APPENDIX C;

The Groundstone

While groundstone did not occur in sufficient frequency to warrant a detailed classification for intra-site analysis, the sum total of groundstone collected is substantial, and the classification used for intra-site comparison obscures some important variation. Which follows is a summary of the more detailed groundstone analysis that was carried out, pointing out some of the major aspects of variation and some inferences drawn from these.

The main categories used are those of metates and manos, with the addition of mortars and the single doughnut stone. In both the metates and manos Woodbury (1954) is used as a guide.

TYPE I. METATES

These slabs have an oval grinding surface which with use develops into an oval deep basin. The grinding motion is primarily rotary with some pounding, the cross section is a roundish one without vertical sides.

See Woodbury (1954) grinding slabs for comparative examples.

TYPE II. UTAH-SEMI TROUGH

This class clines into the previous but shows evidence of a more back and forth grinding motion, with a more trough like grinding surface localized at one end of the grinding slab. These tend to be made on relatively rectuangular usually relatively thin slabs.

They differ from true troughs:

1. Lack of rectangular cross section
2. Always a shelf at one end.
3. Wide areas on both sides of the trough.

Flatter than I but still
tending to roundness.

Ref. may fit Woodbury's Utah but does not fit trough. Brew may illustrate some, Fig.174 abc.

TYPE III. TROUGH METATES

These grinding slabs show evidence of only back and forth grinding motions. The edges of the troughs are thin and the "shelf" is usually absent. The cross section is usually quite rectangular and the overall shape is usually very rectangular and well finished. This class does cline into "Utah" and some have "rim" so thin that they may have been emplaced in bins and thus are functionally "flat" metates.

Ref. Woodbury 1954:52 "Troughed Metates Open at One End" 1954:53 "Troughed Metates Open at Both Ends" [1954:51 "Troughed Metates With shelf at Closed End"?].

TYPE IV. FLAT METATES

These grinding slabs are flat with the entire surface being used for grinding with a slight bend in the middle. Following Woodbury 1954:59-65 these were placed in bins in a permanent fashion.

Ref. Woodbury 1954:54
"Flat Metates"

TYPE V. TABULAR GRINDING STONES

These objects are thin pieces of sandstone showing pecking or grinding. They differ from IV in that the entire surface is not used and from I in that the pieces are too thin for a deep basin to ever develop. These typically show little wear.

Ref. Woodbury's "Tabular Flat Abraders" (1954:98)? Also possibly Woodbury's "Grinding Slabs" (1954:113,114).

TYPE "UNIDENTIFIED"

If a fragment was too small to be placed in any category or any group of categories but still was apparently a neither grinding surface it was designated "undecided".

SYMBOL I/II. DEEP BASIN -- UTAH SEMI-TROUGHS

A few complete metates seemed to fall in between these two categories and were designated as both by I/II. It was not uncommon for fragments to be indeterminate and these were also designated I/II. Probably the fragments came from either I's or II's and not I/II's. Thus using the fragments as a guide, the number of complete metates in this class would be overestimated.

TYPE II/III/IV/V

A few fragments were clearly not deep basin metates, but could have been anything else. These were not as common as I/II's and are not represented in the following tables.

METATES

METRIC MEASUREMENT SUMMARIES

Because of different measurements resulting from complete metates and from what appear to be "complete" measurements from incomplete metates, they are given separately below. First the measurements for "pure" type then the "mixed" types and finally a discussion are given.

Overall width measurement is not greatest width, but instead the width measured midway up the grinding suface.

Length = greatest length along axis of grinding surface.

Thickness = greatest thickness 90° to length width.

Length of grinding surface = greatest length of grinding surface.

Width of grinding surface = greatest width of grinding surface.

Grinding surface depth = greatest depth from unground surface.

