

ADOBE TYPOLOGY AND SITE CHRONOLOGY: A CASE STUDY FROM PECOS NATIONAL HISTORICAL PARK

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ABSTRACT

Form-molded adobes and associated mortars are an underutilized source of significant archaeological data. This paper details how the development of a typology of original adobes and mortars in the Spanish colonial church and convento at Pecos National Historical Park revealed a clearer picture of the mission's construction sequence. The correlation between the typology and the mission's documented history was buttressed by botanical and geochemical analyses of adobe soils, as well as by archaeomagnetic tests. It is likely that this method of research can be applied to other historic, and possibly prehistoric, sites with equally beneficial results.

RESUMEN

Los adobes moldeados y los asociados morteros son una fuente de importantes datos arqueológicos poco utilizados. Este artículo detalla cómo el desarrollo de una tipología de los adobes originales y morteros en la iglesia colonial Española y el convento en el Parque Histórico Nacional de Pecos revelaron una mas clara imagen de la descripción de la secuencia de las construcciones en la mision. La correlación entre la tipología y la historia documentada de la mision fué reforzada por análisis botánicos y geoquímicos de adobes de tierra, asi como tambien mediante exámenes arqueomagnéticos. Es asi como este método de investigación puede ser aplicado a otros históricos, y posiblemente prehistóricos, sitios con igualmente provechosos resultados.

In 1992 a multi-year documentation project was initiated by the National Park Service in the seventeenth and eighteenth century Spanish colonial mission structures of Pecos National Historical Park, located twenty-five miles east of Santa Fe, New Mexico. The project's research objective was a simple one: to demonstrate how a typology of form-molded and associated mortars might be used to shed light on the construction chronology in the church-convento complex at Pecos. Our typology is a classification system created by segregating adobes and mortars into types based on color, composition, dimension, texture, and, occasionally, association with other types. Over the course of four seasons, the project has revealed a surprisingly strong correlation between the typology and the documented history of the mission. A detailed examination of this correlation posed intriguing possibilities, including the potential to date other structures.

The use of adobe, or sun-dried mud, as a construction material has a

long history in the American Southwest. Three hundred years before the arrival of Europeans, the prehistoric pueblos of the Four Corners area were using various adobe technologies, including hand-molded bricks and coursed walls (Moquin 1992). Prehistoric sites that exhibit adobe architecture include Inscription House in northern Arizona, Cliff Palace at Mesa Verde, Bis-sa-Ani, a Chacoan outlier, and Aztec in northern New Mexico. The "Great House" at Casa Grande, in southern Arizona, is a well-known adobe structure. In New Mexico there is a multitude of coursed adobe pueblos, including Forked Lightning Ruin, near Pecos.

Although at least one prehistoric site, Fourmile Ruin near Taylor, Arizona, displayed evidence of form-molded adobe construction (Johnson 1992), it was the Spanish who standardized the production of adobes through the use of wooden forms. The sudden availability of uniformly dimensioned, mass-produced bricks revolutionized the architecture of northern New Mexico, even becoming incorporated into historic Native American architecture (Kidder 1958).

Our work at Pecos and other recent research demonstrates the substantial potential of form-molded adobes for indicating chronological and other data within a specific site. For example, the presence of adobes and mortars of differing dimension, composition, or color in a single wall has important temporal implications. Much can be learned about the structural development of historic architecture if differences between adobe types can be correlated to a site's documented history.

Of course differences between adobe and mortar types do not always indicate chronological developments. Crews may have procured soil from different sources, or a particular soil source may have become exhausted. Dimensional differences among adobes might indicate nothing more than a lack of oversight during construction of the wooden forms. Changes in mortar types may only indicate tiny temporal "windows," such as seasonal or crew-related breaks in the construction sequence. On the other hand, if *patterns* of adobe and mortar-type use are detected across a site, then an association between architectural construction activity and a site's chronology might be inferred.

In the case of Spanish colonial ecclesiastical architecture, there are at least two examples where the typological potentials of adobe and mortars, and their architectural implications for site chronology, have been identified by archaeologists. A brief review of work at Tumacacori and Guevavi will provide a useful backdrop to our work at Pecos.

PAST STUDIES AT TUMACACORI AND GUEVAVI

During the excavation of the south wing of the Franciscan convento at the Tumacacori mission in 1980, archaeologist Lee Fratt observed color and

dimensional differences among Spanish-era adobes. In the adjoining *north* walls of two rooms, for example, Fratt observed that the adobes of one room were light tan and did not have lime plaster wash on the mortared ends as did the dark gray adobes of the adjoining room. These differences suggested to Fratt that the walls were built at different times (Fratt and others 1981).

Fratt made two other important observations. First, there were no visual color or compositional differences between adobes of the *south* walls of these two rooms; unlike the north walls, these walls appeared to have been constructed contemporaneously, indicating a separate episode of construction activity. Secondly, a few adobes in specific convento walls had adhering lime plaster, an indication that the adobes were reused (Fratt and others 1981). Thus, a segregation of bricks appeared to have chronological associations. Adobe documentation, however, was not the focus of Fratt's excavation, so questions related to adobe typology and architectural sequencing were not pursued.

