2002 REPORT ON LLANO GRANDE PALYNOLOGY

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Overview and Caveats

This report describes the outcome of a work of exploration. When it was begun there was no way to predict whether or not sufficient pollen existed in the sampled deposits to support analysis and interpretation. Or, if the quantity of pollen was adequate, whether the quality of recovered palynological data would accommodate traditional forms of palynological studies. The project was therefore designed to deal specifically with those questions and, providing they were answered positively, to then address issues relevant to continuing archaeological studies at Llano Grande and in the Highlands Lake District of Jalisco. It should be explicitly recognized that this effort is a work of *archaeological* pollen analysis because it undertakes study of samples of archaeological site-context deposits and because its general purpose is application of the technology and methodology of palynology to archaeological research. This identification raises certain theoretical and methodological issues not recognized in traditional palynological research, which will be dealt with as they arise in the body of the report. It is also relevant to remind the reader that there are only three forms of archaeological applications of palynological research: to provide information on inter- and intra-site relative chronology, to provide information on vegetation and ecosystem conditions of the past, and to identify human behaviors that induce statistically significant pollen data relationships.

Logistical constraints accommodated study of only forty sediment samples. . While this seems a large number, the fact that pollen analyses deal with populations and subpopulations of pollen assemblages must be considered. The Harris matrix created to express the site's stratigraphy recognizes five construction units, five occupation units and a post occupation unit. If each was equally represented in the population of 40 samples, there would be no more than four, usually three, subpopulations. Should any of the subpopulation samples fail to yield representative data (and there is a 95% probability that two must do so), interpretation of the character of the subpopulations involved would be necessarily biased by data deficiencies. Since, actually, the Harris matrix units could not be and were not equally sampled in the field, biases almost surely exist in the palynological database provided by these forty samples. To some extent these biases could be relieved by increasing the sizes of the pollen assemblages observed in the samples, since confidence intervals surrounding frequency values for members of larger assemblages are narrower, which facilitates comparisons among assemblages. But there is no way to evaluate the representativeness of a single sample of a population or subpopulation, as the standard errors of any statistics it provides cannot be calculated. As it turned out, it was necessary to assume the representativeness of single samples in six of the fifteen palynological subpopulations recognized in this analysis, and to assume that the average value for two samples was representative of another three subpopulations. This sort of database would be rejected as unreliable grounds for support of the types of inferences and conclusions developed in traditional palynological studies. This fact should not be ignored, but it expresses one of the contrasts between a traditional pollen study and an archaeological pollen analysis.

Faced with the problem of a dearth of samples, the traditional palynologist would normally have the option of returning to the sample locus to recover additional samples. If this was not practical, s/he could place the problem in abeyance—recognizing that sooner or later opportunity would arise to sample this same site or a comparable site to obtain sufficient samples to enhance the database. Archaeological sites, however, are not like the benthic, lacustrine, bog or alluvial sites with which palynologists normally deal. Once they have been investigated through excavation, deposits of archaeological site contexts lose integrity, so cannot be resampled. Unexcavated portions of the same deposits can be sampled (if they yet exist), but archaeological deposits are identified on the basis of their archaeological character—that is, on the basis of their artifactual inclusions and their physical and spatial relationships to the other deposits present at the site. These details cannot be securely known until the deposit is excavated. So no two deposits can be confidently identified as "the same" until both have been excavated and have lost their integrity. Also, each archaeological site is unique and must be excavated and analyzed as a suite of unique archaeological contexts. Contemporary sites occupied by culturally comparable populations may share many archaeological characteristics but they cannot be presumed to be essentially comparable manifestations of prior cultural conditions.

Actually, more archaeological research is devoted to identifying how sites are different than how they are similar.

The result is that where palynologists normally reject or ignore portions of their databases that may be unreliable, archaeologists normally do not even assess their databases in such terms. They work with the databases they have managed to recover, assuming them to be interpretable unless positive evidence exists to the contrary. Though this posture would be reprehensible in many scientific disciplines, there is no practical alternative in archaeology. Normal archaeological practice is to make the best of a bad bargain. One outcome of this posture is that the conclusions of archaeological research are more explicitly recognized as models, or testable hypotheses, than the conclusions presented in many disciplines. The conclusions of this and other studies of the pollen records of archaeological sites must also be seen in that light.

Biases were also introduced into the palynological database by logistical constraints on the amount of time available for observing the pollen assemblage of a given sample. In practical terms, this meant larger numbers of pollen grains could be recorded for some samples than others. Samples in which fewer than 100 pollen grains were observed make up approximately one-third of the database. Pollen counts smaller than 200 pollen grains are generally considered inadequate in archaeological pollen studies, but this research presents evidence to suggest a different standard is applicable at Llano Grande. Using the 500-grains/cc^3 standard, only one quarter of the samples are arguably too small to accommodate interpretation.

The database is also very slightly biased by the analyst's familiarity with the pollen types observed. Ms. Lavold was able to discriminate and identify 51 botanical taxa in the Llano Grande pollen record, and to isolate another 11 specific pollen types of unknown botanical affiliation. This is an impressive record, considering that a local pollen reference collection has not been made. The frequencies of unknown pollen types are not large enough to have statistically significant affects. However, at least three pollen taxa were identified that should not have been observed. *Corylus* (hazel) *Myrica* (sweet gale) and *Ulmus* (elm) pollen types are produced by species that have probably never existed in the Highlands Lake District or its environs. *Ilex* (holly) and *Sarcobatus* (greasewood) pollen producers would probably be rare if they occurred at all. It is extremely unlikely that their representation in the Llano Grande pollen record reflects the presence of these plants in the area during prehistory, or their introduction to the site through trade or foreign visitors. But each is a highly distinctive, easily recognizable, pollen type that is unlikely to be confused with any other pollen type. For now, their existence in the Llano Grande record must be assessed as a negative bias of extremely minor affect, and totally mysterious cause.

Objectives

When this project was initiated only two previous palynological studies had been undertaken in this region of Mexico. One remains yet a work in progress (Stuart, n.d.) and the other (Stuart, 2000) had provided no useful information on the palynological record directly associated with prehistoric occupation of the Highlands Lake District. This project was therefore designed to explore the potential of palynological study as an aid to understanding the archaeology of sites in this area. In particular, to determine if sufficient pollen could be recovered from site-context deposits to support interpretations; to evaluate the information quality of the pollen record for reconstructing paleoenvironmental conditions; to determine the ways and degrees such data might vary with respect to temporal and spatial parameters; and to identify palynological/cultural data associations suggesting patterns of prehistoric behavior not otherwise clearly interpretable from the archaeological record.

Strategies

A suite of 88 sediment samples were collected during the 2000 field season from the range of deposits encountered as excavation proceeded. The principal purpose of the collection was to provide subsamples for macroremains analysis, phytolith analysis and archaeological pollen analysis. Fiscal constraints limited the number of samples that could be used for the pollen study to 40.

Selection of the 40 samples for pollen work employed the archaeological dictum "work from known to unknown". The most securely understood information available at the time was a Harris matrix of the site's deposits which expressed their provenience and relative depths, and the occupation episode or construction stage episode during which deposition had occurred. Samples were therefore selected from the total range of structures that had been excavated at the site (Structure 1-1, Platforms 14-2, 14-5, 14-6 and the Patio [14-9]), from at least two provenience units (squares) within each structure, and (excepting at Structure 1-1) from at least two distinct depositional episodes. Because field sampling had emphasized some deposits over others, samples of the post occupation and construction stage 5 depositional episodes were more numerous than samples of other depositional episodes among the 40 chosen. Except for occupation episode 4, however, at least one sample included in the series of 40 had been recovered from each occupation and construction stage sampled at Platform 14-6. The post occupation episode, the occupation 5 episode and the construction stage 1 episode are represented by samples from three structures. Thus, though the 40-sample series does not provide ideal numbers of samples, it is adequate to allow reasonable evaluation of spatial and temporal variability in the pollen record.

The strategy employed to extract pollen from the samples was governed by the assumption that the pollen they contained might be poorly preserved. An initial "run" of four samples was therefore given only minimal treatments to remove extraneous inorganic and organic materials. Flotation and acetolysis steps were abjured. When the initial run samples were viewed microscopically, it was clear that further treatment to remove additional silica was warranted, but other steps were not required.

Since there was no basis for predicting the likely number of pollen taxa the samples would contain or the frequencies in which they were likely to occur, some thought had to be devoted to the question of how many pollen grains should be observed in each sample. Pollen analysts often use "200-grain counts" as an adequate rule of thumb because (A) experiments have repeatedly shown that counts of this size are sufficient to provide stable point estimates for population frequency values, and (B) the 95% confidence interval surrounding a 0.0% point estimate argues that the true frequency of such a pollen type in the population is not greater than 1.0%. Thus, with a 200-grain count, failure to observe any pollen of a given sort means that pollen of that type probably occurs at a true frequency of less than 1.0% in the population of pollen grains in the sample. We were concerned, however, that palynological patterns involving true population frequency values between 0.5% and 1.0% might occur with cultural associations suggesting behavioral interpretations. Also, that it might be necessary to discriminate palynological patterns involving frequency values ca. 15% from those of ca. 20%. To narrow the 95% confidence intervals of such statistics, we initially chose to generate 500-grain counts.

The observation/counting strategy involved scanning one 20x20 mm area of a slide to assess the sample's productivity. If it was obvious that 500 or more pollen grains would be observed, a random selection of rows was observed until approximately that number of identifiable pollen grains was recorded. If it was obvious that less than 200 grains would be observed, all the pollen on that slide would be recorded and the sample set aside for further observation at a later time. If it was obvious that 200-500 grains would be observed, all the pollen on that slide would be recorded and the necessary number of additional pollen grains would be observed on a second slide of the sample.

After 30 samples had been dealt with in this way, certain patterns of pollen data became evident. All of the slides that had yielded pollen counts of 100 grains or less were from samples in which pollen concentration values were lower than 500 grains/cc^3. Since such low pollen concentrations are most likey outcomes of natural processes that act to damage and destroy pollen grains, increasing their pollen counts would not provide reliable information anyway. Additional investment in such samples was considered a waste of time and energy. It also became clear that few pollen taxa occurred at frequency values greater than 2.0%, which exceeds the 95% confidence interval surrounding 0.0%, and that it would be unnecessary to discriminate palynological values within approximately five per cent ranges. So counts for samples with higher pollen concentration values did not need to exceed 250 grains.

Pollen concentration values are the widely accepted standard for monitoring pollen preservation, and are required for calculation of absolute pollen frequency values. As an independent monitor of pollen preservation we recorded both the occurrence and the state of "indeterminate pollen"; that is, pollen grains too damaged to allow identification beyond their status as pollen. We recorded three degrees of mechanical damage (broken, crumpled and folded) and three degrees of physiochemical damage (eroded, corroded and thinned).

