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LATE QUATERNARY ARCHAEOLOGICAL AND PALAEO-ENVIRONMENTAL DATA FROM SEDIMENTS AT RHINO CAVE, TSODILO HILLS, BOTSWANA

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ABSTRACT

This paper reports on the 1996 excavations at Rhino Cave. This site is marked by a painting of a white rhinoceros that is bifurcated by a red giraffe. There are also numerous wall depressions or cupules. Approximately 150 cm of deposits were uncovered revealing that the site was used during the time of local Early Iron Age villages as well as during the LSA and MSA. The MSA deposits contain an abundance of lithic materials characterized by unifacial and bifacial points made on corner struck flakes as well as small core scrapers. A detailed palaeoenvironmental study of the stratified deposits was conducted. Sediment analysis clearly demonstrated 3 units (A, B and C) span much of the Holocene and 3 units (D,E and F) are associated with the MSA and the Late Pleistocene. The results of the analysis of the Holocene sediments agrees especially well with data from other localities in the Kalahari.

INTRODUCTION

Archaeological and palaeoenvironmental research was initiated at Rhino Cave in 1995 as part of the Botswana National Museum's long-term interest in the Tsodilo Hills. As a result of this long-term work, Tsodilo has become one of the most significant archaeological areas in the Kalahari; a region that was previously thought to have been 'marginal' in prehistory. The hills contain over 3,500 rock paintings, rock shelters with Later and Middle Stone Age deposits, Early Iron Age villages and numerous prehistoric specularite mines (Denbow & Wilmsen 1986; Robbins *et al.* 1994; Campbell *et al.* 1994, Robbins *et al.* 1998, Robbins *et al.* 2000). The

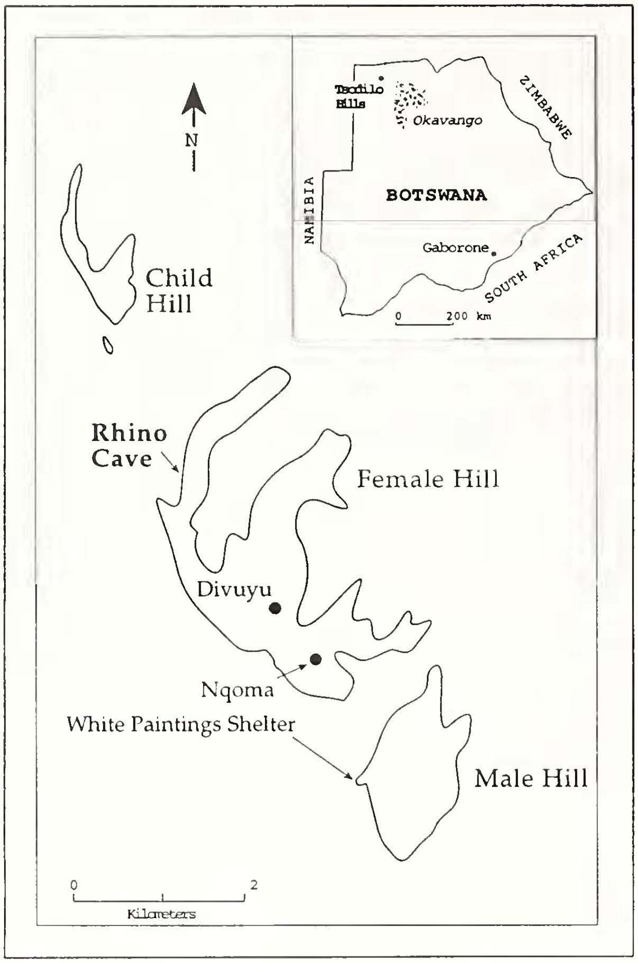

Fig. 1. Map of the Tsodilo Hills showing the locations of Rhino Cave, the Depression and White Paintings Rock Shelter and the villages of Divuyu and Nqoma.

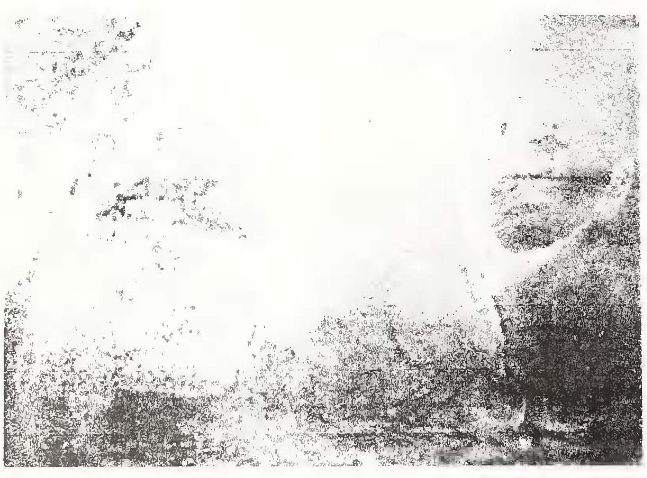

Fig. 2. Painting of rhinoceros and giraffe.

overall archaeological record at Tsodilo covers at least the last 100,000 years (Robbins *et al.* 2000).

Rhino Cave is a small, naturally hidden fissure situated near the north end of Female Hill (Fig. 1). The cave is named after a prominent painting of a rhinoceros on one of the two walls. The rhino is painted in white and is bifurcated by a red giraffe (Fig. 2). There are also several red geometric designs; most notably circles enclosing grids. On the wall of the fissure opposite to the paintings are more than 300 grooves and depressions, or `cupules' that have been intentionally ground into the wall. The depressions and grooves are among the best preserved at Tsodilo and are naturally illuminated by changing pat-terns of afternoon sunlight which shine through a small opening in the boulder choke at the rear of the cave.

Two 1 x 1 m squares were excavated at the site in 1995 adjacent to the painted area of the wall (squares 1 & 2). The upper 50 cm of deposits only contained sparse archa-eological evidence. Denser concentrations of Later Stone Age lithic materials appeared at approximately 55 cm. Middle Stone Age deposits containing small corner-struck (the striking platform and bulb of percussion is on the basal corner of the point) unifacial and bifacial points were uncovered at a depth of 90 cm. These MSA deposits extended to a depth of 130-140 cm. A detailed account of the 1995 findings, including a description of the rock art is presented elsewhere (Robbins et al. 1996a). This paper reports on the follow-up work carried out at Rhino Cave in 1996, emphasizing new findings that either modify, or increase, our original understanding of the site. Particular attention will be paid to the sediment analysis in relation to palaeoenvironmental reconstruction and the implications of this work for regional comparisons in the Kalahari.

In 1996, two additional one meter squares, designated squares 3 and 4, were excavated adjacent to the 1995 excavations (Figs 3 & 4). The excavation of squares 3 and 4 allowed us to extend our cross section of the deposits through most of the width of the cave and recover a large sample of artifacts (Fig. 5). We uncovered 1,50 m of archaeological deposits, excavating most of the area in 5 cm arbitrary levels. As will be shown, most of the artifacts found in the 1996 excavations belong to the Middle Stone Age. However, the upper levels (generally above 35 cm) yielded the first pottery discovered at the site, as well as a low density scatter of lithics, fauna and mongongo (*Ricinodendron rautanenii* Schinz) nut shell fragments (Campbell & Robbins 1990).