In a recent, unpublished paper on the construction history of the church at Tumacacori, Park Service historian James Ivey noted that historical records mention two different compositions of adobes: *de marca* and *sancopinca*. The former were "regulation" adobes, which apparently included a tempering material such as straw to prevent cracking. *Sancopinca* adobes were "nonregulation" and were constructed without straw as a tempering material (Ivey n.d.). Could the presence of these two types of adobes have temporal associations that might reveal something about the construction sequence in the church?

If Tumacacori's architectural chronology can be firmly established from historical records, it may be possible to assign particular adobe and mortar types to specific periods, leading to a general history of adobe use throughout the site, as we have attempted to do at Pecos.

In 1991 the National Park Service conducted limited excavations in the eighteenth-century Spanish mission of Guevavi in southern Arizona. During this work, three different types of adobes were observed in the church: one type in the nave, one type in the tower, and one in the narthex, at the front of the building (Burton 1992). Each type could be described by color, dimension, or both. The mortars associated with these adobes were segregated by color as well. According to Jeffrey Burton, principal author of the report on Guevavi, the presence of these different types of adobes in the church was the "most surprising discovery" of the excavation (Burton 1992).

Burton was roughly able to associate these adobe types to construction activity in the church. For example, a window in the east wall of the nave was discovered to be sealed with dark brown adobe bricks, similar to the adobes in the narthex. This suggested contemporaneity in construction activities (Burton 1992). The patterning of headers and stretchers, or how the

adobes were laid in a wall, was also observed to be different from the nave to the narthex to the tower. This led Burton to conclude that “differences in brick size, color, and pattern suggest separate building episodes” (Burton 1992:39).

Pursuing this observation, six adobes of different types were sampled for flotation analysis with an eye toward detecting building episodes in the church. Although the results were mixed, flotation analyst Lisa Huckell recommended further analysis. She speculated that an identification of building episodes could be detected by the presence of significant compositional differences in the bricks. She recommended extensive and systematic *in situ* sampling of the variously colored bricks present in the structure (in Burton 1992). This is exactly what we have endeavored to do at Pecos.

ARCHITECTURAL HISTORY AT PECOS

The archaeological documentation effort at Pecos, which was integrated into the Park’s annual ruins preservation program, focused on the adobe architecture of the mission’s church and convento complex (Figure 1). Eventually, nearby colonial structures such as Square Ruin and Lost Church were incorporated into the study as well.

Research began with hand-maps, black-and-white photography, and sampling of adobe soils for particle-size analysis. The documentation effort eventually encompassed flotation, pollen, and petrographic analyses, color photography, type collecting, and archaeomagnetic dating. Special attention was paid to variabilities in adobe brick dimensions, color (Munsell), texture, inclusions, patterning, and associations between individual bricks in a wall (White 1993 and 1994).

At the end of the first field season, it became apparent that at least four separate adobe and mortar types were visible in the church-convento complex. By the third field season, the typology had expanded to nine adobe and eight mortar types, based primarily on visual differentiation (Tables 1 and 2). These seventeen adobe and mortar types were subjected to flotation, pollen, and petrographic analyses in an attempt to corroborate the preliminary typology.

Concurrent with the documentation program at Pecos, historian James Ivey launched an investigation into the architectural history of the Park’s Spanish colonial structures. The two projects dovetailed beneficially. Strong associations between the seventeen adobe and mortar types and the documented history of the church-convento complex revealed themselves. In fact, a precise and complex picture of the architectural sequencing at Pecos was opened by this cooperative venture.