Results: Data Quality

The pollen concentration value of a sediment sample (grains/cc^3) is widely recognized as an index of pollen preservation. Normal pollen rains on the earth's

Sample Number	Pollen Concentration Grains/cc^3	% Broken	% Crumpled	% Folded	% M.D.*	% Thinned	% Eroded	% Corroded	% C.D.*
69	58,521	2.7	2.8	2.5	7.0	1.3	0.2	1.2	2.7
70	41,150	3.8	2.6	0.5	6.9	0.7	0.2	0.7	1.6
79	39,655	0.9	3.9		4.8			1.3	1.3
84	34,600	1.8	4.1		5.9		1.1	1.6	2.7
1	33,441	1.8	3.2		5.0	0.4		0.4	0.8
71	31,107	3.4	3.1	0.8	7.3	0.8	0.5	1.8	3.1
58	23,323	2.0	1.1		3.1		0.6		0.6
81	22,717	2.7	5.0	0.9	8.6	1.1		1.2	2.3
46	11,961	2.7	2.9		5.6	0.5		0.9	1.4
42	9,705	2.1	1.2		3.8				0.0
2	6,229	1.9	4.5	0.8	7.2	0.1	0.5	1.2	1.8
85	4,713	4.5	4.0	0.5	9.0	1.3	0.5	0.8	2.8
35	4,698	4.7	2.4	0.5	7.5	1.8	0.2	0.2	2.2
59	2,402	1.5	3.8		5.3	0.8		0.4	1.2
76	2,192	7.4	5.9	2.2	15.5	5.1			5.1
27	2,091	2.3	3.7	0.5	6.5		1.4	0.7	2.1
45	1,852	7.0	3.6		10.6	1.4	1.2	1.6	4.2
48	1,100	6.6	4.8	0.3	11.6	0.6	0.2	1.8	2.6
46	1,691	3.8	6.8		10.6	2.0		0.7	2.7
78	1,455	3.9	6.0	0.6	10.5	0.6		2.1	2.7
73	1,176	3.5	1.2	0.3	5.0	0.6		0.3	0.9
26	1,093	3.4	4.4	0.2	8.0				0.0
32	1,086	6.7	4.4	0.4	11.5	1.0		0.4	1.4
86	897	10.4	4.7		15.1	2.8		0.9	3.7
31	759	11.0	13.7		24.7				0.0
41	691	6.8	3.0		9.8	1.2	0.4	1.0	2.6
30	602	8.0	4.0		12.0	6.0		6.0	12.0
50	556	14.4	2.8		17.2		0.5	2.8	3.3
75	522	9.5	6.5		16.0				0.0

77	444	17.9	5.1		23.0	2.6		7.7	10.3
39	443	11.0	3.1		14.2				0.0
87	427	3.7	0.7		4.4		0.7		0.7
56	370	15.8	2.0		17.8		1.0	2.0	3.0
37	261	1.9	0.8		2.7	0.4		0.4	0.8
67	225	7.3	2.4		9.7	2.4			2.4
62	202	14.9	1.4		16.3	1.4			1.4
38	196	2.5	2.5		5.0				0.0
28	163	3.0	5.6	0.4	9.0	0.4		0.8	1.2
61	121	9.3	7.0	2.3	18.6		1.2		1.2

*M.D = Mechanically Damaged Pollen
C.D.= Chemically Damaged Pollen

TABLE I: Frequencies of damaged pollen grains

terrestrial surface amount to hundreds of thousands of grains per cm^2/ year. The pollen rain is winnowed by the myriad of organisms and microorganisms that feed on pollen grains in aerobic environments, by the mechanical damage induced by forces that cause earth particles to break and distort them, by chemical processes that weaken and corrode them, by the stresses induced through repeated wetting and drying, etc. Further, the morphology of some pollen types makes them more resistant to damage than others. As more and more of the original pollen rain population is winnowed, the probability increases that the relative amounts (i.e. the frequencies, or percentages) of different pollen types in the remaining assemblage are distinct from those of the original population. Hall (1981) argues that pollen concentration values below 2000 grains/gm may be so poorly preserved that the frequency values of pollen types do not reliably approximate those that existed in the original population. Sediment samples with pollen concentration values below 2000-1500 grains/cc^3 are thus normally considered "not analyzable" or, more precisely, "not reliably interpretable".

Table I identifies the concentration values and the percentages of damaged pollen in the Llano Grande samples. As expected, samples with higher pollen concentrations tend to show lower average frequencies of mechanically or chemically damaged pollen grains than samples with lower concentrations. Individual samples vary widely, but this is not unexpected because the mix of factors inhibiting pollen preservation is not likely to have affected each provenience and depositional stratum in exactly the same fashion. The average frequency of mechanically and chemically damaged pollen at concentrations greater than 10,000 grains/cc^3 (5.3% and 1.8%) is not much different from the average frequencies of such pollen at concentrations between 10,000 and 4,000 grains/cc^3 (6.9% and 1.4%). Average frequency values for mechanically and chemically damaged pollen are significantly greater at concentrations of 1500-2500 grains/cc^3 (10.0% and 3.0%), as Hall's evidence would lead us to expect. However, the average frequencies of damaged pollen are not significantly greater at pollen concentration values of 1000-1500 grains/cc^3 (8.8% and 1.3%), 500-1000 grains/cc^3 (9.4% and 3.6%), or less than 500 grains/cc^3 (12.1% and 2.1%). At Llano Grande, then, it seems the adverse affect of processes that act to winnow the original pollen rain is no more marked on samples with pollen concentrations around 4,000 grains/cc^3 than on samples with orders of magnitude higher pollen concentrations. The adverse affect of those processes is clear on samples with pollen concentrations below 2500 grains/cc^3. However, the affect is not obviously any greater on samples with pollen concentrations of less than 500 grains/cc^3 than it is on samples with concentrations as high as 2500 grains/cc^3. Use of the 1500-2000 grains/cc^3 standard to identify pollen samples that contain "reliable" pollen data seems inappropriate at this site. The data of samples that contain more than 2500 grains/cc^3 has been significantly less affected by processes that have winnowed the original pollen rain, but only 13 samples are members of that group. It does not automatically follow that the interpretive value of the data of all of the remaining 27 samples is lower. This would only be true if the samples with lower pollen concentration values were less representative of the original pollen rain than the samples with higher concentration values.

This can be tested by comparing the numbers of pollen taxa that occur in samples of different pollen concentrations. Those in which the adverse affects of

Sample Numbers	Range of Pollen/cc^3	N of Taxa	Average% More Durable Taxa *Pinus*	*Quercus*	*Cheno-Am*
69,70,79,84	58,521 - 33,441	14-19	14.3	14.2	5.5
46,58,71,81	27,891 – 11,981	16-21	10.8	15.1	5.5
2,35,42,85	9,705 – 4,195	20-26	11.1	13.2	5.7
27,43,45,48,59,76	2,402 – 1,691	14-24	9.7	16.8	5.4
26,32,73,78	1,262 – 1,086	13-19	6.1	16.6	5.7
30,31,41,50,75,86	897 – 522	8-15	4.7	12.6	6.0
28,37,38,39,56,61 62,77,87	444 – 121	7-14	6.7	14.3	4.1

TABLE II: Reductions in Taxa and Damage to Durable Pollen Types

processes which winnow the original pollen rain are greater should contain fewer taxa, or contain less easily damaged taxa in greater proportions. Table II makes this comparison. It shows that the numbers of identifiable taxa remain between 13 and 26 in samples with concentrations greater than 1000 grains/cc^{3,} but as few as 7 and not more than 15 in samples with lower concentrations. Also that the average frequency values for durable pollen types are not greater in samples with lower pollen concentration values. If anything, they are lower. However only seven pollen taxa consistently occur at frequency values significantly greater than 0.0% (Appendix II), and these occur in all samples. Table II thus suggests that though pollen is significantly better preserved in samples with pollen concentrations greater than 1000 grains/cc^{3}, which is the case for 24 of the 40 sample series, samples with lower pollen concentrations may not be much less representative of the original pollen rain. That is, may be equally reliable sources of interpretable data.

To some degree, however, measuring the quality of the Llano Grande pollen record in either fashion presents a specious perspective. Limiting interpretations to those samples that have not been adversely affected by processes that inhibit pollen preservation, and are therefore more likely to be representative of the original pollen rain, is important in traditional pollen studies because they are normally concerned with paleoenvironmental reconstructions. In archaeological pollen analysis, paleoenvironmental reconstruction may be undertaken on the basis of palynological data but it is neither the most important nor even a necessary research objective. In such cases, data quality may be assumed to be adequate.

Questions regarding the quality of archaeological record information are usually limited to the issue of site or context integrity. Unless positive evidence exists to suggest that the context from which such data has derived was disturbed, its quality is presumed to be adequate as a basis for inferences and conclusions. In part, this is so because archaeological research incorporates methodological controls that have the purpose of recognizing and assessing any positive evidence of disturbance that may exist. But in part it is because sites are defined as loci of human behavior. Unless positive evidence exists to the contrary, it is reasonable to assume that any archaeological record information that exists at a site is a product of the human behavior that occurred there. Far more reasonable than to assume it is not, and demand that its quality must be evaluated on the basis of positive evidence in each and every case. The rule of thumb is that there is a *prior probability* that any archaeological record information recovered from a site is a product of the human behavior that occurred there.

Since most archaeological record information takes the form of artifacts, archaeologists may not recognize that the principle applies equally to archaeological record information that is non-artifactual in character. The depositional strata that define the physical structure of a site, for example, are normally assumed to be products of human behavior until positive evidence exists to the contrary—usually realization that a deposit incorporates no cultural inclusions. The assemblages of botanical macroremains or fossil faunal remains recovered from a site are assumed to exist there as products of human behavior, if positive evidence is not presented to the contrary. Further, such non-artifactual aspects of the archaeological record are presumed to be of sufficient quality to support inferences and conclusions of a cultural character if their contexts retained integrity until excavation. The principle also applies to pollen assemblages.

The evidence developed as part of this project, then, argues that the palynological database from Llano Grande may be assumed adequate to support inferences relevant to all but one of the archaeological objectives of this research. Specifically, only the data provided by samples with pollen concentration values larger than 1000 grains/cc^3 meets a high standard of adequate quality for reconstruction of paleoenvironmental conditions. To best explore the potential of site-context data from this region for reconstruction of changes in paleoecosystem conditions, however, we have accepted the data provided by samples with concentration values above 500 grains/cc^3.

Results: Intra-site Dating

Palynologists cross-correlate temporal variations in the characteristics of pollen assemblages for purposes of relative dating. The process is termed biostratigraphic dating, and applies to any form of plant or animal fossils. When characteristics such as the frequency values of pollen types are used (e.g. those which identify the pollen zones of northwestern European Quaternary pollen sequences, knowledge of environmental conditions which act as limiting factors on the survival of the plants that produce these pollen types allows the variations to be interpreted as functions of climatic changes. The sequence of temporal variations in pollen assemblages, considered as evidence of a corresponding sequence of climatic changes, then allows cross-dating with sequences of other sorts of events responsive to climatic change, such as sequences of geomorphologic events.

Other sorts of sequences, however, may also be recognized from palynological databases, and these are generally more useful for intra-site dating. Since their characteristics have a prior probability of being controlled by human behavior, characteristics of pollen assemblages from site-context deposits may be quite legitimately used in the same ways characteristics of artifacts (also products of human behavior) are used to resolve intra-site dating problems. (A) Where pollen assemblages of different sorts occur in separate stratigraphic sequences at a site, those of the same sort may be cross-dated in the same fashion (and with the same methodological caveats) as assemblages of the same ceramic types; (B) where pollen assemblages of two different sorts have been established to be sequential, pollen frequency variations of the earlier that trend in the direction of such variations in the latter may be seriated, just as one would seriate sequential sorts of assemblages of ceramic types.

In the case of the Llano Grande pollen records, however, consideration of their properties as archaeological records was not required for intra-site dating because pollen concentration values had been calculated and because the

Palyno-Stratum	Concentration Range	Platform 14-6	Platform 14-5	Structure 1-1	Platform 14-2	Patio 14-9
1	10,000 – 60,000	69 70 1 71	84 58	79		81 46
2	4,000 – 10,000	2 35	85	42		~~40~~
3	1,000 – 2,500	73	59		43	
4	500 – 1,000		86			
5	<500		61 87			
6	500 – 1,000		50			
7	<500		62 67 88 56			
8	500 – 1,000	75				
9	1,000 – 2,500	26 76 27				
10	<500	77 37				
11	1,000 – 2,500	78				
12	<500	28 38 39				
13	500 – 1,000	30 31				
14	1,000 – 2,500	32			45	4~~6~~8
15	<500	41				

TABLE VI: Relative Temporal Order of the Samples

a Harris matrix.

Pollen concentration values decrease over the course of time as processes that act to damage and destroy pollen grains continue to occur. While locally distinctive cultural practices may have distinctive effects on pollen preservation in different parts of the same site—even to the point of statistical significance—non-cultural factors clearly have far more impact. Certainly, only non-cultural factors are capable of winnowing pollen concentrations over the course of time by orders of magnitude.

The Harris matrix created for Llano Grande indicates that the most complete stratigraphically organized series of pollen samples was collected from platform 14-6. Table III identifies the frequency values for all of the pollen types observed in these samples, placed in stratigraphic order, and also their pollen concentration values. The frequency values are not tabulated for those samples in which pollen concentrations are less than 500 grains/cc^3 on Table III as they may be a less reliable basis for interpretation. The frequencies for all samples are tabulated in Appendix II. Table III documents that there is no simple trend from higher to lower pollen concentration values as the stratigraphic column is descended—a situation also reflected on Tables IV and V. Rather, pollen concentrations reckoned in the tens of thousands grains/cc^3 fall off to a few samples with 4,000-6,500 grains/cc^3, and concentration values then range from 163 to 2,400 grains/cc^3 from CS4 to the base of the sequence. In the latter group, five samples contain less than 500 grains/cc^3. These do not occur at the deepest, ostensibly oldest, stratigraphic levels, however. Nor do samples that contain 1,000-2,000 grains/cc^3 occur stratigraphically superimposed above all samples containing fewer grains/cc^3. Clearly, gradual winnowing of the original sample pollen concentrations from tens of thousands of grains to less than 200 grains/cc^3 has not occurred with the passage of time. Instead, there seem to have been episodes during which the processes that inhibit pollen preservation have been effective for longer or shorter periods, or have had greater or lesser affect in a given length of time. The result, at both platform 14-6 and the other sampled structures, has been a suite of superimposed palynostratigraphic horizons characterized by samples with less than 500 grains/cc^3, or 500-1,000 grains/cc^3, or 1,000-2,500 grains/cc^3, or 4,000-10,000 grains/cc^3, or more than 10,000 grains/cc^3.