STRATIGRAPHY AND DATES

The cross section of the 1995 and 1996 excavations shows a stratigraphy dominated by wedge-shaped units (A to F) that thicken in a northwest direction essentially away from the entrance to the rock shelter (Fig. 5). The upper three units (A-C), consisting of medium to fine sand and silt, are generally brown to grayish brown in color. These overly a much coarser, grayish brown deposit, dominated by angular rock fragments usually less than 6 cm long (very coarse gravel) in a matrix of medium to fine sand (unit D). Many of the rock frag-ments are imbricated, with their long axes and flat surfaces paralleling the slope of the deposit. Underlying unit D is 15-25 cm of pale brown, medium to fine sand

Fig. 3. View of the 1996 excavation of squares 3 and 4.

(unit E), and beneath this is a brown to yellowish brown, fine gravel (unit F). Unit F is distinctive as it includes rounded 1-1.5 cm diameter gravel, among larger sub-angular to sub-rounded clasts generally less than 10 cm long, all in a matrix of sand. A more detailed description of the sediments and their possible palaeoenvironmental significance will follow a description of the archaeology.

A radiocarbon date of 1660 ± 80 BP (cal. AD 225-590) was obtained from charcoal fragments recovered from a depth of 20-25 cm in unit A of square 3 (Beta 106240). This date is close to the age of the earliest dates for the Tsodilo Early Iron Age village of Divuyu (Denbow & Wilmsen 1986). Together with the date of 980 ± 80 BP (Beta 84719) obtained from square 2 in 1995, this shows that Unit A was probably laid down during the later part of the Holocene. The ages and artifacts in unit A also suggest that Rhino Cave was probably frequented during the time of Divuyu (1400 ± 70 to 1190 ± 70 BP) as well as during the time of the more recent village of Nqoma (1290 ± 60 to 860 ± 60 BP). Most of the cultural material found during this relatively late period of prehistory is sparse, and supports our original conclusion that the cave was only visited briefly on an occasional basis during the Early Iron Age. A date of 5300 ± 160 BP (Beta 84720) from 70-75 cm in square 2, near the base of unit B suggests that this unit is mid- to late-Holocene in age. It should be noted that this date was obtained from a sample recovered in the 1995 work in an area where the Holocene deposits of unit B were comparatively thick and where the LSA artifacts were very numerous (Robbins *et al.* 1996a). So far, we have no dates for unit C which is restricted to square 1. However, we believe that this is an early Holocene deposit.

Units D-F are clearly late Pleistocene in age as evidenced by numerous finds of MSA points in them. Use of Rhino Cave during the MSA appears to have been quite significant judging from the large numbers of artifacts recovered (Table 1). However, dateable charcoal was rare in the deeper deposits and there was no fauna in the MSA levels. An AMS radiocarbon date of 14 500 ± 50 BP (Beta 106241) was obtained on a small charcoal sample recovered from 65-70 cm in unit D, square 3.

In addition to the radiocarbon date of 14 500 ± 50 BP cited above, a thermoluminescence (TL) age of 18 175 ± 2871 BP (corrected to the radiocarbon timescale according to Bard *et al.* 1990, this is 15 448 BP) was obtained on a sample from unit F. While most of the dates from Rhino Cave are consistent with the natural stratigraphy shown in Figure 3, it is emphasized that the two dates from the levels containing MSA tools (14 500 ± 50 BP and 18 175 ± 871 BP) are substantially younger than ages obtained for the MSA at the Tsodilo White Paintings Shelter as well as elsewhere in southern Africa (Robbins *et. al,* 2000, Brooks et al. 1990, Volman 1984). For example, at the White Paintings Shelter a TL age on sediments from the upper part of the MSA at 500 cm was 66.4 ± 6.5 ka (Robbins *et al.* 2000). For this reason, the age of the MSA deposits (D through F) at Rhino Cave should be regarded as uncertain. As the sample for TL dating was taken close to the wall of the shelter, in heterogeneous deposits, and as no field gamma spectrometer measurements were made, estimation of the annual dose at the sampling site is difficult and this may account for the young age that does not correspond with ages from other MSA sites.

The stratigraphy shown in Figure 5 indicates that most of the cultural material and associated sediments accumulated between two very large boulders which served as natural traps for this material (Figs 4 & 5). Because much of square 4 (1996) contained a massive rock, our detailed discussion of the artifacts obtained in 1996 is based almost entirely on the large amount of material recovered from square 3.

ARCHAEOLOGICAL FINDINGS

Nearly 10,000 artifacts were recovered from square 3, most consisting of lithic debitage; largely flakes, broken flakes, and angular debris (Table 1). Only about 3.5% of the lithic material has evidence of retouch and could, therefore, be classified as formal tools (Table 2).

Most of the artifacts were concentrated in the coarse deposits between 45-95 cm with the MSA points clustering in the same approximate depth range (Tables 1 & 2). Because the MSA deposit slopes markedly (about 25°) to the northwest (see Fig 5), MSA points were encountered at shallower depths in the 1966 exca-

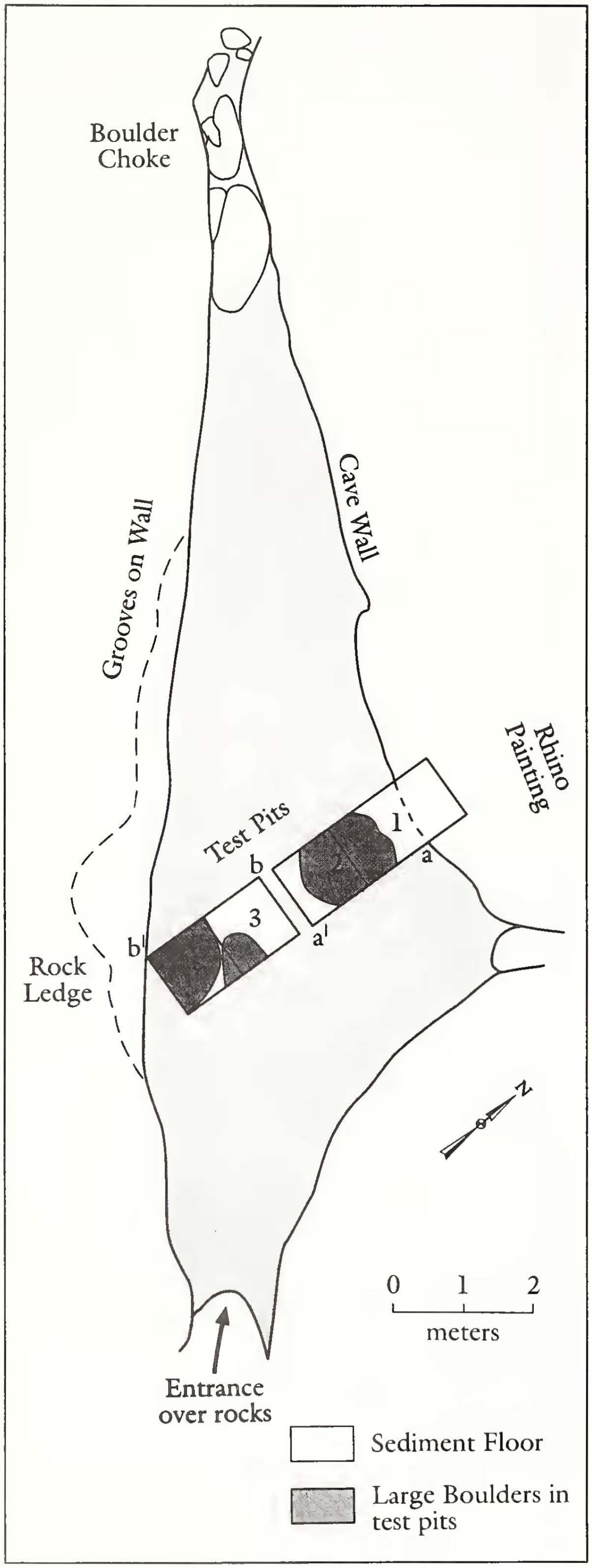

Fig. 4. Map of Rhino Cave showing squares 1-4 excavated in 1995 (1 and 2) and 1996 (3 and 4).

vations than was the case in 1995 (Robbins et al. 1996a). An overview of the 1996 findings follows.

