark is the only completely ubiquitous type of plant macrofossil, indicated by its 100 percent value. Most of the samples also contain juniper wood or wood charcoal. Although not present in the identifiable size range, some kind of wood charcoal was observed during preliminary inspection of all samples (see Table A2). The core and west veneer of Wall 70/Exterior were the only mortar proveniences that had no unburned wood during either flotation analysis or preliminary inspection of mortar samples. Additional types of unburned wood that were identified in the flotation samples include two unidentified gymnosperm occurrences that could be juniper or any kind of conifer, among other possibilities, and

Table A4. Plant Macrofossils Identified during Flotation Analysis of Nine Mortar Samples.

	Perforation 2000-01			Perforation 2000-03			Perforation 2000-05			Ubiquity
	SA-57 71E	SA-54 70W	SA-51 Core	SA-48 64E	SA-45 63W	SA-42 Core	SA-33 70E	SA-27 70X	SA-30 Core	
<b>Uncharred Seeds</b>										
Pigweed								2		11%
Goosefoot	1	11	9	1	1		2	16	5	89%
Purslane		13	9		2		2	17		56%
Beeweed								2		11%
Mustard							1			11%
Ground Cherry		1						6	1	33%
Knotweed								2		11%
Indian Ricegrass		1	1							22%
Prickly Pear Cactus	1	1	1					3		33%
Hedgehog Cactus				3	2	2				33%
Sunflower								4		11%
Sunflower Family		2					1			22%
Pea Family								3		11%
<b>Uncharred Wood</b>										
Juniper						X				11%
Unk. Gymnosperm			X					X		22%
Unk. Dicot	X									11%
<b>Wood Charcoal</b>										
Juniper		X	X	X		X		X		56%
Ponderosa		X								11%
Poplar/Willow			X							11%
Rose Family		X								11%
Unk. Dicot			X					X		22%
<b>Other Plant Parts</b>										
Juniper Bark	X	X	X	X	X	X	X	X	X	100%
Pinyon Needle							2			11%
Grass Stem									X	11%
Saltbush Fruit		1								11%
Mustard Family Capsule							1			11%
Maize Cupule								1		11%

one unidentified dicot occurrence which could represent any one of various shrubs, deciduous trees, or other plants in the area. Two unknown dicot occurrences also are listed in the wood charcoal, along with single samples containing ponderosa pine, poplar or willow, and wild rose family. Two pinyon pine needle fragments also were identified in one of the samples.

The second major category of macrobotanical inclusions was uncharred plant seeds derived from wild plant taxa. Goosefoot was most ubiquitous, occurring in all but one of the samples, followed by purslane in five out of nine samples. Prickly pear and hedgehog cactus seeds were present in a third of the samples, as was sunflower/sunflower family. Additional taxa were present in one or two samples each, including Indian ricegrass, pigweed, wild mustard, beeweed, knotweed and legume (pea family). All of these taxa are relatively common local flora, most of them being weedy types that invade disturbed areas around intensely occupied sites or within agricultural fields. The macrobotanical specialist believes that these seeds are natural inclusions within the soils that were used for mortar, a likely interpretation since no charred seeds were identified that can be more confidently classified as cultural or economic constituents. Additional inclusions of this sort include a saltbush fruit and mustard-family capsule. The only economic is a single maize cupule, another probably incidental inclusion given the likely abundance of such debris in cultural deposits.

Maize and other cultivated plant remains were extremely abundant in excavated rooms at Aztec (Morris 1928), thus providing a ready source of cultigen debris if post-construction contamination was a significant factor. Morris further describes intensive disturbance from packrats and other burrowing animals in room fill. However, evidence of rodent disturbance was noted in only one of the wall perforations. Bug parts were identified in all of the mortar samples, suggesting possible bioturbation, but they also could have been introduced from soils mixed into mortar. Insects are probably not a significant factor in the mechanisms that introduced plant seeds into the mortars. Given their abundance in the rooms themselves, it is reasonable to conclude that cultigens would be more common if insects and rodents were responsible for contamination. In addition to the natural presence of seeds in local soils, the mortar samples were also mixed with large quantities of water, which would be another source of plant and animal debris derived from potentially long-distance transportation through natural agencies.

The pollen analysis provided complementary data on the local floral environment (Table A5). Juniper, pinyon, and other pine are 100-percent ubiquitous arboreal taxa as might be expected in a juniper-pinyon woodland like that in the Aztec vicinity. Their ubiquity does not imply that trees were abundant on-site because they are wind-pollinated plants that are notorious for long-distance pollen dispersal. Non-pinyon pine pollen would be expected with the presence of coniferous forests in mountains to the north. The three 100-percent ubiquitous non-arboreal taxa (Cheno-Am, sagebrush, and sunflower family) are also broadly disseminated wind-pollinated taxa, as anyone allergic to pollen knows. The Cheno-Am category is an analytical hybrid consisting of goosefoot, saltbush, pigweed, and other common taxa whose pollen grains cannot be distinguished. The sunflower family pollen probably consists largely of rabbitbrush and snakeweed,

Table A5. Plant Taxa Identified during Pollen Analysis of Nine Mortar Samples.

	Perforation 2000-01			Perforation 2000-03			Perforation 2000-05			Ubiquity
	SA-58 71E	SA-55 70W	SA-52 Core	SA-49 64E	SA-46 63W	SA-43 Core	SA-34 70E	SA-28 70X	SA-31 Core	
<b>Non-Arboreal Taxa</b>										
Cheno-Am	X	X	X	X	X	X	X	X	X	100%
Greasewood	X	X		X	X	X	X	X	X	89%
Sagebrush	X	X	X	X	X	X	X	X	X	100%
Mormon Tea	X		X		X	X	X	X		67%
Cholla		X								11%
Cattail		X								11%
Beeweed	X	X	X				X	X		56%
Spurge	X	X	X		X	X	X	X		78%
Buckwheat								X		11%
Figwort								X		11%
Globemallow	X	X				X	X			44%
Evening Primrose		X								11%
Buffaloberry	X		X	X		X	X	X	X	78%
High-Spine Composite	X		X				X	X		44%
Low-Spine Composite		X	X			X		X		44%
Sunflower Family	X	X	X	X	X	X	X	X	X	100%
Rose Family	X		X		X	X	X	X		67%
Grass Family	X	X	X		X	X	X	X	X	89%
Maize	X	X	X			X	X	X		67%
Squash		X								11%
<b>Arboreal Taxa</b>										
Juniper	X	X	X	X	X	X	X	X	X	100%
Pinyon Pine	X	X	X	X	X	X	X	X	X	100%
Other Pine	X	X	X	X	X	X	X	X	X	100%
Oak					X			X	X	33%
Willow					X				X	22%
Elm								X		11%

while sunflower itself is more likely included in the high-spine composites category; low-spine composites include ragweed, another taxon notorious for widespread pollination. Long-range wind pollination is also a likely factor in high ubiquity values for greasewood and grass.

Additional arboreal pollen represented include oak, willow, and elm. Elm is the only recent non-native pollen occurrence, represented by one pollen grain in one veneer sample in spite of the abundance of elm trees both within the monument and surrounding Aztec Ruins. This scarcity of obvious contaminants corroborates the inferences drawn from the macrobotanical analysis that recent contamination of the mortar samples is not a serious factor. The lack of exotic pollen is striking in contrast to the abundance of introduced plants, especially during the last century within fields and orchards immediately surrounding Aztec Ruins, and additional exotics in neighboring residential areas. The absence of these taxa supports the assumption that sampled mortar contexts are relatively pure.

Other cultivars are represented by taxa that were common crops among the prehistoric inhabitants: maize pollen (including one aggregate) is present in six out of nine samples; and squash pollen was identified in one sample. Although pollen counts for the cultivars are low, they are significant because maize, squash, and additional aboriginal crops are all insect-pollinated taxa that do not broadcast pollen extensively. Maize pollen, especially, is normally assumed to be present only within or adjacent to agricultural fields or in locations where harvested maize was kept before removal of husks. Of course, maize pollen also is used culturally by Puebloan peoples in ceremonial and religious contexts, and it is certainly possible that important activities such as construction of Chacoan great houses were blessed with maize pollen.

One perplexing occurrence in the pollen record is buffaloberry. The ubiquity value of 78 percent and the identification of a pollen aggregate indicates that it is not a fortuitous occurrence, yet buffaloberry has not been identified at the monument or even during casual inspection of the area around Aztec. This pollen type also includes Russian olive, an exotic that is common in the modern riparian zone along the Animas River; however, the scarcity of other exotics in the pollen record and the lack of Russian olive in proximity to the ruins suggest that pollen of this type is attributable to natural, prehistoric factors. Although buffaloberry pollen could be related to cultural behavior or even ceremonial use of ashes, as noted by the palynologist, buffaloberry was not identified in the macrobotanical samples. The only prospects for buffaloberry wood in the samples analyzed are the unidentified dicot wood that was present as charcoal in one sample and as uncharred wood in another. Thus, buffaloberry is interpreted here as a natural component of the prehistoric pollen rain that potentially represents a shift in the natural distribution of this shrub toward the west and northwest, where it is common in the natural vegetation communities of both upland and lowland areas.

Most of the other pollen occurrences mimic the plant macrofossil record in the dominance of taxa that might be expected in the local non-riverine environment. Some additional taxa are represented in the pollen record and some taxa that are rare in flotation

samples are fairly ubiquitous in the pollen samples. This suggests they are natural occurrences in the ambient pollen rain, since more seeds would be expected if the plants in question were actually growing in the soils used as mortar. This supposition is supported by data on soil colors which demonstrate that ancient buried soils were used and that more recent, organic A-horizon soils were not. Alluvial soils along the Animas River and irrigation ditches that transported river water into agricultural fields or domestic water impoundments would also most likely be darker, organic soils unlike those present in the prehistoric mortars documented at Aztec Ruins.

Another indication that alluvial sediments from riparian sources are not a good candidate for prehistoric mortar sediments is the extreme scarcity of riparian plant taxa. The macrobotanical analysis did not identify any riparian taxa, while the pollen analysis documented scarce willow grains in two standardized pollen counts; sparse cattail pollen was noted during low-power scanning of one sample, but it was not encountered in any of the standard counts, each one comprising over 200 grains. Given the potential for introduction of riparian taxa in the form of water mixed with the mortar samples, the paucity of riparian pollen is surprisingly low. The absence of cottonwood pollen is particularly striking in demonstrating that mortar sources were not situated in the prehistoric riparian corridor along the Animas River. Although cottonwood has very fragile pollen grains, at least some cottonwood pollen might be expected if mud or any alluvial soils along the river were gathered for use as mortar. For comparison, poplar pollen (cottonwood or aspen) was found frequently in buried soils, even away from the river corridor south of Aztec Ruins (Cummings and Moutoux 1997). Thus, lack of preservation does not entirely explain the absence of poplar pollen in mortar.

### **Mortar Typology**

A preliminary and quite subjective analysis of mortar attributes was undertaken to attempt to construct a typology for summary descriptions and more in-depth analysis of mortar resource acquisition and construction characteristics. Toward this end, groupings that were demonstrated within the various analyses discussed above were explored as possible “types” of aboriginal mortar. Superficially, the mortars used in construction appear to be very homogeneous. They tend to be light-colored, fine-grained sediments cemented into a hard, dense, and cohesive mass. However, detailed analyses of the “fine” particles and the inclusions identified in mortar samples suggest that readily visible characteristics may mask significant variation between samples.

To visually distinguish between mortars, variation in color would be most useful and easy to accomplish objectively. Variation in chroma is thought to be more significant than value in distinguishing different soil sources. The mortars examined in this study and those commonly encountered at Aztec Ruins range from chroma 3 (brown) to chroma 4 (yellowish-brown), the two being very close in overall color characteristics. In lightness, these colors range from value 5 (brown to yellowish-brown) to value 6 (pale brown to light yellowish-brown). The two chroma were tentatively considered to represent different mortar types and the two lightness values to be possible subtypes. One sample was heterogeneous and will be considered separately. The other 13 samples

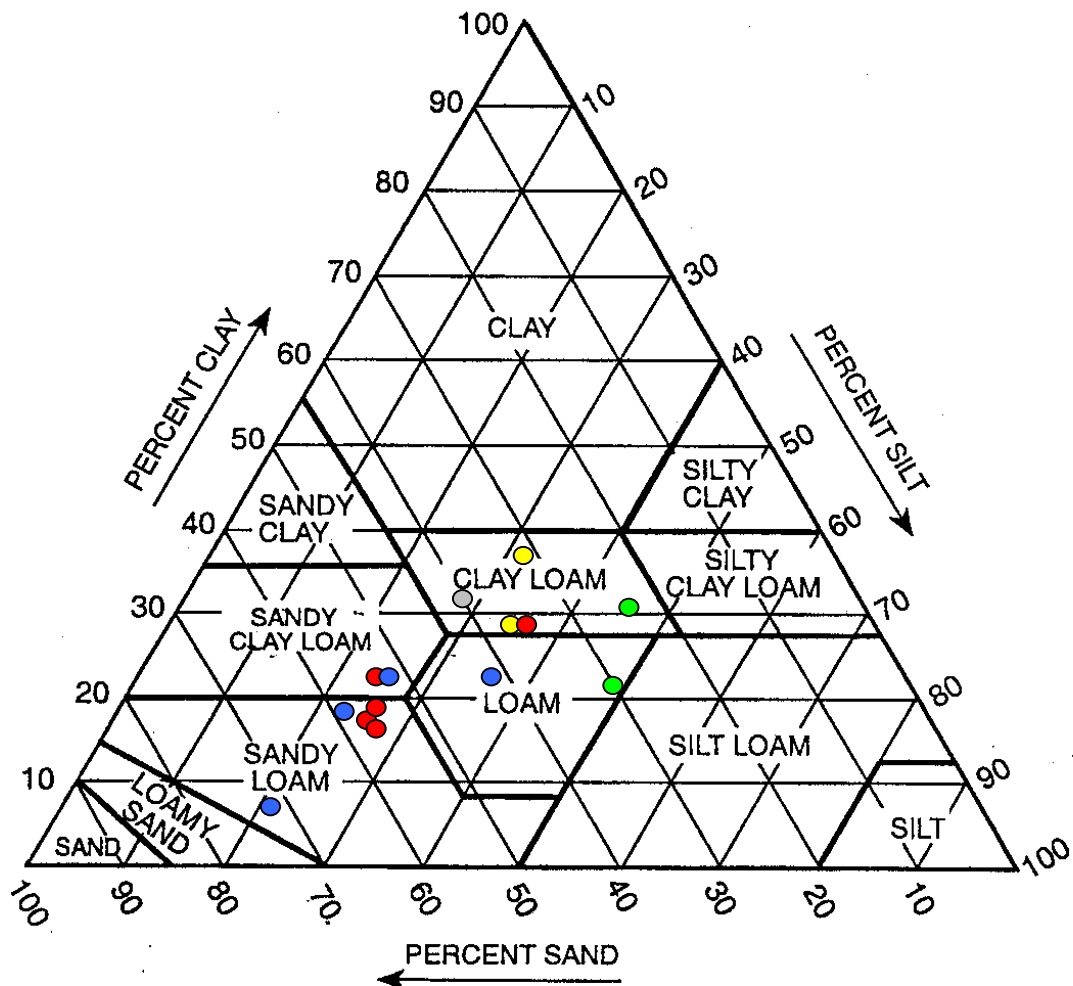


Figure A4. Mortar Types Plotted on Three-Way Classification of Sand, Silt, and Clay Percentages. Type 1A = Blue; Type 1B = Red; Type 2A = Yellow; Type 2B = Green; one heterogeneous sample with mixed mortars is plotted in gray.

occur in the following frequencies: Type 1A, 10YR 5/3 (four samples); Type 1B, 10YR 6/3 (four samples); Type 2A, yellowish-brown (three samples); and Type 2B, light yellowish-brown (two samples).