The history of form-molded adobe construction at Pecos began shortly

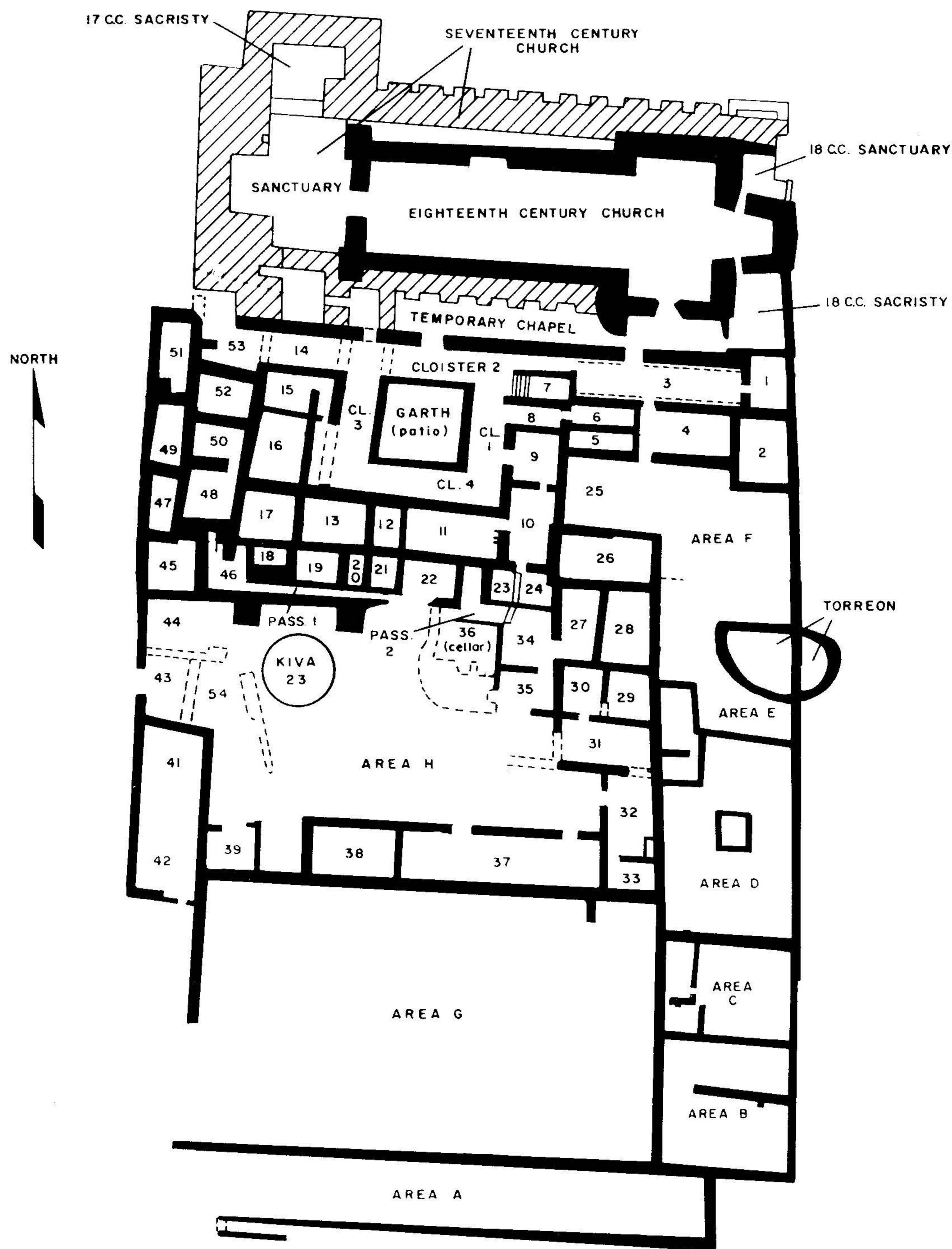


Figure 1. The Spanish Colonial Church and Convento Complex at Pecos National Historical Park, New Mexico. Map drafted by Nancy Lamm, Olathe, Colorado.

after A.D. 1600 when the Franciscan clergy of New Mexico launched a significant missionizing effort in the region. The missionary structures at Pecos were built with adobe and mortar, pulled from native soils located near each construction site, and set on stone foundations. The shape of this religious architecture conformed to the European cruciform design that had come to the New World with Spanish settlement (Ivey 1988).

The first stage of the Franciscans' efforts at Pecos was the construction of a small church on a finger of land near the pueblo. First observed by Bandelier in 1880 (Bandelier 1881) and labelled later by Kidder as the "Lost Church" (Kidder 1958), there is little evidence of this structure in the historical literature (Kessell 1979). There is an allusion to "Mass" being conducted at Pecos in the years after A.D. 1600, possibly at the Lost Church, although archaeological evidence suggests that the building was never completed (Stubbs and others 1957).

Around A.D. 1620 the second stage of mission construction began with the laying of stone foundations for a convento and the raising, eventually, of a massive adobe church. Both structures were located at the south end of the mesilla occupied by the Pecos puebloans. Historical literature clearly documents the date of the church's construction: A.D. 1620-25 (Kessell 1979). Since the convento and the church were built simultaneously, or nearly so, all construction materials found relating to this architectural episode are dated to the first half of the 1620s.

For a time, the mission at Pecos appears to have prospered (Ivey, personal communication); by A.D. 1663 the convento had been modified by the addition of a second story (Kessell 1979). The construction of a hacienda complex adjacent to the convento, as well as the possible construction of Square Ruin across the creek, were probably completed in this period as well. In 1680 the Pueblo Revolt brought all missionary efforts to a halt. The mission was attacked, and the great adobe church was demolished in the uprising. Either by direct action or neglect, the convento was also damaged during the Revolt.

The next stage of construction activity at Pecos occurred about A.D. 1694, when the mission was reoccupied following the Spanish Reconquest of New Mexico by Diego de Vargas. A new chapel was built on the ruins of the second church, and rooms in the convento were remodelled in order to make it inhabitable once more (Hayes 1974).