Later Prehistory: Units A and B:

The upper 25 cm consisted of ashy sand with numerous dispersed charcoal fragments. As mentioned previously, a date of 1660 ± 80 BP was obtained from the 20-25 cm level of square 3. As seen in Tables 1 and 2, the fine sediments, as a whole, contained sparse lithic remains, a few potsherds, mongongo nut shell fragments and animal bone fragments. There were no ostrich egg shell fragments or iron artifacts.

The stone artifacts included very few formal retouched tools. There were two small scrapers (jasper and chert) similar to LSA finds from the Tsodilo Depression shelter where such tools are also commonly found in levels that have yielded small amounts of pottery (Robbins 1990). A small quartz crescent, or segment, was recovered from the adjacent square 4 in the 10-20 cm level. The debitage, which was generally quite sparse, mainly includes small quartz flakes along with jasper, silcrete and several varieties of chert. The quartz is locally available, whereas the other raw materials are believed to come from more distant sources.

Most of the faunal remains were concentrated between 25-35 cm. There were 184 bone fragments thought to come from small animals. Both burned and unburned bone fragments were evident. Since the bones, as well as the nut shells, were found amidst the ashy deposits, they are believed to be food refuse. While the bones were generally too fragmentary for identification, the 35-40 cm level yielded a bird bone in the guinea fowl size range and a small piece of tortoise shell was recovered from 10-20 cm in square 3.

A small, undecorated rim sherd was found in the 0-5 cm level. Another sherd from a different vessel was recovered from 20-22 cm close to where the radiocarbon sample that produced the date of 1660 ± 80 BP was obtained. This large sherd is decorated with two rows of fingernail impressions just below the rim. Sherds with nail impressions are reported by Hendrickson (1986) to form 2.0% of the types of decoration found at the Early Iron Age village of Divuyu where there is a large quantity of decorated pottery. Two additional undecorated body sherds with charcoal temper, a regional Early Iron Age characteristic, were recovered from the 25-30 cm level. Elsewhere at Tsodilo, Early Iron Age sherds have been found in deposits with LSA artifacts at the White Paintings and Depression shelters as well as the Lower Male Hill Cave (Robbins 1990; Campbell *et al.* 1994; Robbins *et al.* 2000).

The Middle Stone Age deposits: Units D, E. and F

As noted previously, the underlying coarse deposits of units D and F, as well as unit E, contain unifacially and bifacially flaked MSA points. Seventy one points were recovered including complete points, fragments and some that were probably not completely finished (Fig. 6). Some of them appear to have been broken while being manufactured. While most of the points, especially the complete specimens, are 'typical' MSA

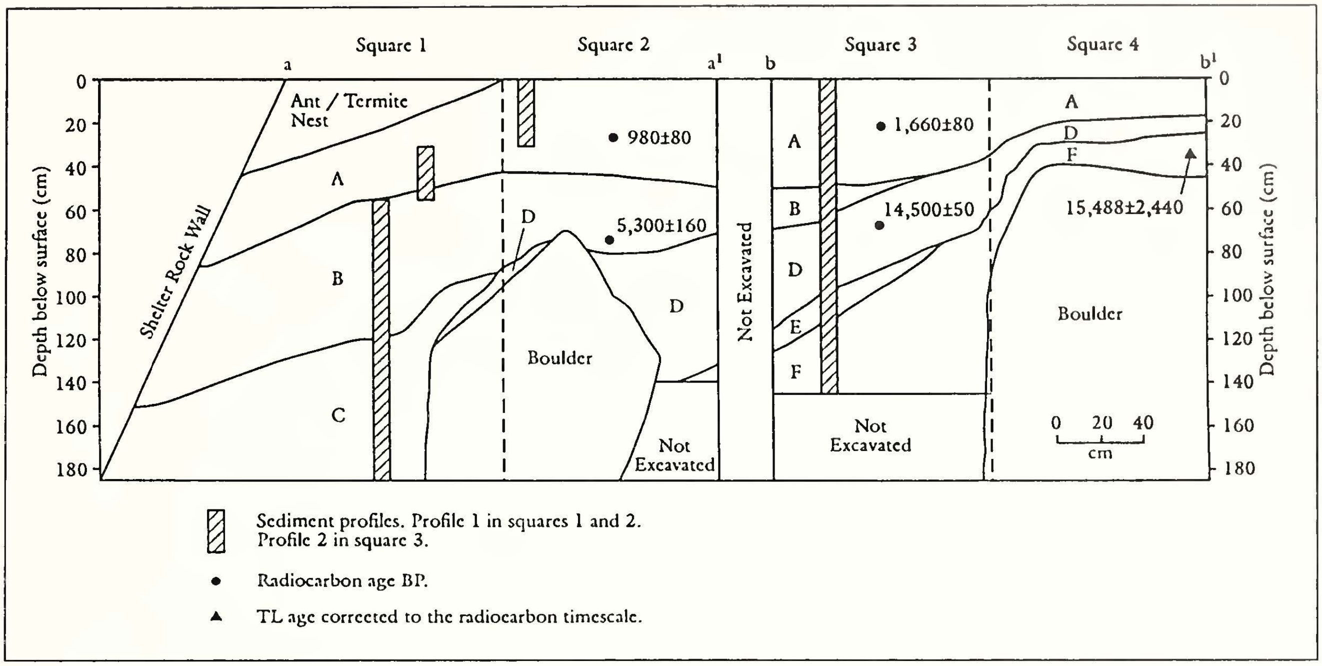

Fig. 5. Stratigraphic cross section of the east wall of squares 1-4 showing sediment profiles 1 and 2 and radiocarbon data.

points, some of the preforms, or point blanks, as well as other specimens that seem to be unfinished, are more difficult to distinguish clearly from other classes of artifacts such as pointed scrapers and awls. The raw materials used in making the Rhino Cave points include quartz, several varieties of chert, jasper, chalcedony and silcrete. The types of chert used by the MSA peoples are distinguished by colour and are detailed in Robbins *et al.* (1996a).

It was possible to classify sixty-seven of the MSA points found in Square 3 into the following groups.

Finished points: 33
Point tips: 12
Point bases: 2
Unretouched point preforms or blanks: 5
Points in manufacture: 8
Failed, or rejected points: 5

The presence of unfinished and broken points along with the large amount of debitage recovered, indicates that the cave served as a location for tool production during the MSA. Non-local raw materials (cherts, jasper, chalcedony and silcrete) were brought to the site to be made into tools. The point tips were either broken in manufacture/ sharpening, or were brought into the cave embedded in the body parts of animals that were going to be butchered further or eaten.

In addition to MSA points, scrapers are well-represented among the retouched tools. We did not find any small scrapers of LSA type in the coarse deposits, though they do occur in the overlying deposits. However, one kind of small core, or steep scraper, was recovered that is quite distinctive. Such tools were typically made in an identical fashion on thick flakes that result from the splitting of a core. Ten of these scrapers were recovered from the 5 cm spits excavated between 70 and 90 cm, within layer D. They may, in fact, be an indicator of a general period within the MSA at the site. The small core, or steep, scrapers included the following raw materials: jasper (2), chert (7) and silcrete (1).

Distally backed bladelets or points were also found in the coarse deposits, clustered between 65-85 cm in Square 3 (Table 2). These finds were first recognized in the 1995 work where they were previously found in both LSA and MSA levels. It could be that these artifacts (given the clustering by depth) are also stratigraphic indicators of change within the MSA, along with the small core/steep scrapers.

