6 DOSE RATE ANALYSIS

6.1 Introduction

Little work has recently been published on the determination of the dose-rate but the use of TSAC as a reliable method has been under debate (Jensen & Prescott, 1983; Wintle & Dijkmans, 1988; Zöller & Pernicka, 1989). This is due to problematic 'overcounting' that occurs when using TSAC. In this study a comparison between TSAC, field gamma spectrometer measurements (FGS), and high resolution gamma spectrometer measurements (HRGS) (performed in Denmark by A. S. Murray) has been made. The use of different dose-rate determinations has been made to determine if it is possible to reproduce the dose-rate using different methods. These methods (TSAC and FGS) are the primary dose-rate evaluation methods used at the Pretoria laboratory.

6.2 Thorium and Uranium analysis

The possibility of disequilibrium in the U and Th series could not be ruled out at RCC due to the suggestion that the sediments were deposited through fluvial processes (Butzer, 1984a). Within the Th and U series are the gaseous elements ^{219}Rn, ^{220}Rn and ^{222}Rn that may escape a porous sample matrix, leading to disequilibrium in the decay chains (Aitken, 1985). Previous studies (Woodborne & Vogel, 1997) suggest that discrepancies, possibly attributed to the migration of uranium, could have lead to disequilibrium in the U series. However, a large contribution from ^{40}K to the dose rate makes the effects of Th and U to the total environmental dose rate negligible. Without the aid of high resolution gamma spectra to test for disequilibrium, a general indicator is taken as a typical ratio of ~3.4 between Th and U concentrations (ppm) (Murray & Aitken, 1988). Table 6.1, Figure 6.1, and figure 6.2 below show the Th/U ratio for all the RCC samples.

Table 6. 1 Th and U ppm comparisons. Samples are given in sequence.

Sample Name	Th ppm	U ppm	Th/U ratio	Technique
RCC 17	3.77 ± 0.12	0.82 ± 0.84	4.61	FGS
RCC 22	3.31 ± 0.04	1.33 ± 0.05	2.50	TSAC
RCC 21	3.33 ± 0.12	0.85 ± 0.04	3.92	FGS
RCC 20	3.14 ± 0.46	1.39 ± 0.05	2.25	TSAC
RCC 10	3.43 ± 0.39	1.26 ± 0.04	2.73	TSAC
RCC 10	3.71 ± 0.12	1.01 ± 0.04	3.68	FGS
RCC 10	3.09 ± 0.08	1.32 ± 0.04	2.34	TSAC 2
RCC 19	4.22 ± 0.57	1.45 ± 0.06	2.91	TSAC
RCC 9	4.09 ± 0.74	1.40 ± 0.08	2.92	TSAC
RCC 9	4.10 ± 0.09	1.50 ± 0.03	2.73	TSAC 2
RCC 18	4.29 ± 0.13	1.13 ± 0.05	3.79	FGS
RCC 16	5.05 ± 0.15	1.30 ± 0.04	3.87	TSAC
RCC 16	3.26 ± 0.14	1.10 ± 0.05	2.97	FGS
RCC 6	3.34 ± 0.68	1.33 ± 0.07	2.51	TSAC
RCC 6	3.36 ± 0.08	1.39 ± 0.03	2.42	TSAC 2
RCC 15	5.80 ± 0.25	1.53 ± 0.07	3.78	TSAC
RCC 15	3.64 ± 0.14	1.29 ± 0.06	2.82	FGS
RCC 14	5.55 ± 0.21	1.61 ± 0.06	3.45	TSAC
RCC 14	3.63 ± 0.17	1.44 ± 0.07	2.52	FGS
RCC 7	6.44 ± 1.19	1.46 ± 0.11	5.11	TSAC
RCC 7	6.47 ± 0.18	1.41 ± 0.03	5.30	TSAC 2
RCC 13	6.15 ± 0.24	1.27 ± 0.07	5.61	TSAC
RCC 13	3.63 ± 0.18	2.03 ± 0.08	1.79	FGS
RCC 12	4.27 ± 0.21	1.59 ± 0.06	2.69	TSAC
RCC 12	3.91 ± 0.18	0.95 ± 0.06	4.11	FGS
RCC 8	6.24 ± 0.78	1.80 ± 0.08	4.01	TSAC
RCC 8	4.91 ± 0.12	0.65 ± 0.02	6.55	TSAC 2
RCC 11	4.09 ± 0.20	1.08 ± 0.06	3.78	TSAC
RCC 11	3.85 ± 0.15	1.19 ± 0.05	3.22	FGS

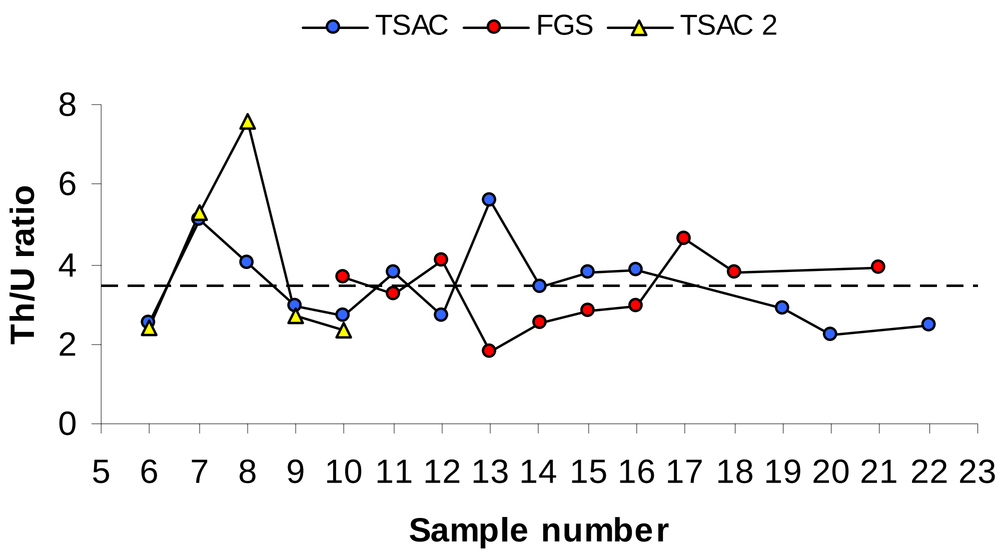


Figure 6. 1 Th/U ratios for RCC samples, the data is plotted in numerical order, where the numbers indicate the sample name. All the samples have good ratios. However, discrepancies between TSAC and FGS occur between samples RCC 8 and RCC 13.