The provisional mortar types showed some correspondence with other characteristics. At first glance, this did not seem to be true because of the intersecting descriptive categories, but when the two main color types are compared to the three-way texture classification discussed earlier, they tend to show some internal clustering (Figure A4). Samples coded in red or blue are Type 1 mortars, which account for the sandier samples. This plot indicates that silt and clay percentages within both types overlap

slightly, but that sand content may be a more definite discriminating factor. All Type 1 samples have sand fractions exceeding 40 percent, while sand in Type 2 samples comprises 35 percent or less. As might be expected, the one heterogeneous sample with admixtures of at least two mortar batches lands in the transitional area between the two types. Subtypes (at least those within Type 1) do not appear to separate in their distribution by texture. Obviously, more samples need to be analyzed before the value of distinguishing Type 1 brown and Type 2 yellowish-brown mortars can be evaluated, but the preliminary results presented here show this distinction is work exploring further.

In addition to the sandier composition of Type 1 samples, Type 2 tends to be somewhat siltier, although this pattern is not as distinct. Inspection of the grain-size curves shows this pattern within the samples that were given full grain-size analysis (see Figure A2). The siltier samples are characterized by more convex curves in which large proportions of “fines” (particles passing #200 sieve) are retained by the #230 and #270 sieves. The Type 2 samples are the highest curves in the middle graph (SA-44 and 47, both Type 2B) and the highest one in the lower graph (SA-35, Type 2A). All nine of the grain-size curves are plotted in Figure A5, which clearly shows some separation between the lower Type 1 samples and upper Type 2 samples based on the siltier composition of the latter and the sandier composition of the former. In short, the brown mortars tend to have more fine-grained and medium-grained sands, while the yellowish-brown mortars tend to have more silts and clays.

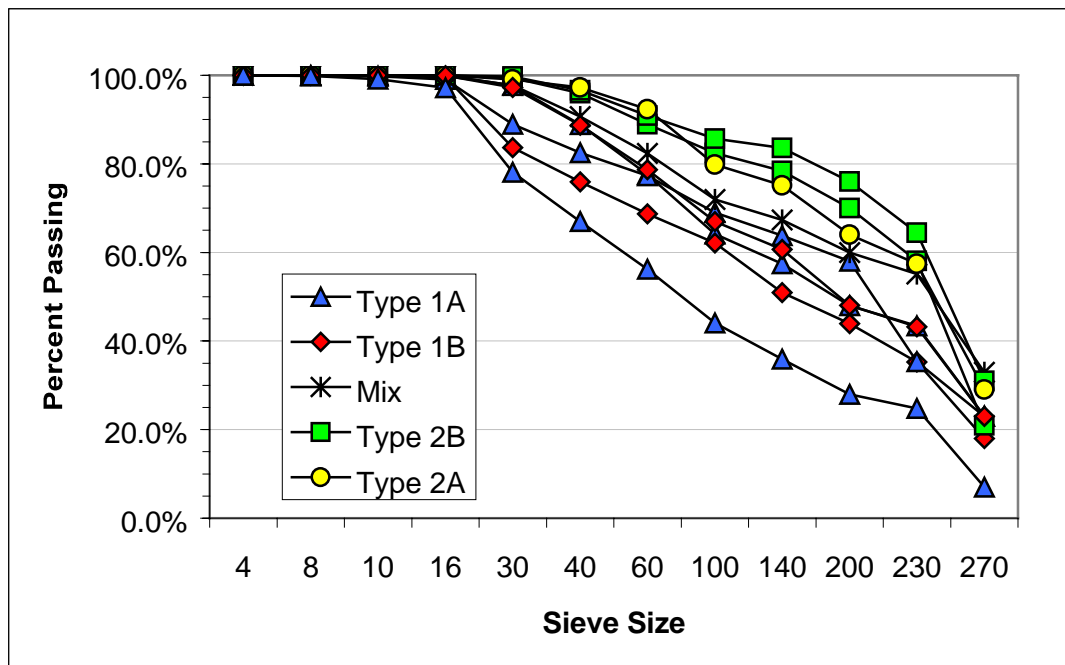


Figure A5. Percentages of Sediments Passing Graduated Sieves for All Nine Samples Distinguished by Mortar Type.

Although the small number of samples and limited nature of the data do not lend themselves to rigorous statistical testing, some significant differences were found between the two types in all three texture classes based on a t-test. The silt percentages overlap, although means are quite different (Type 1 = 26.0 percent; Type 2 = 39.2 percent; p-value = 0.006). The sand values clearly are significantly different and do not overlap (Type 1 = 55.5 percent; Type 2 = 31.6 percent; p-value = 0.00002). Clay fractions also overlap slightly, but have quite different means (Type 1 = 18.5 percent; Type 2 = 29.2 percent, p-value = 0.004). The highest p-value results from comparison of silt fractions, yet even it suggests the probability that these two mortar types are not different in silt composition is less than 1 in 167. In short, the provisional typology serves to reduce considerable variability in texture composition and distinguishes between types of slightly different colors.

### **Intrasite Masonry Comparisons**

The final assessment of mortar variability is accomplished by comparing the mortar analysis results with other information on masonry and wall characteristics recorded during archeological monitoring of wall perforations and pre-backfilling architectural documentation (Table A6). This context provides an effective means of data synthesis and interpretation. The results are summarized for each of the wall perforations. More detailed descriptions of the perforations are provided on the field documentation forms attached at the end of this report.

#### *Perforation 2000-01*

The wall perforation between Rooms 70 and 71 penetrated an interior load-bearing wall separating the two rooms. Both faces of this wall show remnants of Chacoan-style coursed-pattern masonry, a local variation of the Type III facing style in which bands of blocky and tabular sandstone alternate across the veneer (Judd 1954: Plate 5; Lekson 1984:17-19). Within Room 70, most of the first-story veneer on the west wall had collapsed and been rebuilt prehistorically with more typical McElmo-style masonry (see Lekson 1984:17-19; Vivian and Matthews 1974:35-42). Within Room 71, the wall also appears at first glance to be McElmo, but it has been heavily repointed during successive episodes of stabilization and bears remnants of coursed-pattern masonry in areas where stabilization does not appear so significant and where the original mortar is still apparent even in the extant face of the wall. Tree-ring dates associated with vents, doors, and roofs in the two rooms cluster strongly at A.D. 1111-1112, suggesting that both rooms were built in the initial phase of construction at West Ruin, thought to have begun in 1113 (Windes and McKenna 2001:134). Excavation revealed little evidence of actual habitation within these rooms, mentioning no "Mesa Verde" artifacts, so it might be assumed reveneering within Room 70 also took place during the original Chacoan period of occupation.

The perforation revealed an uncoursed masonry-filled core/veneer wall cross-section with sparse animal bone and an obsidian flake tool in the core mortar. A small, burned bone fragment was also recovered from the flotation sample associated with the

Table A6. Architectural Characteristics of Wall Sections Exposed in Wall Perforations.

	<b>Location</b>	<b>Thickness (cm)</b>	<b>Masonry Style</b>	<b>Mortar Type</b>	<b>Mortar Texture</b>	<b>Construction Inference</b>
<b>Perf. 2000-01</b>	Wall 70/71	95	Filled core/veneer	Variable	Variable	Chacoan, A.D. 1112+
	71E	17	Coursed-pattern?	1A	Sandy clay loam	Initial Chacoan construction
	70W	20	Prehistoric repair	1B	Sandy loam	Later Chacoan repair work
	70/71 Core	58	Uncoursed masonry fill	1A	Loam	Initial Chacoan construction
<b>Perf. 2000-02</b>	Wall 63/72	97	Solid core/veneer	1B	Sandy loam	Chacoan, A.D. 1112+
	63E	22	McElmo	1B	Sandy loam	Initial Chacoan construction
	72W	22	McElmo	1B	Sandy loam	Initial Chacoan construction
	63/72 Core	53	Uncoursed masonry	1B	Sandy loam	Initial Chacoan construction
<b>Perf. 2000-03</b>	Wall 63/64	85	Solid core/veneer	Mix	Variable	Chacoan, A.D. 1112+
	64E	22	Chaco Type II	Mix	Clay loam	Initial Chacoan construction
	63W	22	Chaco Type II	2B	Loam	Initial Chacoan construction
	63/64 Core	41	Uncoursed masonry	2B	Clay loam	Initial Chacoan construction
<b>Perf. 2000-04</b>	Wall 64/84	85	Solid core/veneer	Variable	Variable	Chacoan, A.D. 1112+
	84E	26	McElmo	1A	Sandy loam	Initial Chacoan construction
	64W	19	McElmo	2A	Clay loam	Initial Chacoan construction
	64/84 Core	40	Uncoursed masonry	2A	Clay loam	Initial Chacoan construction
<b>Perf. 2000-05</b>	Wall 70/Ext.	99	Filled core/veneer	Variable	Variable	Chacoan, A.D. 1112+
	70E	20	McElmo	2A	Clay loam	Initial Chacoan construction
	70X	20	McElmo	1B	Sandy clay loam	Initial Chacoan construction
	70/X Core	59	Uncoursed masonry	1A	Sandy loam	Initial Chacoan construction

Room 70 veneer. As might be expected on repaired walls, there is some variation in the texture and color of the mortars, although both veneers and the core mortars were classified as Type 1. The original masonry work utilized Type 1A mortar ranging from loam to sandy clay loam. In addition to this minor variation in texture, field observations suggest that the core masonry and the veneer in Room 71 employed slightly different mortars that are believed to represent separate batches. The other veneer was laid at a later time and obviously entailed a different batch of mortar, consisting of a Type 1B sandy loam. All of the mortars contained sparse but consistent small pieces of charcoal,

and unburned wood and juniper bark that were well mixed throughout the mortar. Sandstone detritus up to 7 mm long was noted in the veneer mortars.

The plant records for this perforation also show enough variation to support the conclusion that different batches of mortar were used in all three proveniences. However, this is the only instance in which maize pollen was identified in all three samples; the repair mortar in Room 70 was the only occurrence of squash pollen. The Room 70 veneer indicated additional variation by providing the only occurrences of cattail and cholla pollen, two taxa characterized by very different habitats. The rare riparian pollen identified in the various mortar samples is thought to be more likely related to water that was added as mortars were mixed, rather than derivation of mortar sediments from riparian soils. This would explain the cooccurrence of riparian and xeric pollen in the same sample, and is further supported by a prickly pear cactus seed in the sample, an inclusion that might be more likely to have been introduced along with soil than with water. Most of the pollen and plant seeds found in all three samples would be expected in non-riverine soils. In addition to unburned wood and charcoal found in all three samples, the west wall repair in Room 70 also produced the only instance of ponderosa pine charcoal found in the botanical analysis.

#### *Perforation 2000-02*

The wall between Rooms 63 and 72 was built as part of the original post-A.D. 1112 Chacoan construction episode. Although both the east and west walls had evidently deteriorated considerably during the original occupation, no prehistoric renovation seems to have taken place. Morris (1928:322) described hard-packed, "clean earth" filling the lower story of Room 63, which he believed had been purposefully backfilled to shore up the sagging masonry walls. The walls were stabilized by the excavation crew and later by NPS since Rooms 63 and 72 were excavated during the 1910s. Both of the veneers on the wall shared by the two rooms exhibits fair integrity and appears to have been built in McElmo masonry style. The cross-section is a semicoursed masonry solid core/veneer type in which the core and veneer courses appear to have been laid simultaneously using identical mortar. There were no suggestions that separate mortar batches were represented in the area inspected during removal of the wall perforation. Mortar specimens are hard, dense, and fairly cohesive, reacting vigorously to hydrochloric acid.

Both veneer and core courses were embedded in Type 1B mortar that was classified as sandy loam. Sparse charcoal flecks, unburned wood fragments, and shredded juniper bark were observed throughout the veneer and core mortar joints. Sandstone detritus up to 9 mm in length occurred in the mortar samples. One probable rabbit bone fragment was collected, but no additional noteworthy items or artifacts were found. Results of the hydrometer tests yielded virtually identical sand, silt, and clay fractions, but no detailed grain-size or archeobotanical analyses were performed on samples from this perforation.