It should be noted that the technique of producing bladelets was evident near the base of the deposits in association with the MSA. For example, a well-made single platform bladelet core made on a piece of crystalline quartz was found in square 3, 1,30-1,40 m. This core is identical to specimens found at the base of the Tsodilo Depression site at 5,0 m where the deepest and oldest radiocarbon date of 18 910 ± 180 BP was obtained from the 2,70-2,80 cm level (Robbins 1990). Thus, the Rhino Cave specimen found in an MSA context adds to the information regarding the long antiquity of the microlithic reduction technique in the Kalahari.

A final point is that specularite was found in both the later prehistoric and MSA deposits. The specularite occurs in the form of small metallic crystals and pieces of vein specularite. The latter type of material, including the artifact described below, is often rich enough in iron

Table 1. Artifacts recovered from square3 during the 1996 excavations.

	A.d.	Flk.	Blt.	Bl.	C.	Pb.	Gds.	Hs.	Utl.	Rt.	Sp.	Pot.	F.	Mg.	Mr.	Oth.	Tot.
0-5		2										1	1		1		5
5-10		7															7
10-20	2	8								1			127	1		1	140
20-25	3	10			1							1	37	4			56
25-30	7	25	1	1	2							2	11	7		1	57
30-35	48	68	17	1	3			1		2	2		2	5		1	150
35-40	46	99	11	1	3					3							163
35-40s	13	59	3			1				1			5	8			90
40-45	62	110	16	1	2		2	1		13						1	208
40-45s	2	26	2											2			32
45-50	150	388	30	6	21			1	4	18						1	619
45-50s	5	32	4		1					1				2			45
50-55	208	502	52	3	14		1	1	9	25	4						819
50-55s	7	43	3		1					3			1				58
55-60	189	471	62	7	15				11	44	7					1	807
55-60s	15	52	3	1	1				1	1	1						75
60-65	142	440	30	8	11		1	4	1	23	6						666
65-70	130	478	35	4	13	1	3		12	19							695
70-75	136	372	29	6	6		1	1	12	18	2						583
75-80	145	526	48	10	19		1		19	35	1					2	806
80-85	118	630	48	7	14			2	9	33						6	867
85-90	155	879	50	13	11	1			21	48	4					1	1183
90-95	82	358	28	6	8				13	20	1					1	517
95-100	72	258	13	2	10				10	13	3						381
100-105	73	379	32	3	17		1		11	15	2						533
105-110	35	125	6	2	1		1		3	2							174
110-115	13	100	10			1			3	3	1						131
115-120	7	33	1			1			2								44
120-125	5	4	1	1						1							12
125-130	1	4								1	1						7
130-140	2	3			1												6
140-150	2	5	1		2												10
Total	1875	6496	536	83	177	5	10	12	141	343	35	4	184	29	1	16	9946

Key
A.d=Angular debris, Flk=Flake, Blt=Bladelet, Bl=Blade,C=Core, Pb=Pebble
Gds=Grindstone, Hs=Hammerstone, Utl=Utilized, Rt=Retouched, Sp=Specularite
Pot=Pottery, F=Fauna, Mg=Mongongo nut, Mr=Marula, Oth=Other
S= sand area of unit

to be attracted by a magnet when the artifact is balanced near the midpoint. The crystals are commonly found at exposures on the upper part of the Male Hill and the vein material is derived from the Tsodilo bedrock. Both forms were being intensively mined between AD 800-1000 at Tsodilo (Robbins *et al.* 1998), but it is clear from the work at Rhino Cave that both types of specularite were being used for a long period prior to the intensive mining. One unique thin slab of the vein material, measuring 7.2 x 7.0 x 1.0 cm was recovered from the MSA deposits of square. 3, 1,0-1,05 m (Fig.7) This piece has a beveled edge that is worn and polished from use, perhaps for rubbing hides. The specimen is flat on both surfaces and the polished edge is convex.

Sediment analysis and paleoenvironmental inferences

Sediment Characteristics

In an attempt to understand more about the sediment sequence in the cave and its relation to artifact discoveries, we have examined samples of sediment recovered in both 1995 and 1996 (Profiles 1 and 2).

Table 2. Retouched tools recovered from square 3 during the 1996 excavations.

	B.p	B.	Sc.	Awl	Brn.	Den.	R.b	R.b/1	N.	MSA/1	MSA/2	MRP	Brk.	Oth.	Total
0-5 cm															0
5-10															0
10-20			1												1
20-25															0
25-30					1										1
30-35		1										1			2
35-40												2	1		3
35-40/s												1			1
40-45		2		4	1					1		5			13
40-45/s															0
45-50		1		1	4				1	6	1	4			18
45-50/s		1													1
50-55		1	6					1		4	5	4	3	1	25
50-55/s			1	1								1			3
55-60		2	4	2	2	2				13	1	10	7	1	44
55-60/s	1														1
60-65	1		5	2		1			2	7		4		1	23
65-70	1		1	6	2	1				3	1	2	2		19
70-75			5	1	1			2	1	4		4			18
75-80	1	1	6	5		7	2	2	1	4		5	1		35
80-85	1	2	11	2			2	1	1	5	1	4	3		33
85-90			13	6	3	1		1		7		13	4		48
90-95			3	4			1		1		3	7		1	20
95-100		1					1				2	7	2		13
100-105			1			5	2		2	1		1	2	1	15
105-110						1						1			2
110-115										1	1	1			3
115-120															0
120-125				1											1
125-130								1							1
130-150															0
Total	5	12	57	35	14	18	8	8	9	56	15	77	25	5	344

Key
B.pt=Backed point, B=Other backed,Sc=Scraper, Awl=awl
Brn=Burin,Den=Denticulate,R.b=Retouched blade, R.b/1=Retouched bladelet
N=Notch, MSA/1= MSA unifacial point, MSA/2=MSA bifacial point
MRP=Miscel. retouched piece, Brk=Broken tool, Oth=Other
Note, /s indicates sand area, e.g. 50-55/s

Columns of sediment were removed in increments of 5 cm from deposits exposed by the 1995 and 1996 excavations. Sampling extended to 185 cm in squares 1 and 2 and to 145 cm in square 3. Generally, 400-500 g of sediment was collected but in coarser deposits samples of up to about 1300 g were taken for laboratory analysis. For this report ten samples have been studied from squares 1 and 2 and eight from square 3 (Fig. 5). Sediment color was determined on dry, untreated samples using a Munsell color chart. Visible plant and bone fragments, and stone artifacts, were removed before textural analysis began. Material coarser than 0ϕ was removed from the samples and dry sieved at 0.5ϕ intervals to -3ϕ and sieved at 1ϕ intervals from -3ϕ to -6ϕ to determine gravel percentages.

Sub-samples of about 25 g from the $>0\phi$ fractions were then treated with 0.5 N hydrochloric acid to remove carbonates (there was very little) and then with hydrogen peroxide to remove any remaining organic matter. What remained of each sample was dispersed in a solution of sodium hexametaphosphate and wet-sieved through a 4ϕ sieve to remove silt and clay. Particles

Fig. 6. MSA points from square 3 excavated in 1996. Upper row, left to right: 65-70 cm, 55-60 cm (in manufacture), 50-55 cm (tip). Lower row, left to right: 90-95 cm, 85-90 cm.

coarser than 4ϕ but finer than 0ϕ were dry sieved at 0.5ϕ intervals. The silt and clay separated by wet sieving was then subjected to pipette analysis to determine percentages of silt and clay. Mean grain size, sorting, skewness and kurtosis were determined by the graphical method of Folk and Ward (1957).

