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POLLEN FROM ADOBE BRICK

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ABSTRACT.–Pollen from adobe bricks of the historic Brockman house of Tucson, Arizona, provides clues to the construction history of the building. Seventeen pollen samples were obtained from two separate walls and the mortar joining the bricks of one wall. The cheno-am pollen type is dominant in all samples, and its proportion and concentration are significantly different between the two walls as indicated by chi square contingency tests. Similar differences are seen in high spine Compositae, *Ambrosia* type, Gramineae, Leguminosae, *Pinus* and in the AP:NAP ratio. *Salsola* type pollen was differentiated from other cheno-am pollen in this study. It was present in all adobe brick but it was rare or absent in the clay rich mortar. The variability among three samples from a single adobe brick is not statistically significant. Chi square contingency tests indicate similarity between modern soil (S_2) and the adobe of wall I. The adobe of wall II was distinctly different from the modern soil. Chi square contingency tests also indicate similarity in pollen content of mortar and wall II, and significant differences between pollen content of mortar and wall I. Pollen content in the adobe brick can be interpreted as indicating two building phases for the house. Historic records indicate the earliest construction postdated 1901. Therefore, *Salsola* invasion into the area must predate 1901 based on this pollen evidence.

INTRODUCTION

Pollen analysis has long been used by investigators in an archaeological context throughout the southwest to ascertain: (1) diet (Martin and Sharrock 1964; Kelso 1970, 1976; Bryant 1974), (2) seasonality of site occupation (Kelso 1970), (3) land use (Webb and Solomon 1974), and (4) environmental change (Martin 1963). Recent historic changes in the vegetation of urban Tucson have also been documented using pollen analysis as a tool (Solomon and Hayes 1980). The overall technique has proved valuable for the investigation of past events. This technique can be used to investigate another type of event–that of construction sequence in adobe buildings.

Adobe structures are frequently built in stages. Many times color differences are apparent in the adobe bricks, different types of mortar are used during different building phases, or adjacent walls are not properly joined and wall separation occurs between rooms of different building episodes. These differences are clues to the building sequence of the individual structure.

Adobe construction is common in the arid southwestern United States, as well as in other arid portions of the world. Seventeen samples from the adobe of the historic Brockman house located at 420 East 18th Street in the Armory Park neighborhood of Tucson, Arizona were collected and analyzed for pollen content. Most of the homes in this neighborhood were built for families of railroad workers around the turn of the century. Many are made of fired brick; a few are made of mud adobe brick. Twelve of these samples were taken from 10 different adobe bricks. The other five samples were taken from mud mortar. This study was performed to determine: (1) if pollen is preserved in adobe, (2) if different source areas for raw materials or periods of building are reflected in the pollen content of the adobe, (3) the variability of pollen content within a single brick, (4) if the season of construction can be determined from the pollen content of the adobe. Although it was not one of the goals of this study, the pollen data obtained provided information regarding the appearance and spread of a plant species introduced to the United States in historic time.

HISTORY OF ADOBE AND ADOBE RESEARCH IN THE SOUTHWEST

Use of adobe in construction is varied. Judd (1916) reports that it was used as a mortar between stones, as a plaster over wood and as massive *in situ* mud wall construction (caliche) before the Spanish ventured into the Southwest in 1540 A.D. Evidence for prehistoric construction using adobe brick is rare but not unknown. Morris (1944) reports one prehistoric experiment in the use of mud "bricks" near Aztec, New Mexico. These bricks fractured because no straw or organic matter were added to them; this lack resulted in shrinkage during the drying process. The resulting broken and whole bricks of variable sizes were used to build the walls of a kiva. The building could not have predated 1097 A.D. according to tree ring dates obtained from wood taken out of the ruins of the kiva. Pottery associated with the building and correlated with tree ring dates from other sites supports a date of 1110-1121 A.D.

An adobe brick wall was also found in an upper Gila pueblo. At this site true rectangular bricks were used. They were placed in the wall while still partially wet and as a result each brick is fused to the bricks adjacent to it. Danson (1957:84) states, "This is one of the few recorded finds of bricks used in a prehistoric dwelling in the Southwest."

The Spanish used adobe bricks in construction of their numerous missions. Use of adobe brick spread rapidly, and in 1879 when Anita Rose visited Tucson she was both impressed and shocked by the "gloomy adobe" buildings. She described the adobe as an " . . . ad-mixture of mud and water with a little cut straw, mixed and molded in wooden frames, brick shaped but more oblong, say 1 x 1½ feet and 4 inches thick" (Rose 1879: 23). She further relates that "They (adobe bricks) are laid as bricks and plastered with a similar substance barring the straw and burned by the sun." Many early adobe bricks were made at the site of construction from the surface soils. Another source of adobe brick was the commercial brickyard. Newspaper accounts from the period tell of contracts for making adobe brick being awarded to Lord and Williams (Arizona Weekly Citizen 1873, Oct. 4 and 11). The 1881 city directory (Barter 1881) records two brickyards in Tucson, one was at Silver Lake and the other was probably at or near Warner's Mill. Both were west of town in the floodplain of the Santa Cruz River.