*Perforation 2000-03*

The wall between Rooms 63 and 64 was another example of original Chacoan construction that was probably built in the initial building phase beginning in A.D. 1113. The faces on either side of the wall have been heavily repointed with cement, but there are also many areas that display original mud mortar. Morris described badly deteriorated walls upon excavation and considerable repair work on his part, but this seems to refer to upper sections of this remarkably tall, multistory wall. The lower stories in Rooms 63 and 64 were both purposefully filled with relatively sterile earth “packed to unbelievable hardness,” which Morris thought was intended to shore up the unstable walls (Morris 1928:327). This was done by the site’s original inhabitants, as demonstrated by the fact that in Room 64 the “clean earth” was capped by 6 ft of trash which was attributed to the later Mesa Verde occupants, although it is uncertain exactly when the lower story was backfilled. This places wall construction securely in the initial Chacoan building phase. Stylistically, both veneers have a distinctive chinking pattern in which numerous sandstone spalls fill in thick vertical mortar joints and thinner horizontal joints. This style resembles Type II masonry defined at Chaco Canyon (Lekson 1984:18, Figure 2.4), although examples at Aztec are not nearly as heavily chinked. The work at Aztec is also later in time than Type II at Chaco, where Lekson dates the style between A.D. 1020 and 1060.

The wall perforation demonstrated conclusively that the lower wall is an intact original feature that was built through simultaneous coursing of the veneers and core masonry. Still, subtle differences in the mortar indicate that two batches of mortar were used in the area that was exposed by the perforation. The work appears to have proceeded from within Room 64, laying a few courses of the full wall cross-section simultaneously in the section to the immediate north of the perforation before starting the core masonry within the perforated area. A separate, slightly lighter batch of mortar was used to continue building up the core and both veneers. The lighter mortar is Type 2B ranging from clay loam to loam but fairly consistent in texture composition except in the east wall of Room 64 where pieces of mortar are visually heterogeneous, containing identical Type 2B clods and what may be clods of Type 1B mortar. Both kinds of clods are contained in a light brownish-gray (10YR6/2) matrix that does not resemble more typical mortars encountered at West Ruin. This area may represent a portion of mortar that was not well mixed; it is interesting that it contains clods of both Types 1 and 2 that probably are dried up mortars from previous batches that were not completely moistened and mixed into the batch.

Despite these minor variations within the mortar, most appears to be derived from a single batch. The two Type 2B samples cluster together at the extreme range of Type 2 mortars included in this analysis, while the heterogeneous sample falls in the intermediate area between Types 1 and 2 (see Figure A4). All of the samples contain sparse fragments of charcoal, unburned wood, and juniper bark, but no artifacts or bone were recovered. Small, sparse sandstone granules were observed in the west wall of Room 63, but no other sandstone detritus was observed in any of the mortars within Perforation 2000-03. The flotation analysis identified fibers in all three samples, but these are probably due to

modern lab contamination; a hair found in one sample might be prehistoric. All three samples had a few uncharred wild plant seeds, including hedgehog cactus and some weedy types. Pollen analysis identified arboreal , shrub, and Chenopodiaceae pollen throughout, along with lighter incidences of other weed pollen in some samples. Maize pollen was found in the core masonry sample.

#### *Perforation 2000-04*

The wall between Rooms 64 and 84 suffered deterioration of the veneer, but like the other examples there were no indications of damage or repair that were apparent when the wall perforation was opened. Unlike Room 64 which had been backfilled prehistorically, Room 84 was partially trash-filled and stained with “smoke and filth” (Morris 1928:342). It had a hearth in the ground floor as additional evidence of habitation. Numerous A.D. 1111-1112 tree-ring dates on vents and doorways place Room 64 along with the initial Chacoan building episode. Both sides of the wall are characterized by McElmo masonry style with sparse sandstone chinking. The masonry has been heavily overpointed with cement and much of the eastern veneer in Room 84 was evidently reconstructed by Morris and crew.

Perforation 2000-04 exposed an uncoursed masonry solid core/veneer cross-section in which a few courses in the veneer of Room 64 were laid, then core masonry, and finally some courses on the Room 84 veneer. Construction in this particular section of the wall appears to have been episodic, the entire cross-section most likely going up as one brief event. The Room 64 mortar and core are both classified as Type 2A clay loam, while the sandy loam mortar in Room 84 is Type 1A. No artifacts or bone were encountered, though sparse charcoal and unburned wood were present throughout the mortars. Some small, sparse sandstone detritus also was noted. No botanical analyses were conducted, but juniper bark was identified during inspection of the samples from both veneers and plant fibers were noted in the core sample. The mortar in the Room 84 veneer also had some small twigs and other organic materials. The mortar in Room 64 was hard, dense, and cohesive, while that in Room 84 was not quite as hard and that in the core was somewhat friable; both veneer mortars crumbled with an irregular fracture pattern that differed from the typical angular fracture on most of the mortars. These characteristics suggest that, if masonry work proceeded more or less simultaneously, this particular section of wall was evidently built slightly more expediently than some of the other examples. The core and Room 64 veneer are also distinguished by a less severe reaction to hydrochloric acid than displayed by most samples.

#### *Perforation 2000-05*

Room 70 is well dated to the initial Chacoan construction episode that began after A.D. 1112. Although the west wall veneer was rebuilt prehistorically and large areas in the east have been reconstructed, there are no signs of significant modification in the part of the east wall affected by the wall perforation. Both sides of the wall have been heavily grouted with stabilization mortars, but Perforation 2000-05 exposed intact masonry and prehistoric mud mortar after the grouted joints composed of cement had been removed.

Semicoursed masonry on both sides of the wall is characterized as chinked McElmo style, while the cross-section is uncoursed masonry with unshaped sandstone laid with abundant mud. The wall was built episodically, although separate batches of mortar may have been used.

Mortar in the core is Type 1A, while the exterior veneer is Type 1B and the interior veneer is Type 2A. They range from sandy loam to sandy clay loam to sandy loam, respectively. The core mortar is the sandiest of any mortar samples analyzed (72 percent total sand content), and also has the least clay (7 percent); it also has the highest content of medium-grained sand (32 percent) and the only measurable amount of coarse sand (1 percent). Visual inspection of the core mortar showed heterogeneous sands that may be alluvial in origin, as well as a diversity of particles that appear to include mica, calcite, and metamorphic rocks. It was the only mortar in the entire analysis that did not react to hydrochloric acid. The exterior veneer mortar was also unusually sandy; it and the core mortar were both hard and dense, but they were less cohesive than the interior veneer or most mortar samples examined in this analysis. The exterior veneer mortar had small platelets of brown and gray clay that may be fragmented pieces of shale or alluvial sediment. Sandstone detritus as big as 15 mm also occurred in the exterior mortar.

All three of the mortars had charcoal, juniper bark, and other organic materials, and the exterior mortar also had unburned wood fragments. Plant fibers and hairs were observed in the core and interior veneer mortars, and all three samples had very sparse and small fragments of feathers. The interior veneer mortar contained two pinyon pine needle fragments. An unburned probable bird bone fragment occurred in the core. Uncharred wild plant seeds, especially goosefoot, were identified in all three samples. Seeds were especially abundant in the exterior veneer. The exterior veneer mortar also contained an unburned corn cupule and a small sherd from a Chaco-McElmo Black-on-white bowl, a type manufactured during the initial phase of occupation at Aztec West. A small nodule of white ochre in the exterior mortar also appears to be cultural in origin. This was the only mortar encountered in the five wall perforations that was potentially mixed with some midden materials. The pollen analysis also identified maize, including maize pollen aggregates, in the exterior mortar and sparse maize pollen within the core mortar sample. All three samples produced the usual suite of weedy plants, shrubs, grass, and arboreal pollen taxa consistent with the local floral habitat. No riparian plants or other indicators of alluvial sediments or water were identified.

## Summary and Conclusions

An extensive suite of analyses generated valuable information on Puebloan building technology and masonry mortar resource procurement at Aztec Ruins. Wall perforations opened through five core/veneer walls of Chacoan age in the FY00 backfill project area provided the opportunity to inspect full cross-sections through each wall and to collect mortar samples for special study. The number of samples was small, normally three from each perforation, and the analyses are intended as a pilot study to provide baseline data and to ascertain what kinds of research issues might be addressed with such information. The mortars were fully described and their texture analyzed in order to quantify the fractions of sand, silt, and clay particles, and to identify additional constituents. Samples from three of the five wall perforations were subjected to more intensive grain-size and archeobotanical analyses. The results make it possible to distinguish individual mortar batches in several instances and to identify examples of both solid and filled-core masonry construction. The two major types of mortar identified show differences in color and texture, each having two subtypes with slight color differences but less textural variation.

All of the wall sections can be assigned to the initial phase of major Chacoan construction in the North and East Wings at Aztec's West Ruin. This initial construction episode began in A.D. 1113 and continued perhaps for another few years (Windes and McKenna 2001). One wall face affected by wall perforation had been partially replaced prehistorically, evidently also during the Chacoan occupation. Some stylistic variation in masonry veneers is included in the analysis: there are two examples of coursed-pattern style (one repaired later in McElmo style); two examples exhibit heavily chinked masonry that is roughly comparable to Type II at Chaco Canyon; the remaining wall faces are classifiable as McElmo style (see Judd 1954; Vivian and Matthews 1974; Lekson 1984). Wall construction is characterized as core/veneer with semicoursed masonry cores and faced veneers. The core within Chacoan walls is typically characterized as rubble, but all five instances here consist of roughly shaped sandstone blocks laid on distinct mortar joints, better described as true masonry. Most of the stones in the core are not pecked and ground like veneer stones are, but they could not be characterized as "rubble" any more than building stones in typical Kayenta masonry.

Lekson further distinguishes between solid core and fill core in Chacoan core/veneer walls based on whether or not the core material was laid up on the same course as the facing (1984:20-21). This distinction cannot be easily made at Aztec West. Here, it seems more practical to distinguish between whether or not core and veneer construction proceeded simultaneously. Even then, there are instances where prehistoric masonry work appears to have proceeded from one veneer to the core and then to the opposite veneer, or where the core was built up before the veneers, or where work seemed to be truly simultaneous but no single course was maintained through the wall's cross-section. In a strict sense, these instances all could possibly be considered as fill core/veneer, but the contrasting implication that cores were simply filled with "mud, earth, household trash, rubble, etc." after laying several veneer courses does not seem appropriate for the type of masonry observed at West Ruin (see Lekson 1984:21).

At Lowry Ruin, a small Chacoan great house in southwestern Colorado, core/veneer walls are filled largely with mud, although stones in the fill are generally laid flat (Roys 1936). Where stone coring is more abundant, Larry Nordby defines the hearting in rubble-cored walls as “scrap stone,” even though he infers that construction proceeded by positioning a single course of both veneers and then filling in behind them (Nordby 1981:45, and Appendix A). The procedure he describes seems to be an accurate portrayal of that commonly employed in the Aztec project area, yet neither mud nor “scrap stone” or “rubble” were primary constituents of the cores observed. As described in the attached recording forms, the stones in core masonry were as large and frequently larger than faced stones laid in the veneers, and mud rarely comprised as much as half of the core volume. The distinction may have to do with differences in wall thickness between less massive core/veneer walls where only relatively small rocks can be laid between the veneers, and those monitored at Aztec where core thickness ranges from 40 to 59 cm within walls that are nearly a meter in total thickness (see Table A6).

The only example of true rubble/trash fill that is documented at Aztec Ruins is a masonry-sealed T-shaped doorway between Rooms 52 and 57 (Barthuli 2000; Jim Trott, personal communication; Raymond Torrivio, personal communication). Both the wall and masonry laid in the doorway at some later date were built during the secondary Mesa Verde phase of construction and renovation at West Ruin. During the FY99 backfill project, a wall perforation through this doorway exposed a core filled with loose, ashy sediments that contained charcoal, rocks, bird and mammal bone, ceramic sherds, and a broken mano. Whether or not this technique of filled-core construction is more typical of the later inhabitants, the physical constraints on a sealed doorway would certainly be less stringent than with a full masonry load-bearing wall.

As so often appears to be true, use of typologies and generalizations about architecture based on work at Chaco Canyon are not perfectly suited to Aztec Ruins. The wall cross-sections documented in the five wall perforations reported here are perhaps most aptly described as “uncoursed masonry-filled cores” that were built more or less simultaneously with the adjacent veneers. From a practical point of view, the demands of a vertical wall face and uniform wall thickness like those desired by Chacoan builders could be accomplished most easily by laying veneers and then more expedient core masonry, as Nordby describes, but observations in the FY00 backfill area suggest that strict adherence to this procedure frequently yielded to expediency. What is important to note is that high-quality mortar like that employed in the veneer courses and stones laid on discrete mortar joints are essential characteristics of wall cross-sections observed while monitoring these perforations. Such traits reflect considerable concern for building thick, massive, and strong walls. What remains to be seen is whether such characteristics also are typical of upper wall sections, or whether these observations are unique to situations like these near the base of what prehistorically were three-story walls.

The approach to wall construction described here might result in more consistent mortar within a cross-section than between one wall and another. This expectation was based on evidence of construction techniques visible within the wall perforations, but it

also was difficult to evaluate because of the degree of variation in prehistoric mortars. Superficial characteristics of the original mortars are fairly uniform, but detailed analyses show variation, even between batches that clearly were used in a single work episode. This is probably due to the use of ordinary subsurface soils that were acquired to make mortar, rather than use of more specialized sediment sources. While texture is variable, grain-size analysis shows that samples are well graded, as one would expect in a single natural soil deposit. In contrast, ideal artificial mortars would have a greater tendency to produce bimodal grain-size distributions with large proportions of clays and fine- to medium-sized sand grains serving as binders and tempers, respectively. The large proportions of silts in the prehistoric mortars, decreasing their strength and adhesive qualities, are probably incidental fractions that necessarily occur in naturally sorted soils containing suitable proportions of sand and clay. The extremely fine sands that dominate these mortars are also most likely a byproduct of natural soils with sufficient clays to meet the needs for moderate plasticity and good adhesion while containing enough natural temper.

An extensive suite of specialized mortar analyses conducted at Pecos National Monument demonstrated that grain-size analysis was one of the most useful techniques for establishing typological “fingerprints” that match chronological episodes of adobe construction (White 1996). In contrast to these chronologically meaningful patterns in texture variation, samples from the FY00 project at Aztec are probably all from a single limited timeframe, yet they show considerable variation in texture for such a limited number of samples. In fact, the degree of variation might be considered extreme in comparison to northern Anasazi stone masonry where sedimentary rock features in the Canyonlands region of southeastern Utah were primary sources for mortar sediments. Analysis of 64 aboriginal mortar samples from standing structures in Canyonlands National Park and Natural Bridges National Monument revealed a heavy dominance of sandy loams (Metzger 1989:154-155). Sandy loams comprise about one-third of the Aztec samples, while clay loams make up another third at Aztec and only a minor proportion in southeastern Utah (Table A7). Aztec shows a tendency toward more clay, less silt, and more variability for a much smaller number of samples.