Depth of grinding surface

GS = Grinding surface

OA = Overall

TYPE I DEEP BASIN COMPLETE

Measurement	N	Mean	Median	Low	High	Interquartile
Length GS	28	34.23	35.5	9	57.6	8 , 41.2
Width GS	26	22.83	23	8	37	19.4 , 27.5
Depth GS	28	2.32	.9	.3	10	.3 , 4.2
Length OA	26	44.20	46.5	19.1	64.6	36.2 , 52
Width OA	27	33.05	34.4	18.2	47.4	26 , 40.6
Thickness OA	29	10.29	10.1	3.4	27	7.6 , 11.5

TYPE I DEEP BASIN INCOMPLETE

Measurement	N	Mean	Median	Low	High	Interquartile
Length GS	3	31.3	29.5	29	35.4	
Width GS	9	18.63	18	13.5	26.1	15 , 19.9
Depth GS	12	2.36	1.6	.5	5.6	.5 , 4.6
Length OA	2	42	42	37	47	
Width OA	5	27.60	25.6	24	34.4	25 , 29
Thickness OA	19	7.61	7.6	3.5	12.9	6.4 , 8.9

TYPE II SEMI-UTAH TROUGH COMPLETE

Length GS	19	36.79	38.6	26.5	42	33.7 , 40.5
Width GS	19	21.79	22	15.8	27.8	19 , 23.7
Depth GS	19	3.3	2.5	.5	11	2 , 4.7
Length OA	16	55.23	55.3	47	65.6	49.6 , 59
Width OA	16	38.83	38.15	25.8	49.2	36 , 41.6
Thickness OA	16	8.26	8.45	2.9	18	5.6 , 10

TYPE II SEMI-UTAH TROUGH INCOMPLETE

Length GS	2	36	36	32	40	
Width GS	6	18.3	17.8	14.6	23	15.6 , 21
Depth GS	8	4.15	4.35	2.1	6.2	2.2 , 6
Length OA	2	50.5	50.5	42	59	
Width OA	2	29	29	28	30	
Thickness OA	17	7.95	7.7	2.9	16	5 , 9.8

TYPE III TRUE TROUGH COMPLETE

Measurement	N	Mean	Median	Low	High	Interquartile
Length GS	2	34.2	34.2	31	7.4	
Width GS	2	22.35	22.35	21	23.7	
Depth GS	2	1.55	1.55	1.1	2	
Length OA	2	35.2	35.2	33	37.4	
Width OA	2	25.35	25.35	23.7	27	
Thickness OA	2	9.15	9.15	7.9	10.4	

TYPE III METATES INCOMPLETE

Length GS	2	36.5	36.5	33	40	
Width GS	4	21.30	21.70	19	22.8	
Depth GS	11	2.76	3	1	4.3	1.5 , 3.6
Length OA	3	36.33	36	33	40	
Width OA	3	27.47	27	26.4	29	
Thickness OA	9	7.42	7.6	2.2	14	4.8 , 8

METATE TYPE IV COMPLETE

Length GS	3	39.77	40.6	36	42.7	
Width GS	3	26	25.6	24	28.4	
Depth GS	3	.5	.5	.5	.5	
Length OA	3	39.77	40.6	36	42.7	
Width OA	3	26	25.6	24	28.4	
Thickness OA	3	5.73	6	3.6	7.6	

METATE TYPE IV INCOMPLETE

Measurement	N	Mean	Median	Low	High	Interquartile
Length GS	1	19.8	19.8			
Width GS	3	22.23	21.5	17.2	28	
Depth GS	3	.2	.1	0	.5	
Length OA	0					
Width OA	3	22.57	21.7	18	28	
Thickness OA	3	7.33	7.6	6	8.4	

TYPE V METATES COMPLETE

Length GS	2	24.4	24.4	18	30.8	
Width GS	2	15.9	15.9	14	17.8	
Depth GS	2	.25	.25	0	.5	
Length OA	2	26.4	26.4	22	30.8	
Width OA	2	18.4	18.4	17.8	19	
Thickness OA	2	4	4	2	6	

TYPE V METATES INCOMPLETE

Length GS	0					
Width GS	2	17.5	17.5	15.5	19.5	
Depth GS	3	.17	0	0	.5	
Length OA	0					
Width OA	2	17.5	17.5	15.5	19.5	
Thickness OA	7	2.8	1.8	1.3	5.1	1.6 , 4.7