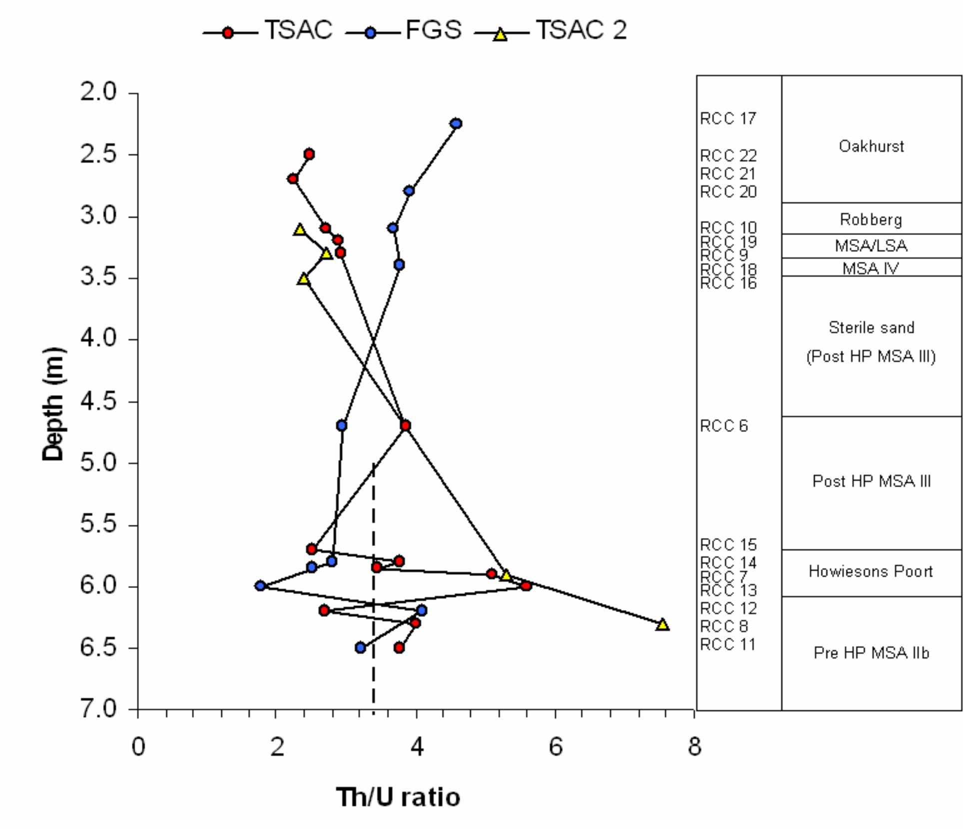


Figure 6. 2 Th/U ratios for RCC samples, the data is plotted according to depth. The spread at ~ 6m is largely attributed to discrepancies between TSAC and FGS for samples RCC 8 and RCC 13, associated with high intensity occupation during the HP whereby hearths could have played a role in potassium migration .

6.3 Potassium analysis

The average contribution of ^{40}K to the total dose rate for all samples from RCC is 65% and is predominantly produced from the decay of high potassium feldspars found throughout the site. The distribution of ^{40}K is complex due to the complexity and spatial arrangement of potassium distributions and the large numbers of hearths present in the archaeological record (Wadley, 1991). Estimates of K% were obtained from XRF and FGS. The ratios between these two techniques are given by FGS/XRF and are shown in table 6.2. Ratios could only be obtained for samples RCC 10-18 and RCC 21 because only one technique was used to obtain the K% for the others. The ratios are generally consistent with an average of 0.86 ± 0.13% indicating discrepancies between various low resolution techniques. This implies that the distribution of ^{40}K is probably inhomogeneous and that no single technique would give a true representation of K% that can be used to estimate beta and gamma dose rates.

Table 6. 2 Ratios of %K from XRG and FGS measurements.

Sample Name	%K FGS	%K XRF	K ratio (FGS/XRF)
RCC 17	1.45	1.89	0.77
RCC 22		1.59	
RCC 21	1.17	1.55	0.75
RCC 20		1.46	
RCC 10	1.20	1.45	0.83
RCC 19		1.55	
RCC 9		1.76	
RCC 18	1.26	1.72	0.73
RCC 16	1.22	1.34	0.91
RCC 6		1.26	
RCC 15	1.14	1.48	0.77
RCC 14	1.18	1.31	0.89
RCC 7		1.66	
RCC 13	1.02	1.26	0.81
RCC 12	1.33	1.15	1.15
RCC 8		1.23	
RCC 11	1.17	1.22	0.95

6.4 Dose-rates for Rose Cottage Cave

The average contribution from alpha, beta and gamma radiation are presented in table 6.3 and figure 6.3. In the table references to TSAC and TSAC2 include measurements of K done using XRF. TSAC2 refers to a second set of data measured by Dr. S. Woodborne. The average Alpha contribution is 1.7% of the total dose rate. The average beta contribution 62.6%, and the average contribution from gamma radiation is 35.6%. Furthermore the alpha contribution is negligible on etched samples. This implies that if there is a possibility of disequilibrium in the U/TH decay series it becomes almost redundant due to the high contribution from ^{40}K to the total dose rate. It is therefore very difficult to obtain the 'correct' dose-rate based on K% measurements. For the RCC samples the dose rates were chosen according to the technique that gave the best Th/U ratio, and in cases where two measurements of K% were done, two results are given.

Table 6. 3 Fractional components of dose-rates to Rose Cottage Cave.

Sample Name	Alpha contribution	Beta contribution	Gamma contribution	Technique
RCC 17	1.3	64.6	34.2	FGS
RCC 22	1.3	64.7	34.0	TSAC
RCC 21	1.4	64.7	33.8	FGS
RCC 20	1.4	64.2	34.3	TSAC
RCC 10	1.4	64.1	34.5	TSAC
RCC 10	1.6	63.9	34.5	FGS
RCC 10	1.4	64.4	34.2	TSAC 2
RCC 19	1.5	63.2	35.3	TSAC
RCC 9	1.3	64.4	34.3	TSAC
RCC 9	1.4	64.2	34.4	TSAC 2
RCC 18	1.6	62.1	36.3	FGS
RCC 16	1.7	61.4	36.9	TSAC
RCC 16	1.5	63.4	35.1	FGS
RCC 6	2.4	64.1	33.5	TSAC
RCC 6	2.0	65.0	33.0	TSAC 2
RCC 15	1.8	61.0	36.2	TSAC
RCC 15	1.8	63.0	35.2	FGS
RCC 14	1.9	60.2	36.9	TSAC
RCC 14	1.8	63.0	35.2	FGS
RCC 7	1.8	60.5	36.7	TSAC
RCC 7	1.8	60.5	36.7	TSAC 2
RCC 13	2.0	58.6	39.4	TSAC
RCC 13	2.2	60.7	36.0	FGS
RCC 12	1.9	60.6	36.5	TSAC
RCC 12	1.5	64.5	34.0	FGS
RCC 8	3.3	56.6	39.1	TSAC
RCC 8	2.2	62.2	35.5	TSAC 2
RCC 11	1.6	62.3	36.1	TSAC
RCC 11	1.7	63.1	35.2	FGS