Studies conducted earlier in the century (Hendry and Kelly 1925; Hendry 1931) utilized adobe bricks as a source of macrofossils to determine the time of introduction of agricultural plants and exotic weedy species into Arizona, California, and Sonora, Mexico. Adobe bricks were obtained from old buildings and missions, dissolved in water and the macrofossils were identified. Montgomery et al. (1949:138) reported that Volney Jones identified the " . . . fibrous reinforcements contained in the adobe bricks" from the 17th century Spanish mission at Awatovi in northeastern Arizona. Studies conducted on adobe brick thus far have centered on the study of plant macrofossils. This study examines microfossils (pollen) contained in adobe.

METHODS

Modern construction techniques serve as the basis for the sampling scheme employed in this study. In Tucson, modern adobe brick is made from a mud mixture poured into wooden forms and sun dried. Then the forms are removed, and the bricks are stacked on pallets. Bricks from the same mud lot generally end up on the same pallet, and they are generally delivered to the same construction site. Hoddies carry mortar and bricks to the mason. Hoddies usually empty the pallets one at a time and removed them from the site. Modern adobe walls are generally built in horizontal tiers, with bricks from one lot in the same tier. Assuming that the same construction techniques were used at the turn of the century, historic adobe bricks separated vertically are more likely to represent different lots. Consequently, historic adobe samples from a vertical sequence were collected to maximize differences in the source of the bricks.

Pollen samples were collected from ten adobe bricks in two different walls which appear visually distinct (Fig. 1). Color differences occur in the adobe bricks and composition differences occur in the mortar. Mrs. Elsa Hanna Wright (nee Borckman), the former owner, recalled her mother saying one room of the house was older than the others. Thus, the interview supports a conclusion of two phases of building construction as employed by the visual differences in the building materials.

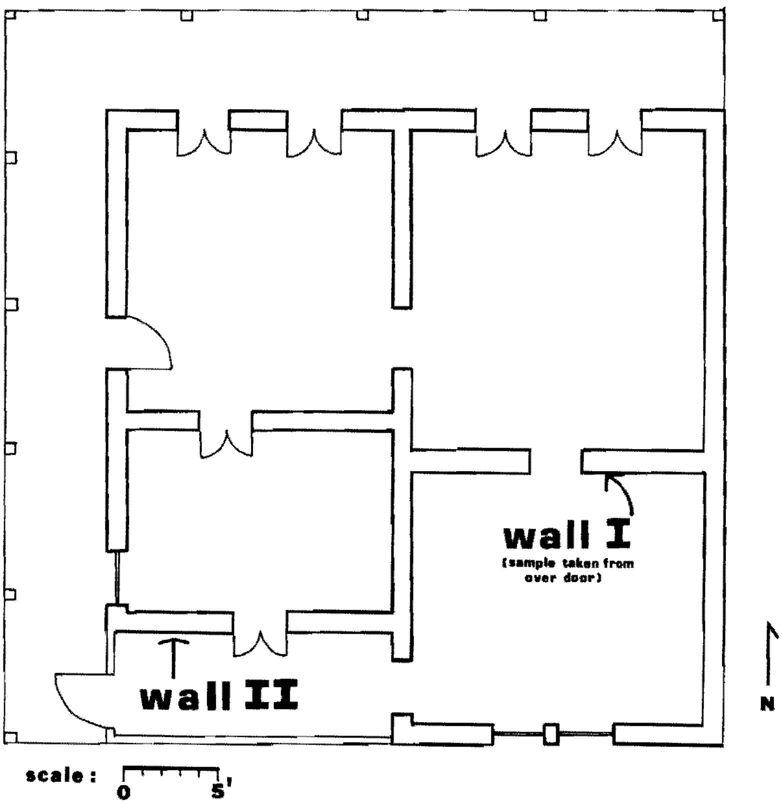

FIG. 1–Floor plan of the Brockman House, Tucson, Arizona and locations where pollen samples were collected.

Adobe bricks exposed during building repair were wetted and their surfaces were scraped to eliminate surface contamination by modern airborne pollen. Subsequently, samples were collected by chiseling about 30 g of material from each adobe brick or mortar seam (see Fig. 1 for sample location.) Three samples were taken from a single brick exposed in a doorway of wall II to test for homogeneity. For comparative purposes, a modern soil sample was obtained from an adjacent vacant lot and collected using the pinch method described by Adam and Mehringer (1975). All samples were collected during the month of January 1981 thus minimizing potential contamination from flowering plants.