The final major stage of construction at Pecos involved the raising of the last church. This is the structure visible today in the Park. Completed by A.D. 1717 (Kessell 1979), it was built within the nave of the former church and was substantially smaller in size. It served the mission until the abandonment of Pecos in A.D. 1838.

DEVELOPMENT OF THE ADOBE TYPOLOGY AT PECOS

In the late 1960s, archaeological excavation by the Park Service in the church-convento complex revealed two distinct periods of construction in the convento, as reflected in the use of two distinct types of form-molded adobes. These adobe types were labelled “black” and “red” by archaeologist Alden Hayes based on his personal observation (field notes n.d.). “Black” bricks were generally composed of dark grey soil laced with charcoal and other inclusions, while “red” bricks were red-brown in color with few inclusions.

In his book *The Four Churches of Pecos*, Hayes (1974) attached this rudimentary typology to the Pecos chronology by theorizing that “black” adobe was used prior to the Pueblo Revolt (before 1680), because of their location in the lower courses of the walls in all the “early” rooms. He also postulated that “red” adobe was generally associated with construction after the Reconquest (after 1694). “Fortunately for archaeologists,” wrote Hayes, “the pre-rebellion walls were mostly built of black, trashy adobes, while Arranegui and his [post-rebellion] successors used local red soil” (Hayes 1974:24).

This basic dichotomy was accepted by subsequent researchers at Pecos (Nordby and others 1975) and remained unrefined until 1988, when Park Service archaeologist Todd Metzger observed two distinct subtypes of “black” adobe, set in two different mortar types in Room 48 of the convento (Metzger 1990). By 1994, after approximately thirty walls had been mapped in the convento as part of the documentation project, a preliminary refinement of the typology was completed.

Working closely with Ivey, who had targeted specific walls in the complex for closer examination, we then developed a construction sequence based on what appeared to be the most logical relationship between the expanded adobe typology and the site chronology of Spanish colonial architecture at Pecos. A summary of this relationship follows.

The First or “Lost” Church

In 1956 the Lost Church was excavated by Stanley Stubbs and Bruce Ellis, who discovered it to be of adobe construction, with bricks set on a stone masonry foundation (Stubbs and others 1957). The mortar was a distinctive dark red color. In the sacristy, a stack of original adobes was found which were generally light yellowish in color. The adobe had not been mixed with straw, grass, or any other fiber. In 1994 we reexamined these materials and confirmed basic observations by Stubbs and Ellis. We labelled them Adobe Type IV and Mortar Type 8 (Tables 1 and 2).

Table 1. Adobe Types in the Churches and Convento at Pecos.

Adobe	Type	Color (Munsell)		Texture	Composition	Average Size (cm)
Ia	Black	brown-black	5YR 3/3	hard	artifacts, some charcoal	51 x 23 x 7
Ib	Black	grey-black	5YR 2.5/2	friable	artifacts, lots of charcoal	51 x 23 x 7
IIa	Red	reddish-brown	2.5YR 3/6	friable	free of inclusions	49 x 25 x 9
IIb	Red	purple-brown	7.5YR 4/4	hard	bits of charcoal	49 x 25 x 7
IIc*	Red	reddish-brown	2.5YR 3/6	friable	free of inclusions	49 x 25 x 9
IId	Red	pink-brown	10R 4/6	friable	bits of white plaster	49 x 25 x 7
IIE	Red	whitish-brown	7.5YR 8/2	friable	free of inclusions	too few
III	Red	red-brown	10R 4/8	hard	artifacts & straw	55 x 28 x 8
IV	Yellow	yellow-brown	2.5Y 5/4	friable	free of inclusions	51 x 25 x 7

*This type appears to be ‘recycled’: Type IIa adobes set in Type 6 mortar.

Table 2. Mortar Types in the Churches and Convento at Pecos.

Mortar Type	Color (Munsell)		Texture	Composition	Adobe Type Association
1	purple-red	7.5R 3/4	friable	small rocks	Types Ia-b
2	orange-brown	2.5YR 5/8	friable	small rocks	Types Ia-b
3	brown	5YR 5/6	friable	free of inclusions	Types Ia-b
4	deep red	7.5R 3/8	friable	free of inclusions	Type IIa
5	purple-brown	7.5R 4/6	hard-packed	bits of charcoal	Type IIb
6	red brown	10R 4/6	very friable	bits of white plaster	Types IIc-e
7	red-brown	10R 4/8	hard-packed	artifacts & straw	Type III
8	red	7.5R 3/6	deteriorated	free of inclusions	Type IV

The Second Church and Construction of the Convento

This episode of construction is represented by “black” adobe brick, which was laid on the stone foundations and raised to a height of four to eight (or more) courses, depending on location. We verified Metzger’s observations concerning the two subtypes of “black” adobe in the convento. Adobe Type Ia is characterized by its grey-brown color (Munsell 5YR 3/3), hard-packed texture, and low quantity of charcoal and ash. Adobe Type Ib is characterized by its grey-black color (Munsell 5YR 2.5/2), looser texture, and heavy content of charcoal and ash. In most walls, the “black” subtypes appeared to be randomly intermixed, with no discernible patterning or relationship.