Arraying these palynostratigraphic horizons data against the information on stratigraphic relationships among the samples from different structures produces Table VI. Most of the fifteen palynostratigraphic horizons are not coincident with the construction stage or occupation episodes of the individual structures. Palynostratigraphy thus expands the information of the Harris matrix, suggesting the following intra-site dating relationships:

1. Lot 11 at N8E-8 is actually older than lots 24,23 and 22 at N6E-10.
2. Sample 28 was mislabeled in the field, as there is no lot 21 at N6E-6. It should be relabeled N6E-10/21, as it was deposited in the same palynostratigraphic episode as N8E-8/8.
3. Samples 45 and 48, from platform 14-2 and the patio, cross-date to the same palynostratigraphic horizon as sample 32 from N6E-6/24.

4. Samples 28,38 and 39, from N6E-6/21, N8E-8/8 and N8E-8/9, cross-date, and are younger than samples 30 and 31 (N6E-10/22 and /23). The Harris matrix suggests that sample 39 is older, derived from CS1. Palynostratigraphy suggests its pollen record accumulated during CS2.

5. Sample 78, from N6E-6/11, is younger than samples 28 38 and 39, from N6E-10/21, N8E-8/8 and /9.

6. Samples 26, 76 and 27, from N6E-10/19,N6E-6/8 and N6E-10/20, cross-date. The Harris matrix positions of these samples suggest palynostratigraphic horizon 9 covers the time period during which CS2, occupation 2, CS3, occupation 3, and the early part of CS4 occurred.

7. Sample 75 (N6E-6/7) is younger than sample 27 (N6E-10/20). Its pollen apparently accumulated during the later part of CS4 at platform 14-6, and sample 27's during the earlier part.

8. The samples from N16E-12/5 and /6, and N14E-14/5 and /6, contain pollen records older than that collected from the posthole fill at N14E-16/9. The posthole may have filled after occupation 5 was terminated at platform 14-5.

9. The post occupation deposits sampled at N14E-14/5 (sample 87), N16E-12/5 (sample 61) and N14E-12/4 (sample 86) are older than the post occupation samples analyzed from other structures. Occupation 5, then, was initiated and concluded at platform 14-5 before occupation 5 deposits were initiated at platform 14-2 or 14-6.

10. Sample 73, from N6E-6/5) is older than sample 35 from N6E-8/5.

11. Cross-dating amongst samples 73 (N6E-6/5) and 43 (N0E-36/5) suggests occupation 5 was occurring at platform 14-2 about the time that CS 5 was initiated at platform 14-6. Sample 59 (N16E-12/4) was deposited in post occupation debris at platform 14-5 at this time. Samples 35 (N8E-8/5) and46 (N4E-18/3) also cross-date, but are younger. These records suggest occupation 5 was not coincident on the three platforms. Occupation 5 was concluded first at platform 14-5, then at platform 14-2. CS 5 was initiated at platform 14-6 before occupation 5 at platform 14-2 was concluded, but may not have been finished until after platform 14-2 was abandoned.

12. Post occupation samples 2 and 85, collected at N8E-12/3 and N14E-14/3 from platforms 14-6 and 15-5, cross-date with sample 42 from N20E-2/3. The latter sample was collected from the floor of Structure

1-1. These records suggest structure 1-1 was not occupied until the structures on platforms 14-2, 14-5 and 14-6 lay in ruins.

13. Post occupation deposit samples stratigraphically superimposed on sample 2 at platform 14-6 (N8E-12/3), sample 85 at platform 14-5 (n14E-14/3) and sample 42 in the patio (N4E-18/3) cross-date with sample 79, which was also collected from the floor of Structure 1-1.

Results: Vegetation and Ecosystem Reconstructions

The value of pollen analysis for reconstructing vegetation patterns and ecosystem conditions is widely appreciated by modern archaeologists. What is not well understood, however, are the particular advantages and constraints that distinguish interpretations of palynological records from site-context deposits. Traditional pollen studies involve analyses of the pollen of deposits formed by wholly physical and biological processes, e.g. benthic, lacustrine, fluvial, alluvial, aeolian or bog deposits or the strata of soil profiles. Archaeological sites may be located upon, buried by or incorporate such deposits but are principally composed of deposits that are themselves artifacts (e.g. floors, middens, wall falls) or "natural" deposits that have been transported, churned, burned or otherwise impacted by human behavior.

The archaeological advantage to study of the pollen assemblages from such deposits is that their prior probability of being products of human behavior allows them to be treated as archaeological data. Thus methods for resolving archaeological problems may be used that archaeologists have devised for other categories of artifacts, are accustomed to implementing, and can justify on the basis of anthropological and archaeological theory. The disadvantage is that the methods and theory of traditional forms of pollen study *cannot* be applied to the pollen records of site-context samples unless evidence exists which allows identification of the particular features of such records that are *not* products of human behavior, but are instead products of the physical and biological processes that control the characteristics of pollen records from non-site deposits. Only such features can be considered data for reconstructions of the sorts of processes responsible for the palynological expression of paleoenvironmental conditions, such as vegetation patterns and ecosystem conditions.

The problems of identifying such features are two-fold. First, there is the problem of how one should proceed to make identifications of this sort: where should one look, what should one look for, what logistical parameters will affect the research? Second, there is the theoretical problem imposed by appropriate application of the principle of uniformity. The uniformitarian assumption is a requirement for reconstruction of prior physical and biological events or processes. Since it is not possible to demonstrate the case, one must *assume* that the physical processes that produce a certain geological effect today also operated in the past, or that the genetic structures responsible for a particular biological outcome today were also responsible for that outcome in the past. If one were required to present positive evidence in support of an argument of uniformity in each and every case, reconstructions of past environmental events and conditions could not be achieved through the known methods of science.

The uniformitarian assumption must be rejected, however, when the object is reconstruction of prior culturally-controlled events or processes, and such reconstructions must be based upon arguments supported by positive evidence. Not only must the archaeologist recognize that absence of evidence is not evidence of absence, s/he must recognize that wholly distinctive cultural processes can be responsible for identical archaeological outcomes. Copper pins occur in the archaeological record of the Archaic Stage of New World prehistory and the Chalcolithic Stage of Old World prehistory. The archaeologist must evolve positive evidence to support an argument that reconstructs their occurrence in each case as the outcome of the same cultural process, not assume it to be true.

The result of this distinction is that palynologists who are not well-versed archaeologists tend to apply the uniformitarian assumption to pollen records of site-context deposits to support reconstructions of paleoenvironmental conditions without realizing they are required to have positive evidence to support such usage. Also, that archaeologists who are not well-versed natural historians fail to recognize the power of appropriate application of the principle of uniformity, so propose unlikely reconstructions of biological processes.

While the pollen records of site-context sediment samples are more likely to be artifacts, they are artifacts in the same ways as stone projectile points or middens are artifacts. Some of the features and characteristics of all artifacts are products of human behavior and others are not. The flake scars of a stone projectile point are products of human behavior; the physical properties of the stone itself are not. The inclusions that occur in a midden are products of human behavior; the mineralogy of the sediment particles is not. The trick is to isolate those characteristics of site-context pollen assemblages that are *not* products of human behavior, ad do so on the basis of positive evidence that they are not. Once isolated, these characteristics may identify a database for reconstruction of such things as vegetation patterns and ecosystem conditions.

Isolating the non-behaviorally induced component of site-context pollen assemblages requires use of so-called "control samples" for application of the principle of uniformity. Control sediment samples are recovered from the modern landscape surface at locations where differences in vegetation and degrees of modern human environmental impact can be observed and assessed. Archaeologists do not, on the whole, realize that the numbers of such samples and the quality of the observations involved are directly proportional to the reliability of the vegetation pattern and ecosystem conditions reconstructions they can support.

No control samples were collected as an aspect of the Llano Grande project, but this was neither an oversight nor poor planning because there was no basis for predicting that any of the site-context samples would yield pollen records at all. The only available control samples data from the region is, unfortunately, of minimal value for this project's research objectives. Stuart (n.d.) designed a system for collecting and analyzing surface pollen samples likely to provide controls for the sort of archaeological site-context pollen records he proposed to collect and analyze. Since he anticipated that most of the samples from the lacustrine deposits at the sites he studied would not have an archaeological character, and would reflect vegetation and ecosystem conditions on a basin-wide geographical scale, he collected and analyzed control samples appropriate to those expectations. Specifically, he collected samples that would provide data useful for identifying which of his fossil records were products of agricultural impact, identifying palynological data trends that would allow recognition of climatically-induced basin-wide vegetation changes, and identifying pollen data patterns that control recognition of changes in ecosystem changes in the districts lowlands.

Stuart's data suggest that modern vegetation pattern variations are not well represented in 200-grain count pollen data in this district. Local ecosystem conditions are reflected more clearly, especially the contrast between relatively well watered basin-bottom and less watered upland ecosystems. Relatively more and less disturbed plot conditions, and relatively dense versus relatively open shrub canopy conditions can also be discriminated from the surface sample data of Stuart's research. Discriminations are based upon frequency variations in four pollen types: Asteraceae Hi-spine pollen (generally referable to the Tubuliflorae division of the large Asteraceae family); Asteraceae Lo-spine pollen (generally referable to the Ambrosieae division); Cheno-am pollen (referable to most genera of the Chenopodiaceae family and the genus *Amaranthus* of the Amarantaceae family); and Poaceae (all genera of the large grass family excepting domesticated cereals and the wild relatives of maize). Statistically significant increases in Asteraceae Hi-spine pollen accompany greater or lesser degrees of shrub canopy coverage. Significantly higher or lower frequency values for Asteraceae Lo-spine pollen correlate with degrees of human impact on

Palynostratum	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
N of Samples	9	4	3	1	2	1	4	1	3	2	1	3	2	3	1
N of Observations	4,662	1,442	1,085	211	110	216	679	47	1,225	114	195	166	145	1,526	500
% *Pinus*	13.6	11.8	5.6	4.7		4.2		8.5	7.9		5.4		3.6	6.8	3.4
% Hi-spine	10.3	9.3	13.3	6.6		6.4		2.8	8.9		5.7		9.7	9.4	10.8
% Low-spine	14.9	12.9	13	11.4		10.6		4.9	17.7		29.2		16.9	18.4	11.4
% Cheno-am	4.5	5.5	7	9.5		8.3		4.3	2.8		10.2		4.1	3.4	5.3
% Poaceae	29.3	29.8	21.8	26.1		30.1		29.8	30.1		21.7		21.4	22.5	37.6

TABLE VII: Average frequency values by palynostratigraphic horizon

upland sites, while significantly higher or lower frequency values for Cheno-am pollen correlate with degrees of human impact on lowland sites. Significant change in Poaceae pollen frequencies in the control samples is a palynological index of the differences between lowland and upland ecosystems.

Table VII charts the average frequency values for six pollen types by palynostratigraphic horizon, excepting those horizons identified by concentrations less than 500 pollen grains/cc^3. It will be noted that in a number of instances a palynostratigraphic horizon is represented by only one sample. The average pollen frequency in those cases equals the observed pollen frequency, which may not be as representative of the pollen records of that horizon as an average pollen frequency.

Few patterns of significant variation occur on Table VII over the course of time. *Pinus* pollen values increase significantly in palynostrata 1 and 2, which occur after the occupation of the guachimonton. Lower frequency values for Asteraceae Hi-spine and Asteraceae Lo-spine pollen types are noted for palynostratigraphic horizon 8, but the difference is not statistically significant. The higher frequency of Cheno-am pollen in palynostratigraphic horizon 11 is statistically significant, but it cannot be evaluated as representative of the population of Cheno-am pollen in the original pollen rain, since only a single sample is referable to this palynostratum. Finally, the Poaceae pollen frequency value is significantly higher for palynostratigraphic horizon 16 than the subsequent horizons. Though the single significantly larger samples may not be representative in this regard, we are inclined to accept that statistic at face value.

In our opinion, the variability in Poaceae pollen is best interpreted as indicating a reduction in grass pollen production, the rise in Cheno-am pollen as indicating a relative increase in plants adapted to disturbed soil conditions, and the increased values for *Pinus* pollen as indicating a relative increase in the number of pine trees in the district. Each of these ecosystem condition changes seem likely to be a product of human environmental impact rather than the outcome of purely physical or biological processes. We suggest that the higher *Pinus* pollen frequency values reflect reduced construction and fuel wood harvesting after abandonment of the guachimonton, that the reduction in Poaceae values following the earliest horizon of cultural activity reflects replacement of grasses by cultivated plants in the best arable upland habitats; and that the horizon in which Cheno-am pollen is more frequent reflects the period of peak local human population.