INDETERMINATE "TYPES"
TYPE I/III COMPLETE

Measurement	N	Mean	Median	Low	High	Interquartile
Length GS	2	39.55	39.55	37.9	41.2	
Width GS	2	25.55	25.55	24	27.1	
Depth GS	2	6.9	6.9	6.6	7.2	
Length OA	2	53.45	53.45	53	53.9	
Width OA	2	39	39	38.4	39.6	
Thickness OA	2	7.6	7.6	6.6	8.6	

TYPE I/II INCOMPLETES

Length GS	0					
Width GS	3	13.2	14.2	11.1	14.3	
Depth GS	1	2.30	2.30			
Length OA	0					
Width OA	1	39.9	39.9			
Thickness OA	5	9	7.9	6.4	14.3	

TYPE II/III METATES

No complete metate, only four measurements from incomplete ones.

Depth GS	2	2.7	2.7	1.7	3.7	
Thickness OA	2	4.7	4.7	3.3	6.1	

No valid measurements for Type III/IV complete or incomplete, or for type IV/V's (although two very fragmentary specimens of the latter do exist).

METATE MEASUREMENT SUMMARY

One of the striking points in the metric measurements is the general lesser size of the measurements of the "incomplete" metates. This is in spite of the fact that only such measurements that seemed to be complete were used in the summaries. With the exception of depth of grinding surfaces this is true for mean and medians for every other measurement in Type I and Type II metates. And even in Types III, IV and V where the numbers are very small this same trend continues, where eight of the 12 possible comparisons are larger for the complete metates.

While some of these differences do not appear significant, others are. For instance comparing width of grinding surface of the deep basin of Type I metates, we find the difference significant at .01 by the Wilcoxex test (0.01 d 98 this d 95). And the consistency of the difference clearly shows a systematic bias. This difference is in accord with smaller and lighter metates having less of a chance of surviving "complete" in the archaeological record compared to large and heavier metates. This systematic difference then is one that should appear in most metate studies wherever.

When this difference was first noted and the reason for it suggested M. Powers asked whether all such metric measurements should show this and on examining the different measurement classes postulated in accord with this general wear model that the incomplete metates would have a greater depth of grinding surfaces. That is metates with their bottoms nearly worn through are more likely to break than those with thick bottoms. And this turns out to be so for metates Type I, II, and III. For Type IV, flat metates, besides an insufficient sample size, the measurement is merely a measurement of flatness. For Type V grinding slabs, a similar situation occurs.

The fact that the measurements for depth of ground surface are larger for incomplete metates also indicates that the other measurements for incomplete metates are not small due to mistaken identification of "incomplete" measurements as valid "complete" ones. If this was the situation one would expect the depth of ground surface measurement also to be low. Thus in all, the data are in agreement with the "wear" model.

The question of whether "depth" differences are significant can be approached in several different ways. If we assume as the null hypothesis that there is no differences in populations and the differences found due to sampling error, the chance for any given comparison to be higher or lower would be 50 percent, as in flipping a coin. Since we are dealing with three "independent" sets of measurements (three types of metates) the product model is appropriate. Thus the chances of obtaining three heads in a row (1/2 x 1/2 x 1/2 = 1/8) is also the probability of the observed situation occurring by chance. Thus it appears that it unlikely (one chance in eight) that all three measurements would be higher in incomplete metates.

Actually the probabilities are not 1/2 for each case as the differences between incomplete complete in Type II metates seems to be relatively great. If we compare the Type II measurements we find they are significant at between .10 and .05 according to the Wilcoxen test (d for .10 = 87, .05 = 80, this d = 84). By interpolation this gives a probability of about .08. Substituting this figure for one of the .50's in the above paragraphs gives an overall probability of .02, clearly demonstrating the significance of this relationship.

It should be borne in mind that these systematic differences suggest that analyses dealing with only whole metates or only broken ones may well lead to different results.