Nearly all “black” adobes of both subtypes were set in the same original mortar, labelled Mortar Type 1. It is characterized by its deep red color (7.5R 3/4), friable texture, and relative lack of inclusions. It is by far the predominant mortar type in the convento, found in every wall mapped thus far. Two other mortar types were also observed in the convento’s “black” walls. Mortar Type 2 is characterized by its orangish color (2.5YR 5/8) and highly friable texture. It was found primarily among the upper courses of adobes in the convento’s north wall. Mortar Type 3 is characterized by its brown color (5YR 5/6) and hard-packed texture; it has only been observed in one wall and relates, possibly, to the reuse of “black” adobe in that wall.

Second Story of the Convento

At some point in time, construction in the convento switched from “black” to “red” adobes. This latter type was broadly designated Adobe Type II. The earliest “red” material, Adobe Type IIa, is characterized by its reddish brown color (2.5YR 3/6), friable texture, and nearly complete lack of inclusions. It is often set directly above the last “black” adobe course. The mortar associated with Adobe Type IIa has been labelled Mortar Type 4 and resembles Mortar Type 1 in appearance, except that it has a deeper red color (7.5R 3/8).

The presence of “red” adobe above the “black” adobe suggests an association with the addition of a second story to the convento. It is likely that the second story of the convento was constructed with Adobe Type IIa which would, according to the documented history of the mission, put its use no later than A.D. 1663 (Kessell 1979). The precise date and reason, however, for the changeover from “black” to “red” is not yet apparent. (The entire second story is missing from the ruined convento; its construction sequence is inferred from a series of “black” rooms on the west side. Apparently never completed in the 1620s, they were “topped” later with “red” Type IIa brick.)

In Room 47 of the convento, a variant of Adobe Type IIa was observed

in the southern half of the east wall; seven courses of purple-brown adobes (7.5R 4/4), which contained numerous bits of charcoal, were observed and labelled as Adobe Type IIb. Since this wall rested beneath two courses of Type IIa adobes, it was assumed to be part of the early phase of the convento construction sequence. The purple-brown mortar (7.5R 4/6) associated with these adobes was labelled as Mortar Type 5.

Post-Reconquest Rehabilitation

This episode is represented by Adobe Types IIc-e and Mortar Type 6 (10R 4/6). These adobe and mortar types are characterized by the presence of *bits of white plaster mixed into the soil*, which is quite distinctive, particularly in the mortar. In some instances it appears that Type IIa adobes were re-used — set, as they were, in brown mortar that was shot through with bits of plaster (Mortar Type 6). In other instances new adobes were made utilizing plaster-mixed soil. In either case, it appears that Type IIa adobes from the dismantled pre-Revolt convento were “recycled” into new bricks and mortar, most likely during the repair of the convento in A.D. 1694. This theory is supported by the presence of Adobe Types IIc-e in walls that either abut or sit upon the walls of the plastered pre-Revolt convento.

The Last Church

This church’s distinctive adobes, which include numerous bits of wheat chaff binder, as well as ceramics and other artifacts, have been labelled as Type III (10R 4/8); its mortar, which is nearly identical to the adobe bricks in appearance and composition, is labelled Mortar Type 7. No adobes of this type have been observed in the convento.

A summary of the typology/chronology at Pecos is offered in Table 3.

FLOTATION, POLLEN, AND PETROGRAPHIC ANALYSES

Corroborating evidence for the typology/chronology association was sought from soil sample analyses for each adobe and mortar type. Flotation and pollen samples were collected directly from adobe bricks and mortar *in situ*, using standard collection procedures. The geochemical tests were performed on a variety of “black” adobe samples; and an archaeomagnetic sample was collected from a newly uncovered fireplace in the convento.

Hayes (1974) speculated that the “black” adobes were composed of pre-historic cultural midden — Anasazi trash, mined from the adjacent pueblo. This conclusion was confirmed by the flotation analysis by Mollie Toll and the pollen analysis by Glenna Dean (Toll 1992; Dean 1992). Toll observed that pre-contact agricultural crops, including goosefoot, pigweed, and purslane, were the principal organic components in both “black” subtypes.

Table 3. Suggested Relationship Between Adobe and Mortar Typology and the Pecos Chronology.

Period*	Structure	Adobe Color	Adobe Type	Mortar Type
pre-1620	First Church	"Yellow"	Type IV	Type 8
1620-1640	Second Church and First Story of Convento	"Black"	Types Ia-b	Types 1-3
1640-1680	Second Story of Convento	"Red"	Types IIa-b	Types 4-5
1694-1705	Third Church and Rehabilitation of Convento	"Red"	Types IIc-e	Type 6
1715-1800	Fourth Church	"Red"	Type III	Type 7

*Approximate dates A.D.