Results: Palynological indices of Local Culture Patterns and Human Behaviors

There are two types of indices of this sort. On the one hand, there are pollen types produced by plants whose life requirements are so closely related to human behavior that their occurrence in pollen records identifies that behavior. Most often, such pollen types are produced by domesticated cultivars. They may also be pollen types produced by plants that disperse their pollen over such small areas that their occurrence in site-context deposits is most reasonably attributed to cultural processes. In the Llano Grande pollen record, the occurrence of *Zea mays* (maize), *Gossypium* (cotton) and *Lagaenaria* (bottle gourd) pollen argues for local production of the latter two, and probably all three, cultivars. *Gossypium* and *Lagaenaria* are insect-pollinated taxa that disperse relatively small quantities of pollen. Experimental studies (Lavold, n.d.) document that *Gossypium* pollen does not accompany the harvested seeds or fiber, and one anticipates very little *Lagaenaria* pollen would cling to the rind of harvested fruit. Maize pollen remains on the foliage, silks and husks of the plant long after the harvest, so its presence could reflect introduction to the site of plants that were cultivated and harvested at some distance. All these pollen types, however, would contaminate the skin, hair and clothing of people cultivating such crops, and then could have been shed at the site if/when they arrived from fields or gardens not many kilometers distant.

A number of the pollen types observed in the Llano Grande record are produced by plants of riparian, shallow water or moist soils habitats: *Salix* (willow), *Populus* (cottonwood), *Juglans* (walnut), *Prosopis* (mesquite), *Polygonum* (dock), *Urtica* (nettle), Cyperaceae (sedge) and *Typha* (cattail). Though none of these pollen types ever occurs in statistically significant frequency in any sample, their ubiquity in the sample series, and their combined frequency in most samples, is far beyond expectations for a locus so geographically distant from habitats of these sorts. Given wetter climatic conditions, *Prosopis*, *Juglans*, *Populus* and even *Salix* populations of the canyons flanking the Llano Grande mesa might have flourished sufficiently that their pollen was dispersed to the site by other means. But the most likely explanation of their ubiquity, and that of the other pollen types, is that they were introduced to the site inadvertently by people who consistently and regularly visited the shorelines of the basin lakes of the district during prehistory. These data are consistent with the inference that some of the people who occupied this site produced crops on nearby wetland fields.

The other type of palynological index of human behavior is the occurrence of statistically significant quantities of pollen types produced by plants that do not introduce such quantities to the "natural" pollen rain. The most reliable means of identifying such types is through analysis of a sufficiently representative number of modern surface control samples. They may also be recognized, however, as statistically significant quantities of pollen produced by plants that disperse very limited amounts of pollen over very limited areas.

Pollen of *Bursera*, produced by species of the genus that includes copal, was recognized in statistically significant quantities in samples 37, 38 and 85. Pollen attributable to the legume family, Fabaceae, which generally has insect-pollinated flowers, occurs in statistically significant quantities in samples 26,27,28,31,38,39,42,43,62,67,69,70,71 and 77. The morphology of this pollen type does not allow identification at the generic level, but it is clearly *not* the pollen type produced by species of huisache (acacia), mesquite or domesticated or wild beans. Laminaceae (mint family) pollen was recovered in statistically significant frequency in samples 30, 37, 50 and 61. We can discern no particular patterned relationship of these occurrences to occupation or construction episodes, and I suspect that most date earlier than palynostratigraphic horizon 6 only because there are more samples from the earlier horizons of the palynostratigraphic sequence. Though we believe it is more likely than not that the occurrence of Fabaceae and Laminaceae pollen in statistically significant quantities is a product of cultural activities, we cannot suggest a testable hypothesis of their nature. We suspect the *Bursera* pollen was introduced as a byproduct of use of copal in ceremonies.

Though they do not occur in statistically significant frequencies in the samples, the ubiquity of Cyperaceae and *Celtis* (hackberry) pollen is noteworthy. Cyperaceae pollen was observed in 30 of the 40 samples. Pollen of *Typha* was observed in only five samples. While both pollen types are produced by plants that shed large amounts of pollen and grow in proximate habitats, neither disperses its pollen widely; most probably finally comes to rest on the foliage of the parent plants. That the sedge pollen is so much more common in the Llano Grande record suggests the pollen was not casually introduced, but rather that the pollen-bearing foliage of sedge plants were brought to the site in significant quantities. We suspect that sedge, not grass, was common thatching material.

Celtis pollen was observed in twelve (30%) of the Llano Grande samples. In contrast, pollen of *Prosopis* and *Juglans*, which probably shared the canyon habitat with *Celtis*, was observed in only five and three samples, respectively. As they are larger trees, so shed more pollen over wider areas, one would expect mesquite and walnut pollen to be more ubiquitous in the original pollen rain. That hackberry pollen occurs so much more commonly, then, is probably a product of cultural activity. Hackberry fruits are small but quite sweet; we suspect they were an important component of highly prized foods.

Summary

The two most significant findings of this study are probably (A) demonstration that interpretable palynological data can be recovered from upland archaeological site-context deposits in the Highland Lake District of Jalisco, and (B) that though 42.5% of the samples exhibit pollen concentration values less than 1000 grains/cc^3, an independent measure of pollen assemblage quality argues that only 25% of the samples have been affected by the processes that damage and destroy pollen to the degree that the data they contain is unreliable.

Another significant finding is that the total pollen concentration values of the samples, taken in consideration of their relative stratigraphic positions and the absolute stratigraphy expressed by the samples' relationships to the site's Harris matrix, allows cross-dating through recognition of a suite of fifteen palynostratigraphic horizons. They suggest (A) that Structure 1-1 was not occupied—possibly not even constructed—until the structures that stood on platforms 14-2, 14-5 and 14-6 were already collapsed in ruins; (B) that occupation 5 at platform 14-2 occurred after occupation 5 had ceased at platform 15-5 but before construction stage 5 was completed at platform 14-6; (C) that three distinct temporal episodes of unknown duration occurred during construction stage 1, another occurred before occupation 2 was initiated, and three more encompass the time prior to occupation 4 at platform 14-6; and (D) Structure 1-1 was occupied through two temporal episodes of unknown duration.

The number of palynostratigraphic horizons/temporal episodes recognized in this report is the *maximum* number that can be supported by available data. Further research is likely to demonstrate that some are not adequately evidenced, while yet others were not sampled.

The pollen record suggests maize, cotton and bottle gourd were cultivated in the site's environs, possibly through wetland agriculture, since the data argue that the site's occupants regularly visited the district's lowland. The record further suggests the occurrence of cultural activities involving a member of the copal genus, one or more members of the legume family (though not huisache, mesquite or beans), and one or more members of the mint family. Use of sedge for thatch and hackberry fruits to sweeten certain dishes is also indicated.

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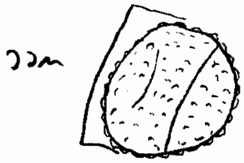
1981 Deteriorated pollen grains and the interpretation of Quaternary pollen diagrams. *Review of Palaeobotany and Palynology* 32:193-206.

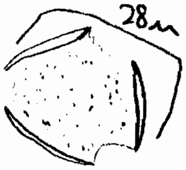
Stuart, Glenn
2000 Archaeological Palynology of Teuchitlan. Report prepared for the Foundation for the Advancement of Mesoamerican Studies, Inc.

Unknown 1 small oblate, tricolpate grain
~22μ, exine 2μ thick

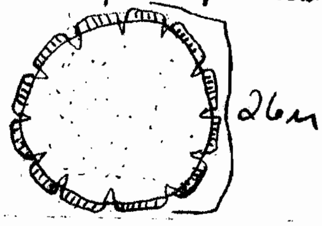


Unknown 2: Small (16μ) oblate, perporate grain
~9 pores - pores small (1½-2μ) non-annulate
exine thick ~3μ + granulate

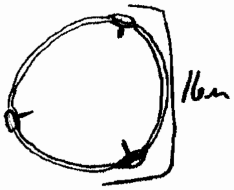
Unkown 3: Tricolpate grain, granular textured exine which thins, next to colpus



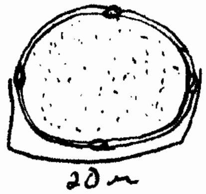
Unknown 4: Stephanocolpate, tectate, 12 colpi, 26μ in diameter



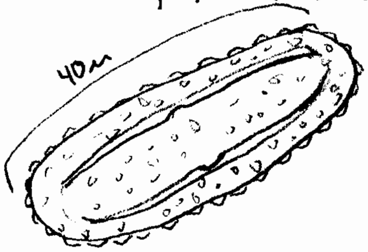
Unknown 5: Small oblate (16μ) tricolporate, very short colpi



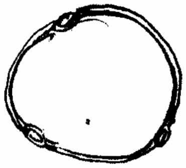
Unknown 6: Tetraporate, granular exine



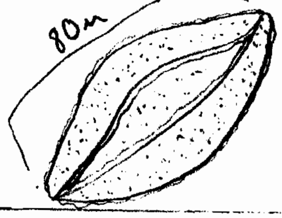
Unknown 7: large prolate verrucate tricolporate



Unknown 8: Psilate, oblate, triporate - pore slightly annulate

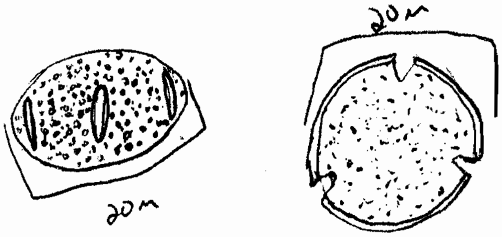


Unknown 9: large Prolate monocolpate, scabrate



Unknown 10: Small (14μ) oblate, tricolpate, scabrate

Unknown 11: Tricolpate - microreticulate, very short colpi



SAMPLE NUMBER	1	2	26	27	28	30	31	32	35	37	38	39	41	42	43	45	46	48	50	56	58	59	61	62	67
	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count
POLLEN TYPE																									
Anacardiaceae		1							1				1												
Apiaceae										1															
Betulaceae, *Alnus*	2		1	1	1			1					1	2			1	2				1			
Burseraceae, *Bursera*								1		2	1							1							
Corylaceae, *Corylus*			1						1																
Cupressaceae																									
Pinaceae, *Pinus*	42	48	28	42	2	2	3	20	47	1	3	5	17	52	14	56	42	27	9	7	100	24	3	3	3
Fabaceae	4	7	11	13	1		5	7	2		1	2	3	7	8	5	8	8	2	1	7	4		2	2
Fabaceae, *Dalea*																	2		z						
Fabaceae, *Erythrina*															2										
Fabaceae, *Parkinsonia*																		1						1	
Fabaceae, *Prosopis*	1													1											
Fagaceae, *Quercus*	54	51	86	64	5	7	19	99	61	4	2	8	48	62	39	80	74	56	24	14	145	58	13	16	7
Myricaceae, *Myrica*				1																	1				
Rosaceae																			3						
Myrtaceae		2						2					2	1			1								
Saliaceae, *Populus*		1		1														1							
Saliaceae, *Salix*		1		1									1	1			1	1	1		1				
Sapindaceae				3					2				1					1				1			
Sapotaceae	1							1					1	1							2				
TCT	4	10	2	3				1	14				6	4	1	6		1	1	1	4	2		1	
Ulmaceae, *Celtis*		1	1	2								1	2	2								2			
Ulmaceae, *Ulmus*					1																				
Amaryllidaceae													1	1		1		1				1			
Aquifoliaceae, *Ilex*								1				1	3			1		1							
Apocynaceae																									
Asteraceae, Hi-spine	19	62	51	58	3	6	7	43	55	6	6	5	54	22	27	32	68	68	15	2	33	26	3	4	5
Asteraceae, Low-spine	41	63	90	116	6	10	13	118	78	4	2	19	57	34	88	104	88	110	23	14	65	49	4	7	6
Brassicaceae																1		1							
Boraginaceae, *Cordia*																									1
Cheno-Am	10	33	9	30		2	4	10	35			3	29	11	14	18	24	24	18	4	30	20	1	7	1
Chenopodiaceae, *Sarcobatus*													1												
Convolvulaceae				1												1									
Convolvulaceae, *Ipomea*		1		2																					
Lamiaceae		2	4	10		1		3	1	1		1	8			6	5	4	5	1	4	2	1	1	2
Liliaceae		2											2		1	1						3			
Malvaceae, periporate		4		3					4			1	2					3							
Malvaceae, triporate			1					1								1		3							
Nyctaginaceae				1								1													
Poaceae x<40	76	212	194	153	10	10	22	136	207	12	6	33	186	62	51	105	195	100	63	21	121	74	9	17	7
Poaceae 40<x<60	1	4	1	1				1	2				2	1		2			2						
Polygalaceae		2		1												1	1					1			
Polygonaceae, *Polygonum*																									1
Typhaceae, Angustifolia type				1					1			1			1										
Urticaceae, *Urtica*	1	1	3			1		4	3				1	3	1	2	2	4			3	1			
Cucurbitaceae, cf *Lagaenaria*																									
Juglandaceae, *Juglans*														1			1							1	
Solanaceae		3		1				3	3				1	1	3	2	2	4	2		4	1		1	1
Cyperaceae	1	3	1				1	3	9	1		1	3	2	4	2	2	4		1	2	1			
Malvaceae, *Gossypium*									1				1			1			2						
Zea (Poaceae>60)				1					2				1	1							3				
Unknown	1	5	0	4	1	0	0	2	4	0	1	0	4	1	0	3	4	4	2	1	1	1	0	0	0
Indeterminates	16	58	42	49	14	11	21	67	51	5	5	13	62	11	39	70	39	71	44	24	20	12	9	13.0	5.0
Total	274	576	526	563	44	50	95	524	583	36	27	95	500	284	293	501	560	501	216	91	546	284	43	74	41
Lycopodium observed	7	79	411	130	231	71	107	412	106	118	118	183	618	25	148	231	40	389	332	210	20	101	303	313	156
Total Indeterminates	16	58	42	49	14	11	21	67	51	5	5	13	62	11	39	70	39	71	44	24	20	17	9	13	5
broken	5	11	18	13	7	4	8	35	27	2	5	10	34	6	11	35	15	33	31	19	11	4	4	11	3
crumpled	9	26	23	21	3	2	13	23	14			3	15	5	20	18	16	24	6	2	6	10	3	1	1
folded		5	1	3	1			2	3									1					1		
thinned	1	6			1	3		5	5	1			6		6	7	3	3				2		1	1
eroded		3		8					1				2			6		1	1	1	3				
corroded	1	7		4	2	3		2	1	2			5		2	4	5	9	6	2		1	1		
Unknowns																									
Unk 1																									
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Unk 11																									