COMPARISON WITH OTHER REPORT

Our Type I, deep basin grinding slabs, appear to be the same as Woodbury's "grinding slabs" (1954:113-114). The only figures he gives are for length and these seem to indicate a smaller size. His median length is between 20 and 30 centimeters, while his lower quartile is between ten and 20 centimeters and his upper quartile is less than 30 centimeters as compared to our of 46.5, 36.2 and 52. However, his show an abundance from P. V contexts far later than any known from Cedar Mesa.

Our type II, semi-Utah troughs, apparently overlap with Woodbury's "troughed metates with shelf at closed end" (1954:51:52). His means for length, width and thickness (overall) are 45 centimeters, 36 centimeters, 13.3 centimeters compared to our complete metate measurements of 55.23, 38.83, 8.26, showing fair agreement considering the sample sizes (3 and 16).

Woodbury has only one "troughed metate open at both ends" (1954:53) that is complete and two more incomplete but partially measurable. This category overlaps with our Type III troughed metates likewise a small class. Woodbury's complete one is 47 x 33 x 8 centimeters, the two incomplete are 22 and 26 centimeters wide and 5 and 11 centimeters thick (1954:53). This suggests this class may be larger than ours with means of (34.2 complete, 36.35 incomplete) by (25.3, 27.47) by (9.15, 7.6) but of the same general size.

Woodbury's "troughed metates open at one end" also overlaps with our Type III (1954:52) and he gives means apparently based on ten complete specimens of 48 x 31 x 9 centimeters again seemingly larger than those found at Cedar Mesa.

One of Woodbury's largest classes is that of "flat metates" which is the same as our "flat metates" (1954:54-58). He gives means of 39.5 by 27.2 and 8.8 for overall measurements. These are in close agreement with our small samples of 39.77 for length, 26 for width and 5.73 for thickness (7.33 from incomplete metates). Even though the great bulk of Woodbury's are from late Pueblo IV and Pueblo V times, the uniformity of measurement suggests the size was standardized far before.

MANOS

While a wide variety of attributes were measured on manos, the only ones determined of significance are those listed in the following tables, length, width, thickness, completeness, whether one hand, or two hand, and whether made on cobbles or not. The last attribute refers to the material type, that is if it was not sandstone of some sort. These non-sandstone tools were assumed to have been made from river cobbles transported to Cedar Mesa from some location such as the San Juan River. While many manos were clearly made from such cobbles, others were modified sufficiently so that the original shape was impossible to determine. It was assumed that one handed cobble manos would be associated with Basketmaker II sites.

The following tables illustrate the distribution of the above attributes. Measurements are:

Length = longest measurement of complete mano. Presumably perpendicular to line of movement. For fragments, the mano was orientated in that fashion and the length existant was measured and given a plus (+) above and to the right of the measurement.

Width = longest measurement 90° from length for complete manos, fragments measured after orientation.

Thickness = longest measurement 90° from width for complete manos, fragments as before. Note that a mano can be thicker than it is wide.

MANO METRIC MEASUREMENT

1 HAND MADE MANOS (COBBLES) COMPLETE

Measurement	N	Mean	Median	Low	High	Interquartile
Length	41	11.83	12.3	7.9	14.8	10.4, 13.2
Width	40	9.16	9.2	7.4	12	7.9, 10.1
Thickness	40	5.05	4.7	3.2	13.6	4.3, 5.6

INCOMPLETE

Measurement	N	Mean	Median	Low	High	Interquartile
Length	2	11	11	9	13.8	
Width	14	8.35	8.35	6.3	10	7.4, 10.
Thickness	19	3.74	3.8	2.3	5	3 , 4.50

1 HAND MANOS (NOT COBBLES)
COMPLETE

Length	56	11.8	11.5	5.9	17.1	10.5, 13.2
Width	59	8.78	8.7	5.1	11.6	8 , 9.4
Thickness	58	4.06	3.8	2.3	8	3.2, 4.3

INCOMPLETE

Length	1	12	12			
Width	21	9.19	9	7.2	12.1	8.3, 9.8
Thickness	30	2.96	2.8	1.4	5	24 , 3.5

COMPLETE 2 HAND MANOS (NOT COBBLES)

Length	74	21.46	20.95	15	32	19.2, 24
Width	71	11.32	11.5	7.5	17.7	10.2, 12.1
Thickness	72	4.08	3.7	1.5	10	3.1, 4.9