The only notable differences between the subtypes involved *quantities* of trashy inclusions, with the Type Ib subtype containing a greater amount of burned Anasazi trash than the Type Ia adobes (Toll 1992).

This observation was echoed by Dean in her pollen analysis of comparable soil samples (Dean 1992). Additionally, she observed burned Anasazi organics, including maize and beeweed, in the maroon-colored Type 1 mortar, which is associated with the "black" adobes, though in much lower quantities. This was a bit of a surprise since this mortar's soil source was expected to be any one of a number of naturally-occurring, non-cultural maroon-colored soil deposits in Pecos National Historical Park.

In 1993 the flotation and pollen sample collection was expanded to include all the "red" types. Toll's (1994) analysis of the flotation samples generally confirmed our theory that the "red" adobes were pulled from non-cultural, or non-midden, sediment sources. With the exception of those from one room, all "red" samples contained only *unburned remains*, including pigweed, goosefoot, seepweed, purslane, and groundcherry seeds, all of which occur in the vicinity of the church-convento complex.

Toll noted a similarity between Type 1 and Type 4 mortars, the mortars associated with Type I and Type IIa adobes. Both samples had comparable amounts of unburned remains indicating that they might be related compositionally (Toll 1994). This supported our theory that the time gap may be quite narrow between the last use of "black" adobes and the first use of "red" adobes, as represented by these abutting mortar types.

Twenty-seven pollen samples, of all adobe and mortar types, were analyzed by Suzanne Fish, University of Arizona. To our surprise she found *no* pollen from crops of Old World origin in any soil sample from the convento. This included the recycled Type IIc adobes, dating from the period of Reconquest (A.D. 1694) seventy years after the initial occupation of Pecos by the Spanish. Fish found this unusual, because Old World crops and weeds probably were well established at the mission by the time of the Reconquest (Fish 1994).

This observation might support our contention that Type IId adobes were recycled Type IIa adobes. If the Type IIa adobes were made in the earliest years of the Spanish occupation, before the full introduction of Old World crops, this might explain the absence of Spanish cultigens in adobes re-manufactured in A.D. 1694, though some contamination would be expected during the process of reformulating the adobe bricks and the creation of fresh mortar.

Perhaps these Type IId adobes were mined from another sediment source altogether, one buried deep enough to be clean of Old World pollen. Fish considered this possibility, but rejected it. In her view, the presence of Anasazi cultigens in *every* soil sample, including Adobe Type IId, suggested a preference for near-surface rather than older, more deeply buried soil as raw sources of adobe and mortar materials (Fish 1994).

Both Toll and Fish noted the significant difference between the organic content of convento adobes and those used in the construction of the final church. The primary difference was the heavy abundance of Old World domesticates in the adobes of the church. Toll noted that the church was the only location, among all samples submitted, that indicated the presence of crop plants introduced by the Spanish (Toll 1994). The presence of wheat, and other domesticates, completely segregates Type III adobe from any other type found at Pecos.

In summary, the flotation and pollen analyses strongly confirmed our typological scheme at Pecos. With the addition of a flotation sample from Lost Church, Toll concluded her final report with the observation that the samples had successfully discerned distinctive physical attributes of building materials from various construction episodes at Pecos. She wrote:

The earliest building episode at Pecos . . . is characterized by yellow bricks with very few carbonized inclusions. . . . Black bricks of the second church and convento . . . show many signs of their Pueblo midden origin. . . . Red bricks of the later seventeenth-century third church and convento remodelings have few carbonized materials and an abbreviated list of unburned materials. The fourth church . . . stands out with highly diverse and abundant vegetal material, combining both economic and ambient sources. (Toll 1995)

In 1994 we decided to further test our hypotheses by submitting brick and mortar samples to petrographic analysis. This analysis, conducted by Maury Morgenstein, GeoSciences, Inc., Las Vegas, Nevada, included geochemical and X-ray diffraction tests. Our goal was to explore the possibility of establishing a mineralogical fingerprint for each adobe and mortar subtype that might allow us to track them through the convento, or to nearby colonial structures.

Fourteen "black" adobe samples, collected from the convento and adjacent Spanish colonial structures, were sent to the laboratory for analysis. Ac-

cording to Morgenstein, of all the tests performed on the samples, geochemical and bulk grain size analyses proved to be the two best fingerprinting methods investigated that provided a clear typology for the samples (Morgenstein 1995).

In nine geochemical element plot graphs, clear patterns of segregation within adobe and mortar types were evident. Additionally, certain structures, such as Square Ruin and Lost Church, could be delineated in the graphs. In other words, the establishment of a typology based on the constituent mineralogical elements of adobe and mortar soils appears to be possible.

While this type of analysis is preliminary it does hold promise for further investigation. Morgenstein (personal communication) suggests that since the test fingerprinting worked well with the geochemistry and grain size analyses, a full typology based on these two techniques can be done if we use a large suite of samples and run both techniques on each sample.