TABLE OF OBSERVATIONS

								occ surf	occ surf						occ surf
SAMPLE NUMBER	69	70	71	73	75	76	77	78	79	81	84	85	86	87	88
	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	raw count	
POLLEN TYPE															
Anacardiaceae									1	4				1	
Apiaceae															
Betulaceae, *Alnus*			5	1		1			1	1		1	1		
Burseraceae, *Bursera*			1									30	3		
Corylaceae, *Corylus*	1											1			
Cupressaceae															
Pinaceae, *Pinus*	91	73	58	33	18	15	2	4	80	46	80	58	10	10	
Fabaceae	15	12	14	6	9	1			9	9	7	9	2	2	
Fabaceae, *Dalea*					1										
Fabaceae, *Erythrina*															
Fabaceae, *Parkinsonia*	2					1							4		
Fabaceae, *Prosopis*	1														
Fagaceae, *Quercus*	51	54	65	78	27	16	7	4	118	59	70	71	26	9	
Myricaceae, *Myrica*		1	1									1			
Rosaceae										1		1			
Myrtaceae									1			1	1		
Saliaceae, *Populus*															
Saliaceae, *Salix*	1							1	1			1			
Sapindaceae	2	2													
Sapotaceae									3		2				
TCT	2	5	9	3	2				7	13	4	10	1		
Ulmaceae, *Celtis*	1	2	3		1					4					
Ulmaceae, *Ulmus*															
Amaryllidaceae								1				1			
Aquifoliaceae, *Ilex*												2			
Apocynaceae										1	1				
Asteraceae, Hi-spine	64	71	80	34	19	9	10	6	39	58	47	40	14	9	
Asteraceae, Low-spine	79	83	78	47	98	21	12	7	73	71	83	94	24	12	
Brassicaceae		1													
Boraginaceae, *Cordia*															
Cheno-Am	38	35	42	31	34	2	5	2	35	31	30	39	20	7	
Chenopodiaceae, *Sarcobatus*															
Convolvulaceae									1						
Convolvulaceae, *Ipomea*															
Lamiaceae		1	2	3		2				1		1			
Liliaceae			3	1		1			3	5	2	1	1		
Malvaceae, periporate	2	1	2			1				1	1	1			
Malvaceae, triporate				1											
Nyctaginaceae					1									1	
Poaceae x<40	168	171	172	74	72	35	12	14	133	207	170	148	55	9	
Poaceae 40<x<60	3	2	2						4	2	6				
Polygalaceae												1			
Polygonaceae, *Polygonum*															
Typhaceae, Angustifolia type									2						
Urticaceae, *Urtica*	4	4	3		3	1	1		1	2	6	5			
Cucurbitaceae, cf *Lagaenaria*												1			
Juglandaceae, *Juglans*												1			
Solanaceae	1	1	5		1		1	1		3		1	3		
Cyperaceae	1	4	7	7		2	1			5	1	12	5		
Malvaceae, *Gossypium*				1											
Zea (Poaceae>60)		1							1	1					
Unknown	9	5	3	0	2	0	1	0	11	1	9	8	1	1	
Indeterminates	64	49	64	20	44	28	26	7	34	63	48	71	40	7	
Total	600	578	619	340	332	136	78	47	557	585	567	611	211	67	
Lycopodium observed	8	12	17	247	195	53	150	77	12	22	14	111	201	134	
Total Indeterminates	64	49	64	20	44	28	26	7	34	63	48	71	40	7	
broken	16	22	21	12	13	10	14	4	5	16	10	27	22	5	
crumpled	17	15	19	4	20	8	4	3	22	29	23	25	10	1	
folded	15	3	5	1	2	3				5		3			
thinned	8	4	5	2	2	7	2			6		8	6	1	
eroded	1	1	3								6	3			
corroded	7	4	11	1	7		6		7	7	9	5	2		
Unknowns															
Unk 1												4			
Unk 2	2								2						
Unk 3									2		2				
Unk 4	3								2						
Unk 5									1						
Unk 6									1						
Unk 7	4								1						
Unk 8									2						
Unk 9					1						2				
Unk 10											5				
Unk 11												4			

				occ surf	occ surf	occ surf					occ surf	occ surf		occ surf				
SAMPLE NUMBER	1	2	26	27	28	30	31	32	35	37	38	39	41	42	43	45	46	48
Anacardiaceae		0.2							0.2				0.2					
Apiaceae										2.8								
Betulaceae, *Alnus*	0.7		0.2	0.2	2.3			0.2					0.2	0.7			0.2	0.4
Burseraceae, *Bursera*								0.2		5.6	3.7							0.2
Corylaceae, *Corylus*			0.2						0.2									
Cupressaceae																		
Pinaceae, *Pinus*	15.3	8.3	5.3	7.5	4.5	4.0	3.2	3.8	8.1	2.8	11.1	5.3	3.4	18.3	4.8	11.2	7.5	5.4
Fabaceae	1.5	1.2	2.1	2.3	2.3		5.3	1.3	0.3		3.7	2.1	0.6	2.5	2.7	1.0	1.4	1.6
Fabaceae, *Dalea*																	0.4	
Fabaceae, *Erythrina*															0.7			
Fabaceae, *Parkinsonia*																		0.2
Fabaceae, *Prosopis*	0.4													0.4				
Fagaceae, *Quercus*	19.7	8.9	16.3	11.4	11.4	14.0	20.0	18.9	10.5	11.1	7.4	8.4	9.6	21.8	13.3	16.0	13.2	11.2
Myricaceae, *Myrica*				0.2														
Rosaceae																		
Myrtaceae		0.3						0.4					0.4	0.4			0.2	
Saliaceae, *Populus*		0.2		0.2														0.2
Saliaceae, *Salix*		0.2		0.2									0.2	0.4			0.2	0.2
Sapindaceae				0.5					0.3				0.2					0.2
Sapotaceae	0.4							0.2					0.2	0.4				
TCT	1.5	1.7	0.4	0.5				0.2	2.4				1.2	1.4	0.3	1.2		0.2
Ulmaceae, *Celtis*		0.2	0.2	0.4								1.1	0.4	0.7				
Ulmaceae, *Ulmus*					2.3													
Amaryllidaceae													0.2	0.4		0.2		0.2
Apocynaceae								0.2				1.1	0.6			0.2		0.2
Aquifoliaceae, *Ilex*																		
Asteraceae, Hi-spine	6.9	10.8	9.7	10.3	6.8	12.0	7.4	8.2	9.4	16.7	22.2	5.3	10.8	7.7	9.2	6.4	12.1	13.6
Asteraceae, Low-spine	15.0	10.9	17.1	20.6	13.6	20.0	13.7	22.5	13.4	11.1	7.4	20.0	11.4	12.0	30.0	20.8	15.7	22.0
Brassicaceae																0.2		0.2
Boraginaceae, *Cordia*																		
Cheno-Am	3.6	5.7	1.7	5.3		4.0	4.2	1.9	6.0	0.0		3.2	5.8	3.9	4.8	3.6	4.3	4.8
Chenopodiaceae, *Sarcobatus*													0.2					
Convolvulaceae				0.2												0.2		
Convolvulaceae, *Ipomea*		0.2		0.4														
Lamiaceae		0.3	0.8	1.8		2.0		0.6	0.2	2.8		1.1	1.6			1.2	0.9	0.8
Liliaceae		0.3											0.4		0.3	0.2		
Malvaceae, periporate		0.7		0.5					0.7			1.1	0.4					0.6
Malvaceae, triporate			0.2					0.2								0.2		0.6
Nyctaginaceae				0.2								1.1						
Poaceae x<40	27.7	36.8	36.9	27.2	22.7	20.0	23.2	26.0	35.5	33.3	22.2	34.7	37.2	21.8	17.4	21.0	34.8	20.0
Poaceae 40<x<60	0.4	0.7	0.2	0.2				0.2	0.3				0.4	0.4		0.4		
Polygalaceae		0.3		0.2												0.2	0.2	
Polygonaceae, *Polygonum*																		
Typhaceae, Angustifolia type				0.2					0.2			1.1			0.3			
Urticaceae, *Urtica*	0.4	0.2	0.6			2.0		0.8	0.5				0.2	1.1	0.3	0.4	0.4	0.8
Cucurbitaceae, cf *Lagaenaria*																		
Juglandaceae, *Juglans*														0.4			0.2	
Solanaceae		0.5		0.2				0.6	0.5				0.2	0.4	1.0	0.4	0.4	0.8
Cyperaceae	0.4	0.5	0.2				1.1	0.6	1.5	2.8		1.1	0.6	0.7	1.4	0.4	0.4	0.8
Malvaceae, *Gossypium*									0.2				0.2			0.2		
Zea (Poaceae>60)				0.2					0.3				0.2	0.4				
Unknown	0.4	0.9		0.7	2.3	0.0	0.0	0.4	0.7	0.0	3.7	0.0	0.8	0.4	0.0	0.6	0.7	0.8
Indeterminates	5.8	10.1	8.0	8.7	31.8	22.0	22.1	12.8	8.7	13.9	18.5	13.7	12.4	3.9	13.3	14.0	7.0	14.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Pollen Sum	274.0	576	526	563	44	50	95	524.0	580	36	27	95	500	284	293	501	560	501
Lycopodium observed	7.0	79	411	230	231	71	107.0	412.0	106	118	118.0	183	618	25.0	148.0	231.0	40.0	389
Concentration per cc	33440.5	6229.0	1093.4	2091.2	162.7	601.6	758.5	1086.6	4674.6	260.6	195.5	443.5	691.2	9705.1	1691.3	1852.9	11960.5	1100.3