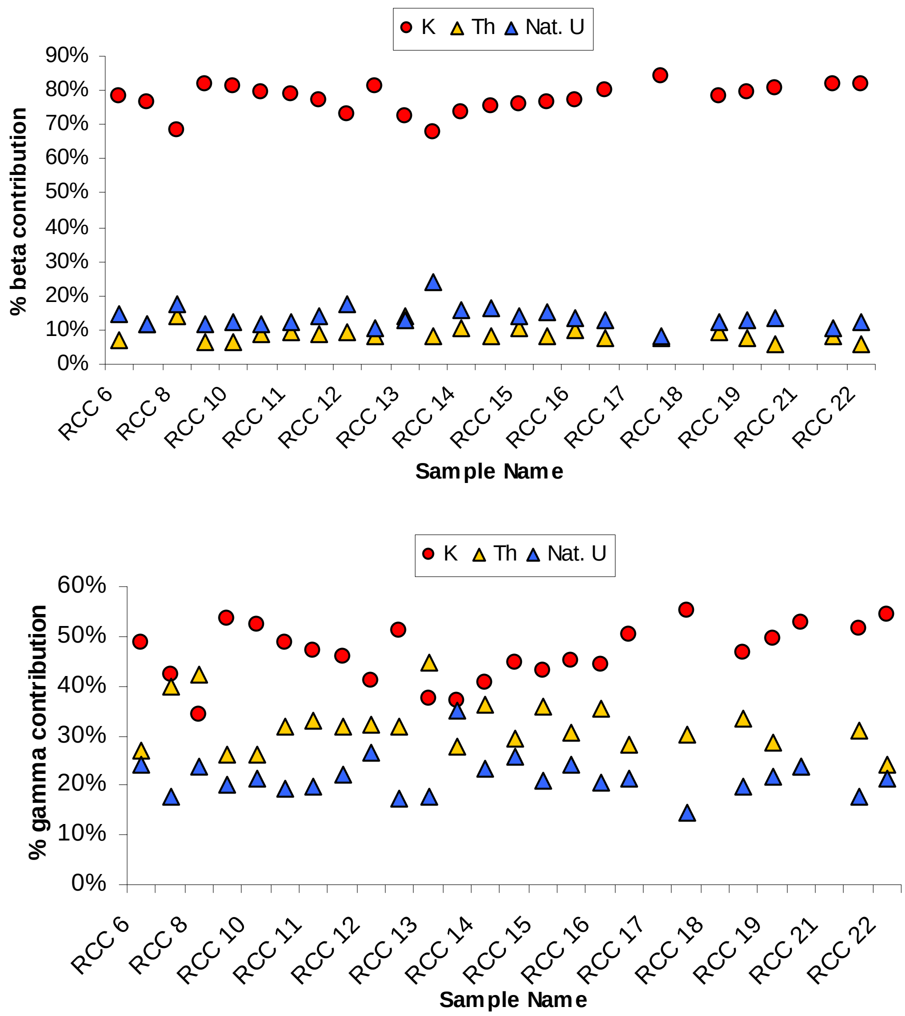


Figure 6. 3 Contribution of ^{40}K, ^{232}TH and natural U to the Beta and gamma dose rates of Rose Cottage Cave.

Dose rates were calculated according to Adamiec & Aitken (1998) (see Appendix C) and are corrected for moisture content unless FGS measurements were done. Figure 6.4 below summarises the dose-rates obtained for RCC using all the available techniques, and demonstrates the scatter in dose-rate when using these various techniques. Table 6.4 illustrates the dose-rates obtained using the best Th/U ratio and both (when available) measurements of K%. Note the moisture content and cosmic ray contribution were both estimated to be approximately 5 ± 0.05 for all samples. It should be noted that comparisons using the measured moisture content relating to between 1.5% and 2.4% were done, but 5% moisture was chosen for the site's history as it is assumed that RCC was in general wetter in the past compared to today (Wadley *et al.,* 1992).