Table A7. Comparison between Texture Classifications of Mortar Samples from Aztec Ruins and Northern Anasazi Sites at Canyonlands National Park and Natural Bridges National Monument (see text for explanation).

<b>Texture:</b>	<b>Aztec Ruins</b>		<b>Southeast Utah</b>	
	Frequency	Percent	Frequency	Percent
Sand	0	0	11	17
Loamy Sand	0	0	1	2
Sandy Loam	5	36	36	56
Sandy Clay Loam	2	14	1	2
Loam	2	14	9	14
Clay Loam	5	36	3	5
Silty Loam	0	0	2	3
Silty Clay Loam	0	0	1	1
<b>Total Samples</b>	14	100	64	100

The southeastern Utah team cites an extensive soil study by Dennis Fenn and George Chambers that defines optimum soil mortar as sandy loam with 60 to 70 percent sand, 0 to 10 percent silt, and 20 to 25 percent clay (see Metzger et al. 1989:154). The prehistoric mortars from Utah and those from Aztec are similar in having much more silt, but the Aztec mortars tend to be closer to the optimum type in clay content. When one sample having very little clay is eliminated, the clay in Aztec samples ranges from 18 to 36 percent, affording the mortar good cementation without a substantial sacrifice in strength. The moderate silt content, which is generally lower than Utah, further reduces mortar strength and adds nothing to enhance mortar quality. Like Utah, however, fairly abundant intermediate-sized silt particles are probably just an inevitable occurrence in sediments that contain both sands and clays in suitable quantities. A mixture of relatively pure sands and clays would require acquisition of poorly-graded sediments from two separate sources, a time-consuming and evidently unnecessary procedure in both areas.

The soils used as mortar offered an expedient source for prehistoric construction, yet one that was well suited for stone masonry work. Most of the mortars were extremely well bonded to stones; mortar joints were pried off only with great difficulty. Considerable work was needed to open up wall perforations, even in eroded wall sections that were 900 years old and had been exposed to the elements through excavation almost a century ago. Although Morris (1928) described instances of severe deterioration of the masonry wall facing in these rooms, and similar problems are still readily apparent, this may be attributable more to the sheer weight of the multistory walls than deficiencies in the quality of masonry. What is apparent is the weakness resulting from consistent veneer thickness and veneer courses that are not tied into the core masonry. No instances of compound wall cross-sections were observed in the wall perforations examined during this project. The rehabilitated veneer on the west interior wall of Room 70 might have been avoided if such a masonry technique had been used, but it certainly was not caused by mortar that did not bind individual stones together into a cohesive mass.

The consistent presence of small particles of charcoal, splinters of wood, and shredded juniper bark suggest that such inclusions may have been added to further temper the mortars. Although the macrobotanical specialist felt such debris was more likely background material that simply occurred naturally in local soils around the site, charcoal and wood specifically were probably not that common in subsurface soils. There is no evidence for intentional use of middens in production of mortar, even within core construction. Juniper is not prolific within the Animas Valley and probably was quickly depleted through prehistoric exploitation. The low to moderate juniper pollen values recorded by the palynologist demonstrate that juniper was not that abundant in the immediate vicinity. Rather than broadcasting sheet trash around the pueblo, trash disposal was confined within rooms and in discrete mounds (Morris 1928:414). Moreover, mixing with trash would introduce ash as well as charcoal into the mortars, and much more abundant artifacts would be present.

The color of prehistoric mortars is consistent with the use of inorganic subsurface soils that would probably not be contaminated inadvertently with abundant residues from habitation or natural plant growth. The relatively sparse occurrence of wild weed seeds

and occasional cultural inclusions is consistent with residues that might be introduced accidentally within sizable borrow pits; topsoils should have much more debris of this sort. Given the excellent preservation of organic inclusions, diverse items such as twigs, roots, and leaves would be expected if topsoils were used or if the organic constituents were simply random surficial contaminants.

If discrete borrow pits dug into subsurface soils around the site where mined for mortar, then pollen identified within mortar samples should be largely attributable to natural pollen rain during the season of construction. This is also suggested by the good condition of pollen identified in the samples, which might be due to incorporation into mortar as it was mixed and placed into sealed architectural contexts. Naturally occurring pollen in surface soils would be more heavily degraded. The specific pollen taxa identified are abundant during spring and summer, possibly suggesting that considerable construction in this part of the pueblo occurred during the growing season when such labor demands would have conflicted with agricultural work. Despite the obvious scheduling conflicts, tree-ring analyses indicate that seasonality of wood procurement for construction at West Ruin was also substantially a spring-summer activity, contrasted with East Ruin where architectural wood-cutting took place mainly during the non-growing season (Windes and McKenna 2001:124-125). More specifically, based on tree-ring evidence, Windes and McKenna predict that major construction at West Ruin occurred between spring and fall of A.D. 1113 after four years of stockpiling beams.

The mortar samples collected in the northeastern section of West Ruin were fine-grained loams with varying mixes of sands, silts, and clays. Two types were tentatively identified: Type 1 is a brown sediment that ranges from straight loam to sandy loam; Type 2 is a yellowish-brown sediment that ranges from straight loam to clay loam. The first type is sandier and tends to have more abundant medium-grained sands, as well as fine sands; the second type tends to have more silts and clays. Each type has two less distinct color variations: Types 1A (brown) and 1B (pale brown); and Types 2A (yellowish-brown) and 2B (light yellowish-brown). Further sampling and analysis are needed to determine whether distinguishing between these subtypes has any validity, but the provisional work with the two main types shows that making this distinction may have value in locating specific quarry locales for each mortar type. However, the two mortar types co-occur within wall segments and appear to have been used concurrently during Chacoan construction.

Although most inclusions within mortar samples are fortuitous particles of debris and natural plant seeds, some items probably were added to temper the mortar. As noted, the soils used for mortar are self-tempered in that aplastic particles (mainly fine sands) occur naturally with the more plastic sediments (clays). The ubiquitous and thoroughly mixed charcoal flecks, wood splinters, and shredded juniper bark are more likely to be cultural inclusions that were added to the mortar. Also present in numerous samples were small pieces of sandstone detritus identifiable as Type 2 rock in the AZRU architectural documentation format. Sandstone is present geologically in the Animas Valley, but it is rare in the immediate vicinity and was imported more than a mile for masonry construction in the Aztec Ruins complex (Stein and McKenna 1988:54-56).

Thus, sandstone fragments in mortar can be considered to be cultural, most likely representing debris that resulted from shaping of building stones and other masonry tasks. Similarly, juniper bark and wood might also be construction debris that was derived from stripping and splitting logs for construction of ceilings, which typically consist of juniper splints. Whether or not these construction byproducts were purposefully added, they suggest that stockpiles and staging areas were situated in much the same areas and that these materials would have been readily available for mixing into batches of mortar.

The consistent occurrence of small particles of charcoal, wood, and juniper bark in the Aztec mortar samples provides another significant contrast with northern Anasazi masonry, even at cliff dwellings with outstanding organic preservation (Metzger et al. 1989:154-156). Charcoal and other vegetal inclusions are not common in mortar at the latter sites, and only a single occurrence of juniper bark is reported by Metzger et al. They believe that such inclusions are incidental, a plausible interpretation of the sparse organics mixed in the mortars at those sites, but the more widespread presence of such items at Aztec Ruins indicates that further consideration of possibly artificial ingredients in local mortars is warranted. This seems to be especially true of charcoal flecks, which are ubiquitous, despite the complete absence of sizable chunks. Charcoal may have been pulverized and mixed into the mortar intentionally.

This pilot study of mortar samples has generated preliminary baseline data for refining mortar classifications and describing masonry and architectural features in the pre-backfilling architectural documentation program at Aztec Ruins. Some exploratory insights into the cultural behavior of the Chacoan building crews are also provided. Some of these results might be worth considering in ongoing ruins stabilization activities. The results are certainly valuable enough to justify continuation of mortar analyses in future work at the site.

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**AZTEC RUINS NATIONAL MONUMENT  
 ARCHEOLOGICAL MONITORING FIELD NOTES  
 WEST RUIN BACKFILL PROJECT – WALL PERFORATIONS**

Wall Perforation: 2000-01

Location: East Wing, Rooms 70 and 71

Wall No.: 70W/71E

Perforation Size: 40 cm high, 56 cm wide, 95 cm deep

Personnel: Gary M. Brown (archeological monitor), James D. Brown, Harry Etcitty

Date: June 6, 2000

Observations: Perforation started on west interior wall of Room 70, several courses above modern ground surface within the room in the approximate horizontal center of the wall. Mortar joints have been pointed with tinted and untinted Portland cement, contrasting with northern and southern portions of wall which display original masonry and mortar. The vertical boundary between these areas is obvious. As noted by Morris (1928:313), “The veneer on all but the extreme ends of the west wall had peeled away from the core and fallen, necessitating replacement.” During pre-backfilling documentation, Jim Trott interpreted this statement and the abundance of untinted cement typical of that used by Morris and crew to indicate that Morris had initiated reconstruction of the collapsed prehistoric veneer. However, the removal of untinted cement during perforation revealed unammended mud similar to that in unstabilized parts of the wall, well bonded to masonry stones, showing considerable original integrity. The untinted cement clearly was overpointed. Morris actually observed the same disjunction in the wall face which is still apparent, and meant to imply that the veneer had been replaced *prehistorically*. After excavation, his crew evidently repointed extensive parts of the veneer to help stabilize the masonry. The positional integrity of stones in the area removed for the drainage perforation was good, though the wall face and chinking patterns have obviously been impacted by stabilization.

The first-story west wall veneer was typical McElmo style masonry, except for the northern part where the facing prior to collapse was a rough version of coursed-patterned Type III masonry. Both styles are semi-coursed. The perforation affected a stabilized McElmo portion of the wall where the veneer was shown to average 20 cm in thickness. Core masonry was uncoursed and consisted of about equal amounts of mortar and rock. Thickness of the core varies from 55 to 60 cm. Rocks in the core are unshaped sandstone, while sandstone in the veneers have been faced. Rocks in the core were generally laid flat but not in courses. The west side of the wall (east interior wall of Room 71) is slightly thinner than the east (17 cm), but otherwise it is similar. In Room 71, most of the east interior wall masonry can be described as McElmo in style, but there

are tabular bands and very tightly packed stones reminiscent of coursed-patterned masonry. In conjunction with extensive tinted cement grouting throughout much of the wall, it is likely that the original masonry style was Type III similar to the remnant on the opposite veneer prior to collapse and reveneering (see above). Like the east interior wall of Room 70, the masonry exposed in the perforation through this veneer also revealed aboriginal mortar in the joints between stones. Thus, the entire wall exposed by this perforation had intact prehistoric masonry, with one side rebuilt prehistorically, and both faces overpointed with 20th-century cement.

Aboriginal mortar in the west wall veneer in Room 70 consisted of pale brown (10YR6/3) fine sandy loam with charcoal and uncharred organic inclusions. Similar mortar occurred in the core, but it was slightly darker in color, classifiable as a brown (10YR5/3) fine-grained loam, containing charcoal and uncharred organics, including splinters of wood and bone. An obsidian flake, probably utilized, was collected, as were two bone fragments, both of them butchered. The bone specimens include a large mammal longbone shaft fragment with green spiral fractures and a splinter from a longbone shaft that was probably derived from a bird in the turkey size range. The bones are unburned. The east wall veneer in Room 71 contained brown (10YR5/3) fine sandy clay loam mortar, also with charcoal and organics, similar in color to the core mortar but with slightly more fine particles in the sediment. The core was the only area that produced artifacts or bone.

The presumed reconstruction of the veneer inside Room 70 is supported by the different color of the mortar and the evident mixing of the two mortars in the eastern part of the core masonry where chunks of lighter mortar were intermixed with darker core mortar as if the original light-colored pieces were mortared back into place when the veneer was rebuilt. The core masonry was generally fractured, though solid. Some pieces had small water rivulets, evidently representing water drainage through the wall from above, most likely after site abandonment when the cap of the wall was exposed to the elements. The original veneer on the west, the rebuilt veneer on the east, and core masonry all seem to have been constructed with different batches of mortar. In addition to the obsidian and bone, aboriginal mortar samples were collected from both the core and veneer mortar joints and submitted for analysis. Samples of the cement grouting were also collected for type references.

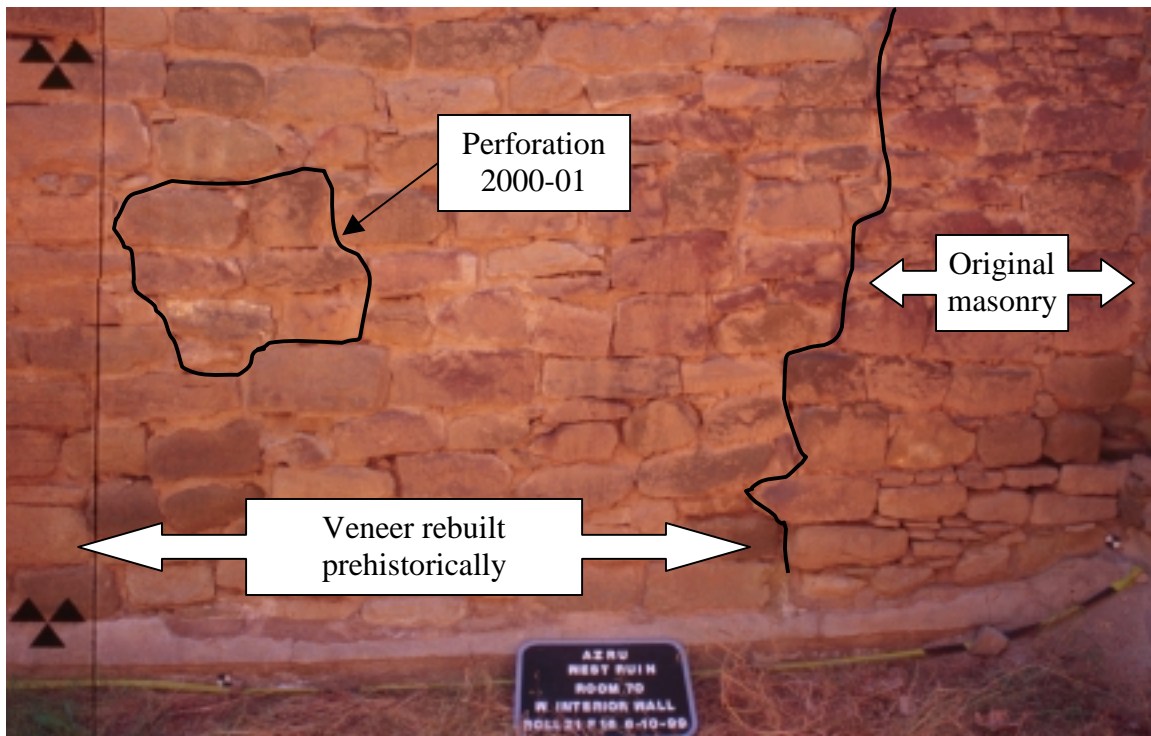


Figure 01A. West interior wall of Room 70, looking southwest at location of wall perforation that was opened during FY-2000 backfilling project. Pre-backfill photo taken June 10, 1999.