Clay mineral analysis was conducted on samples from units A (35-30 cm), B (90-85 cm) and C (1,70-1,65 m) in Profile 1, and from units A (25-20 cm), B (65-60 cm), D (85-80 cm), E (1,05-1,0 m) and F (1,25-1,20 m and 1,45-1,40 m) in Profile 2. Samples were prepared via centri-fugation to yield a <2 micron sub-fraction. All samples were oxidized with standard soil procedures to remove organic matter prior to X-ray analysis. X-ray diffraction (XRD) mounts were prepared by air drying a suspension of each clay fraction on a glass slide. Diffraction data were collected on a Scintag XDS-2000 diffractometer over the range 2-30 degrees 2-theta.

Sediment characteristics through Profile 1 for test pits 1 and 2, and through Profile 2 for test pit 3, are shown in Figs. 8-11. In essence, the results reflect the stratigraphic sequence observed in the field and discussed briefly above (Fig. 3). Profile 1 passes through units A, B and C. Mean grain size varies from 1.7 to 2.1ϕ which is in the range of medium to fine sand. The sediments are poorly to very poorly sorted (standard deviation 1.1-2.7ϕ), positive (fine)-skewed to very positive (fine)-skewed (skewness 0.1-0.4ϕ), indicating a fine tail, and leptokurtic to extremely leptokurtic (kurtosis 1.2-3.8ϕ) reflecting relatively peaked particle size distributions (Fig. 9). Average properties of sediments in units A-C are shown in Table 3. The data indicate that unit B is

Fig. 7. MSA artifact with polished and ground edge from square 3, 1,0-1,05 m.

slightly coarser than units A and C, that the sediments are better sorted upwards in the profile, that all units have a fine tail (positively skewed), and that peakedness increases with depth (Table 3).

Profile 2 passes through units A, B, D, E and F. Unit C is missing in the sediments of squares 3 and 4 or is poorly represented. Average sediment characteristics for the various units are shown in Table 3. Unit A is similar in test pit 3 as in test pits 1 and 2 while unit B appears a little coarser (mean grain size is 1.6ϕ equivalent to medium sand compared to 1.9ϕ), not as well sorted (2.7 compared to 1.9ϕ), negatively rather than positively skewed (-0.1 compared to 0.3ϕ), and has a slightly more peaked distribution (kurtosis 2.8 compared to 2.5ϕ). Unit D, which contains the bulk of the artifactual material, has a mean grain size of -0.2ϕ, equivalent to very coarse sand, is very poorly sorted (2.7ϕ), negatively (coarse)-skewed (-0.1ϕ), and very leptokurtic (2.8ϕ). By contrast, the mean grain size of unit E is fine sand (2.0ϕ), the sediment is poorly sorted (2.8ϕ), has a nearly symmetrical particle size distribution (skewness -0.04ϕ) and is extremely leptokurtic (3.8ϕ). The basal unit F has the coarsest sediments in the sequence with a mean grain size of -2.2ϕ equivalent to fine gravel. It is very poorly sorted (3.4ϕ), very positively (fine)-skewed, and very platykurtic (0.5ϕ) indicating a wide range of particle sizes (Fig. 10).

Palaeoenvironmental Inferences

Because of the scarcity of fauna, the results of the

Table 3. Average particle size characteristics of sediment units A-F at Rhino Cave.

Square/Unit	Particle Size Characteristics (ϕ units)					Sand Fraction Percentages	
	Mean	Sorting	Skewness	Kurtosis	Gravel and small cobbles (% sediment)	Very coarse and coarse sand (% sand fraction)	Medium, fine and very fine sand (% sand fraction)
Squares 1&2							
unit A	1.93	1.69	0.26	2.19	1.4	18.1	81.9
unit B	1.87	1.90	0.28	2.55	3.4	18.5	81.5
unit C	1.90	2.19	0.27	3.01	3.3	22.2	77.8
Square 3							
unit A	1.98	1.66	0.22	2.15	1.8	16.5	83.5
unit B	1.61	2.67	-0.11	2.80	12.9	18.6	81.4
unit D	-0.24	3.50	-0.49	0.63	39.5	12.8	87.2
unit E	1.99	2.76	-0.04	3.76	9.2	12.5	87.5
unit F	-2.18	3.37	0.46	0.52	56.2	14.1	85.9

sediment analysis are of major importance in interpreting the palaeoenvironmental record at Rhino Cave. As mentioned previously, the Rhino Cave excavations have revealed a cave stratigraphy consisting of a series of overlapping wedge-shaped sediment units thickening towards the northwest away from the entrance to the rock shelter (Figs 4 & 5). The geometry of these units suggests that much of the sediment in the shelter was transported through the entrance by gravity, water or wind. The coarsest material was probably produced by chemical/ mechanical weathering (including frost weathering) of the shelter walls and ceiling, and of the rocks above and around the cave entrance. Logically, finer-grained, positively-skewed sediment units should equate with drier conditions when more material was transported into the shelter by wind. Under wetter conditions the input of aeolian sand and silt should be reduced due to a denser vegetation cover on the nearby dunes and rock surfaces. Wetter conditions should also lead to a greater accumulation of coarse material produced by increased break-down both within and outside the shelter. Furthermore, under wetter conditions we might expect rock fragments to be more rounded than would be the case under drier conditions. Increased runoff into the cave will carry coarse rock fragments that will be deposited on the cave floor where water flow velocities are reduced. The particle size most easily entrained by running water is 0.2 mm (fine sand of diameter 2-3ϕ) while that most easily entrained by wind is 0.08 mm (very fine sand of diameter 3-4ϕ) (Bagnold, 1941; Sundborg, 1956). Logically, therefore, coarse, negatively-skewed sediments in Rhino Cave should equate with somewhat wetter conditions while fine, positively-skewed sediments should reflect drier climates.

As Figure 8 shows, units A-C in squares 1 and 2 are unimodal being composed largely of medium and fine sand with gradually decreasing percentages of coarser material to fine gravel size. By contrast, units A, B, and D-F in square 3 are either strongly (units D and F) or weakly (units A, B and E) bimodal with peaks in the medium and fine sand range and peaks in the small cobble to coarse gravel range. In terms of sand content alone, all units are dominated by medium, fine and very fine sand (77.8-87.5%) with lesser amounts (12.5-22.2%) of very coarse and coarse sand (Table 3). Most of this sand is probably of aeolian origin. The bimodality of units A, B, and E in square 3 is probably related to the proximity of this square to the cave entrance where there is an increased likelihood of coarser particles entering the cave and being incorporated into sediments even during relatively dry intervals. Units D and F, however, are so strongly bimodal, with 39.5% and 56.2% gravel and small cobbles respectively, that it seems likely that these units accumulated under different conditions from those prevailing when the other units were laid down (Table 3). In essence, the input of aeolian sands during deposition of units D and F was extremely slow allowing accumulation of considerable thicknesses of coarse fragments derived from weathering of the local bedrock. This implies that much wetter and possibly