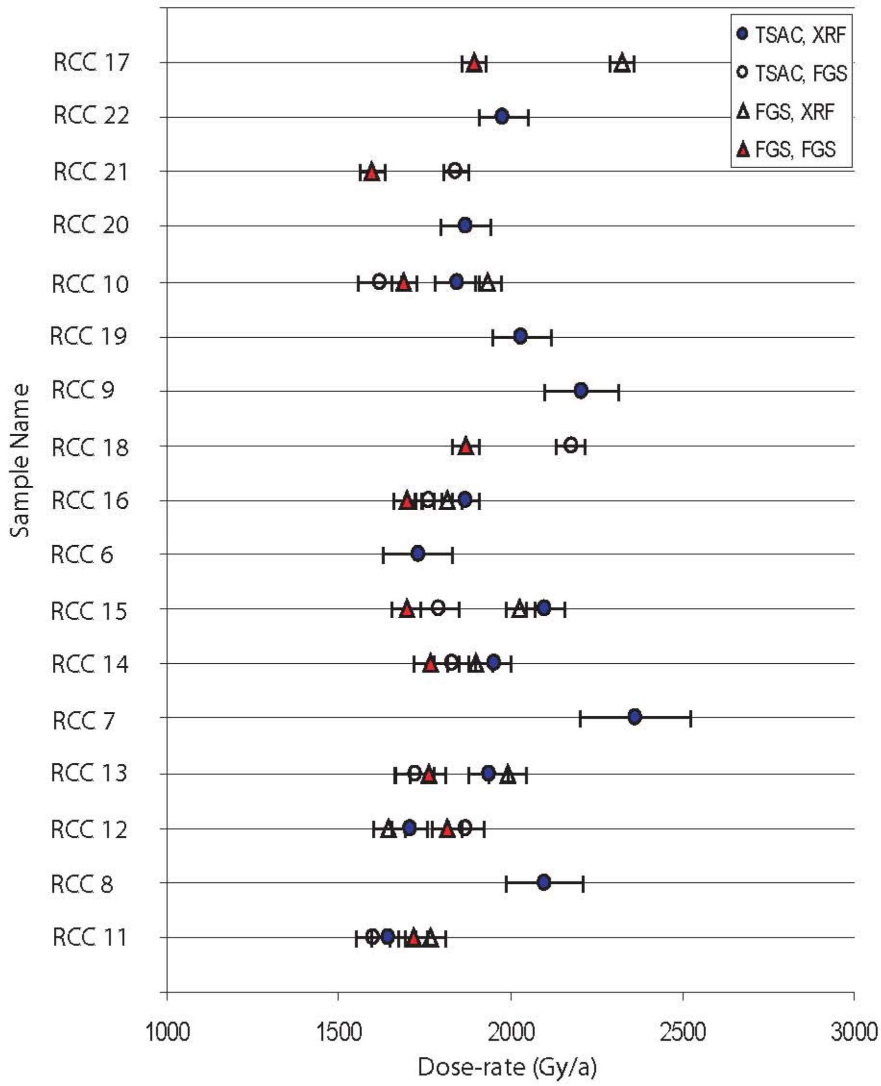


Figure 6. 4 Dose-rates obtained for RCC using all the available techniques, demonstrating the scatter in dose-rates when using various techniques. TSAC, XRF stands for all measurements done using TSAC with values for K% obtained by XRF. TSAC, FGS stands for all measurements done using TSAC with values for K% from FGS measurements. FGS, XRF stands for all measurements done using a FGS, using values for K% obtained by XRF. FGS, FGS stands for all measurements done using a FGS.

Table 6. 4 Dose-rates obtained for RCC using the best Th/U ratio and both (when available) measurements of K%.

Sample Name	Dose-rate TSAC, XRF	Dose-rate TSAC, FGS	Dose-rate FGS, XRF	Dose-rate FGS, FGS
RCC 21				1596.94 ± 35.65
RCC 10			1936.28 ± 36.97	1691.03 ± 36.97
RCC 19	2033.15 ± 86.09			
RCC 9	2206.88 ± 106.90			
RCC 18				1869.33 ± 40.29
RCC 16	1870.47 ± 39.82	1762.48 ± 39.82		
RCC 6	1731.30 ± 101.80			
RCC 15	2102.46 ± 56.52	1794.04 ± 56.52		
RCC 14	1951.75 ± 50.03	1829.94 ± 50.03		
RCC 7	2365.05 ± 161.53			
RCC 13	1936.53 ± 56.24	1721.82 ± 56.24		
RCC 12			1646.37 ± 46.22	1816.74 ± 46.22
RCC 8	2098.73 ± 112.96			
RCC 11			1768.19 ± 43.32	1716.46 ± 43.32

Note: TSAC, XRF stands for all measurements done using TSAC with values for K% obtained by XRF. TSAC, FGS stands for all measurements done using TSAC with values for K% from FGS measurements. FGS, XRF stands for all measurements done using a FGS, using values for K% obtained by XRF. FGS, FGS stands for all measurements done using a FGS.

7.0 RESULTS, DISCUSSION AND CONCLUSION

7.1 Results

Table 7.1 summarises the final D_e values and dose-rates which were chosen to calculate the depositional age of the RCC sediments. The dose-rates were chosen according to the technique which gave the best Th/U ratio and include both XRF and FGS estimates of %K. Therefore two dose-rates are presented representing those chosen from table 6.4 in chapter 6. It is believed that the D_e measurements are probably correct. Therefore any deviation from correct ages is associated with problems intrinsic to the dosimetry of RCC. This is evident in chapter 6, where it was noted that no two techniques could return the same dose-rates.

The D_e values for samples RCC 21, 19, 18 and 7 were a straightforward choice as only one mask size was either used or accepted after all SAR protocol rejection criteria were performed. D_e values for samples RCC 11-16 were measured in Denmark and the values were obtained by Andrew Murray. Some of the RCC samples are believed to still be contaminated by feldspars (as is shown by single grain measurements done on sample RCC 21, shown later in this chapter), these samples such as RCC 10 have higher D_e values for un-etched material. However, this is only an assumption as significant fading could have occurred in the un-etched material. The lowest D_e value was use in age calculations. The remainder of the samples were chosen as 2mm mask size, etched material due to the fact that they either passed the IR-OSL depletion ratio test exceptionally well or they relayed the lowest D_e values.

Table 7. 1 D_e values and Dose-rates chosen according OSL criteria to be used in age determination for Rose Cottage Cave.

Sample Name	Sample affinities	D_e values	Dose rate 1	Dose rate 2	Comment
RCC 21	2mm mask size, etched, FGS	20.2 ± 0.8	1597.94 ± 35.65		The only values that were obtained
RCC 10	2mm mask size, un-etched, FGS	25.1 ± 2.0	1936.28 ± 36.97	1691.03 ± 36.97	Lowest D_e value was chosen, due to feldspar contamination. Dose rate values were chosen according to Th/U ratios.
RCC 19	2mm mask size, etched, TSAC	64.4 ± 1.6	2033.15 ± 86.09		The only values that were obtained
RCC 9	2mm mask size, etched, TSAC	59.7 ± 2.0	2207.88 ± 106.90		Lowest D_e value was chosen, due to feldspar contamination. Dose rate values were chosen according to Th/U ratios.
RCC 18	2mm mask size, etched, FGS	67.8 ± 2.6	1869.33 ± 40.29		The only values that were obtained
RCC 16	>5mm mask size, TSAC	65 ± 3	1870.47 ± 39.82	1762.48 ± 39.82	D_e values were obtained by A. Murray. Dose rate values were chosen according to Th/U ratios
RCC 6	2mm mask size, etched, TSAC	97.5 ± 4.0	1731.30 ± 101.80		Lowest D_e value was chosen, due to feldspar contamination. Dose rate values were chosen according to Th/U ratios.
RCC 15	>5mm mask size, TSAC	130 ± 3	2102.46 ± 56.52	1794.04 ± 56.52	D_e values were obtained by A. Murray. Dose rate values were chosen according to Th/U ratios
RCC 14	>5mm mask size, TSAC	122 ± 3	1951.75 ± 50.03	1829.94 ± 50.03	D_e values were obtained by A. Murray. Dose rate values were chosen according to Th/U ratios
RCC 7	2mm mask size, un-etched, TSAC	127.6 ± 3.8	2365.05 ± 161.53		The D_e values were the only values that were obtained. Dose rate values were chosen according to Th/U ratios
RCC 13	>5mm mask size, TSAC	133 ± 2	1936.53 ± 56.24	1721.82 ± 56.24	D_e values were obtained by A. Murray. Dose rate values were chosen according to Th/U ratios
RCC 12	>5mm mask size, FGS	122 ± 4	1646.37 ± 46.22	1816.74 ± 46.22	D_e values were obtained by A. Murray. Dose rate values were chosen according to Th/U ratios
RCC 8	2mm mask size, etched, TSAC	129.2 ± 6.7	2097.73 ± 112.96		Lowest D_e value was chosen, due to feldspar contamination. Dose rate values were chosen according to Th/U ratios.
RCC 11	>5mm mask size, FGS	158 ± 7	1767.19 ± 43.32	1716.46 ± 43.32	D_e values were obtained by A. Murray. Dose rate values were chosen according to Th/U ratios