Known quantities of *Eucalyptus* sp. (eucalypt) pollen were added to each sample as a tracer for quantitative analysis (Stockmarr 1971). *Lycopodium* spores might prove a better tracer for future use because several species of *Eucalyptus* are planted as ornamental trees in Tucson. Only a few *Eucalyptus* trees currently grow in the neighborhood and both were planted long after 1910. Rogers (1979) discusses cultivated plants commonly used in Tucson during its early history and no mention is made of *Eucalyptus*. He also states that most exotic landscape plants arrived in Tucson after 1920. Modern airborne data (Solomon and Hayes 1972) reflect some *Eucalyptus* pollen in the area of the Tucson Clinic, but that is a local effect (O'Rourke 1980) of trees planted in the neighborhood during the 1930's and 40's. Other airborne pollen studies conducted in neighborhoods with few *Eucalyptus* trees show no more than 20 *Eucalyptus* grains captured by volumetric sampling for the entire year (O'Rourke, unpubl.). Although *Eucalyptus* is not the best tracer, it is certainly adequate, especially for samples from the Tucson area predating 1920. Pollen was extracted from all samples using the HC1 swirl and standard chemical techniques including treatment with HF, HNO_3, and KOH as described by Mehringer (1967).

Pollen stained with Safranin 0 was mounted on slides in glycerine, examined with a microscope, and minimum counts of 200 grains were obtained for all samples. Routine pollen counts were made scanning at 390 x with occasional identification of difficult grains attempted at 1560 x under oil immersion. *Salsola* (tumbleweed) pollen was separated from other cheno-am [Chenopodiaceae (Goosefoot) and *Amaranthus* (Pigweed)] types primarily on the basis of number and structure of pores, and secondarily on the basis of the wall structure between adjacent pores. At high focus only 9 pores can be seen clearly in *Salsola.* Most *Amaranthus* and many Chenopodiaceae have a larger number of pores visible at high focus. In addition, the pores of *Salsola* are depressed, not annulate, as are those of *Sarcobatus. Salsola* also has elements in each pore. The wall between pores is scabrate having generally fewer elements than most other cheno-am type pollen grains. Based on these characteristics *Salsola* can be separated from the 8 *Amaranthus* spp. and 26 Chenopodiaceae types in the University of Arizona Pollen Reference Collection (Kapp 1969; Martin and Drew 1970).

RESULTS

Pollen-percentage values were calculated for all pollen types and appear with confidence intervals (Maher 1971) for major types in Fig. 2. Samples 1-4 were all obtained from the light colored adobe bricks held by a mud mortar and designated as wall I. These samples were taken from the north wall of the SE room above the door in vertical sequence. Samples 5-9 were obtained from the same location but are from the mud mortar which joined the bricks vertically. Samples 10-14 were obtained from the darker adobe bricks making up the south wall of the southwest room designated as wall II. These bricks were held together by a high lime and sand mortar. Samples 15-17 were all taken from the same brick in wall II and sample 18 is a modern soil surface sample taken from soil adjacent to the house (Fig. 1).

Adobe and mortar samples contain from 67-93% cheno-am pollen type. This is the most prevalent pollen type found in all samples (Fig. 2). The cheno-am type is carried by

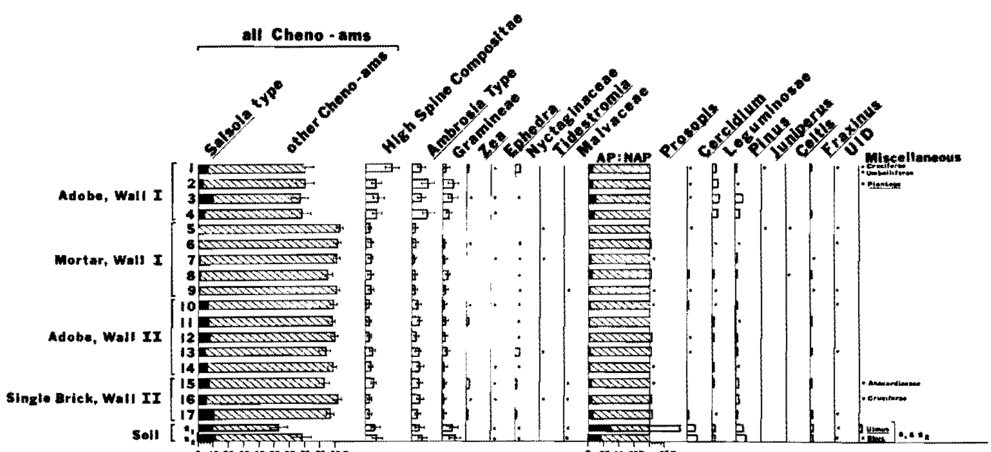

FIG. 2–Relative pollen frequencies and selected 95% confidence intervals for adobe, mortar and soil. Brockman House, Tucson, Arizona.