APPENDIX II: POLLEN FREQUENCY VALUES (%)

							occ surf								occ surf	occ surf						occ surf
SAMPLE NUMBER	50	56	58	59	61	62	67	69	70	71	73	75	76	77	78	79	81	84	85	86	87	88
Anacardiaceae																0.2	0.7				1.5	
Apiaceae																						
Betulaceae, *Alnus*				0.4						0.8	0.3		0.7			0.2	0.2		0.2	0.5		
Burseraceae, *Bursera*										0.2									4.9	1.4		
Corylaceae, *Corylus*								0.2											0.2			
Cupressaceae																						
Pinaceae, *Pinus*	4.2	7.7	18.3	8.5	7.0	4.1	7.3	15.0	12.6	9.4	9.7	5.4	11.0	2.6	8.5	14.4	7.9	14.1	9.5	4.7	14.9	
Fabaceae	0.9	1.1	1.3	1.4		2.7	4.9	2.5	2.1	2.3	1.8	2.7	0.7			1.6	1.5	1.2	1.5	0.9	3.0	
Fabaceae, *Dalea*												0.3										
Fabaceae, *Erythrina*																						
Fabaceae, *Parkinsonia*						1.4		0.3					0.7							1.9		
Fabaceae, *Prosopis*								0.2														
Fagaceae, *Quercus*	11.1	15.4	26.6	20.4	30.2	21.6	17.1	8.4	9.3	10.5	22.9	8.1	11.8	9.0	8.5	21.2	10.1	12.3	11.6	12.3	13.4	
Myricaceae, *Myrica*			0.2						0.2	0.2									0.2			
Rosaceae	1.4																0.2		0.2			
Myrtaceae																0.2			0.2	0.5		
Saliaceae, *Populus*																						
Saliaceae, *Salix*	0.5		0.2					0.2							2.1	0.2			0.2			
Sapindaceae				0.4				0.3	0.3													
Sapotaceae			0.4													0.5		0.4				
TCT	0.5	1.1	0.7	0.7		1.4		0.3	0.9	1.5	0.9	0.6				1.3	2.2	0.7	1.6	0.5		
Ulmaceae, *Celtis*				0.7				0.2	0.3	0.5		0.3					0.7					
Ulmaceae, *Ulmus*																						
Amaryllidaceae				0.4											2.1				0.2			
Apocynaceae																			0.3			
Aquifoliaceae, *Ilex*																	0.2	0.2				
Asteraceae, Hi-spine	6.9	2.2	6.0	9.2	7.0	5.4	12.2	10.5	12.3	12.9	10.0	5.7	6.6	12.8	12.8	7.0	9.9	8.3	6.5	6.6	13.4	
Asteraceae, Low-spine	10.6	15.4	11.9	17.3	9.3	9.5	14.6	13.0	14.4	12.6	13.8	29.2	15.4	15.4	14.9	13.1	12.1	14.6	15.4	11.4	17.9	
Brassicaceae									0.2													
Boraginaceae, *Cordia*							2.4															
Cheno-Am	8.3	4.4	5.5	7.0	2.3	9.5	2.4	6.3	6.1	6.8	9.1	10.2	1.5	6.4		6.3	5.3	5.3	6.4	9.5	10.4	
Chenopodiaceae, *Sarcobatus*																						
Convolvulaceae																0.2						
Convolvulaceae, *Ipomea*																						
Lamiaceae	2.3	1.1	0.7	0.7	2.3	1.4	4.9		0.2	0.3	0.9		1.5				0.2		0.2			
Liliaceae				1.1						0.5	0.3		0.7			0.5	0.9	0.4	0.2	0.5		
Malvaceae, periporate								0.3	0.2	0.3			0.7				0.2	0.2	0.2			
Malvaceae, triporate											0.3											
Nyctaginaceae												0.3									1.5	
Poaceae x<40	29.2	23.1	22.2	26.1	20.9	23.0	17.1	27.7	29.6	27.8	21.8	21.7	25.7	15.4	29.8	23.9	35.4	30.0	24.2	26.1	13.4	
Poaceae 40<x<60	0.9							0.5	0.3	0.3						0.7	0.3	1.1				
Polygalaceae				0.4															0.2			
Polygonaceae, *Polygonum*							2.4															
Typhaceae, Angustifolia type																0.4						
Urticaceae, *Urtica*			0.5	0.4				0.7	0.7	0.5		0.9	0.7	1.3		0.2	0.3	1.1	0.8			
Cucurbitaceae, cf *Lagaenaria*																			0.2			
Juglandaceae, *Juglans*						1.4													0.2			
Solanaceae	0.9		0.7	0.4		1.4	2.4	0.2	0.2	0.8		0.3		1.3	2.1		0.5		0.2	1.4		
Cyperaceae		1.1	0.4	0.4				1.2	0.7	1.1	2.1		1.5	1.3			0.9	0.2	2.0	2.4		
Malvaceae, *Gossypium*	0.9										0.3											
Zea (Poaceae>60)			0.5						0.2							0.2	0.2					
Unknown	0.9	1.1	0.2	0.4	0.0	0.0	0.0	1.6	0.9	0.5	0.0	0.9	0.0	1.3	0.0	2.0	0.2	1.6	1.3	0.5	1.5	
Indeterminates	20.4	26.4	3.7	4.2	20.9	17.6	12.2	10.54	8.5	10.3	5.9	13.3	20.6	33.3	5.9	6.1	10.8	8.5	11.6	19.0	10.4	
											0											
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Pollen Sum	216	91	546	284	43	74	41	548	529	555	340	288	136	78	47.0	557	526	567	545	211	67	
Lycopodium observed	332.0	210.0	20	101	303	313	156	8	12	17	247	195	53	150	77	12	22	14	111	201.0	134.0	
Concentration per cc	555.8	370.2	23322.9	2402.2	121.2	202.0	224.5	58520.9	37661.3	27891.0	1176.0	1261.8	2192.2	444.2	521.5	39654.7	20426.0	34600.0	4194.6	896.8	427.2	

SAMPLE NUMBER	69	70	1	71	2	35	73	75	26	76	27	77	37	78	28	38	39	30	31	32	41
PROVENIENCE	N6E-6/2	N6E-6/3	N8E-12/2	N6E-6/4	N8E-12/3	N8E-8/5	N6E-6/5	N6E-6/7	N6E-10/19	N6E-6/8	N6E-10/20	N6E-6/10	N8E-8/7	N6E-6/11	N6E-6/21	N8E-8/8	N8E-8/9	N6E-10/22	N6E-10/23	N6E-10/24	N8E-8/11
STRATUM	Post Occ.	Post Occ.	Post Occ.	Post Occ	Post Occ.	CS 5	CS 5	CS 4	CS 4	Occ. 3.	Occ3&CS3	CS 3	CS 3	Occ. 2.	Occ2&CS2	CS 2	Occ1&CS1	Occ1&CS1	CS1	CS1	CS1
POLLEN TYPE																					
Anacardiaceae					0.2	0.2															0.2
Apiaceae																					
Betulaceae, *Alnus*			0.7	0.8			0.3		0.2	0.7	0.2									0.2	0.2
Burseraceae, *Bursera*				0.2																0.2	
Corylaceae, *Corylus*	0.2					0.2			0.2												
Cupressaceae																					
Pinaceae, *Pinus*	15.0	12.6	15.3	9.4	8.3	8.1	9.7	5.4	5.3	11.0	7.5			8.5				4.0	3.2	3.8	3.4
Fabaceae	2.5	2.1	1.5	2.3	1.2	0.3	1.8	2.7	2.1	0.7	2.3								5.3	1.3	0.6
Fabaceae, *Dalea*								0.3													
Fabaceae, *Erythrina*																					
Fabaceae, *Parkinsonia*	0.3									0.7											
Fabaceae, *Prosopis*	0.2		0.4																		
Fagaceae, *Quercus*	8.4	9.3	19.7	10.5	8.9	10.5	22.9	8.1	16.3	11.8	11.4			8.5				14.0	20.0	18.9	9.6
Myricaceae, *Myrica*		0.2		0.2							0.2										
Rosaceae																					
Myrtaceae					0.3															0.4	0.4
Saliaceae, *Populus*					0.2						0.2			2.1							
Saliaceae, *Salix*	0.2				0.2						0.2										0.2
Sapindaceae	0.3	0.3				0.3					0.5										0.2
Sapotaceae			0.4																	0.2	0.2
TCT	0.3	0.9	1.5	1.5	1.7	2.4	0.9	0.6	0.4		0.5									0.2	1.2
Ulmaceae, *Celtis*	0.2	0.3		0.5	0.2			0.3	0.2		0.4										0.4
Ulmaceae, *Ulmus*																					
Amaryllidaceae																					0.2
Apocynaceae														2.1						0.2	0.6
Aquifoliaceae, *Ilex*																					
Asteraceae, Hi-spine	10.5	12.3	6.9	12.9	10.8	9.4	10.0	5.7	9.7	6.6	10.3			2.8				12.0	7.4	8.2	10.8
Asteraceae, Low-spine	13.0	14.4	15.0	12.6	10.9	13.4	13.8	29.2	17.1	15.4	20.6			4.9				20.0	13.7	22.5	11.4
Brassicaceae		0.2																			
Boraginaceae, *Cordia*																					
Cheno-Am	6.3	6.1	3.6	6.8	5.7	6.0	9.1	10.2	1.7	1.5	5.3			4.3				4.0	4.2	1.9	5.8
Chenopodiaceae, *Sarcobatus*																					0.2
Convolvulaceae											0.2										
Convolvulaceae, *Ipomea*					0.2						0.4										
Lamiaceae		0.2		0.3	0.3	0.2	0.9		0.8	1.5	1.8							2.0		0.6	1.6
Liliaceae				0.5	0.3		0.3			0.7											0.4
Malvaceae, periporate	0.3	0.2		0.3	0.7	0.7				0.7	0.5										0.4
Malvaceae, triporate							0.3		0.2											0.2	
Nyctaginaceae								0.3			0.2										
Poaceae x<40	27.7	29.6	27.7	27.8	36.8	35.5	21.8	21.7	36.9	25.7	27.2			29.8				20.0	23.2	26.0	37.2
Poaceae 40<x<60	0.5	0.3	0.4	0.3	0.7	0.3			0.2		0.2									0.2	0.4
Polygalaceae					0.3						0.2										
Polygonaceae, *Polygonum*																					
Typhaceae, Angustifolia type						0.2					0.2										
Urticaceae, *Urtica*	0.7	0.7	0.4	0.5	0.2	0.5		0.9	0.6	0.7								2.0		0.8	0.2
Cucurbitaceae, cf *Lagaenaria*																					
Juglandaceae, *Juglans*																					
Solanaceae	0.2	0.2		0.8	0.5	0.5		0.3			0.2									0.6	0.2
Cyperaceae	1.2	0.7	0.4	1.1	0.5	1.5	2.1		0.2	1.5				8.1					1.1	0.6	0.6
Malvaceae, *Gossypium*						0.2	0.3														0.2
Zea (Poaceae>60)		0.2				0.3					0.2										0.2
Unknown	1.6	0.9	0.4	0.5	0.9	0.7	0.0	0.9		0.0	0.7	1.3	0.0	0.0	2.3	3.7	0.0	0.0	0.0	0.4	0.8
Indeterminates	10.54	8.5	5.8	10.3	10.1	8.7	5.9	13.3	8.0	20.6	8.7	33.3	13.9	14.9	31.8	18.5	13.7	22.0	22.1	12.8	12.4
							0														
Total	100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0			100.0				100.0	100.0	100.0	100.0
Pollen Sum	548	529	274.0	555	576	580	340	288	526	136	563	78	36	47.0	44	27	95	50	95	524.0	500
Lycopodium observed	8	12	7.0	17	79	106	247	195	411	53	230	150	118	77	231	118.0	183	71	107.0	412.0	618
Concentration per cc	58520.9	37661.3	33440.5	27891.0	6229.0	4674.6	1176.0	1261.8	1093.4	2192.2	2091.2	444.2	260.6	521.5	162.7	195.5	443.5	601.6	758.5	1086.6	691.2
									TABLE III:		**PLATFORM 14-6**										