The values from table 7.1 can be used to calculate the ages for RCC by using the age equation and are presented in table 7.2. These results are compared to the RCC radiocarbon chronology as well as to previous luminescence studies performed at the site in figure 7.1. These include luminescence dates obtained by S. Woodborne using TL techniques and OSL dates performed by Andrew Murray. If the results correlate to both the radiocarbon chronology and the existing luminescence chronology, then a coherent MSA chronology is feasible. Figure 7.2 presents a more detailed comparison between OSL and radiocarbon and identifies miscorrelations, as well as a comparison between OSL and previous luminescence studies performed at the site.

Table 7. 2 Preliminary results for Rose Cottage Cave.

Sample name	Sample layer	Archaeological affiliation	Age 1 (ka)	Age 2 (ka)
RCC 21	H	Oakhurst	12.6 ± 0.8	
RCC 10	DB	Robberg	13.0 ± 1.3	14.8 ± 1.5
RCC 19	G	MSA/LSA transition	31.7 ± 2.0	
RCC 9	RU	MSA IV	27.0 ± 2.1	
RCC 18	CD	MSA IV	36.8 ± 2.1	
RCC 16	Lyn	'Sterile sands'	34.8 ± 2.3	36.9 ± 2.5
RCC 6	CLY	Post-HP MSA III	56.9 ± 5.3	
RCC 15	ANN	Post-HP MSA III	61.8 ± 3.0	72.5 ± 3.8
RCC 14	ETH	HP	62.5 ± 3.1	66.7 ± 3.4
RCC 7	BER	HP	54.4 ± 5.0	
RCC 13	EMC	HP	67.7 ± 2.9	77.2 ± 3.6
RCC 12	KUA	Pre-HP MSA IIb	74.1 ± 4.0	67.2 ± 3.8
RCC 8	KUA	Pre-HP MSA IIb	61.6 ± 6.2	
RCC 11	LEN	Pre-HP MSA IIb	89.4 ± 6.0	92.0 ± 6.2

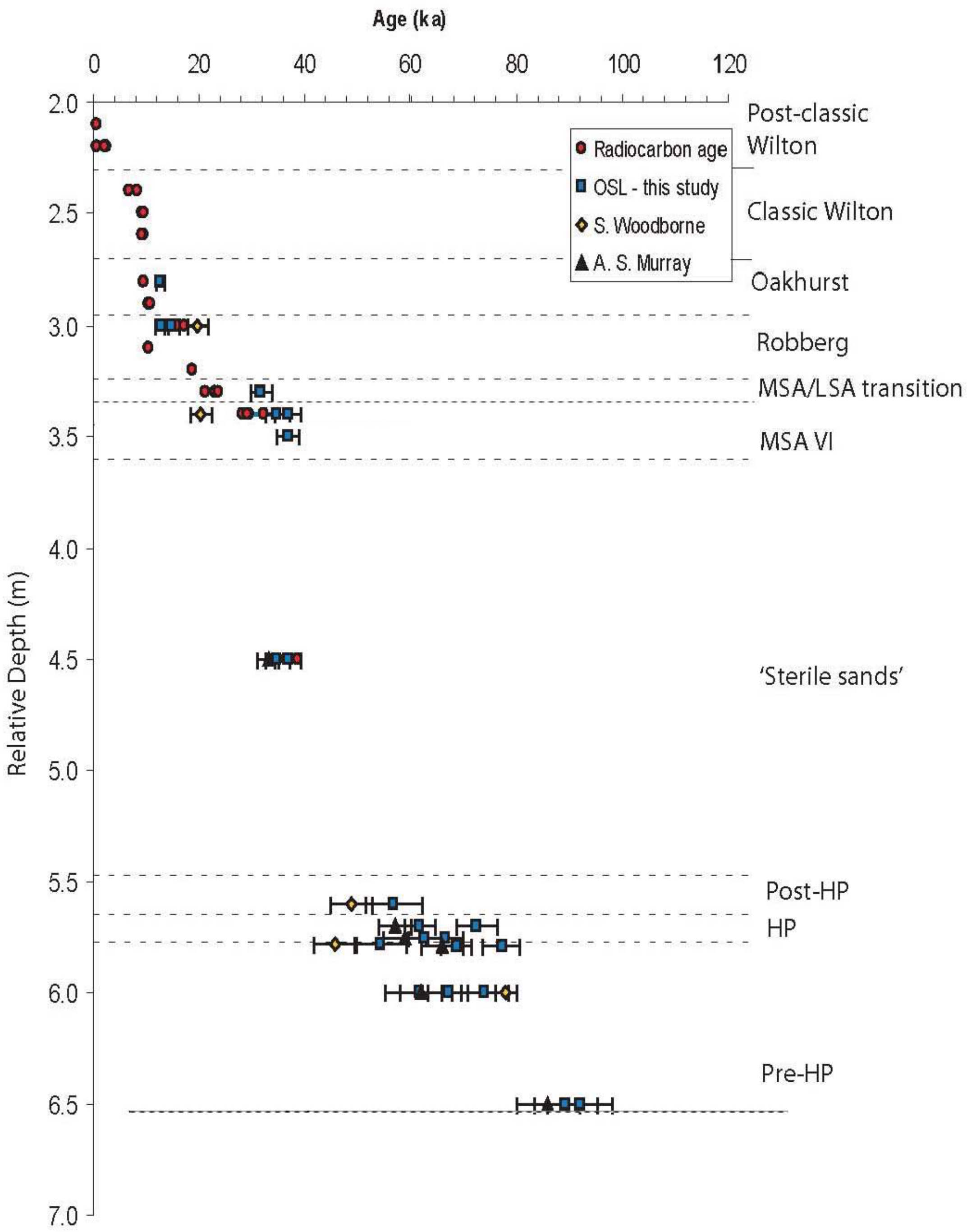
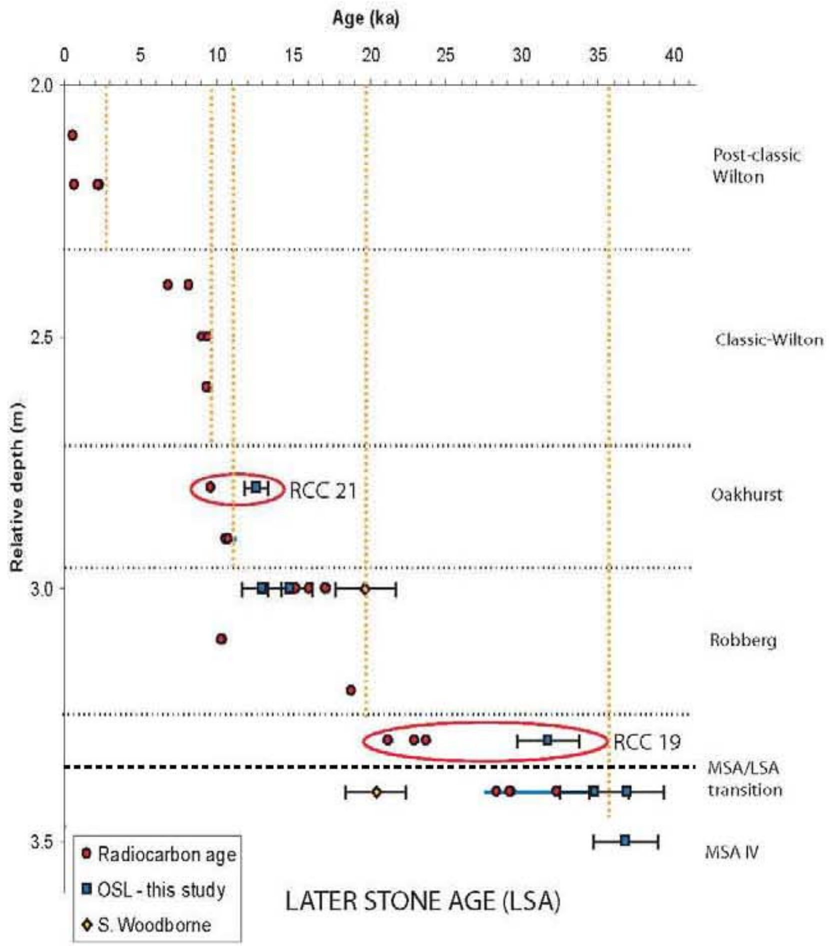