the wind (Solomon 1979) and resistant to degradation (Hall 1981). High cheno-am concentrations are associated with disturbed soils like those of floodplains (Martin 1963). Confidence intervals associated with cheno-am values from wall I do not overlap with those of any other samples taken from the structure. Cheno-am values for wall I range from 67-70% and are significantly lower than concentrations from the mortar samples (85-93%) and from the samples of wall II (84-90%). *Salsola* is recorded as the black portion of the cheno-am curve in Fig. 2. The adobe samples from both walls have approximately equal amounts of *Salsola* pollen, whereas mortar samples from wall I have appreciably less.

Adobe samples from wall I have higher values of *Ambrosia* (ragweed), high spine Compositae (i.e. *Erigeron,* etc.), Gramineae (grass), and some members of the Leguminosae (pea family, excluding *Acacia, Mimosa, Prosopis* and *Cercidium)* than wall II. *Pinus* (pine) and the AP:NAP (arboreal pollen: nonarboreal pollen) ratio are also slightly higher in adobe samples from wall I.

The lack of overlapping confidence intervals for the principal pollen type (cheno-am) of wall I and wall II suggest different source material for the adobe of the two walls. Mean percentage values for the ten principle pollen types [cheno-am, high spine Compositae, *Ambrosia,* Gramineae, *Ephedra* (mormon tea), Nyctaginaceae (four o'clock family), Leguminosae, *Pinus, Cercidium* (palo verde), and *Fraxinus* (ash)] of each wall were transformed using an arc sine function. A chi square contingency test was used between transformed mean values for the two walls (Sokal and Rohlf 1969). Test results indicate that the pollen content in the adobe of wall I is significantly different (.05 level) from the pollen content in the adobe of wall II.

Mortar samples joining adobe bricks in wall I have cheno-am values that exceed 90% of the total pollen present in 4 of the 5 samples collected. The 95% confidence intervals of cheno-am values from the mortar of wall I overlap with the cheno-am confidence intervals associated with adobe samples from wall II. There is no significant (.05 level) difference within the cheno-am values from the mortar samples and wall II even though the percentages in the wall are lower.

Ambrosia pollen content in the mortar is lower than the *Ambrosia* pollen content found in the adobe of wall II. This in turn is lower than the *Ambrosia* pollen content found in wall I. Pollen content in the mortar of wall I and the adobe of wall II are about the same for high spine Compositae, but pollen values of both taxa are lower than those of the adobe of wall I. The same relationship holds for the Gramineae values.

Pollen types that occur in the adobe and mortar samples in less than 3% include *Zea* (corn), Nyctaginaceae, *Cercidium,* and *Fraxinus.* Pollen from *Ephedra, Plantago* (plantain), Malvaceae (mallow), *Juniperus* (juniper), *Celtis* (hackberry), Anacardiaceae (cashew family), *Tidestromia* (tidestromia), and the Umbelliferae and Cruciferae (carrot and mustard families) are all present in less than 1% in adobe and mortar samples.

Chi square contingency tests were calculated in the same manner as above among the adobe of wall I, wall II, and the mud mortar of wall I. Significant differences (.05 level) exist between wall I and the mud mortar joining wall I.

Samples 15, 16, and 17 were all taken from the same brick in wall II to test the homogeneity of pollen by type and amount. Comparisons among all taxa at the 95% confidence level overlap except the cheno-am values between samples 15 and 16. Chi square contingency tests were calculated in the same manner as above among the three samples. All three values were significant (.05 level) indicating homogeneity among the samples from a single brick.

The modern soil sample at the site shows a significantly (.05 level) lower cheno-am value and higher *Prosopis* (mesquite) value than seen in the adobe samples. This may be due to the influence of locally produced pollen from vegetation growing at or near the site today. Such localized effects of pollen over-representation have long been recognized by palynologists (Tauber 1965; Janssen 1966, 1967; Leuschner and Boehm 1977). Plants growing at or near the Brockman house today include *Prosopis velutina* (velvet mesquite), *Parkinsonia aculeata* (Mexican palo verde), *Fraxinus velutina* (velvet ash), *Ulmus pumila* (Siberian elm), *Rhus lancea* (South African sumac), *Pinus halepensis* (Aleppo pine) and some Gramineae (grasses). Neither *Prosopis velutina* nor *Ulmus pumilia* trees occur in a 1907 photo of the site. Local pollen production varying with time accounts for the presence of *Prosopis* pollen in the modern soil. If *Prosopis* is excluded from the pollen sum, then the cheno-am value returns to 68% of the remaining pollen present (n changes from 259 to 203). Therefore, Fig. 2 has two soil spectra; one includes *Prosopis* in the pollen sum (S_1), the other excludes *Prosopis* from the pollen sum (S_2). No significant (.05 level) differences are seen between the adobe sample from wall I and the pollen spectrum of the soil sample as depicted (S_2). All confidence intervals overlap for major pollen types and chi square analysis conducted as above for 6 major NAP types (Cheno-am, *Ambrosia*, high spine Compositae, Gramineae, *Ephedra*, Nyctaginaceae) indicate a significant similarity (.05 level) between pollen of the modern soil (S_2) and pollen from the adobe of wall I.