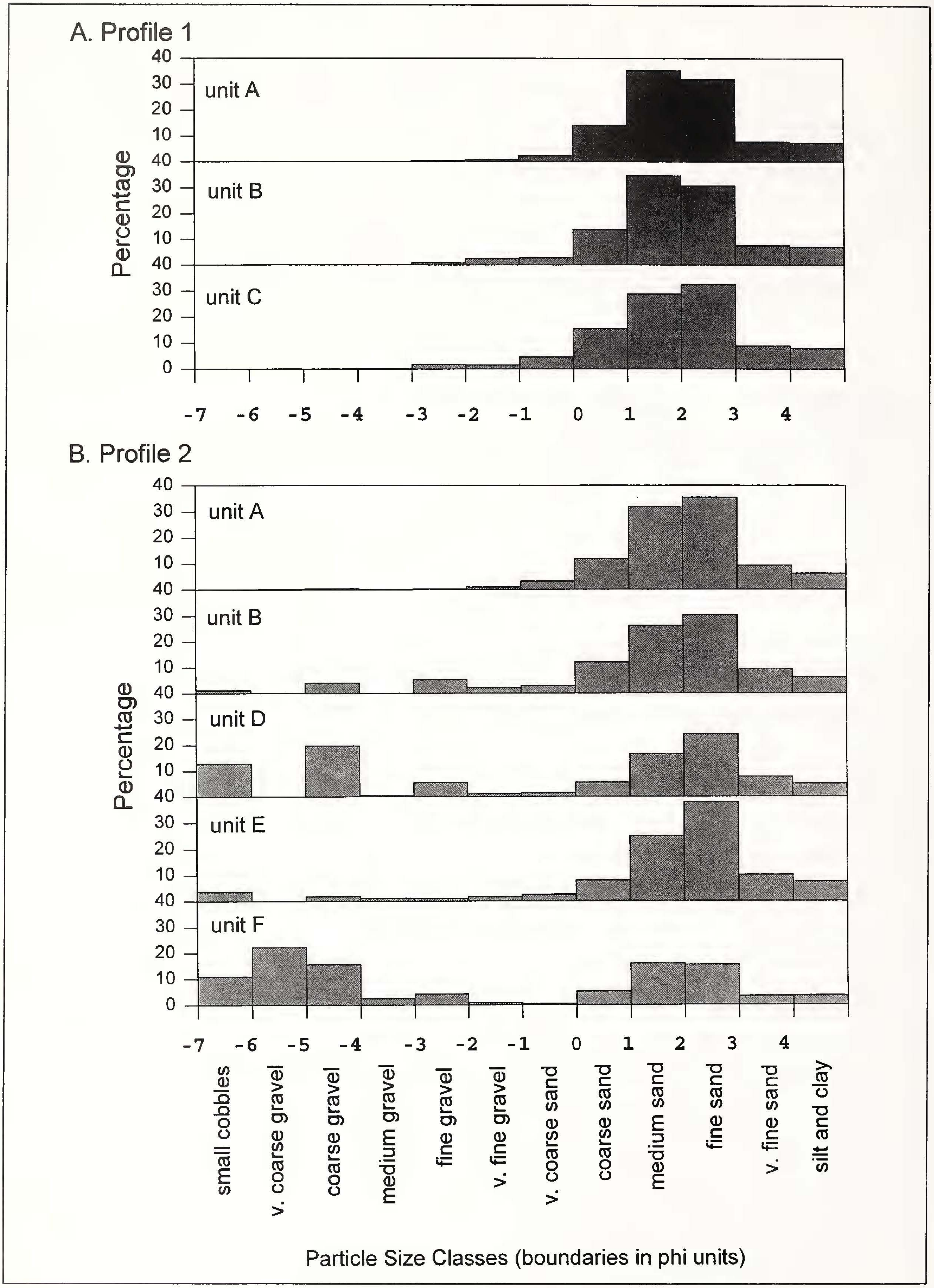

Fig.8. Grain size-frequency histogram for units A-F in sediment profiles 1 and 2.

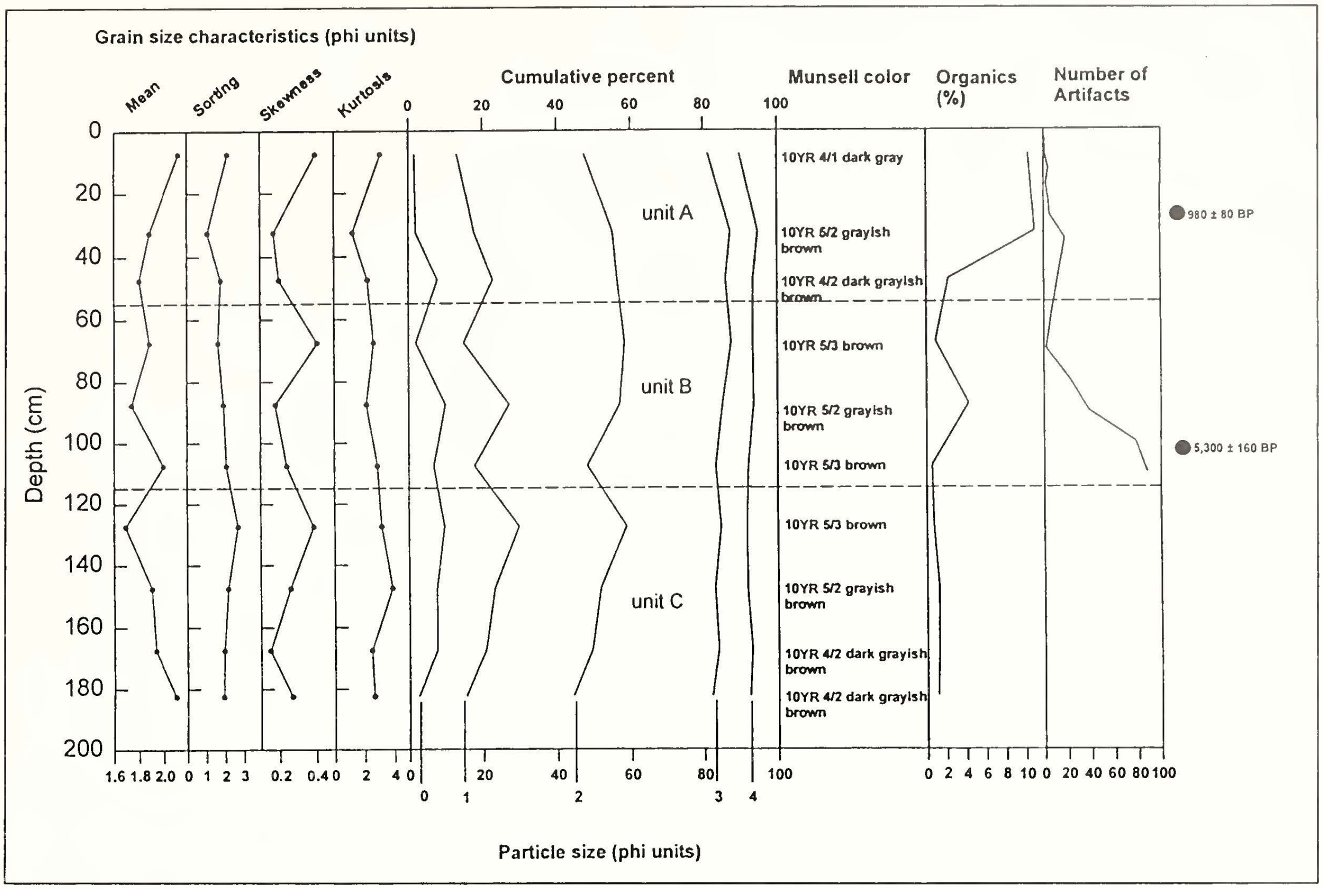

Fig. 9. Sediment characteristics and artifacts in units A-C of profile 1 through squares 1 and 2.

colder conditions existed when unit D (containing the main MSA deposits) was deposited, than when units A-C and E were deposited, a fact born out by evidence of highly weathered quartzite fragments in unit F, which impart a localized yellow/orange color to this unit. It is possible that increased moisture coupled with lower temperatures and more frequent frost may have influenced the breakdown of the quartzite along fractures and grain boundaries during deposition on units D and F. On the other hand, unit E almost certainly represents an arid phase when the input of aeolian sands into the cave far exceeded the production of coarser debris, so that this unit is dominated by medium and fine sands. Unit E has a much lower gravel and small cobble content than units D and F and is more like units A-C than units D and F.