Figure 01B. West interior wall of Room 70, looking southwest, prior to removal of Perforation 2000-01 on June 6, 2000. Perforation is outlined.



Figure 01C. West interior wall of Room 70, looking southwest, after initial wall penetration on June 7, 2001, showing initial placement of PVC pipe.



Figure 01D. West interior wall, looking southwest, after masonry closure around Perforation 2000-01.

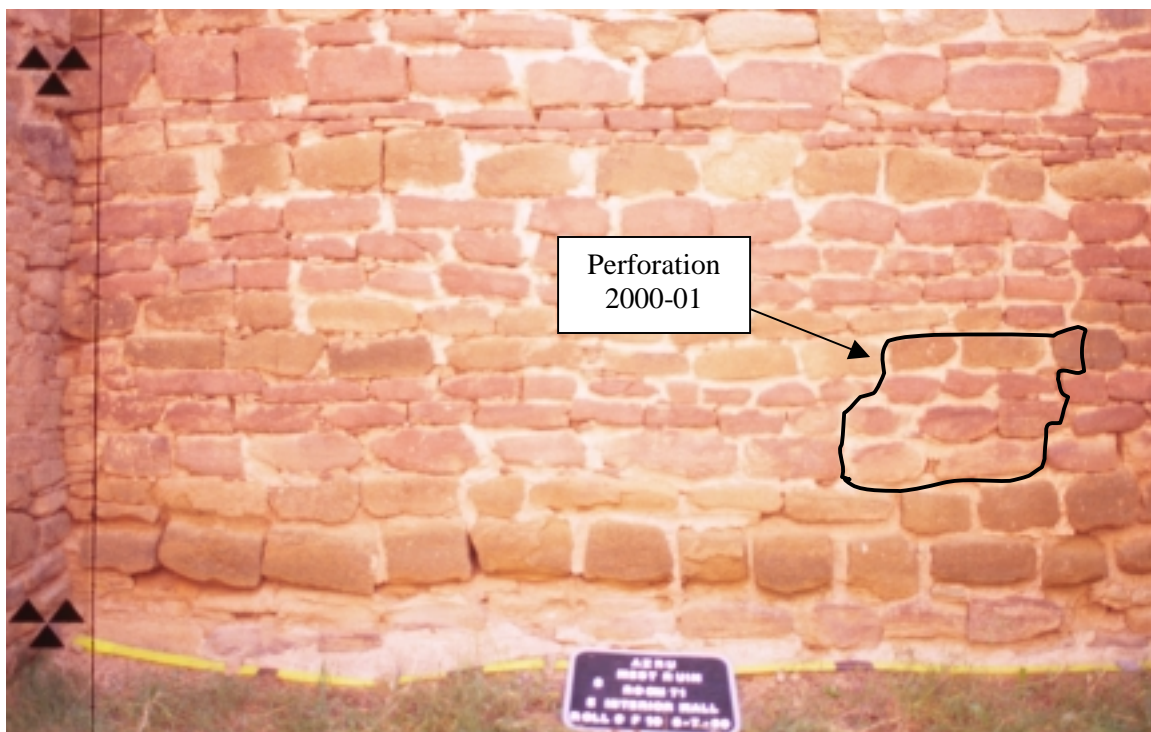


Figure 01E. East interior wall of Room 71, looking northeast at location of wall perforation removed during FY-2000 backfilling project. Pre-backfill photo taken June 7, 1999.



Figure 01F. East interior wall of Room 71, looking northeast, prior to removal of Perforation 2000-01 on June 6, 2000. Perforation is outlined.



Figure 01G. James Brown chiseling out building stones for Perforation 2000-01 on east interior wall of Room 71.



Figure 01H. East interior wall of Room 71, looking northeast, after initial wallpenetration on June 7, 2001, showing initial placement of PVC pipe.



Figure 01I. Masonry-filled core construction in Perforation 2000-01, looking east from Room 71, after completion of penetration and installation of PVC drain pipe.



Figure 01J. East interior wall, looking northeast, after masonry closure around Perforation 2000-01.

**AZTEC RUINS NATIONAL MONUMENT  
 ARCHEOLOGICAL MONITORING FIELD NOTES  
 WEST RUIN BACKFILL PROJECT – WALL PERFORATIONS**

Wall Perforation: 2000-02

Location: East Wing, Rooms 63 and 72

Wall No.: 63E/72W

Perforation Size: 63 cm high, 42 cm wide, 97 cm deep

Personnel: Gary M. Brown (archeological monitor), Eric Ellison, Robert Decker, Cliff Bannowsky

Date: June 14, 2000

Observations: This wall has been stabilized and exhibits considerable cement mortar, most of it tinted. Although presently standing one and a half stories tall, when Morris excavated Room 72, he indicated the wall had been found to have “collapsed” into Room 63 (to the west), depositing masonry and wall fall into the latter room (1928:319-320). However, his description of Room 63 does not mention significant damage to the east wall of that room. Intact masonry removed for the wall perforation supports the inference that characterization of a “collapsed” wall is quite an exaggeration. Stabilization records also document deep grouting of the wall, but no substantial reconstruction. The veneer on either side of Wall 63/72 has been heavily stabilized, but much of the stonework appears to have reasonable integrity, at least on the first story.

The veneer on both sides of the wall can be classified as semi-coursed McElmo style masonry, although the integrity of the prehistoric fabric has been compromised by stabilization. There is some sandstone chinking in the east interior wall of Room 63, but the west wall of Room 72 has none, possibly due to the extensive repointing and stabilization which has taken place. Most of the masonry consists of shaped sandstone blocks. No prehistoric features occur in this wall. Tinted Portland cement covered most of the mortar joints on both veneer faces, but the perforation showed that this repointing had not substantially altered the integrity of the original masonry.

Perforation 2000-02 was started on the east interior wall of Room 63, about 1 m up from modern ground surface in the approximate horizontal center of wall. Six rocks were initially removed from the veneer. The opposite side of the wall (west interior wall of Room 72) was worked on once the position of the perforation was determined and five stones were initially removed from the veneer. After cement grouting was removed, original mud mortar was seen to occur throughout the mortar joints of the veneer courses on either wall face. Identical mortar continued into the core of the wall with no perceptible stratigraphic break anywhere through the width of the wall. The mortar was consistently a pale brown (10YR6/3) fine sandy loam containing charcoal, uncharred

wood fragments, and shredded juniper bark. One fragment of unburned bone was collected, probably derived from a rabbit.

The core masonry was semicoursed sandstone with one broken river cobble. Most of the sandstone consisted of rough flagged blocks with few indications of shaping, but one stone was noted with a pecked and ground face. The shaped face on the latter was randomly oriented, suggesting it may have been reused or intended originally for use in veneer masonry. Although laid in courses, mortar joints were much thicker than in the veneer masonry. The wall construction, rather than rubble core/veneer masonry common in Chacoan wall cross sections, can be described as semicoursed solid core/faced veneer. Both veneers average 22 cm in thickness and the core is 53 cm thick; total wall thickness is 97 cm. Veneer stones in the west interior wall of Room 72 average 30 by 21 by 12 cm, while those in the core and the opposite veneer average 20 by 20 by 12 cm.

The perforation had to be enlarged in order to lower the PVC pipe when final adjustments were made to the drainage system. Three additional stones were removed from the bottom in the east interior wall of Room 63 and two more stones were removed from the bottom in the west interior wall of Room 72. Samples of both the original mortar and cement grouting were collected during archeological monitoring. The results show that the original wall was intact in the area that was perforated, and that Morris' description of a collapsed wall in this location did not affect the lower section of the wall that was involved.

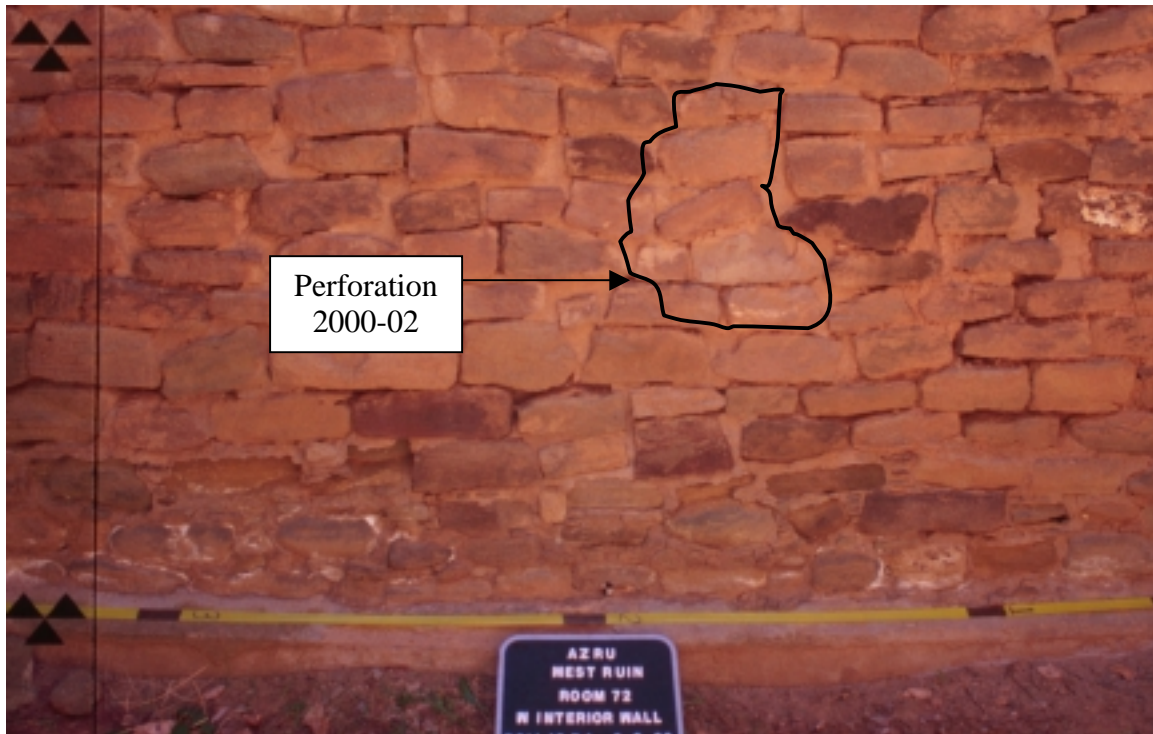


Figure 02A. West interior wall of Room 72, looking southwest at location of wall perforation that was opened during FY-2000 backfilling project. Pre-backfill photo taken June 9, 1999.



Figure 02B. West interior wall of Room 72, looking southwest, prior to removal of Perforation 2000-02 on June 14, 2000. Perforation is outlined.



Figure 02C. West interior wall of Room 72, looking southwest, after initial wall penetration on June 14, 2000.



Figure 02D. West interior wall, looking southwest, after masonry closure around Perforation 2000-02.



Figure 02E. East interior wall of Room 63, looking northeast at location of wall perforation that was opened during FY-2000 backfilling project. Pre-backfill photo taken June 24, 1999.



Figure 2F. East interior wall of Room 63, looking northeast, prior to removal of Perforation 2000-02 on June 14, 2000. Perforation is outlined.



Figure 02G. East interior wall of Room 63, looking northeast into Room 72 through initial wall penetration on June 14, 2000.



Figure 02H. East interior wall of Room 63, looking north, after masonry closure around Perforation 2000-02.

**AZTEC RUINS NATIONAL MONUMENT  
 ARCHEOLOGICAL MONITORING FIELD NOTES  
 WEST RUIN BACKFILL PROJECT – WALL PERFORATIONS**

Wall Perforation: 2000-03

Location: East Wing, Rooms 63 and 64

Wall No.: 63W/64E

Perforation Size: 44 cm high, 60 cm wide, 85 cm deep

Personnel: Gary M. Brown (archeological monitor), Harry Etcitty, Robert Decker, Eric Ellison, Cliff Bannowsky

Date: June 14, 2000

Observations: The west interior wall of Room 63 displayed good prehistoric masonry throughout much of the first story. According to Morris (1928:322), "...the facing had to be rebuilt to the level of the second floor," but this seems to be a gross overstatement. Despite extensive stabilization, mainly consisting of cement overpointing, the positional integrity of the stones, abundant patches of original mortar, and the finely chinked character of the masonry all suggest that most of the wall is original. The opposing face on the east interior wall of Room 64 shows similar masonry characteristics and an abundance of exposed mud mortar; sandstone chinking is not as abundant on this wall. Both walls are dominated by tabular sandstone blocks that have been faced by pecking and grinding. In the Chacoan typology, sections of this wall with greatest integrity can probably be classified as Type II masonry, though horizontal and especially vertically stacked chinking are nowhere as abundant as typical of Chaco.