Pollen concentrations expressed in grains/gram are illustrated with confidence intervals (Maher 1971) in Fig. 3. Pollen concentration in wall I is relatively low ranging from 3,602 to 4,584 grains/gram. Pollen concentrations obtained from the mortar of wall I and from the adobe of wall II are a great deal more variable and are much higher (28,593 to 151,484 grains/gram). The disparity between pollen concentrations of the two walls again suggest either differences in the source material of the adobe or differences in building episodes.

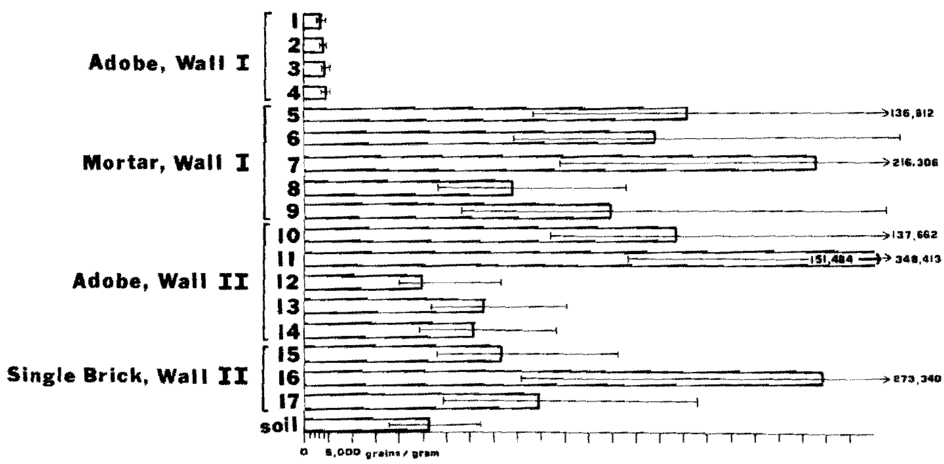

FIG. 3–Pollen concentration in grains/gram for adobe, mortar and soil Brockman House, Tucson, Arizona.

DISCUSSION

The primary purpose of this research was to determine whether adobe bricks contain pollen. Consequently, only a limited number of pollen samples were collected. In these, I found pollen in countable numbers in both adobe brick and mortar. Perhaps the pollen is preserved because the adobe is kept dry (under plaster).

The second goal of this paper was to determine whether different source areas of raw material or different building episodes could be determined using pollen analysis as a tool. These two questions are related. From other evidence at the Brockman house (historic records, interviews, wall separation due to poor wall joints, differences in mortar composition and variability in adobe color and texture) a conclusion of two phases of building construction is probable. The pollen spectra of the two walls investigated adds additional evidence to support such a conclusion. Differences in the pollen spectra are a function of the pollen incorporated in the adobe. If the same sources of raw materials were utilized and combined in the same proportion during each phase of construction, then no differences would be seen among the pollen spectra of the two walls examined. Conversely if different sources of raw materials were selected during a single building phase then the resulting differences in the pollen spectra have a different meaning. As with paleoecologic studies, all evidence must be considered in concert before a conclusion is formulated.

Interpretation of the pollen spectra obtained from adobe brick is complex due to the variety of pollen sources contributing to the pollen spectra of the adobe. To examine the biases inherent in a sample of this type a hypothetical scenario of pollen sources contained in adobe brick is examined. Major pollen sources, in this scenario, include: (1) pollen contained in the soil or alluvium making up the 'mud' of the adobe, (2) pollen adhering to or contained in tempering material like 'straw' or manure added to the mud mixture, (3) pollen contained in the water added to the soil or alluvium to make the 'mud', and (4) atmospheric pollen incorporated in the mud while the wet adobe is mixed and drying. Additional assumptions must be made regarding the proportion of each component to the adobe mixture. Values of 30% tempering material and 5 l of water per adobe brick are probably excessive based on observation of modern adobe mixtures. These numbers provide an upper limit for pollen contributed from these sources.