Figure 7. 1 Comparison between OSL dating and other dating techniques performed at RCC.



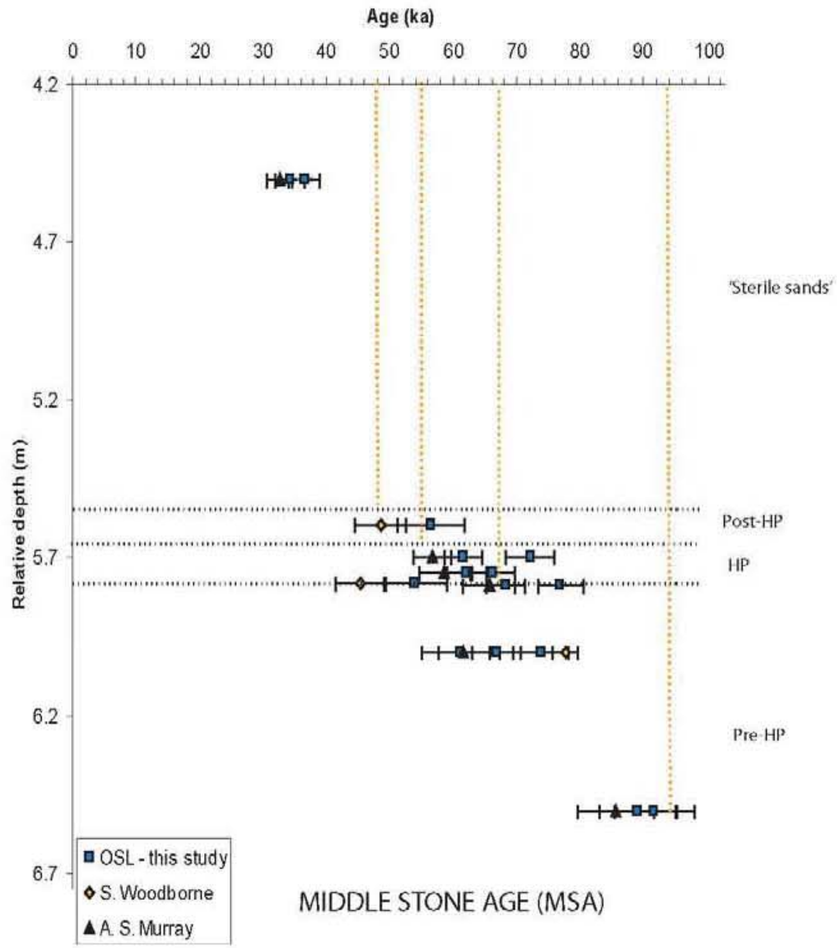


Figure 7. 2 Age sequence for RCC. The vertical dashed lines represent the most probable ages for the lithostratigraphy of RCC. Note that sample RCC 21 and sample RCC 19 do not correlate with the existing radiocarbon chronology.

7.1.1 Resolving age discrepancies between OSL and radiocarbon

From figure 7.2 it can be seen that sample RCC 21 and sample RCC 19 do not correlate to the existing radiocarbon age chronology. Sample RCC 21 was selected to perform single grain analysis in an attempt to resolve the discrepancies in age correlation on the basis of incorrect D_e determination in the forgoing analysis. It was found during single grain analysis that there was a total rejection of over 50% of grains due to feldspar contamination. However, the grains were first put through rejection criteria defined by Jacobs *et al.,* (*in press*) that eliminated 23% of the feldspar contaminated population, after this elimination a further 27% of the grains were rejected due to feldspar contamination alone. It was also found that for sample RCC 21, 20% of the grains were responsible for the 'light' produced when averaging out single aliquots. The analysis is available on request in the form of a Microsoft excel spreadsheet. The analysis did not form part of this study and was only done as a test to resolve discrepancies in sample RCC 21. Two radial plots for sample RCC 21 of all the grains versus the accepted grains are presented in figure 7.3 below.