Perforation 2000-03 was started on the west interior wall of Room 63, slightly off-center toward the south of the wall and just over 1 m above the modern ground surface prior to backfilling. Initially, three sandstone blocks, two tabular slabs, and 21 sandstone chinking stones were removed from aboriginal mortar. The core of the wall had slightly darker mortar, but similar mortar also occurred throughout the wall to the north of the perforation and within veneer mortar joints just below the perforation. Some parts of the core also had the lighter mortar. Rather than separate core masonry, separate batches of mortar are most likely represented by the slightly different colors. Core construction consists of semicoursed masonry with abundant mortar but not as voluminous as the sandstone building stones. A rodent nest and additional voids were noted within the core. Drip marks were also observed in the core demonstrating internal drainage. The east interior wall of Room 64 had more cement overpointing with aboriginal mortars joint throughout the veneer and core masonry.

The light-colored mortar, which makes up much of the eastern veneer and portions of the core, is a light yellowish-brown (10YR6/4) fine loam; the color of the core

mortar ranges from light yellowish-brown to light brownish gray (10YR6/2) clay loam; the west veneer is very heterogeneous in color, consisting mainly of light brownish-gray mottled with light yellowish-brown and pale brown (10YR6/4). The west veneer mortar also consists of a clay loam. Very sparse charcoal and no artifacts occurred in the mortar, though a piece of weathered white ocher (probably kaolinite) was found in the core. Other than the rodent nest and abundance of associated organic debris (including rodent bones) within voids in the core, the mortar itself contained very sparse inclusions.

Veneer stones removed from the west interior wall of Room 63 averaged 26 by 26 by 9 cm, while those in the core are similar in size. Tabular sandstone used to chink mortar joints averaged 4 by 2.5 by 1 cm. Veneer stones in the opposite face were quite large, averaging 35 by 28 by 10 cm. Most of the veneer stones are pecked on the side facing the wall face and some grinding is also apparent. Total wall thickness is 85 cm, the veneers each averaging 22 cm and the core averaging 41 in thickness.



Figure 03A. West interior wall of Room 63, looking southwest at location of wall perforation that was removed during FY-00 backfilling project. Pre-backfill photo taken June 24, 1999.



Figure 03B. West interior wall of Room 63, looking southwest, prior to removal of Perforation 2000-03 on June 14, 2000. Perforation is outlined.



Figure 03C. West interior wall of Room 63, looking southwest after initial wall penetration on June 14, 2000.



Figure 03D. East interior wall of Room 64, looking northeast at location of wall perforation that was removed during FY-00 backfilling project. Pre-backfill photo taken August 1996.



Figure 03E. East interior wall of Room 64, looking northeast, prior to removal of Perforation 2000-03 on June 14, 2000. Perforation is outlined.



Figure 03F. East interior wall of Room 64, looking northeast, after initial wall penetration on June 14, 2000.



Figure 03G. East interior wall of Room 64, looking NE, after masonry closure around Perforation 2000-03.

**AZTEC RUINS NATIONAL MONUMENT  
ARCHEOLOGICAL MONITORING FIELD NOTES  
WEST RUIN BACKFILL PROJECT – WALL PERFORATIONS**

Wall Perforation: 2000-04

Location: East Wing, Rooms 64 and 84

Wall No.: 64W/84E

Perforation Size: 54 cm high, 60 cm wide, 85 cm deep

Personnel: Gary M. Brown (archeological monitor), Harry Etcitty, Robert Decker, Eric Ellison

Date: June 15, 2000

Observations: This work was begun on the west interior wall of Room 64. Five large rocks, two smaller tabular ones, and a few chinking stones were removed. After cement grouts were removed, aboriginal mortar was exposed in all mortar joints. The mortar has a high clay content and is well bonded with stones. A vertical void exposed behind the veneer probably indicates that the semi-coursed masonry core was laid separately after the veneer courses, although the mortar appears very similar. More abundant mortar was used in the core. All of the masonry consists of sandstone, the core consisting mostly of unshaped rocks that were laid horizontally. Both vertical and horizontal mortar joints are well defined, though some irregular areas in the core were packed with copious quantities of mortar. Both veneers and core construction can be described as semi-coursed masonry. The east interior wall of Room 84 had indistinguishable mortar. This veneer and the core masonry were probably constructed simultaneously after the opposite veneer masonry (within Room 64) was laid in this part of the wall. Only three stones were removed on this side of the perforation. Morris (1928:342) indicates that about two-thirds of the east wall veneer had collapsed, but the features exposed were certainly not affected by the extensive damage he reported.

Rocks in the west-facing veneer average 20 by 18 by 9 cm, those in the east veneer average 28 by 19 by 13 cm, and those in the core average 30 by 15 by 12 cm. One exceptionally large stone was removed from the core. Evidence of shaping was noted only on the veneer stones which generally were faced on one side to provide a flat surface comprising the wall face. Mortar samples were collected from veneer joints on either side and from the core. Sparse charcoal and organics were noted in the mortars; no artifacts were found. The east veneer and the core mortar were yellowish-brown (10YR5/4) clay loam, while the west veneer (within Room 84) was a brown (10YR5/3) fine sandy loam. Total wall thickness is 85 cm, the east veneer averaging 19 cm in thickness and the west veneer 26 cm. Wall construction can be characterized as semi-coursed masonry core/faced veneer. The masonry on both faces is classifiable as McElmo style. It is well coursed and has sparse chinking.



Figure 04A. West interior wall of Room 64, looking southwest, prior to removal of Perforation 2000-04 on June 15, 2000. Perforation is outlined.



Figure 04B. West interior wall of Room 64, looking southwest, after initial wall penetration. The stone in center below the initial perforation was later removed to accommodate pipe.



Figure 04C. Perforation 2000-04 through west interior wall of Room 64, looking west, showing semi-coursed masonry in solid core construction.



Figure 04D. West interior wall, looking southwest, after masonry closure around Perforation 2000-04.

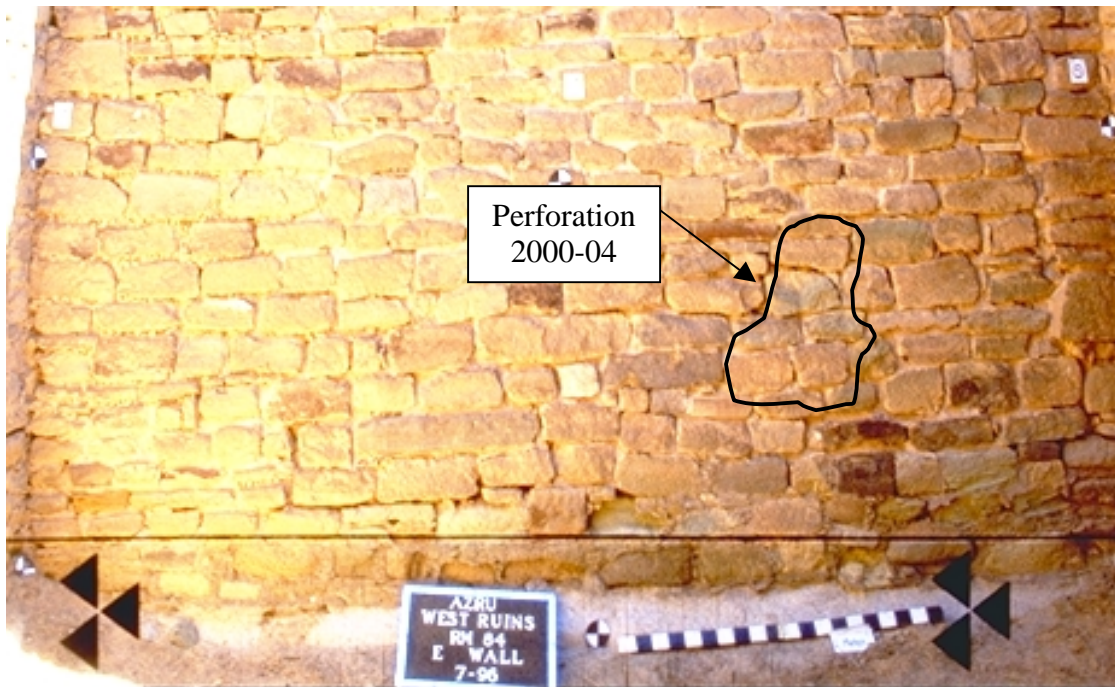


Figure 04E. East interior wall of Room 84, looking northeast at location of wall perforation that was removed during FY-00 backfilling project. Pre-backfill photo taken July 1996.



Figure 04F. East interior wall of Room 84, looking northeast, prior to removal of Perforation 2000-04 on June 15, 2000. Perforation is outlined.



Figure 04G. East interior wall of Room 84, looking northeast after initial wall penetration. Area that was later enlarged to lower drainage pipe is outlined below initial perforation.

**AZTEC RUINS NATIONAL MONUMENT  
 ARCHEOLOGICAL MONITORING FIELD NOTES  
 WEST RUIN BACKFILL PROJECT – WALL PERFORATIONS**

Wall Perforation: 2000-05

Location: East Wing, Room 70 and east pueblo exterior

Wall No.: 70E/Exterior

Perforation Size: 48 cm high, 49 cm wide, 99 cm deep

Personnel: Gary M. Brown (archeological monitor), Harry Etcitty, Cliff Bannowsky

Date: June 20, 2000

Observations: The final exit for the drainage system in the northeastern corner of West Ruin passes through the exterior wall on the east side of Room 70. The exterior and interior wall faces have been heavily stabilized and grouted with a variety of modern materials, mainly cement. The wall perforation is located just above the modern ground surface at the exterior and about a half-meter above ground surface within the room, near the southeastern corner. The interior and exterior sides of the perforation were started simultaneously after the position was marked. After removing modern grouting materials, aboriginal mortar was visible throughout the mortar joints; inspection showed that much of the interior and exterior courses are set in original mortar that has only been overpointed with cement and other stabilization materials. The prehistoric masonry is McElmo in style with shaped stones and chinking. The exterior has more tabular stones and unshaped pieces than the interior which is mainly pecked blocks with a few partial bands of tabular stone. Four stones and one broken in half were removed from the exterior and five rocks were removed from the interior veneer. The veneers are quite variable in thickness, with an average of about 20 cm. The core is 59 cm thick and total wall thickness is 99 cm. The size of the stones averages about 28 by 22 by 8 cm.

Core masonry is semicoursed with unshaped sandstone, generally tabular, laid with abundant mortar. There are some well-defined horizontal mortar joints, while vertical joints are wide and filled with mortar. Although the wall appears to have been constructed more or less simultaneously, the two veneers and the core were evidently constructed with separate mortar batches. The cross section shows construction technique best described as semicoursed solid core/faced veneer. The veneer mortars are both pale brown (10YR5.8/3), the interior being finer (clay loam) than the exterior (fine sandy clay loam). The mortar in the core is a brown (10YR5/3) fine sandy loam. Charcoal, juniper bark, and other organics occur in all of the mortars. An unburned longbone splinter derived from a bird was recovered from the mortar in the interior veneer. A small Chaco-McElmo Black-on-white sherd in the mortar of the exterior veneer was the only artifact observed in this wall perforation.

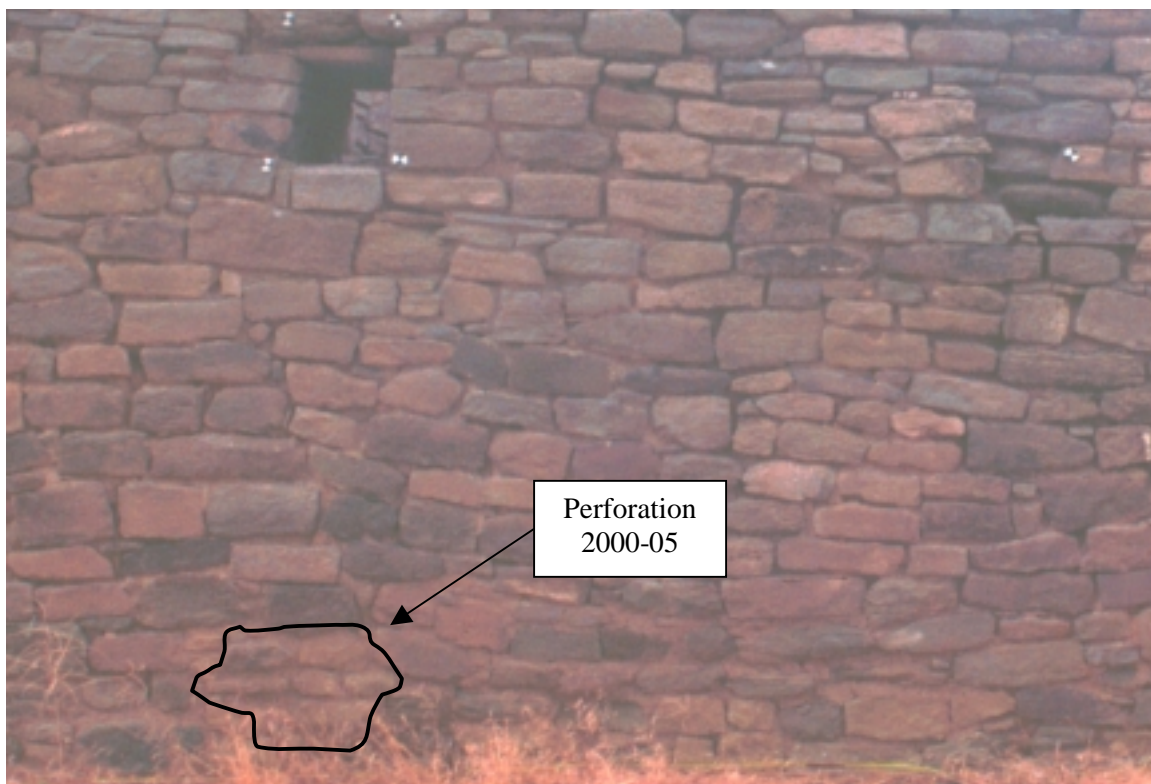


Figure 05A. Exterior wall of Room 70, looking southwest at location of wall perforation that was opened during FY-00 backfilling project. Pre-backfill photo taken July 14, 1999.



Figure 05B. East exterior wall of Room 70, looking southwest, prior to removal of Perforation 2000-05 on June 20, 2000. Perforation is outlined.



Figure 05C. East exterior wall of Room 70, looking southwest, after initial wall penetration.



Figure 05D. East interior wall of Room 70, looking northeast at location of wall perforation that was opened during FY-00 backfilling project. Pre-backfill photo taken June 10, 1999.