Studies conducted in southern Arizona demonstrate the prolific occurrence of pollen in samples of surface soil (Hevly et al. 1965; Adam and Mehringer 1975) and alluvial deposits (Martin 1963), but these studies do not contain pollen-concentration values. Soils in the Tucson area have variable pollen concentrations depending on the surrounding vegetation. Pollen concentrations as low as 2,000 grains/g or concentrations as high as several million pollen grains/g soil can occur (O'Rourke, unpubl. data). For the purpose here, soil pollen concentration is 26,000 grains/g; this is the pollen concentration of the modern surface soil at the site today.

Pollen contained in the tempering material is also variable. Reliable pollen concentrations for the amount of Gramineae pollen per gram of plant are not available in the literature. Pollen contained in the manure will reflect the diet of the animal producing the manure (Martin and Sharrock 1964; King 1977). The primary feed of horses and cows is grass obtained either as hay or free range grazing. A single horse dung ball chisseled from an adobe brick in the Tucson Barrio contained 75% Gramineae pollen and 14,400 pollen grains/g dung. The Gramineae pollen in an adobe sample may be a function of pollen content in the manure or pollen adhering to the straw (Tauber 1965). Gramineae inflorescences are also added to the adobe with the straw component. The presence of the *Zea* could be accounted for as a portion of the tempering material, especially since its pollen has a short airborne range (Raynor et al. 1972). This means that the Gramineae (including *Zea)* concentrations probably do not include useful interpretive information.

Pollen contained in surface water could potentially contribute a large amount of pollen to adobe. Martin (1963) reported high concentration of *Pinus* pollen in flood water scum collected in August 1959. Over 4900 pollen grains were counted on a single slide. Solomon and Hayes (1972) indicate peak airborne pollen concentrations for native *Pinus* species in mid-June with low airborne Pinus concentrations persisting through late August in the Tucson area. Pollen input from surface water would vary seasonally, with storm intensity and with storm frequency. Numerous studies in temperate areas report variation in pollen concentration in streamflow (Crowder and Cuddy 1973; Peck 1973; Bonny 1976; Starling and Crowder 1980). The seasonal similarity between flowering plants and pollen content in water is demonstrated by Bonny (1976), and Peck (1973). Inferences drawn from the research conducted by Martin (1963) and Solomon and Hayes

(1972) suggest that this pollen source could contain the greatest potential for revealing time of adobe fabrication. Maximum pollen concentrations obtained by Starling and Crowder (1980) in a temperate region were 600 pollen grains/l water. Pollen concentrations in river water of temperate environments should be much higher than those of the Tucson area. Pollen captured by stream water in temperate environments is generated from a predominantly wind pollinated flora which, due to this mechanism of pollination, will produce larger amounts of pollen than the predominantly insect pollinated flora of the desert southwest (Solomon and Hayes 1980).

Atmospheric pollen incorporated in the adobe mud at the time of mixing will be relatively minimal and will vary seasonally by type and amount. Monthly atmospheric pollen concentrations per cm^2 for urban Tucson from 1954-1970 ranged from a maximum of 400 grains in March to a minimum of 25 grains in the month of December (Solomon and Hayes 1972). This averages about 13 pollen grains/cm^2/day at a maximum and less than 1 pollen grain/cm^2/day at a minimum. Obviously this will not be a major contribution to the pollen contained in adobe brick or mortar.

A single adobe brick from the Brockman house weighed 20.96 kg. Based on the composition assumptions and the pollen concentration values for each source as given above then the brick contains 14,672 g of soil and 6,288 g of temper. Thus, a single adobe brick could contain 381,472,000 pollen grains from the soil, 90,547,200 pollen grains from manure temper, 3,000 pollen grains for 5 l water and 540,000 grains of atmospheric pollen over the entire surface of a drying adobe brick. Each adobe brick will contain 472,562,200 pollen grains per adobe brick. The major pollen contribution to adobe comes from the soil (81%). The temper (manure) component contributes nearly 19% and the remaining pollen (1%) is contributed from the air and water (.1% from air; .0006% from water). Thus, the overall pollen spectra, eliminating the Gramineae and *Zea* curves, will reflect the pollen spectra of the soil component.

Pollen concentration in adobe is variable, and it will be dependent on the components of that adobe as discussed above. Marked variation in pollen concentration may delineate one adobe building episode from others. In this study, adobe of wall I has far lower pollen concentration than adobe of wall II. In addition, the relative concentration of cheno-am type pollen is significantly (.05 level) less in wall I than in wall II. Such a difference is consistent with two phases of building construction, which can also be seen in mortar differences, adobe color changes, structural discontinuity and verbal accounts of prior owners. Because the pollen of the brick is derived chiefly from the soil material, these differences point to adobe obtained from two different source locations.