INCOMPLETE

Measurement	N	Mean	Median	Low	High	Interquartile
Length	4	23.28	23.25	17.6	29	
Width	83	11.9	11.19	8.3	15	10.1, 12.2
Thickness	87	3.48	3.2	1	13	2.4, 3.9

2 HANDED COBBLES MANOS COMPLETE

Length	23	17.69	17.2	13.6	24	15.9, 20.2
Width	23	10.33	10.4	7.4	12.4	9.9, 12.4
Thickness	22	5.29	5.05	2	8.8	4.1, 6.3

INCOMPLETE 2 HANDED COBBLE MANOS

Length	1	17.2	17.2			
Width	6	10.92	10.75	9.6	12.6	10.4, 11.9
Thickness	6	4.73	4.85	3.4	5.7	4.0, 5.6

UNCLASSIFIED INCOMPLETE NON-COBBLE MANOS

Length	0					
Width	99	9.89	9.8	6.7	18	8.7, 10.6
Thickness	99	3.31	3.2	.8	5.5	2.5, 3.8

MANOS DISCUSSION

The handstones associated with the neither grinding stones come in a wide variety of sizes and shapes, but much of this variety is due to amount of wear rather than deliberate shaping. The basic division that we, along with other workers, perceived was short or one handed manos and long or two handed manos. The one handed manos as well as being smaller (three fourths being less than 13.2 centimeters long) were rounder in outline and generally had a longitudinal cross-section in which both grinding surfaces were not exactly flat but were slightly lens shaped. One hand manos presumably were used with a slight rotary motion and thus used with deep basin or semi-troughed metates.

Two handed manos on the other hand have a rectangular longitudinal cross section and were presumably used on flat surfaces in a back and forth motion. Two handed manos also tended to have grips, triangular or wedge cross-sections. About three-fourths of complete two handed manos had lengths greater than 18 centimeters. While the lengths of two handed manos would seem to be in accord with the width of grinding surfaces of the semi-trough class of metates, in fact because of the curvature of these grinding surfaces, few would actually fit. Thus, only the relatively rare types III, IV and V metates are compatible with these manos in spite of the fact we have about as many two handed manos as one handed (types I and II outnumber types III, IV and V about four to one). A similar situation is noted by Woodbury (1954:80) for Basketmaker III and Pueblo I times.

Within each of these two broad classes a subdivision was made on the basis of whether the mano was made on a pebble or cobble of exotic origin. It was thought that such manos tended to be less modified and in the one hand

with more convex longtitudinal cross-sections and being typical of Basketmaker II. These can be seen to be somewhat wider and thicker than one handed manos not made on pebbles. In the two handed case pebbles were much less common and differed from the non-pebble case in being shorter, narrower and much thicker. These measurements may be somewhat biased in that a well worn cobble is difficult to identify, but the general trends are probably valid.

The length of both one hand mano types agree very closely with that reported by Woodbury who lists a mean length of 11.7 centimeters (1954:79). The mean width (8.6) and thickness (4.0) are also close considering that both these measurements fall close to the non-pebble manos which apparently was the only type found by Woodbury.

The length of all two handed manos found by Woodbury is significantly greater than that found on Cedar Mesa. Only 14 of the 74 complete non-pebble two handed manos were 25 or more centimeters long which was the mean of all two handed classes reported by Woodbury (1954:68-78). The widths on the other hand of manos with a single grinding surface (which most of our two handed manos fit) are very close with a mean of 11.2 centimeters compared to our 11.32 centimeters (1954:69). Manos with more than one grinding surface become progressively smaller in width and thickness. The thickness or Cedar Mesa two handed manos is less than that reported by Woodbury (4.08 to 4.6 centimeters) for manos with a single grinding surface, and even for two opposite grinding surfaces (4.4 centimeters) but more than for manos with three or four grinding surfaces (3.1 and 3.5 centimeters).