APPLICATIONS OF THE TYPOLOGY

The adobe typology has proven to be a useful investigative tool for dating convento walls and adjacent adobe structures. The convento's south wall of Passage 1, for example, was identified by previous researchers simply as "red" (Nordby and others 1975). But which "red?" Did it belong to pre- or post-Revolt construction? We took a closer look in 1994, and based on our new typology, after sixty seconds of removing stabilized materials, we were able to date the wall. The mortar was shot through with white plaster bits, identifying it as Mortar Type 6; the bricks contained plaster bits as well, identifying them as Adobe Type IId. Thus the wall, according to the typology/chronology association, was constructed in the A.D. 1694-1705 period, as Ivey had expected.

This process was repeated throughout the church-convento complex, each time with corroborating results. One wall in the convento was particularly illustrative: it held four courses of "red" Type IIa adobes (A.D. 1660 roughly) set above eight courses of "black" adobe (A.D. 1625), both of which had been cut through by a door which, at a later date, had been filled in with Type IId adobes and Type 6 mortar (approximately A.D. 1694). Thus all three major construction episodes in the convento were represented in this one wall.

The typology proved useful in dating a number of contemporaneous adobe structures in the vicinity. The date and function of Square Ruin, across Glorieta Creek from the Pecos church-convento complex, had eluded researchers for over a century (Bandelier 1881, Nordby and Cruetz 1993). Most estimates for the date of its use fell in the eighteenth century. A quick look at its adobe in 1994, however, revealed "black" adobes, which sug-

gested to us that it belonged in the A.D. 1620-1640 era of construction activity at the mission. Geochemical analysis of the adobe indicated that convento "black" adobe and Square Ruin "black" adobe had similar compositions.

The application of our adobe typology at Square Ruin, however, exposes a weakness in the strategy at Pecos. The current typology does not adequately address the issue of adobe re-use. On occasion new walls were constructed of old materials; for example, "black" bricks (1620s) may have been reused to build a wall in the 1700s. Visual or compositional identification of adobe bricks in reuse walls could be misleading. Mortar, on the other hand, was generally *not* reused, mostly because fresh mortar gives a structure additional strength. We hope, as the documentation strategy is refined through more soil analyses, the fingerprinting of mortar types will allow us to date walls built of reused adobes.

Strong confirmation of the typology/chronology association came in 1994 when we reopened a portion of the convento's "cellar," which was originally excavated in 1967 and subsequently backfilled. This room, containing stairs, is a subterranean plastered adobe brick structure, which Hayes (n.d.) had described as being constructed of "red" adobe. The question was: which "red?"

We thought this would be a good test case for the typology/chronology association. We expected the construction date to fall before A.D. 1680, mostly for historical reasons (Ivey, personal communication). If we saw bits of white plaster in the mortar, indicating the presence of Mortar Type 6 (A.D. 1694), then the room's theoretical date of construction would need to be revised.

As it turned out, the room held a number of surprises. Not only was it constructed with Type IIa adobes, which put its date of construction prior to A.D. 1680, the "red" adobes in the room's floor were observed to have "black" brick dimensions. Evidently "red" soil was poured into the same size wooden forms used to build the earliest portions of the convento. This suggested an earlier date of construction of the floor, perhaps as early as A.D. 1640. The dimensions of the adobes in the walls and stairs conformed to the Type IIa standard, suggesting that there were two distinct phases of "red" construction within that subtype.

More significant was the discovery of a massive fireplace in the room. The architectural implications of a large fireplace in a small subterranean room aside, the possible confirmation of our dating estimates by the archaeomagnetic technique was tantalizing. In August of 1994 two sets of samples were collected from a nearly ceramicized adobe in the back wall of the fireplace. The samples were sent to Jeff Eighmy of Colorado State University for analysis.

The estimated date range provided to him was A.D. 1640-1660. This

range was based on the typology of the brick sampled, Adobe Type IIa, and the suggestion, from dimensions of the floor adobes, of an earlier, rather than later, construction date. The subsequent archaeomagnetic analysis verified our estimate. The samples produced a strong magnetic direction and plotted close to the expected A.D. 1640-1660 date range. "It seems to me," wrote Eighmy (1994), "that this sample strongly confirms your assessment of the age for this feature."

CONCLUSIONS

The establishment and refinement of an adobe/mortar typology has significantly improved our understanding of the construction sequence in the church-convento complex at Pecos. The ability to identify and tie specific adobe/mortar combinations to particular periods of time allowed us to map the architectural development of the mission. It also provided a method to date other structures in the Park constructed with similar materials.

The initial classification of adobes and mortars based on visual observations was strongly supported by flotation, pollen, geochemical, and archaeomagnetic analyses, all of which confirmed the basic typology. In addition to providing chronological information, adobe soil is proving to be a high quality source of archaeologically significant data. As analyses expand and are refined, I believe that adobe and mortar will continue to yield important information.