Frost breakdown cannot be ruled out as a cause of the accumulation of angular debris in Rhino Cave in the past. At the present time Shakawe, 46 km northeast of Tsodilo, has a mean annual temperature of 22.5° C and exper-iences an average 3 winter ground frosts per year with the lowest recorded temperature (1959-85) being -7.5° C. Maun, some 220 km to the southeast has a mean annual temperature of 22.6° C and experiences an average 10 ground frosts per year with the lowest recorded temperature (1959-80) being -5.8° C (Bhalotra, 1987). If temperatures in southern Africa during the last glacial period were as much as 5.3 to 6.0° C lower than now (Heaton *et al.*, 1986; Talma *et al.*, 1974; Stute & Talma, 1997), then frost was probably requente ouhin northern Botswana to cause substantial rock disintegration. Some of the large angular fragments of units D and F may, therefore, have been produced by frost when sufficient moisture was available to make the process effective.

XRD analysis shows similar clay minerals in the nine samples analyzed. All contain kaolinite, mica, a 2:1 mineral, and pyrophyllite. Mixed-layering is indicated by the low-angle shoulders on the mica and kaolinite reflections in units A and B of Profile 2 (Fig. 11). This appears to be the most significant difference between the samples. The presence of mixed layering may reflect the exposed position of the shallow sediments in Profile 2 in respect of the cave entrance. It is likely that this part of the cave floor receives more moisture than other parts and this may have resulted in some additional weathering of the clays blown into the cave from outside. That all of the samples are similar in clay content suggests that they originated from a similar source and were emplaced in the cave by the same process. It seems likely that the clay minerals were transported to the cave by wind from the dunes that surround the Tsodilo Hills or from rock outcrops of the Hills themselves.

The four radiocarbon ages for the Rhino Cave

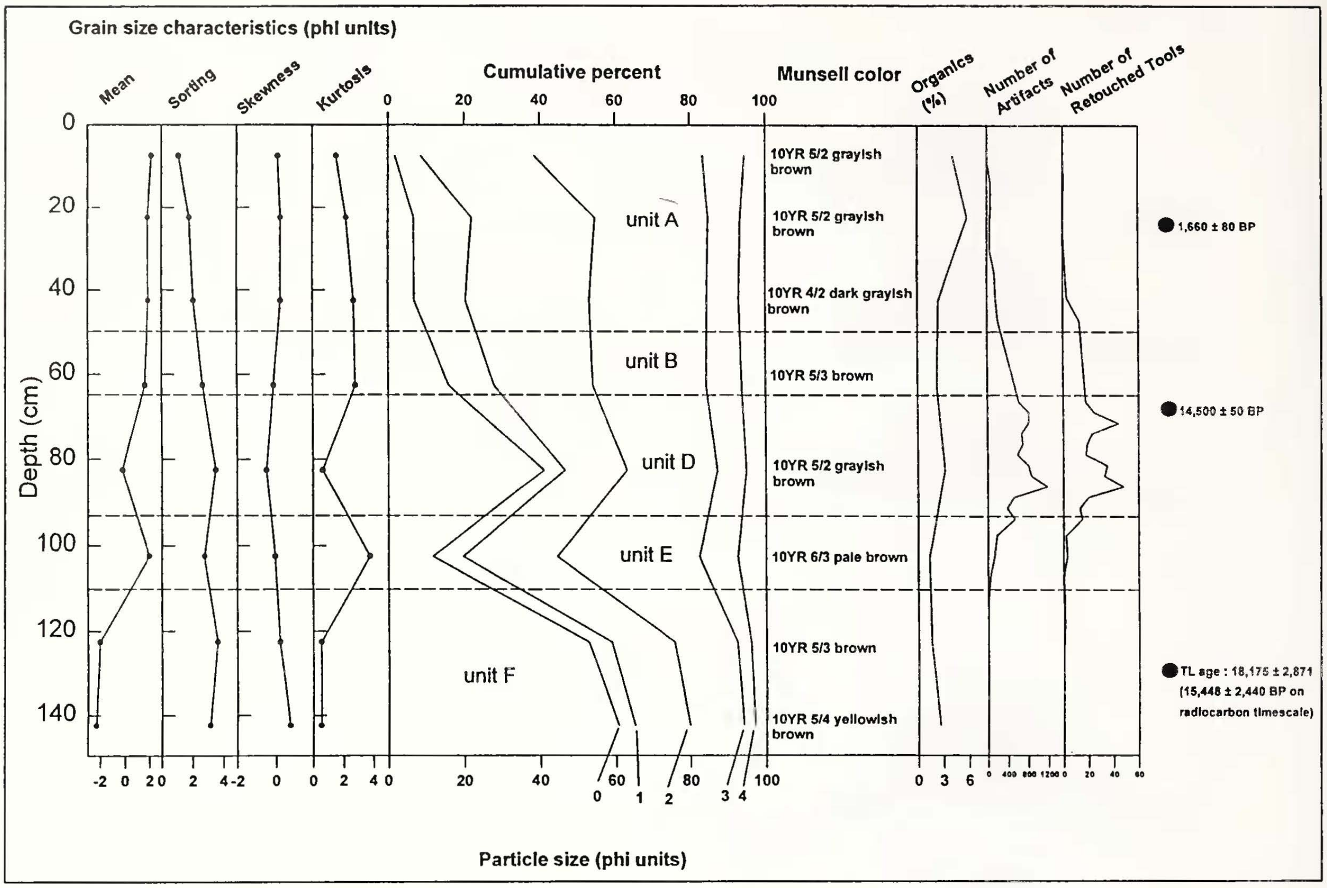

Fig. 10. Sediment characteristics and artifact concentrations in units A-B and D-F of profile 2 through square 3.

sediment sequence indicate that units A-C were deposited within the last 14 500 years. Unit A is late Holocene as indicated by charcoal ages of 980 ± 80 and 1660 ± 80 BP and unit B mid Holocene based on a single charcoal age of 5300 ± 160 BP. Unit C was deposited some time between 14 500 ± 50 and 5300 ± 160 BP and we believe that it is probably of early Holocene age. The unit C sands are characterized by irregular, indurated, clay-rich bands up to 0.5 cm thick which slope towards the north wall of the shelter. Similar clay deposits have been observed in El Garrah Cave in the hyperarid Western Desert of Egypt by one of us. These are deposited by occasional heavy rains which pond in the lowest levels of the cave. The runoff waters carry fine silt and clay from the surrounding area which are deposited as a thin layer across the flooded portion of the sandy cave floor (at El Garrah sand on the cave floor is more than 6 m thick). We believe that units A-C record three pulses of aeolian deposition in the rock shelter in the early, mid, and late Holocene. See Brook *et al.* (1999), Thomas *et al.* (1997) and Blümel *et al.* (1998) for comparative data on aeolian deposition during the Holocene. The upper surfaces of units D, C and B, dating to > 14 500, 5500 and 2000/2500 BP, are considered to record periods of reduced Aeolian input to the cave during wetter climatic times when dune and hill surfaces at and near the Tsodilo Hills were less susceptible to deflation because of a denser vegetation cover.