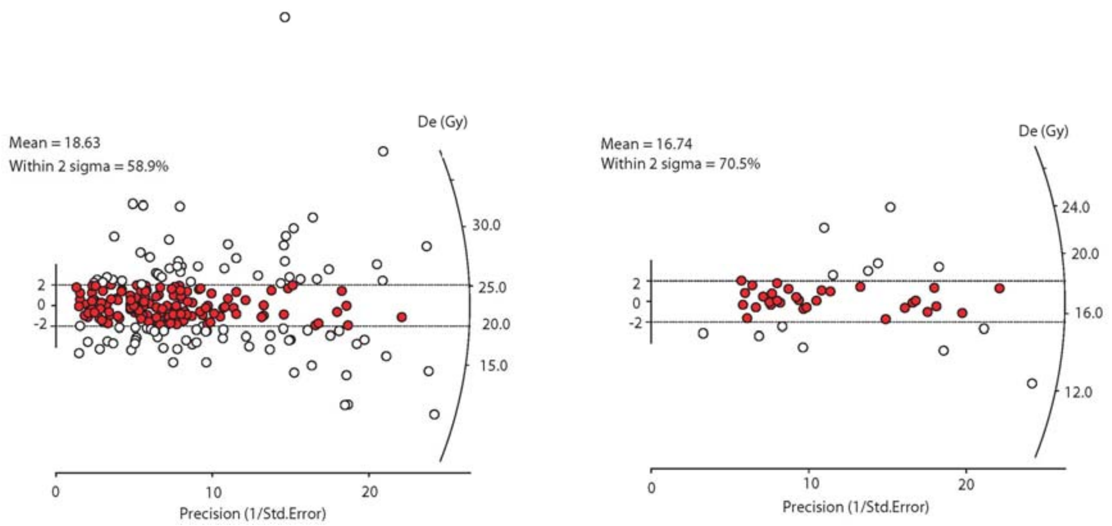


Figure 7. 3 Radial plots showing all the grains from sample RCC 21 (right) and the accepted grains of sample RCC 21 (left).

From figure 7.3 it is clear that the radial plot on the left returns the same D_e value obtained using a single aliquot. In the plot on the right, grains that were giving higher D_e values have been rejected. This is due to feldspar contamination not detected when using a single aliquot approach. It is important to note that the single aliquot measurements were performed on HF etched material, emphasising the importance of single grain analysis when dealing with a potassium rich site such as RCC. The new age values when using a central age model with a D_e value of 17 ± 1 Gy for RCC 21 becomes 10.6 ± 0.8 thousand years. This shifts the OSL value for RCC 21 to correlate perfectly with the radiocarbon age.

In most instances feldspar contamination will result in scattered D_e values. Sample RCC 19 appears to have a single population with minimal scatter around the central value (overdispersion = 7.2%). For this reason it was assumed not to be feldspar contaminated in contrast to RCC 21 (where the single aliquot analysis gave an overdispersion value of 15.8%). The fact that radiocarbon ages associated with sample RCC 19 are all consistent, suggests the OSL age is erroneous. The most likely scenario for the erroneous age would be that layer mixing occurred during sample collection either as a result of the sample tube penetrating more than one layer, or through the misidentification of the layer. From figure 7.2 it can be seen that RCC 19 yields the same date as the (calibrated) radiocarbon analyses from layers Ru, Dc and Dy (stratified below). This may be the result of localised turbation (such as pit digging) that would elevate older sediments to the surface without necessarily zeroing the OSL signal. Alternatively the dosimetry surrounding sample RCC 19 is possibly incorrect and single grain analysis may be necessary to clarify this. The conclusion on the basis of the radiocarbon comparison is that RCC 19 is erroneous either as a result of dosimetry, mis-sampling, or through a taphonomic process. Further analyses can be done to clarify this, but for the immediate discussion it is recommended that sample RCC 19 be excluded from the age chronology.

7.2 Discussion

When OSL dating an archaeological cave site it is important to apply strict rejection criteria in order to exclude any contamination of the samples. It has been demonstrated (Fullagar *et al.,* 1996; Roberts *et al.,* 1998, 1999) that ages can be overestimated due to either partial bleaching, or unbleached grains that contaminate the site due to roof or wall spalling. The possible forms of sedimentary contamination at RCC are:

- Cave roof or wall spalling
- Sample mixing
- Feldspar contamination
- Partial bleaching due to water lain sediments.

It is more than likely that the majority of the deposition at RCC is from aeolian origin as opposed to Butzer's (1984a, 1984b) original observations as no evidence for partial bleaching exists, and large accumulations of sand were deposited in a very short time period. The possibility of sample mixing however could be a major source of inaccuracy at RCC. This is easily discernable through cross-checking results with established chronologies and observing overdispersion values when performing D_e analysis. Although RCC samples present scatter in D_e values, it has been shown by single grain analysis that this is more probably attributed to feldspar contamination as opposed to layer mixing. It is more than likely that inaccuracies in ages are attributed to dosimetry as apposed to D_e evaluation.

Little research has gone into dose-rate evaluation in recent years. At RCC there is an existing chronology to check whether OSL ages are correct using the available dose-rate determination methods in South Africa. This could have a large impact on other OSL dated sites where no correlation record exists. To illustrate this point, the moisture content for RCC was measured today to be between 1 and 3%. However, an average of 5% moisture content was assumed for the site. The problems associated with no uniformity of K% estimates (possibly due to scattered feldspar depositions) create a second concern. There is no way of knowing when doing standard analysis, whether the right K% is being used. Figure 7.4 below demonstrates how moisture content and estimates of K affects a sample that is older than 40ka. In the example a sample having 7.44 ± 1.19 pmm Th, and 1.46 ± 1.66 ppm U was chosen using a D_e value of 150 Gy. The graph represents the different ages that can be obtained by adjusting the moisture content from between 1% and 20% and by using two values of K (1% and 1.5%).