The Pecos case study will have implications for research at other historic sites. Wherever adobe bricks and mortar have been used as construction materials, the potential exists to build a typology and weave it into the site chronology, following the methods detailed here. Visual differentiation coupled with the botanical and mineralogical analyses should reveal a segregation of types, based on varying criteria (soil sources primarily). A correlation of these types to the known documentary history of a site will reveal significant information about architectural sequencing there.

Finally, there is reason to believe that techniques at Pecos could be applied to prehistoric sites as well. The establishment of an adobe typology, based on visual and textual differentiation and supported by flotation, pollen, geochemical, and grain size analyses, might allow an investigator to discern architectural episodes in a prehistoric site, including those constructed with hand-molded, coursed, or rammed adobe soil.

A. V. Kidder, in fact, provides us with a promising example. During his excavation of Forked Lightning Ruin, he observed that the coursed adobe walls of the pueblo contained a variety of adobe types, including "soft red, harder red, charcoal-flecked red, red with many small river pebbles, and very hard gray. Charcoal-flecked red walls were by far the most common" (Kidder 1958:14). This field of investigation might prove very intriguing indeed.

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REFERENCES

- Bandelier, Adolf F.
1881 A Visit to the Aboriginal Ruins in the Valley of the Rio Pecos. In *Papers of the Archaeological Institute of America, American Series*, vol. 1, pp. 35-135. A. Williams and Co., Boston.
- Burton, Jeffrey F.
1992 *San Miguel de Guevavi: the Archeology of an Eighteenth Century Jesuit Mission on the Rim of Christendom*. WACC Publications in Anthropology 57. Western Archeological and Conservation Center, National Park Service, Tucson, Arizona.
- Dean, Glenna
1992 Pollen Analysis of Adobe and Mortar Samples. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.
- Eighmy, Jeff
1994 Archaeomagnetic Lab Report for Samples LA625A-1a and LA625A-1b. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.
- Fish, Suzanne
1994 Pollen results from adobe and mortar of the Pecos mission. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.
- Fratt, Lee, C. Michael Barton, and Kay Simpson
1981 *Tumacacori Excavations 1979/1980: Historical Archeology at Tumacacori National Monument, Arizona*. WACC Publications in Anthropology 17. Western Archeological and Conservation Center, National Park Service, Tucson, Arizona.
- Hayes, Alden C.
n.d. Field notes. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.
1974 *The Four Churches of Pecos*. University of New Mexico Press, Albuquerque, New Mexico.
- Ivey, James
n.d. Money and Design: The Complicated Construction of San Jose de Tumacacori. Ms. on file, Division of History, Intermountain Cultural Resources Center, National Park Service, Santa Fe, New Mexico.
1988 *In the Midst of a Loneliness: The Architectural History of the Salinas Missions*. Southwest Cultural Resources Center Professional Paper 15. National Park Service, Santa Fe, New Mexico.
- Johnson, Douglas A.
1992 Adobe Brick Architecture and Salado Ceramics at Fourmile Ruin. In *Proceedings of the Second Annual Salado Conference*, pp. 121-138. Arizona Archeological Society, Phoenix, Arizona.
- Kessell, John L.
1979 *Kiva, Cross, and Crown*. Dept. of Interior, National Park Service, Washington, D.C.
- Kidder, Alfred Vincent
1958 *Pecos, New Mexico: Archaeological Notes*. Papers of the Robert S. Peabody Foundation for Archaeology 5. Phillips Academy, Andover, Massachusetts.
- Metzger, Todd R.
1990 Prestabilization Documentation of Selected Walls of Convento Rooms 6, 3, 9, 48, and 17. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.

Moquin, Michael

- 1992 From Bis Sa Ani to Picuris: Early Pueblo Adobe Technology of New Mexico and the Southwest. *Traditions: The Adobe Journal* 8:10-27.

Morgenstein, Maury

- 1995 Petrographic, geochemical and X-ray diffraction analysis of adobe and mortar samples, Pecos National Historical Park. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.

Nordby, Larry A., Gary Matlock, and William Cruetz

- 1975 A Stabilization History of Pecos National Monument, 1971-1974. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.

Nordby, Larry A., and William Cruetz

- 1993 Test Excavations at Square Ruin, Pecos National Historical Park, 1982. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.

Stubbs, Stanley A., Bruce T. Ellis, and Alfred Dittert, Jr.

- 1957 Lost Pecos Church. *El Palacio* 64:67-92.

Toll, Mollie

- 1992 Plant parts found in adobe bricks, at the Spanish mission of Pecos, NM. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.
- 1994 Plant parts found in adobe bricks, at an 18th c. Spanish mission, Pecos, NM: II. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.
- 1995 Plant parts found in adobe bricks, at an 18th c. Spanish mission, Pecos, NM: III. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.

White, Joseph Courtney

- 1993 Documentation of original architectural fabric in the Church/Convento complex at Pecos National Historical Park, 1988-1992. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.
- 1994 Documentation of original architectural fabric in the Church/Convento complex at Pecos National Historical Park, 1993. Ms. on file, Pecos National Historical Park, National Park Service, Pecos, New Mexico.