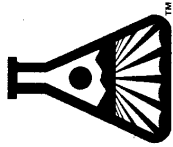
Figure 05E. East interior wall of Room 70, looking northeast, prior to removal of Perforation 2000-05 on June 20, 2000. Perforation is outlined.



Figure 05F. East interior wall of Room 70, looking northeast after initial wall penetration on June 20, 2000.



Figure 05G. East interior wall, looking northeast, after masonry closure around Perforation 2000-05.



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## SOIL ANALYSIS REPORT

Page 2

Today's Date: 1/29/2001  
 Grower: FY00 Backfill Project  
 Submitted By: Gary Brown  
 Send Report To: United States Deptmt of Inter  
 Report Number: 6612676  
 Crop: No Interpretive Levels  
 Date Received: 1/22/2001

VL = Very Low  
 L = Low  
 M = Medium  
 H = High  
 VH = Very High

Sender Sample Number	Depth	Lab #	Organic Matter %	Cation Exchange Capacity MEQ/100G	Gypsum Requirement Tons/Acre	Sand %	Silt %	Clay %	Soil Texture
00-023		863				32	32	36	Clay Loam
00-026		864				36	35	29	Clay Loam
00-029		865				52	25	23	Sandy Clay Loam
00-032		866				72	21	7	Sandy Loam
00-035		867				36	35	29	Clay Loam
00-038		868				56	26	18	Sandy Loam
00-041		869				56	26	18	Sandy Loam
00-044		870				24	45	31	Clay Loam
00-047		871				30	49	21	Loam
00-050		872				40	27	33	Clay Loam
00-053		873				42	35	23	Loam
00-056		874				56	26	18	Sandy Loam
00-059		875				52	25	23	Sandy Clay Loam
00-060		876				58	24	18	Sandy Loam

**RESULTS OF ANALYSIS OF MACROBOTANICAL REMAINS FROM  
MORTAR SAMPLES FROM AZTEC RUINS**

**By**

**Meredith Matthews  
San Juan College  
Cultural Resources Management Program  
Report 2001-SJC-075  
May 15, 2001**

**Prepared For**

**Aztec Ruins National Monument  
Aztec, New Mexico**

## INTRODUCTION

The following report provides the results of macrobotanical analysis of mortar samples collected at Aztec National Monument (LA 45). Nine mortar samples were floated in order to retrieve botanical remains. Samples were taken out of walls within/between four rooms, Rooms 63, 64, 70, and 71, located in the east wing of the West Ruin of the monument. The main purpose for conducting the macrobotanical analysis was to identify the plant materials found in the mortar and to assess if particular plants were being selected as temper material.

## PROCESSING AND ANALYTICAL METHODS

The flotation samples were processed by Navajo Nation Archaeology Department (Farmington) personnel. Because the mortar samples were quite compacted and hard, they were soaked in water prior to floating to help release the botanical remains. The samples were then processed using a froth flotation system that allows for the separation of the samples into light and heavy fractions. The principle behind a water flotation system is that material with a specific density less than water, such as botanical remains, will float and can be separated from a soil matrix. The resultant light fraction should contain this floated material. The heavy fraction will contain cultural and noncultural materials that did not float but will be separated from the soil matrix, which is rinsed away. Both the light and heavy fraction residues from the samples were submitted to the analyst.

The heavy fractions were spread out and picked through for botanical remains as well as non-botanical remains such as bone fragments. The floated residues were small, between 1 ml and 10 ml. There are two levels of analysis that can be conducted on the light fraction residue: scan analysis or full sort analysis. It is standard procedure to initially scan the light fraction residue of each flotation sample. Scanning is a cursory inspection of the light fraction, used as a means to expediently examine the botanical content of a sample and to assess the diversity and cultural integrity of botanical remains. Based on the contents of a sample, it either remains as a scan sample or it is subjected to full sort analysis. Selection of samples for complete analysis is subjectively based on diversity of taxa, type of remains recovered, and/or quantity of remains of individual taxon. Given the small amount of residue, only scan analysis was conducted on the floated residues from the mortar samples.

To facilitate analysis of the floated residue, it was first poured through graduated screens (5.6 mm, 2.0 mm, 1.0 mm, 0.5 mm, catch pan) and scanned by size grades. Usually during the scan process, only a few pieces of charcoal from these screens are selected for taxa identification and the charred wood is not quantified in any way. Consequently, wood identified during a scan analysis is not necessarily representative of the full range of woody taxa that may be in the sample. For this project, however, all of the wood from these screens were analyzed, but not quantified. The contents of the 1.0 and 0.5 mm screens were thoroughly analyzed and remains in the catch pan were briefly inspected. Botanical remains were identified and separated to the finest taxonomic level possible and information such as quantity, plant part, and condition (e.g., charred, fragmented) was recorded for each taxon. Some plant parts, like bark/bast, are difficult to quantify and were just noted as present. Analysis of flotation samples was conducted with a binocular microscope with a magnification range of 10X-70X.

## RESULTS

Plant remains represented include fragments of wood, various seeds, coniferous bark and needles, grass stems, a single corn (*Zea mays*) cupule, and some type of fiber that may be a contaminant. In addition, strands of what may be animal hair, a few bone fragments, and some type of very small feather were found in some of the samples. Twenty-four taxa of plants were identified from the

samples (Table 1). With the exception of some of the wood fragments, all of the remains were uncharred. Usually the charred condition of plant remains from open-air sites, especially seeds, is considered to indicate association with the occupation of the site. Uncharred remains are believed to be postoccupation contaminants (Gasser 1982; Keepax 1977; Lopinot and Brussell 1982; Minnis 1981; Pearsall 1989). However, given that the samples came from undisturbed and protected cultural contexts, most of the remains are believed to be associated with the use of the site. All of the floated residues contained bug body parts, which could indicate that bugs invaded the mortar joints, bringing in some seeds. The bug parts, however, could have been incidental constituents of the soil used in the mortar and were incorporated at the time of production. Results of analysis are presented in Table 2.

Table 1. Taxa Identified

Taxon	Common Name
<i>Amaranthus sp.*</i>	pigweed
<i>Atriplex sp.*</i>	saltbush
<i>Chenopodium sp.*</i>	goosefoot
<i>Cleome sp.*</i>	beeweed
Compositae*	Sunflower family
Cruciferae*	Mustard family
<i>Descurainia sp.*</i>	tansy mustard
Dicotyledoneae	Dicot class
<i>Echinocereus sp.*</i>	hedgehog cactus
Gramineae*	Grass family
Gymnospermae*	Gymnosperm class
<i>Helianthus sp.*</i>	sunflower
<i>Juniperus sp.</i>	juniper
Leguminosae*	Pea family
<i>Opuntia sp.*</i>	prickly pear cactus
<i>Oryzopsis hymenoides*</i>	Indian ricegrass
<i>Physalis sp.*</i>	ground cherry
<i>Pinus edulis</i>	pinyon
<i>Pinus ponderosa</i>	ponderosa pine
<i>Polygonum sp.*</i>	knotweed
<i>Populus/Salix</i>	cottonwood/willow
<i>Portulaca sp.*</i>	purslane
Rosaceae	Rose family
<i>Zea mays*</i>	maize

\* - only uncharred remains recovered

Table 2. Results of Macrobotanical Analysis

Taxon	Part	Provenience				
		East Wall Rm 70 (exterior)			Rm 63/64 Divider SA-00-42	West Wall Rm 63 SA-00-45
		SA-00-27	SA-00-30	SA-00-33		
<i>Amaranthus sp.</i>	seed	2				
<i>Atriplex sp.</i>	fruit					
<i>Chenopodium sp.</i>	seed	16	5	2		1
<i>Cleome sp.</i>	seed	2fg				
Compositae	seed			1		
Cruciferae	capsule			1		
<i>Descurainia sp.</i>	seed			1		
Dicotyledoneae	wood	X*				
<i>Echinocereus sp.</i>	seed				2	2
Gramineae	stem		X			
Gymnospermae	wood	X				
<i>Helianthus sp.</i>	seed	4fg				
<i>Juniperus sp.</i>	bark wood scale	X X*	X X	X	X X*	X X
Leguminosae	seed	3				
<i>Opuntia sp.</i>	seed	3				
<i>Oryzopsis hymenoides</i>	seed					
<i>Physalis sp.</i>	seed	6	1			
<i>Pinus edulis</i>	needle			2fg		
<i>Pinus ponderosa</i>	wood					
<i>Polygonum sp.</i>	seed	2fg				
<i>Populus/Salix</i>	wood					
<i>Portulaca sp.</i>	seed	17		2		2
Rosaceae	wood					
<i>Zea mays</i>	cupule	1				
other	fiber hair bone feather		X X X	X X X	X X	X

Note: All remains are uncharred and all samples scanned unless otherwise noted.

\* - charred

X - present

fg - fragment(s)

Table 2, con't

Taxon	Part	Provenience			
		East Wall Rm 64 SA-00-48	Rm 70/71 Divider SA-00-51	West Wall Rm 70 SA-00-54	East Wall Rm 71 SA-00-57
<i>Amaranthus sp.</i>	seed				
<i>Atriplex sp.</i>	fruit			1	
<i>Chenopodium sp.</i>	seed	1	9	11	1
<i>Cleome sp.</i>	seed				
Compositae	seed				
Cruciferae	capsule				
<i>Descurainia sp.</i>	seed				
Dicotyledoneae	wood		X*		X
<i>Echinocereus sp.</i>	seed	3			
Gramineae	stem				
Gymnospermae	wood		X		
<i>Helianthus sp.</i>	seed			2	
<i>Juniperus sp.</i>	bark wood	X X*	X X*	X X*	X
Leguminosae	seed				
<i>Opuntia sp.</i>	seed		1	1	1
<i>Oryzopsis hymenoides</i>	seed		1	1	
<i>Physalis sp.</i>	seed			1	
<i>Pinus edulis</i>	needle				
<i>Pinus ponderosa</i>	wood			X*	
<i>Polygonum sp.</i>	seed				
<i>Populus/Salix</i>	wood		X*		
<i>Portulaca sp.</i>	seed		9	13	
Rosaceae	wood			X*	
<i>Zea mays</i>	cupule				
other	fiber hair bone feather	X	X 1fg	X 1fg*	X

Note: All remains are uncharred and all samples scanned unless otherwise noted.

\* - charred

X - present

fg - fragment(s)

Not all of the fiber found in the samples, and potentially none of the fiber found, is prehistoric. Fibers were usually represented as single strands or extremely small bundles of strands. Some of the fibers were brightly colored (red, purple, blue) and possibly polyester. When held up to a very hot light bulb, some melted. Regardless, the colored fibers are believed to be contaminants. Some of the other fibers are white and almost translucent. It could not be determined if these white fibers are prehistoric or not. The flotation machine used to process the samples decants the floated residue into white mesh bags that are made out of some synthetic material, like nylon. It is considered likely that this white fiber is also a contaminant, although it did not melt when placed against the hot light bulb. When NNAD personnel were asked about processing, it was noted that the samples, which were extremely hard, were soaked in buckets for some undetermined amount of time prior to processing. Based on a description of the soaking process, it appears that the buckets were not sealed shut. Consequently, some of the fiber, and even the animal hair found, may be debris that drifted in from the NNAD office or originated from the flotation machine itself. Another indication that some contamination occurred during processing is that two of the samples (SA-00-30, SA-00-33) contained single, small fragments of a flexible plastic or possible silicone, which probably came off of the flotation machine.

As can be seen in Table 2, a majority of the remains identified are seeds. Many of the plants represented by the seeds are invasive plants, common in disturbed habitats such as around habitations, pathways, and agricultural fields. All of the plants represented could have been growing within or near Aztec Ruins at the time of occupation, with the exception of ponderosa pine (*Pinus ponderosa*) trees. Nonetheless, ponderosa pine was available and used. In addition to the plant materials presented in Table 2, each samples contained rootlets and root hairs, and insect parts. Looking over the remains from the nine samples, and noting the high presence of seeds, it is believed that the plant remains do not represent plant materials intentionally incorporated into the mortar mix as temper. It is likely that the seeds were part of the natural seed rain and within the soil mined and used for the mortar. The charred and uncharred wood fragments and corn cupule are probably part of the broadcasted debris related to the use of the site and within the soil used for the mortar. It is possible that the juniper bark, which is more like bast than bark, may have been intentionally incorporated. However, it was not found in great quantity in any of the samples, and if a tempering element, was used only in a limited way. Furthermore, there is a high probability that the juniper bark is also incidental material, debris left from using juniper for fuel or construction.

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**Pollen Analysis of Nine Samples from Wall Mortar, West Ruin  
at Aztec Ruins National Monument, New Mexico**

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**INTRODUCTION**

Nine samples were analyzed for pollen from the mortar in three walls at West Ruin, a 12<sup>th</sup> century Chacoan great house at Aztec Ruins National Monument along the Animas River. Table 1 lists the sample contexts. The walls are massive core/veneer, wetlaid masonry, and samples were collected from both faces and the core of each wall. The goal of the analysis was to contribute information to understanding the technology of mortar production.

Modern vegetation at the Monument is composed mainly of sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus*), and four-wing saltbush (*Atriplex canescens*). Cottonwood and willow trees grow in the riparian zone along the Animas River, and the valley sideslopes support a sparse pinyon and juniper woodland. There is also a variety of introduced plant species at orchards, farms, and private homes that have been developed around the Monument.

**SOURCES OF POLLEN IN MORTAR**

Pollen assemblages from archaeological contexts are the dynamic product of natural processes and cultural activities. The natural component is determined by the regional to local vegetation and species' pollination strategies, which for most plants fall into two categories, wind- or insect-pollinated. Wind-pollinated taxa (tree, grass, and some shrub species) produce abundant, aerodynamic pollen, and tend to be over-represented in assemblages. Insect-pollinated plants (the cacti and majority of herb species) are generally under-represented in pollen assemblages, because these taxa produce small amounts of poorly dispersed pollen. Sourcing pollen in mortar samples is more complicated than other natural and archaeological contexts because the mix of mud, water, and any other ingredients all will contain individual pollen assemblages formed by different depositional processes. And overlain on the mortar pollen spectra will be some component of atmospheric pollen from the period of time the wet mortar was mixed and applied. Within all of these different pollen sources, there are opportunities for seasonal pulses of pollen that could record the season the mortar was manufactured and embed a unique signature in individual batches.