The third goal of this study relates to methodology. Three samples taken from a single adobe brick reflect essentially the same pollen spectra. Three samples are statistically a small number of replicate samples, but they do suggest homogeneity of pollen distribution within a single brick.

The last goal of the study addresses the question of identifying seasonality from pollen contained in the adobe brick. The scenario discussed earlier demonstrates that seasonal input from airborne or waterborne pollen sources makes up less than 1% of the pollen incorporated in an adobe brick. As a result the likelihood of obtaining reliable seasonal information from the pollen contained in adobe brick is low.

Other information regarding the spread of non-native plants in the southwest is also contained in adobe brick. In this instance plant macrofossils may provide the best information since they can frequently be keyed to the species level. Adobe brick can serve as a time capsule whether for micro- or macrofossils since additional pollen or plants cannot penetrate beyond the surface of the brick once it has dried. Therefore, the pollen or plants contained in the brick cannot postdate the building's construction, and so pollen and plants from the adobe can be indicators of local vegetation at the time of construction. Thus, comparisons between pollen spectra of adobe brick and modern soils may also provide an indication of how man has modified his environment since the period of construction.

Salsola pollen occurs in all adobe brick samples examined but not in all mortar samples. From this data it is safe to assume that the adobe brick used in this house was manufactured after *Salsola* invaded the Tucson area. The earliest known record of *Salsola kali* in Tucson is a specimen collected by J.W. Toumey on July 31, 1892 from a local garden (Univ. of Ariz. Herb. Spec. No. 44358). Historical records indicate the earliest construction of the Brockman house postdates 1901. By this time *Salsola kali* must have occurred commonly to provide pollen percentages comparable with those of modern soil. Future research using pollen in adobe brick may give an idea of the speed with which *Salsola* spread in Tucson.

The scarcity of *Salsola* pollen is the only significant difference between the pollen spectra of the mud mortar joining wall I and the pollen spectra of the adobe of wall II. *Salsola* pollen is in the adobe brick of wall I although much reduced in the mortar which was mixed at the time of construction. This means that although *Salsola* plants were assumed to be prevalent at the time of construction, their pollen was barely present in mortar dating from the period. I propose that the mortar may have quarried from alluvium deposited prior to significant *Salsola* invasion, and that it may have come from a different site than the bricks from the same wall.

The initial goals of this study were more than fulfilled and useful information was obtained to help interpret the history of the Brockman house. The method has potential for use on other buildings in Tucson as an aid in historical research. Future work may also yield additional data on the spread of exotic weedy species like *Salsola*. Studies of this type carried on in other areas must be related to the history and vegetation of that area.

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LITERATURE CITED

ADAM, D.P. and P.J. MEHRINGER, JR. 1975. Modern pollen surface samples: an analysis of subsamples. J. Research, U.S. Geol. Survey 3:733-736.

ARIZONA WEEKLY CITIZEN, 1873. Oct. 4.

ARIZONA WEEKLY CITIZEN, 1873. Oct. 11.

BARTER, G.W. (compiler). 1881. The directory of the city of Tucson for the year 1881. G.W. Barter, H.S. Crocker and Co., San Francisco, p. 114.

BONNY, A.P. 1976. Recruitment of pollen into the seston and sediment of some Lake District lakes. J. Ecology 64:859-887.

BRYANT, V.M. 1974. Prehistoric diet in southwest Texas: the coprolite evidence. Amer. Antiquity 39:407-420.

CROWDER, A.A. and D.G. CUDDY. 1973. Pollen in a small river basin: Wilton Creek, Ontario. Pp. 61-77. Quaternary Plant Ecology. (H.J.B. Birks and R.G. West, eds.). Blackwell, Oxford.

DANSON, E.B. 1957. An archaeological survey of west central New Mexico and east central Arizona. Peabody Mus. Arch. and Ethn. 44(1):1-133. Harvard Univ.

HALL, S.A. 1981. Deteriorated pollen grains and interpretation of Quaternary pollen diagrams. Rev. of Paleobot. and Paly. 32:193-206.

HENDRY, G.W. 1931. The adobe brick as a historical source. Agric. History 5:110-127.

———— and M.P. KELLY. 1925. The plant content of adobe brick. California Hist. Soc. Quar. 4:361-373.

HEVLEY, R.H., P.J. MEHRINGER JR. and H.G. YOCUM. 1965. Modern pollen rain in the Sonoran desert. J. Arizona Acad. Sci. 3:123-135.

JANSSEN, C.R. 1966. Recent pollen spectra from the deciduous and coniferous-deciduous forests of northeastern Minnesota: A study in pollen dispersal. Ecology 47:804-825.

————. 1967. A comparison between recent regional pollen rain and the sub-recent vegetation in four major vegetation types in Minnesota (USA). Rev. of Paleobot. and Paly. 2:331-342.