The biggest difference is thus the 3.5 centimeters or so in length. Woodbury has a mano category we did not recognize called "Convex Surface Manos" which has a mean length of 18 centimeters) intermediate between one and

two handed manos (1954:67:68). The question arises if our two handed mano category includes this class and if that accounts for the difference observed. The answer appears to be no. We did not recognize many convex surface manos except in the two handed cobble class, and only 14 of the 74 complete two handed manos were less than 18 centimeters long. Further Woodbury reports this form as being most abundant during Basketmaker III and Pueblo I periods to which few Cedar Mesa manos could be assigned. It appears then that at Cedar Mesa the two handed manos were shorter than those from primarily later contexts at Antelope Mesa.

On checking our assumption that one hand cobble manos were distinctive of Basketmaker II, we find it apparently not so. Inspecting complete one hand manos found during the quadrat survey we find that about as many were made on cobbles as not, but that this was also true of one hand manos found in other contexts.

TABLE _____

COMPLETE ONE HAND MANOS (QUADRATS)

	Basketmaker II	Basketmaker III Pueblo II/III	
Cobble	13	1	25
Non-Cobble	12	17	29
	23	29	54

The frequency of one hand manos made on cobbles then does not seem to vary between Basketmaker II and later times. The same manos were checked to see how many came from sites in which a Basketmaker III component was found.

TABLE _____

COMPLETE ONE HAND MANOS (QUADRATS)

	Basketmaker II/III	Pueblo II/III	
Cobble	19	6	25
Non-Cobble	22	7	29
	41	13	54

What the tables do show is that most cobble one hand manos are found on either Basketmaker II or Basketmaker III sites. This fact plus the absence of two handed manos on Basketmaker II sites gave us the impression that one handed manos made on cobbles were distinctive of Basket maker II. It now appears that the dominance of one handed manos on Basketmaker II sites is what is distinctive not the presence of one handed manos made on cobbles.

One problem with mano fragments not made on cobbles was they often could not be assigned to the one handed or the two handed class upon inspection. Our impression was, however, that most unclassified fragments were in fact pieces of two handed manos. It was hoped that a plot of complete one handed and two handed manos by width and thickness might help to clarify this matter (Figure _____). Upon inspection it can be seen that thickness does not distinguish these two classes, but that width does. A line drawn at 9.6 centimeters "misclassifies" 17 manos out of 113 for a rate of 15 percent (assuming the original classification was "correct"). If we plot the unclassified fragments that were given length and width we find the concentration is in the area of overlap (Figure _____).

If we use the 9.6 centimeter width as a dividing line for unclassified fragmentary manos we find that 63 out of 99 are one the "two handed" side, about two out of three. If we remember that most of our measurements for incomplete ground stone are less than for complete ground stone, for the reasons above, this estimate is thus a conservative one. In summary, most of the unclassified fragments are from two handed manos, however, the distinctions between the two classes are not good enough to clasify members of this group as individuals with any certainty.

MORTARS

These appear to be cobble mortars made out of either sandstone or quartzite. Woodbury's roughly shaped mortars and bowl-shaped mortars appear to correspond to these objects. (1954:116-117).

#	Material	Overall Length/Width/Height			Length/Width/Height		
UGG.C23.1.2976	Medium Sandstone	12+	16+	13	6+	9+	9
	Bowl	10x10x9 cm., overall 18x18x13 cm.					
UGG.C12.2.72	Coarse Quartzite	19	16	9+	5+	6+	4+
	Bowl may be only 6x6x5 cm.						
WJ 2.2484 WJ 2.2485	Fine Sandstone	18.5	17	9.5+	8.5	8.3	4.5
	Bowl probably 8.5x8.3x 6, overall 18.5x17x 10						

UGG.C23.1.2976

UGG.C12.1.72

May be fragments of original top surface.

WJ2.2484,2485

The sizes of the three mortars are more in accord with Woodbury's bowl shaped mortars, although the finish and shaping is in more accord with his roughly shaped mortars.

Doughnut Stone

UGG.9.884 10.5 x 11.5 x 4 cm.

Depression #1 4 x 3.5 x 1

Depression #2 5 x 3 x 1.5

This piece of eroded sandstone may be a concretion. Nothing similar was noted by Woodbury.