Table 1. West Ruin Wall Samples.

Sample No: SA-00-	Perforation No	Location		Context
028	2000-05	E Wing, Wall	exterior	McElmo style veneer masonry joints in filled core/veneer wall, exterior courses
031	2000-05	70/exterior (E wall	core	semi-coursed masonry core in filled core/veneer wall
034	2000-05	Room 70)	interior	McElmo style veneer masonry mortar joints in filled core/veneer wall, interior courses on E side Room 70
055	2000-01	E Wing, Wall 70/71 (dividing	east side	McElmo style veneer masonry mortar joints in veneered Type III filled core/veneer wall on W side Room 70
052	2000-01	Rooms 70 & 71)	core	uncoursed masonry core in filled core/veneer wall
058	2000-01		west side	McElmo style veneer mortar joints in filled core/veneer wall on E side of Room 71
043	2000-03	E Wing, Wall 63/64 (dividing	core	semi-coursed masonry core in filled core/veneer wall
046	2000-03	Rooms 63 & 64)	east side	McElmo style veneer masonry mortar joints in solid core/veneer on W side Room 63
049	2000-03		west side	McElmo style veneer masonry mortar joints in solid core/veneer wall on E side Room 64

## METHODS

Subsamples (20 cc volume) were taken from the sample bags and spiked with a known concentration (25,084 grains) of tracers (*Lycopodium* spores). Addition of tracers allows pollen concentrations to be calculated, which estimate the raw number of pollen grains in a sample. The samples were processed with acids (overnight hydrochloric and hydrofluoric), followed by a heavy liquid gravity separation (zinc bromide 1.9 specific gravity) and acetolysis, which reduces organics.

Pollen assemblages were documented by counting a minimum of 200 pollen grains on slide transects at 400x magnification; pollen aggregates (clumps of grains of the same taxon) were included in the sum as one grain per occurrence. Larger pollen types were also documented in 100x scans of entire slides. If preservation is moderate, grains larger than about 30  $\mu\text{m}$  can be identified, which includes cacti, most cultigen pollen, and some of the herb types. Three parameters were calculated from the pollen counts: taxa richness, pollen concentration, and pollen percentages. Taxa richness is the number of different pollen types identified in a sample. Pollen concentration is a measure of the

absolute number of pollen grains in a sample and was calculated by taking the ratio of the pollen count to the tracer count and multiplying by the initial tracer concentration. Dividing this result by the sample volume yields the number of pollen grains per cubic centimeter of sample sediment, abbreviated gr/cc. Concentrations are used as the first level of analysis, followed by comparison of pollen percentages. Percentages represent the relative importance of each taxon in a sample ( $[\text{pollen counted}/\text{pollen sum}] * 100$ ).

## RESULTS

All nine samples produced significant counts of more than 200 pollen grains, and the data are documented in Appendix 1. Pollen concentrations ranged from greater than 78,000 gr/cc to less than 3200 gr/cc, but generally, concentrations were remarkably consistent (between 3000 and 5300 gr/cc). Pollen preservation was moderate to excellent, as measured by degraded values of 1 to 9 percent. A diverse list of 27 pollen types was identified, and palynomorphs, micorrhizae, and two types of spores were also documented. Micorrhizae are elements in the spore and bacteria microflora and microfauna resident in all soils. Palynomorphs are fossil spores and pollen grains that have eroded from rock and become mixed in Quaternary sediments. Palynomorphs were identified only in SA-00-028, the mortar sample from the exterior wall of Room 70, and were probably derived from one or more of the Cretaceous age geologic formations that occur throughout the region (e.g. Animas Formation and Mesa Verde Group, Chronic 1987). Palynomorphs could become incorporated in mortar from use of river water with a suspended load of modern and fossil pollen or use of colluvial or alluvial sediments that contained older, recycled rocks. Another possibility is deliberate use of Cretaceous rock as a special mortar ingredient or other cultural use.

Most of the pollen taxa identified from the mortar samples represent plant genera common in the Animas River valley. Forty to 64 percent of the pollen counted in each sample was Cheno-Am, followed by sunflower family, pine, and juniper. The Cheno-Am category encompasses two plant families, Chenopodiaceae and Amaranthaceae, that include several common native plants, such as saltbush (*Atriplex*), and the weed types, goosefoot (*Chenopodium*) and pigweed (*Amaranthus* spp.). The sunflower family subsumes several genera that are also common natives, such as rabbitbrush (*Chrysothamnus*) and snakeweed (*Gutierrezia*), and weeds, such as asters and groundsel (*Senecio*). One pollen type identified in the mortar samples was Long Spine, which represents a special division in the sunflower family. The sunflower family is typically divided into sunflower family (high spine) and ragweed/bursage (*Ambrosia* or low spine); the Long Spine type is defined as a grain with spines greater than 3.0  $\mu\text{m}$  and a tricolporate aperture system with pores aligned transverse to furrows. The Long Spine type probably represents sunflower (*Helianthus*), but other possible genera are *Layia*, fetid marigold (*Pectus*), coneflower (*Rudbeckia*), marigold (*Tagetes*), crown-beard (*Verbesina*), and *Viguiera*.

Elaeagnaceae family was identified in the mortar samples, and this grain type could represent silver buffaloberry (*Shepherdia argentea*) or Russian olive (*Elaeagnus angustifolia*), an introduced tree. There are also Cretaceous and Paleocene

palynomorphs that compare favorably to the Elaeagnaceae grain morphology (e.g. Normopolles and Postnormopolles types, Traverse 1988:269, 293). The mortar samples were carefully collected by breaking well-cemented blocks of adobe and removing an interior chunk, and the sampling was done inside a building with care taken to avoid modern pollen contamination. The mortar should contain A.D. 1100s pollen, which would rule out the introduced Russian olive. However, silver buffaloberry does not grow within Aztec National Monument today and Northwest New Mexico is the eastern range limit for this shrub (Carter 1997). It is possible buffaloberry was extirpated from the monument, and replaced by introduced species. There are ethnographic references to ceremonial and medicinal uses for buffaloberry ash (Mayes and Bayless Lacy 1989; Moerman 1998) and food use of the tart berries (Carter 1997:135). Thus, another possibility is that shrub wood and berries were harvested elsewhere during the A.D. 1100s and brought back to West Ruin.

The results from individual walls are summarized in Table 2 and discussed below.

Table 2. Summary Pollen Results from West Ruin Wall Samples.

Wall	Sample SA-00-	Pollen Conc. gr/cc <sup>a</sup>	Taxa Richness	Cheno-Am Percent	Highlights
Room 70/7	058 west side	3200	16	43	juniper (14%), buffaloberry (10%)
1	052 core	16,700	15	53	pine (15%), buffaloberry (7%)
	055 east side	5300	19	51	most economic pollen <sup>b</sup> of all nine mortar samples, cattail
Room 70	031 west side	4400	11	61	juniper (10%), willow, buffaloberry
	034 core	3800	10	64	pine (12%),
	028 east side (only sample from exterior wall face)	4300	21	44	sagebrush (6%), maize & maize aggregates, beeweed, Long Spine, buffaloberry (1%)
Room 63/6	049 west side	4600	9	43	pine (21%) and pinyon pine (22%), buffaloberry (2%)
4	043 core	78,100	16	59	maize, willow
	046 east side	37,600	14	58	juniper (11%)

a. Pollen concentration is a measure of the absolute number of pollen grains per cubic centimeter of sample sediment (gr/cc), and is rounded to the nearest 100 grains in this table.

b. Economic pollen types include the obvious cultigens, maize and squash, plus cholla, beeweed, Long Spine (cf. sunflower), and aggregates of maize and beeweed

### **Room 70/71 Wall**

High taxa richness numbers, ranging from 15 to 19 different taxa, and high representation of economic pollen and buffaloberry pollen characterized the samples from this wall. The economic types are defined here as squash, maize, cholla, beeweed, Long Spine type (cf. sunflower), and aggregates of maize and beeweed. These taxa represent plants consistently identified in regional archaeobotanical and ethnographic studies as important subsistence resources (Dunmire and Tierney 1997; Minnis 1989; Moerman 1998; Toll 1985), and were undoubtedly important subsistence plants for West Ruin residents.

The only squash, cholla, and cattail pollen, and the only beeweed pollen aggregates identified from all nine samples were from SA-00-055, the face of the west wall in Room 70; this sample also had the highest percentage of maize (3 percent) and beeweed (2 percent) out of all nine samples. The other two samples from the Room 70/71 wall (core sample SA-00-052 and Room 71 east wall face SA-00-058), included more economic pollen (maize and beeweed) than the other two walls sampled, but at lower frequencies than SA-00-055. No buffaloberry pollen was identified in SA-00-055, but the project maximum percentages of buffaloberry pollen were in the other two samples from the Room 70/71 wall (7 and 10 percent buffaloberry).

### **Room 70 Wall**

The pollen assemblages from the Room 70 wall produced the most generic pollen spectra of all the wall samples, with the exception of SA-00-028 from the exterior wall face. Chenopodium percentages were higher in Room 70 wall samples than most of the other wall samples. SA-00-028 had the maximum taxa richness (21 different pollen types) of all nine samples, and was the only sample from this wall with economic pollen (maize and beeweed). The highest project sagebrush percentage (6 percent) was from SA-00-028. Willow pollen was identified in SA-00-031.

### **Room 63/64 Wall**

The main discriminating characteristic about the Room 63/64 wall was the maximum pollen concentrations in two of the samples (SA-00-043 and SA-00-046). The west side sample (SA-00-049) produced the highest pine percentage out of all nine samples (43 percent pine plus pinyon pollen).

## **INTERPRETATIONS AND CONCLUSIONS**

There is a weak relationship for sample wall trios to produce similar pollen assemblages, which could reflect a consistent sediment source for the mortar used on individual walls. The Room 70 wall was characterized by willow pollen and high Chenopodium percentages. High pollen concentrations distinguished the Room 63/64 wall. Pollen from subsistence plants in the samples from the Room 70/71 wall could reflect cultural

activities in this room, perhaps food processing or storing crops and other plants, or that the source of the mortar sediment was in or near fields.

The strongest pattern in the results was for each sample to produce a unique assemblage, and this result suggests each wall face and core represents a separate mortar batch. There may be seasonal signals in the results. High pine values in SA-00-049 could reflect the May through June pollination period for pines. High pine percentages from two of the core samples, SA-00-034 and SA-00-052, may represent a seasonal pollen peak. Only three wall samples produced riparian pollen (cattail and willow), which could represent use of river water, but might also reflect air-borne pollen from the riparian zone along the river, especially during the spring season for willow and late summer for cattail.

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Appendix 1. West Ruin Wall Samples: Pollen Concentrations, Taxa Richness, and Pollen Percentages.

Room No Context	Room 70		Room 70/71		Room 63/64		east side (Room 63)
	exterior	west side	core	west side (east wall Room 71)	core	west side (Room 64)	
Sample SA-00-							
Pollen Sum	028	031	034	058	052	049	043
Tracers	234	254	226	208	253	225	249
	68	72	74	82	19	61	4
Pollen Concentration gr/cc	4315.9	4424.5	3830.4	3181.4	16700.7	4626.1	78074.0
Taxa Richness n=31	21	11	10	16	15	9	16
Degraded	8.5	6.7	4.3	4.3	2.0	2.7	1.2
Unknown	0.4	1.6	-	-	-	-	-
1 Pine	6.0	3.5	6.3	6.3	14.6	21.3	10.8
2 Pinyon Pine	5.1	4.3	8.2	8.2	4.0	22.2	4.4
3 Juniper	7.3	10.2	14.4	14.4	5.9	3.6	8.0
4 Oak	0.4	0.8	-	-	-	-	-
5 Rose Family	0.4	-	0.5	0.5	0.4	-	1.2
6 Mormon Tea	0.9	-	0.5	0.5	0.8	-	0.8
7 Sagebrush	6.0	2.0	1.9	1.9	2.8	2.2	2.0
8 Willow	-	0.8	-	-	-	-	-
9 Cattail	-	-	-	-	-	-	-
10 Greasewood	2.1	0.8	1.9	1.9	-	1.3	2.8
11 Cheno-Am	44.0	61.4	43.3	43.3	51.4	43.1	58.6
12 Cheno-Am	-	-	-	-	-	1.8	1.2
Aggregates	6.4	7.1	5.3	5.3	2.4	1.3	6.0
13 Sunflower Family	5.1	-	-	-	3.6	-	1.2
14 Ragweed/Bursage	1.7	0.4	1.0	1.0	1.2	-	0.4
15 Grass Family	0.4	-	-	-	-	-	-
16 Buckwheat	0.4	-	0.5	0.5	2.8	-	0.8
17 Spurge	0.4	-	-	-	-	-	-
18 Figwort Family	0.4	-	-	-	-	-	-
19 Phlox Family	-	-	X	X	-	-	-
20 Globemallow	-	-	-	-	-	-	0.4
21 Evening Primrose	-	-	-	-	-	-	-
22 Squash	-	-	-	-	-	-	-
23 Maize	X	-	0.5	0.5	X	-	X
24 Maize Aggregates	X	-	-	-	-	-	-

	1	2	3	4	5	6	7	8	9
25 Beeweed	1.3	-	0.5	0.5	1.6	2.0	-	-	-
26 Beeweed	-	-	-	-	-	0.4	-	-	-
Aggregates	-	-	-	-	-	-	-	-	-
27 Cholla	-	-	-	-	-	X	-	-	-
28 Sunflower (cf. Helianthus)	1.7	-	1.4	1.4	-	0.8	-	-	-
29 Buffaloberry	0.9	0.4	9.6	9.6	6.7	-	2.2	1.2	-
30 Buffaloberry	-	-	-	-	X	-	-	-	-
Aggregates	-	-	-	-	-	-	-	-	-
31 Elm	0.4	-	-	-	-	-	-	-	-
Colonial Spores	1.0	1.0	-	-	-	1.0	-	-	1.0
Monolete Spores	-	-	-	-	-	1.0	-	-	-
Palynomorph	1.0	-	-	-	-	-	-	-	-
Micorrhizae	-	1.0	1.0	1.0	-	1.0	-	-	-

X notes taxa identified during low (100x) magnification scans.