SAMPLE NUMBER	84	58	85	59	86	61	87	50	62	67	88	56
PROVENIENCE	N14E-14/2	N16E-12/2	N14E-14/3	N16E-12/4	N14E-14/4	N16E-12/5	N14E-14/5	N14E-16/9	N16E-12/5	N16E-12/6	N14E-14/6	N14E-14/6
STRATUM		Post occ.	Post Occ.	Past Occ.	Post Occ.	Post Occ?	Post Occ?	Occ.5	Occ. 5.	Occ. 5.	Occ. 5	CS 5
								Posthole fill			floor	
POLLEN TYPE												
Anacardiaceae												
Apiaceae												
Betulaceae, *Alnus*			0.2	0.4	0.5							
Burseraceae, *Bursera*			4.9		1.4							
Corylaceae, *Corylus*			0.2									
Cupressaceae												
Pinaceae, *Pinus*	14.1	18.3	9.5	8.5	4.7			4.2				
Fabaceae	1.2	1.3	1.5	1.4	0.9			0.9				
Fabaceae, *Dalea*												
Fabaceae, *Erythrina*												
Fabaceae, *Parkinsonia*					1.9							
Fabaceae, *Prosopis*												
Fagaceae, *Quercus*	12.3	26.6	11.6	20.4	12.3			11.1				
Myricaceae, *Myrica*		0.2	0.2									
Rosaceae			0.2					1.4				
Myrtaceae			0.2		0.5							
Saliaceae, *Populus*												
Saliaceae, *Salix*		0.2	0.2					0.5				
Sapindaceae				0.4								
Sapotaceae	0.4	0.4										
TCT	0.7	0.7	1.6	0.7	0.5			0.5				
Ulmaceae, *Celtis*				0.7								
Ulmaceae, *Ulmus*												
Amaryllidaceae			0.2	0.4								
Apocynaceae			0.3									
Aquifoliaceae, *Ilex*	0.2											
Asteraceae, Hi-spine	8.3	6.0	6.5	9.2	6.6			6.9				
Asteraceae, Low-spine	14.6	11.9	15.4	17.3	11.4			10.6				
Brassicaceae												
Boraginaceae, *Cordia*												
Cheno-Am	5.3	5.5	6.4	7.0	9.5			8.3				
Chenopodiaceae, *Sarcobatus*												
Convolvulaceae												
Convolvulaceae, *Ipomea*												
Lamiaceae		0.7	0.2	0.7				2.3				
Liliaceae	0.4		0.2	1.1	0.5							
Malvaceae, periporate	0.2		0.2									
Malvaceae, triporate												
Nyctaginaceae												
Poaceae x<40	30.0	22.2	24.2	26.1	26.1			29.2				
Poaceae 40<x<60	1.1							0.9				
Polygalaceae			0.2	0.4								
Polygonaceae, *Polygonum*												
Typhaceae, Angustifolia type												
Urticaceae, *Urtica*	1.1	0.5	0.8	0.4								
Cucurbitaceae, cf *Lagaenaria*			0.2									
Juglandaceae, *Juglans*			0.2									
Solanaceae		0.7	0.2	0.4	1.4			0.9				
Cyperaceae	0.2	0.4	2.0	0.4	2.4							
Malvaceae, *Gossypium*								0.9				
Zea (Poaceae>60)		0.5										
Unknown	1.6	0.2	1.3	0.4	0.5	0.0	1.5	0.9	0.0	0.0		1.1
Indeterminates	8.5	3.7	11.6	4.2	19.0	20.9	10.4	20.4	17.6	12.2		26.4
Total	100.0	100.0	100.0	100.0	100.0			100.0				
Pollen Sum	567	546	545	284	211	43	67	216	74	41		91
Lycopodium observed	14	20	111	101	201.0	303	134.0	332.0	313	156		210.0
Concentration per cc	34600.0	23322.9	4194.6	2402.2	896.8	121.2	427.2	555.8	202.0	224.5		370.2

TABLE IV: PLATFORM 14-5

SAMPLE NUMBER	81	46	48			43	45			79	42
PROVENIENCE	N4-E20/2	N4E-18/3	N4E-18/5			N2E-34/5	N0E-36/5			N20E-2/3	N20E-2/3
STRATUM	Post Occ.	Post Occ.	CS1			Occ. 5.	CS1?			floor	floor
POLLEN TYPE											
Anacardiaceae	0.7									0.2	
Apiaceae											
Betulaceae, *Alnus*	0.2	0.2	0.4							0.2	0.7
Burseraceae, *Bursera*			0.2								
Corylaceae, *Corylus*											
Cupressaceae											
Pinaceae, *Pinus*	7.9	7.5	5.4			4.8	11.2			14.4	18.3
Fabaceae	1.5	1.4	1.6			2.7	1.0			1.6	2.5
Fabaceae, *Dalea*		0.4									
Fabaceae, *Erythrina*						0.7					
Fabaceae, *Parkinsonia*			0.2								
Fabaceae, *Prosopis*											0.4
Fagaceae, *Quercus*	10.1	13.2	11.2			13.3	16.0			21.2	21.8
Myricaceae, *Myrica*											
Rosaceae	0.2										
Myrtaceae		0.2								0.2	0.4
Saliaceae, *Populus*			0.2								
Saliaceae, *Salix*		0.2	0.2							0.2	0.4
Sapindaceae			0.2								
Sapotaceae										0.5	0.4
TCT	2.2		0.2			0.3	1.2			1.3	1.4
Ulmaceae, *Celtis*	0.7										0.7
Ulmaceae, *Ulmus*											
Amaryllidaceae			0.2				0.2				0.4
Apocynaceae			0.2				0.2				
Aquifoliaceae, *Ilex*	0.2										
Asteraceae, Hi-spine	9.9	12.1	13.6			9.2	6.4			7.0	7.7
Asteraceae, Low-spine	12.1	15.7	22.0			30.0	20.8			13.1	12.0
Brassicaceae			0.2				0.2				
Boraginaceae, *Cordia*											
Cheno-Am	5.3	4.3	4.8			4.8	3.6			6.3	3.9
Chenopodiaceae, *Sarcobatus*											
Convolvulaceae							0.2			0.2	
Convolvulaceae, *Ipomea*											
Lamiaceae	0.2	0.9	0.8				1.2				
Liliaceae	0.9					0.3	0.2			0.5	
Malvaceae, periporate	0.2		0.6								
Malvaceae, triporate			0.6				0.2				
Nyctaginaceae											
Poaceae x<40	35.4	34.8	20.0			17.4	21.0			23.9	21.8
Poaceae 40<x<60	0.3						0.4			0.7	0.4
Polygalaceae		0.2					0.2				
Polygonaceae, *Polygonum*											
Typhaceae, Angustifolia type						0.3				0.4	
Urticaceae, *Urtica*	0.3	0.4	0.8			0.3	0.4			0.2	1.1
Cucurbitaceae, cf *Lagaenaria*											
Juglandaceae, *Juglans*		0.2									0.4
Solanaceae	0.5	0.4	0.8			1.0	0.4				0.4
Cyperaceae	0.9	0.4	0.8			1.4	0.4				0.7
Malvaceae, *Gossypium*							0.2				
Zea (Poaceae>60)	0.2									0.2	0.4
Unknown	0.2	0.7	0.8			0.0	0.6			2.0	0.4
Indeterminates	10.8	7.0	14.2			13.3	14.0			6.1	3.9
Total	100.0	100.0	100.0			100.0	100.0			100.0	100.0
Pollen Sum	526	560	501			293	501			557	284
Lycopodium observed	22	40.0	389			148.0	231.0			12	25.0
Concentration per cc	20426.0	11960.5	1100.3			1691.3	1852.9			39654.7	9705.1
		PATIO				**PLATFORM**				**STRUCTURE**	
		14-9				**14-2**				**1-1**	
					TABLE V						

PALEOETHNOBOTANICAL STUDIES AT LLANO GRANDE, JALISCO, MEXICO

PAPER DELIVERED AT THE ANNUAL
MEETINGS OF THE SOCIETY FOR
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ABSTRACT

62 samples examined for macrobotanical material and 40 pollen samples represent the range of structures and stratigraphic units at this guachimonton in the core district of the Teuchtitlan Tradtion. 17 samples were examined for both forms of botanical remains. An intra-site pollen chronology based on changes in pollen concentration values suggests details of the construction and occupation sequences that are not obvious from site stratigraphy.

Vegetation and ecosystem patterns seem to have been very little impacted by the site's construction and occupation. Recovery of carbonized maize cob fragments and starchy seed fragments, as well as small amounts of maize, bottle gourd and cotton pollen, document agricultural production, but the site was not embedded in an agricultural landscape. Similarly small quantities of walnut, cotton, willow, nettle, dock and cattail pollen were inadvertently introduced to the site by people working or visiting wetland agricultural systems in the lowlands of the core district. A ubiquitous sedge pollen record, accompanied by charred sedge seeds in samples of construction fill, occupation floors and the collapse of burnt buildings suggest use of reeds for thatch and matting.

Llano Grande is a guachimonton site located on a mesa at the western margin of the Tequila Valleys district [photo from east]. When it was partially excavated in the summer of 2000 [photo of trench], particular attention was paid to the recovery of sediment samples for paleoethnobotanical studies: pollen analysis, phytolith analysis and analysis of floatable botanical macroremains. Altogether, 88 such samples were collected; so far, study has focused on 59 one-liter bulk samples studied for macroremains and 40 samples from which pollen has been extracted. Both sorts of analyses have been performed on 17 samples. Four sherds from ollas and a bowl provided scrapings of cooking residue which have been analyzed for phytoliths. The analysis of phytoliths from other sediment samples is currently in progress and will be reported on another time.

The samples were collected and distributed to myself, Bruce Benz and Robert Thompson, for research on the question of the similarities and differences in archaeologically significant conclusions that would result from application of the methods and techniques peculiar to each of these three forms of paleoethnobotanical study. Also, to discover the ways the studies might be integrated synergistically with each other and with other aspects of the archaeological record to test existing and produce new ideas about the cultural history and character of the Teuchtitlan tradition. That research design is still a work in progress. As I've said, the planned phytolith work is only partially complete, and there has not yet been much opportunity to reflect upon the ways conclusions so far developed affect our and others thinking about the region's prehistory. Today, then, I will mostly discuss the major findings of the paleoethnobotanical studies so far undertaken and the ways they reinforce and differ from each other.

I shall start with the study of the botanical macroremains floated from the sediment samples. Normally, such studies yield significant information on the character of diet and other uses of local and exotic flora by the residents of an archaeological site. That turned out not to be the case at Llano Grande.

The botanical macroremains data base breaks down into 3 primary categories: there were 281 seeds of various genera of grasses recovered from the samples, 72 seeds of other plants, and charred and uncharred wood fragments. However, 90% of the grass seeds and 75% of the other seeds were recovered from post-occupation contexts such as wall slump, rock fall and the soil horizon that developed on those deposits. Thus only 28 grass seeds and 19 seeds of other plants are associated with the construction fill or floor deposits exposed by excavation. Most importantly, none of those seeds were charred.

Most paleoethnobotanists abjure recognizing uncharred plant remains as archaeologically relevant, because they recognize it is unlikely that such plant material can remain preserved for very long. It is therefore more probable that uncharred botanical macroremains represent post-occupation material that has reached deeper strata. At Llano Grande, recovery of rootlets and insect parts in almost all of the bulk sediment samples suggests the existence of channels through which such intrusion may have occurred. Further, one of the uncharred grass seeds recovered from an occupation floor context is identified to a European genus (*Digitaria*), and seven other grass seeds recovered from a construction fill context have the shiny seed coats of recent dispersals. Conventional wisdom does seem valid in this case, and cultural interpretation of the seed flora is not appropriate.

However, there were 3 sorts of charred macroremains in the 21 samples of post-occupation deposits. Four samples contained charred grass seeds of a local genus (*Panicum*), six samples contained charred sedge seeds (Cyperaceae), and four samples contained charred fragments of starchy seeds that could derive from corn or beans. These remains probably represent construction and dietary materials of the final occupations. The only other charred plant remains of clear cultural significance were three maize cob fragments recovered from a sample of the platform construction fill at structure 14-2. It is tempting to suggest it may represent a dedicatory offering. It is interesting to note that none of the nine samples of occupation floor context yielded charred seeds and only four produced significant numbers of charred wood fragments. All four were samples from the wall slump overlying the occupation floor at structure 14-5. These minimal results suggest, like the minimal artifact inventory, that in most cases occupation floors were swept clean and superstructures were dismantled when a subsequent construction cycle was begun.

The principle result of study of the phytoliths of food residue scraped from the interior of sherds from four ollas and a bowl associated with the occupation of structure 14-5 was identification of maize phytolith assemblages. Use of a variety of statistical techniques for comparing these with the assemblages of maize phytoliths of modern reference materials provides convincing evidence that the maize held in these vessels represents an early lineage related to the modern Reventador lineage – one of those Benz identifies in the West Mexican Alliance of varieties still in use in Jalisco.

In addition, phytoliths diagnostic of *Prunus* and *Celtis* were observed in the food residue samples. Both genera produce fruits that may have been used to sweeten food. *Celtis* pollen, and Rose Family pollen that may have been produced by *Prunus,* was also recovered in sediment samples from this and other contexts.

The palynological research produced evidence that supports development of three different kinds of archaeologically significant inferences. Archaeologists are most familiar with the potential of pollen studies to reveal details of the paleoenvironmental contexts in which ancient cultural activity was embedded, and their potential to identify cultivated plants and other resource plants associated with cultural horizons. The pollen record of the Llano Grande samples allowed exploration of both of these matters.