JUDD, N.M. 1916. The use of adobe in prehistoric dwellings of the southwest. Pp. 241-252; Holmes Anniversary Volume, (F.W.

LITERATURE CITED (continued)

Hodge ed.), J.W. Bryan Press, Washington, D.C.

KAPP, R.O. 1969. How to Know Pollen and Spores. Wm. C. Brown Co., Dubuque, Iowa. 191 pp.

KELSO, G.K. 1970. Hogup Cave, Utah: Comparative pollen analysis of human coprolites and cave fill. Pp. 251-262 in Hogup Cave, (C.M. Aikens, ed.), Univ. Utah Anthrop. Papers 93.

________. 1976. Absolute pollen frequencies applied to the interpretation of human activities in northern Arizona. Unpubl. Ph.D. dissert., Univ. Arizona, Tucson, 170 pp.

KING, F.B. 1977. An evaluation of the pollen content of coprolites as environmental indicators. J. Arizona Acad. Sci. 12:47-52.

LEUSCHNER, R.M. and G. BOEHM. 1977. Individual pollen collector for use of hay-fever patients in comparison with the Burkhard trap. Grana 16:183-186.

MAHER, L.J. Jr. 1971. Nomograms for computing 0.95 confidence limits of pollen data. Rev. of Paleobot. and Paly. 13:85-93.

MARTIN, P.S. 1963. The Last 10,000 Years. Univ. Arizona Press, Tucson. 87 pp.

________ and F.W. SHARROCK. 1964. Pollen analysis of prehistoric feces:A new approach to ethnobotany. Amer. Antiquity 30:168-180.

________ and C.M. DREW. 1970. Additional scanning electron photomicrographs of southwestern pollen grains. J. Arizona Acad. Sci. 6:140-161.

MEHRINGER, P.J. Jr. 1967. Pollen analysis of Tule Springs, Nevada. Nevada State Mus. Anthrop. Papers 13:130-200.

MONTGOMERY, R.G., W. SMITH and J.O. BREW. 1949. Franciscan Awatovi. Peabody Mus. Amer. Arche. and Ethn., 36:1-336. Harvard Univ.

MORRIS, E.H. 1944. Adobe bricks in a pre-Spanish wall near Aztec, New Mexico. Amer. Antiquity 9:434-438.

O'ROURKE, M.K. 1980. Pollen dispersal and its relationship to respiratory disease. Pp. 81-88 in Proc. 1st Intern'l. Conf. on Aerobiology, Federal Environmental Agency (ed.), Federal Republic of Germany, Erich Schmidt, Berlin.

PECK, R.M. 1973. Pollen budget studies in a small Yorkshire catchment. Pp. 43-68, in, Quaternary Plant Ecology (H.J.B. Birks and R.G. West, eds.). Blackwell, Oxford.

RAYNOR, G.S., E.C. OGDEN and J.V. HAYES 1972. Dispersion and deposition of corn pollen from experimental sources. Agron. J. 64:420-427.

ROGERS, W. 1979. Looking backward to cope with water shorages . . . A history of native plants in southern Arizona. Landscape Archit. 69:304-314.

ROSE, A. 1879. "Glimpse of border life in Arizona." Correspondence with the newspaper Enterprise, Nevada, Ohio, April 17, 1879. Transc. for the Arizona Hist. Soc., Tucson, by Mrs. George Kitt.

SOKAL, R.R. and F.J. ROHLF. 1969. Biometry: The Principles and Practice of Statistics in Biological Research. W.H. Freeman & Co., San Francisco, California. 776 pp.

SOLOMON, A.M. 1979. Sources and characteristics of airborne materials: Factors in the production, release, and viability of biological particles (pollen). In Aerobiology: The Ecological Systems Approach, (R.L. Edmonds ed.). Dowden, Hutchinson and Ross, Inc., Stroudsburg, Pa. 386 pp.

________ and H.D. HAYES. 1972. Desert pollen production I: Qualitative influence of moisture. J. Arizona Acad. Sci. 7:65-74.

________. 1980. Impacts of urban development upon allergenic pollen in a desert city. J. Arid Environ. 3:169-178.

STARLING, R.N. and A. CROWDER. 1980. Pollen in the Salmon River system, Ontario, Canada. Rev. of Paleobot. and Paly. 31:311-334.

STOCKMARR, J. 1971. Tablets with spores used in absolute pollen analysis. Pollen et Spores 13:615-621.

TAUBER, H. 1965. Differential pollen dispersion and the interpretation of pollen diagrams. Geol. Survey of Denmark. II Series, No. 89:34-41.

WEBB, J.L. and A.M. SOLOMON. 1974. Human disturbance in arid lands: Pollen evidence of prehistoric land use. Bull. Ecol. Soc. 55:28.