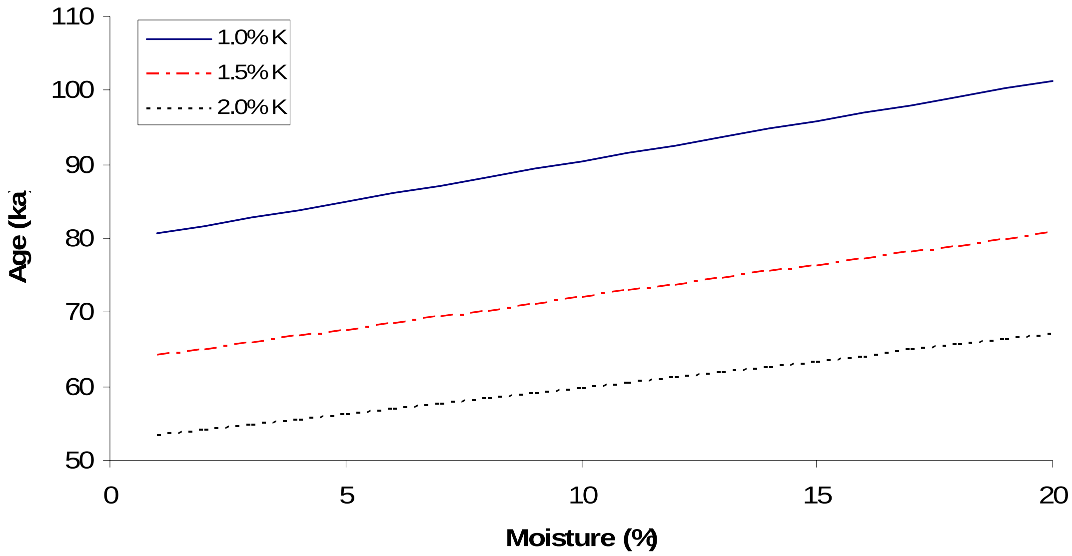


Figure 7. 4 The effects of moisture content and %K on a sample.

The fact that there is a consistent OSL chronology at RCC assumes that the K% and moisture content estimates are generally correct. The causes of inconsistencies in K% are of great concern and are not understood at RCC. Two scenarios present themselves: the measurements of K were done with an incorrectly calibrated FGS; the dynamics of K change spatially to such an extent that all measurements do not represent the true K% of the dated sample. It should be noted that the age ranges obtained for RCC are the most probable and to fine tune these results further study will need to be conducted focusing on the dosimetry. Using the obtained values however, it is possible to correlate archaeological events at RCC to environmental changes.

The most probable ages for RCC, presented in table 7.3, reflect combined OSL and radiocarbon dates that have been calibrated and presented in years before AD 2005. The values in table 7.3 are rounded to the nearest 500 years and exclude outliers from both the radiocarbon and OSL chronology. The transition between the Robberg and MSA/LSA transition at RCC is clearly defined at 20 ka. The final MSA at RCC is currently dated to 27 ka while the MSA/ELSA transition at BC is placed at 41 ka (calibrated relative to AD 2001) (Grun & Beaumont, 2001). It is unlikely that the RCC 19 date of 31.7ka (MSA/LSA transition) can be correct in the context of the other OSL dates stratified above and below it as well as the radiocarbon dates, but a literal acceptance of this date would shift the MSA/LSA transition at RCC closer to the age range defined at BC. If it is shown that RCC 19 is a mixture of MSA/LSA transition deposits with MSA IV deposits, then the date is an overestimation of the MSA/LSA, and the radiocarbon chronology will stand. The issue then becomes a typological debate around the MSA/LSA vs. the ELSA. With this in mind it is important to check other lines of evidence for potential mixing of sediments in some areas of RCC at this time.

Table 7. 3 Most probable age ranges for the Rose Cottage Cave sequence.

Archaeological affiliation	**Probable age range (calendar years relative to AD 2005)**
Post-Classic Wilton	< 3 000 years ago
Classic-Wilton	3 000 years ago – 8 500 years ago
Oakhurst	8 500 years ago – 10 500 years ago
Robberg	10 500 years ago – 20 000 years ago
MSA/LSA transition	20 000 years ago – 27 000 years ago
MSA IV	>27 000 years ago – 36 000 years ago
‘Sterile sands’	>36 000 years ago – 48 000 years ago
Post-HP MSA III	48 000 years ago - 55 000 years ago
HP	55 000 years ago – 68 000 years ago
Pre-HP MSA IIb	68 000 years ago – 94 000 years ago

7.3 Conclusion and recommendations

Most of this thesis was concerned with applying standard OSL measurement procedures using the SAR protocol to the Stone Age layers at RCC. The protocol along with standardised single grain measurements have been two of the most significant developments in OSL dating in recent years. The SAR protocol has been applied successfully to a variety of different samples (Murray & Olley, 2002) and was not problematic at RCC. There are, however, still contentious issues surrounding dosimetry studies. Standardised measurement procedures need to re-look at the dosimetry. The HP dates for RCC are consistent with the emerging HP chronology from the rest of the country. Table 7.4 presents the final results obtained from the RCC sequence after single grain analysis was performed on sample RCC 21.

Table 7. 4 Results for Rose Cottage Cave.

Sample name	**Sample layer**	**Archaeological affiliation**	**D_e Method**	**Age 1 (ka)**	**Age 2 (ka)**
RCC 21	H	Oakhurst	Single Grain	10.6 ± 0.8	
RCC 10	DB	Robberg	SAR	13.0 ± 1.3	14.8 ± 1.5
RCC 19*	G	MSA/LSA transition	SAR	31.7 ± 2.0	
RCC 9	RU	MSA IV	SAR	27.0 ± 2.1	
RCC 18	CD	MSA IV	SAR	36.8 ± 2.1	
RCC 16	Lyn	'Sterile sands'	SAR	34.8 ± 2.3	36.9 ± 2.5
RCC 6	CLY	Post-HP MSA III	SAR	56.9 ± 5.3	
RCC 15	ANN	Post-HP MSA III	SAR	61.8 ± 3.0	72.5 ± 3.8
RCC 14	ETH	HP	SAR	62.5 ± 3.1	66.7 ± 3.4
RCC 7	BER	HP	SAR	54.4 ± 5.0	
RCC 13	EMC	HP	SAR	67.7 ± 2.9	77.2 ± 3.6
RCC 12	KUA	Pre-HP MSA IIb	SAR	74.1 ± 4.0	67.2 ± 3.8
RCC 8	KUA	Pre-HP MSA IIb	SAR	61.6 ± 6.2	
RCC 11	LEN	Pre-HP MSA IIb	SAR	89.4 ± 6.0	92.0 ± 6.2

*Sample RCC 19 is believed to be erroneous and should not be used until further analysis is done.

It is recommended that further studies are performed at RCC dealing with dosimetry issues and the dating feldspars from the site. It is also recommended that further analysis be performed on sample RCC 19. RCC offers an excellent opportunity for those who wish to study feldspars. This is now possible due to a coherent OSL correlation dataset.