Surface sample control data recovered as an aspect of Glenn Stuart's dissertation research allows recognition of the palynological indices of kinds of vegetation patterns that reflect different ecosystem conditions in the core area of the Teuchtitlan Tradition. One can, for example, distinguish pollen assemblages that indicate the moister environments of the basin floor from the more arid environments of the valley slopes, or distinguish those that identify more disturbed and less disturbed local environments or that identify the environments of open grassland or more shrub-and-arboreal dominated habitats. We anticipated that pollen assemblages associated with the Formative occupation of the site would be distinct from those associated with post-occupation and very recent deposits at the site, allowing us to determine the character of environmental changes in the district over the course of time. In fact, however, the pollen records of Llano Grande are remarkably consistent and similar in samples of deposits representing all time periods. Only six pollen taxa occur in statistically significant frequencies in any sample, the same six occur in all the samples, and each occurs in its own very narrow range of values.

[Photo of mesa's vegetation] The way that the pollen record expresses the modern environment of the site's placement at the ecotone of grassland and montane flora, then, seems to be about the same way the site's pollen record has expressed its environmental context throughout its history. This photo showing the vegetative landscape at the site today, then, is probably essentially the same as one that might have been taken before, during or following its occupation.

Prehistoric habitation sites tend to yield pollen assemblages that reflect the existence of disturbed habitats in the site environs. This is not the case at Llano Grande, which suggests that there was little or no development of agricultural fields or other disturbance in the vicinity. Agriculture is palynologically evidenced by the occurrence of maize, bottle gourd and cotton pollen, and pollen that may be derived from *tomate* plants. The quantities of pollen of cultivars, however, are very small; far less, for example, than occurs at Puebloan or Hohokam sites or Formative Era samples from the sites in the Valley of Oaxaca.

A second type of inference to be drawn from the pollen record of the Llano Grande samples is that developed from evidence of cultural patterns. Given the ways in which pollen of certain taxa is naturally distributed, patterned pollen distributions that cannot be accounted for by "natural" processes constitute evidence for human activities. The occurrence and distribution of pollen of *Bursera* at the site is one example. *Bursera* is the botanical name for the genus that includes copal. Since all species of this genus are insect pollinated, one would not expect to find any *Bursera* pollen dispersed to a significant distance from the tree, and then not to observe it commonly or in significant frequency. At Llano Grande, however it was observed in four samples. They were samples of the earliest construction deposits at platform 14-6 and at the central altar in the site patio, and the other two samples were of sediments deposited just subsequent to the occupation of platform 14-5. Ethnographic analogy suggests this pollen identifies rituals performed for the dedication of ceremonial structures when their construction was initiated and for their secularization at the ends of their ceremonial lives.

A second example is the occurrence and distribution of sedge pollen. Sedge pollen occurs in 30 of the 40 pollen samples analyzed. Its ubiquity argues for its use as a construction material – probably for thatch and for baskets and mats used to transport construction fill. Third, there is a suite of pollen types representing willow, cottonwood, walnut, mesquite, cattail, nettle and dock which all derive from plans of bottomland and marsh habitat. While none of these pollen types is ever recovered in statistically significant frequency, two or more of these pollen types occur in practically every sample. The most likely explanation of the ubiquity of this suite of pollen types is that they were inadvertently introduced to the site on the bodies and clothing of people who consistently and regularly visited the shorelines of the lakes and marshes of the basin floor. Stuart has demonstrated the existence of prehistoric wetland agriculture in that sort of habitat, and it seems likely that the maize and cotton pollen we recovered was introduced from such fields at the same time.

The third class of inferences developed from the palynological data relate to development of an intra-site chronology that allows reconstruction of the relative antiquity of the various occupations evidenced at the site. To explain these, I must review the site's basic stratigraphy and discuss some information obtained from the flotation record.

[Site map] The essential stratigraphic history of the site begins with undisturbed deposits weathered from local bedrock and continues with leveling and construction fill deposits that established the site's patio and banquette architecture. The construction fills and use surfaces of the central altar and the structures placed at regular intervals on the banquette were then added. The 2000 excavation season exposed single use/occupation surfaces at the altar and at platforms 14-2 and 14-5. Structure 14-6, however, was rebuilt and its surface re-occupied four times. Final occupation floors at all the structures are overlain by wall slump and wall fall strata upon which the A horizon of a soil formed. This soil also caps the occupation floor of a nearby habitation structure.

Neither the ceramic record nor the substantial series of radiocarbon assays reveals much more of an intra-site chronology than this stratigraphic record. Particularly, it does not advise whether or not the final occupation of platform 14-6 took place when the other two platforms were occupied, and whether the construction of structures on the platforms was simultaneous or sequential. When the flotation and pollen data was arrayed in terms of the depositional sequence and the relative stratigraphic positions of samples within the strata, however, two patterns emerged that suggest answers to those questions. (SEE SAA CHART)

The first pattern was reflected in the flotation data of samples from the A horizon. Amongst the material recovered when floating the bulk samples for botanical remains, Benz observed organic items he calls “black spherical objects”, which are ½ to 1 ½ mm in diameter [photo]. We do not know what these items are, only that they are organic but are not likely to be of botanical origin since they have no cellular structure. There are large numbers of black spherical objects in most of the very youngest of the A Horizon samples, however, and fewer in older A Horizon and wall collapse samples. Generally, A Horizon samples with larger numbers of black spherical objects contain seeds from a wider variety of botanical taxa, while those with smaller numbers of black spherical objects contain seeds of fewer taxa or no seeds at all. The correspondence is so striking that I think it requires explanation, and my inclination is to suspect some aspect of the soil formation process. Certainly, the pattern cannot be explained by some aspect of the site's occupation or the culture of its occupants, since the stratum in which the pattern is observed formed subsequent to the site's abandonment and ruin.

The A Horizons of a soil forms through accumulation of material on its upper surface. All of the flotation samples were of equal volume. If black spherical objects and seeds were being dispersed to the site from the surrounding environment at the same rate each year, the number of black spherical objects and seed types would be indices of the number of years' accumulation and thus the rate at which the A Horizon developed. If it was developing slowly, there would be more black spherical objects and seed taxa in a sample; if it were building up more rapidly, there would be fewer.

Unfortunately, we cannot use both the number of seed taxa and the number of black spherical objects as indices of deposition rates in the older deposits. Because seeds in the deeper strata are not charred, they were probably distributed to the site after its occupation and found their way into older strata through root channels and other means. However, a second pattern of paleoethnobotanical data strongly suggests that the numbers of black spherical objects observed in the older strata index deposition rates as effectively as they do in the A Horizon. This second pattern is the correspondence between the numbers of black spherical objects and the pollen concentration values in samples from the deeper strata.

Pollen concentration values are estimates of the number of pollen grains that occur in a given amount of sample. Pollen concentrations may be expressed in terms of the amount of pollen per gram dry weight of the sample or in terms of the amount of pollen per cubic centimeter of sample. These values must be calculated independently and are also calculated independently from the frequency, or percentage, values of the pollen of the botanical taxa. There is no logical way to derive one of these values from calculation of one or more of the other two.

In a recent comment published in *American Antiquity*, Glenna Dean pointed out that the number of pollen grains per **gram** of sample provides a better way to estimate of the amount of a cultivar such as maize or cotton than the number of grains per **cubic centimeter**. She has therefore argued that archaeological pollen studies focused on subsistence issues would be more productive and precise if this sort of pollen concentration was calculated. She is perfectly correct, but the Llano Grande case illustrates the value to collecting both sorts of pollen concentration data. Here, pollen concentration per cubic centimeter values seem to be chronologically significant.

Pollen concentration per cubic centimeter is the outcome of the balance among 3 ecosystem processes: pollen production by source vegetation, pollen dispersal to and deposition within the sampled stratum, and the combined effect of mechanical, chemical and biological factors that determines how well pollen is preserved in that stratum. Each of these is a complex process which affects the other two in certain fashions, but, basically, if any two of the three processes have been essentially constant, the third process must be responsible for the number of pollen grains in a given volume of sample.

In the course of the Llano Grande study, we made a special effort to recover data about pollen preservation, and as a result we can demonstrate that pollen has not been preserved differentially at any time during the history of deposition at the site. The observed lack of variation in the nature of the prominent pollen taxa and the narrow range of their representation in the pollen record has demonstrated that the nature of the vegetative environment has not undergone any change over time either. Thus, such variation as we observe in the sequential record of pollen concentration per cubic centimeter of sample, is attributable to changes in deposition rate.

The sequence of changes in deposition rates suggested by the numbers of black spherical objects in the sediment samples is matched and paralleled by the sequence of changes in pollen concentration per cubic centimeter of sample. When integrated with information on the depositional sequence, the two forms of paleoethnobotanical data allow identification of a fairly detailed relative chronology that can be linked to the cultural events of the archaeological record.

Perhaps the most unexpected result of this chronology is the conclusion that the structures that occupied different platforms located on the banquette surrounding the patio were not all in use at the same time or abandoned at the same time.

The intra-site chronology suggests that construction of the altar in the center of the patio and platform 14-2 preceded construction at platforms 14-5 and

14-6. No sample from the occupation horizon of platform 14-2 was collected, so we cannot say if the structure placed on that platform was abandoned before or after the initial construction of platform 14-6. But we can say that a first cycle of construction and occupation at platform 14-6 occurred before the sole cycle of construction and occupation at platform 14-5. Further, that the structure on platform 14-5 was abandoned before the one on platform 14-6 was rebuilt and re-occupied a third time but the structure on platform 14-5 had not collapsed until the structure on platform 14-6 was re-built and re-occupied for a fourth and final time.

Such a complex chronology was completely unexpected and we are yet struggling with the question of whether it should be anticipated at other guachimonton sites. We also struggle with the question of its sociological, political or religious implications. A good deal more research will be required to address those issues, and it is not unlikely that resolving them will require additional paleoethnobotanical study. This finding, and the evidence that cotton production was part of the economy of the core area of the Teuchtitlan Tradition, have been the most archaeologically significant products of the ethnobotanical studies at Llano Grande generated so far. Additional valuable insights into the cultural character of the tradition are likely when the phytolith studies are completed.

SAMPLE NUMBER	SITE STRATIGRAPHY	POLLEN CONCENTRATION (k)	POLLEN ZONE	N OF BLACK SPHEROIDAL OBJECTS	DEPOSITION RATE
69		58.5			
70		37.4			
84		34.6	I		
8				500	
?	A			400	
10	SOIL		(>2.5 k)	262	
52	HORIZON			275	SLOW
71		27.8			
58		23.3		264	
54				360	
2		6.2		220	
9				254	
85		4.2			
53				660	
54				360	
10	----------------------			262	----------------
33	14-5 POST-			33	
35	OCCUPATION	4.7		32	RAPID
34	COLLAPSE &		---------------	72	----------------
23	14-6			75	
59	WALL	2.4		70	
60	FALL			54	MODERATE
73	------------------	1.2			
	14-6 4TH				-------------
11	OCCUPATION FLOOR			1	VERY
36	-----------------			2	RAPID
75	14-5 POST-	1.3	II		
	OCCUPATION				--------------
3	COLLAPSE &		(1.0 - 2.5 k)	66	
26	14-6	1.2		90	MODERATE
86	4TH CONSTRUCTION	0.9			
5	STAGE			50	---------------
12				6	VERY
13	---------------			6	RAPID
49	ALTAR OCCUPATION	1.7		15	
76	14-6 3RD	2.2			-------------
27	OCCUPATION FLOOR	2.1		66	
56	-----------------	0.4	---------------	70	
61		0.1			MODERATE
62	14-6	0.2		36	
6	3RD CONSTRUCTION			80	
77	STAGE &	0.4			
37	FIRST POST-OCCUPATION	0.3		26	-------------
14	DEPOSITION AT 14-5			1	
15				3	
16	------------------			3	
50		0.6	III		
78	14-5 OCCUPATION &	0.5			
87	14-6 2ND	0.4			
67	OCCUPATION	0.2			
88		0.2	(<0.6 k)		
17				2	VERY
18				0	RAPID
28		0.2		14	
38	-----------------------	0.2		12	
29	14-6 CONSTRUCTION			6	
19	STAGE 2			7	
7	--------------------			12	
39	14-6 FIRST	0.4		17	
30	OCCUPATION FLOOR	0.6		5	
20	--------------------		--------------	0	
21				2	
22			IV	6	
31		0.8		8	
41	FIRST CONSTRUCTION	0.7	(0.6 - 1.0 k)	0	
57	STAGE AT			4	
	BOTH 14-5 & 14-6		---------		----------------
40	-------------------			42	
32	FIRST CONSTRUCTION		V	23	MODERATE
48	STAGE AT	1.2		144	----------------
45	14-2 AND ALTAR	1.9	(1.0 - 2.5 k)	18	V. RAPID