Detrital sand and silt in a stalagmite from Drotsky's (Gcwihaba) Cave located to the southwest of Tsodilo, suggests that there were marked drier intervals in Botswana ca AD 300 and AD 800 with wetter intervals centered near AD 500 and AD 1000 (Robbins *et al.* 1996b; Railsback *et al.* 1999). The wet intervals appear to correlate well with the occupation of the Divuyu and Nqoma villages, with the period of specularite mining at the Tsodilo Hills (Robbins *et al.* 1998), and with the two ages for charcoal recovered from Unit A at Rhino Cave. This suggests that the upper part of Unit A was deposited during the drier interval centered at AD 800 and the lower part during the drier interval at ca AD 300.

The aeolian deposition seen in units A-C at Rhino can be discussed in relation to data at Shakawe. Present mean monthly wind velocities at Shakawe, 46 km from Tsodilo, are highest in March when they are 0.8 m/sec at 2 m and 1.3 m/sec at 10 m (Bhalotra, 1987) but are generally not strong enough to move substantial quantities of sand. At Maun, 220 km to the southeast, they are highest in October (2.4 m/sec at 2 m and 3.8 m/sec at 10 m) and frequently attain speeds capable of moving sand - as anyone who has walked the streets of Maun can attest. Winds at Shakawe are predominantly from the east (21%), southeast (10.1%), and south (8%), and to a lesser extent from the north (8%) and northeast (5.2%), while those at Maun are predominantly from

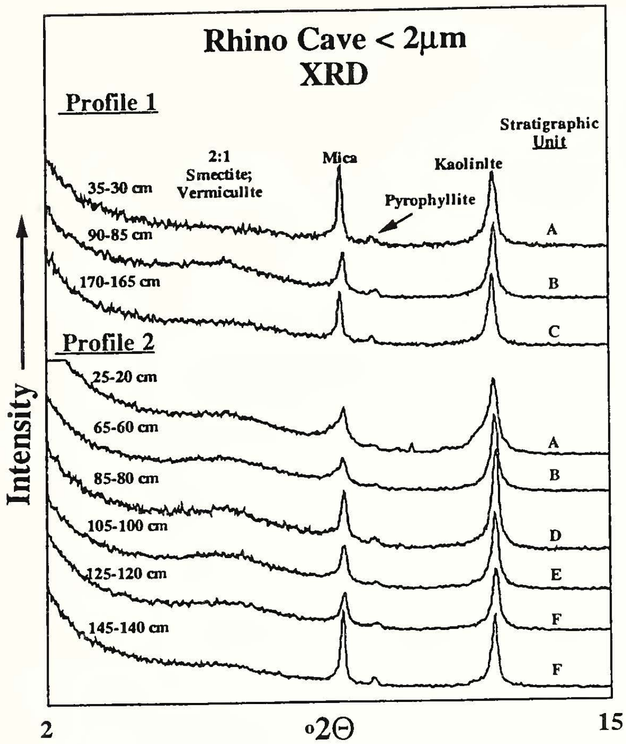

Fig. 11. Clay mineral diffractograms for sediments in units A-F.

the east (20.1%), northeast (16.5%), north (12.3%), and southeast (11.2%). At Maun the easterly and north-easterly direction is predominant in all seasons (Bhalotra, 1987). As Figure 1 shows, Rhino Cave is sheltered from the effects of easterly and southeasterly winds but would be directly in the line of strong northeasterly winds funneling into the northeast-facing valley leading to the cave. The October and January wind regimes at Maun, with 17.7% of winds coming from the northeast, might bring about deposition of aeolian sands at Rhino Cave. It is possible that during the Holocene there were times when, under slightly drier conditions, the winds at Tsodilo were stronger than now and more from the northeast. It is also possible that Rhino Cave was sheltered by the Male and emale Hills from the sand-transporting winds that produced the east-west-trending linear dunes in the Tsodilo area. In fact, as Lancaster (1981) points out, sand is piled up against the eastern side of the Tsodilo Hills, whilst to the west there is an area free of dunes that extends for almost 40 km. If the wind regime during linear dune construction did not include a strong northeast component, sand was probably not transported into Rhino Cave at these times. This being the case, aeolian sediments in Rhino Cave may not mark the driest episodes in the region's history but may simply reflect times when rainfall was lower than present and winds were stronger and more from the northeast. According to Lancaster (1981) there may have been a strong northeast sandflow west of the Okavango Delta when the dunes of the southwest Kalahari were forming (see Lancaster 1981: fig 9c). As this region experienced multiple periods of Holocene dune development, it would seem reasonable that sand might be blown into Rhino Cave during the same intervals. Lancaster also notes that this wind regime closely resembles the modern October pattern, a situation which may prevail for longer in modern drought years.

Unit D is in marked contrast to the three Holocene units. As noted above, a radiocarbon date of 14 500 ± 50 BP for charcoal in the upper part of the unit appears too young given the content of MSA artifacts. However, in square 1, unit C overlies an artifact-rich, angular pebble layer, 3-5 cm thick, resting on the north-sloping upper surface of the large boulder (Fig. 5). If unit C is early Holocene, as suggested, the 14 500 BP date is reasonable for the upper surface of unit D. The TL age of 15 448 BP for unit F appears much too young given a likely date for the MSA/LSA boundary of about 30 ka BP (Brooks *et al.* 1990). If the MSA use of the site follows that of its use during the Holocene, this suggests wetter climates at the times of high artifact frequency separated by a drier interval.

SUMMARY AND CONCLUSIONS

The 1995 and 1996 excavations at Rhino Cave have demonstrated that the site was used over an extensive period. The stratigraphy consists of six wedge-shaped units (A-F) thickening away from the shelter entrance. The upper three units consist of aeolian sand deposited during pulses of aeolian activity in the early, middle and late Holocene. The timing of these pulses agrees well with information from other parts of the Kalahari suggesting three Holocene dune-building episodes in the region, particularly in the southwest. In the wetter conditions separating these aeolian phases sedimentation in the cave likely slowed substantially. The upper three units contain LSA artifacts. Unit D is of pre-Holocene age and its content of MSA artifacts suggests accumulation over a lengthy period. The underlying units E and F suggest, respectively, drier/aeolian and wetter conditions than today.

The 1996 excavations revealed a more complex stratigraphy than was expected based on the 1995 work. Artifacts were especially dense in the deposits of square 3 situated between two large rocks. The earliest occupants were MSA peoples who carried out extensive "flint knapping" at the site using non-local materials as well as locally available quartz. Some of the points recovered are quite exceptional because of their small size and because they were made in an identical way, the bases being corner struck (Robbins *et al.* 1996a). Although the dating of the MSA at Rhino Cave is problematic, there do appear to be some changes in artifact characteristics within the deposits regarding the clustering of distally backed pieces and small core/steep scrapers. Further work might clarify the dating, as well as enable firm correlation of the Late Pleistocene sedimentary record (units D, E and F) with other localities in southern Africa.

LSA deposits were abundant above the MSA in square 2 excavated in 1995, but similar LSA levels were not found in square 3 excavated in 1996. While the LSA was concentrated in square 2, we cannot entirely rule out compacting/admixture of such materials in the adjacent sloping square 3 uncovered in 1996. However, it is interesting that the comparatively high density of LSA materials occurs in an area that is slightly closer to the painted wall of the shelter.

Finally, Rhino Cave was used periodically during the period when Tsodilo was settled by Early Iron Age peoples. Traces of pottery (first found in the 1996 excavations), nutshells, bone fragments and a scattering of debitage in an ashy context marks this period (ages of 980 ± 80 and 1660 ± 80 BP). Use of the site for rituals in connection with the rock art may have occurred during this period. The numerous wall depressions or 'cupules' found at the site on the wall opposite to the paintings remain enigmatic in relation to age and function.

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