

APPENDIX 15: ASSESSMENT OF LUMINESCENCE DATING

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1. Introduction

1.1 Samples were taken from two locations:

- Location 1: sediments beneath the sarsen stones (Group 1, Figure 9)
- Location 2: sediments from a large cut, possibly a well adjacent to the sarsen stones (Group II, [630] Figure 9)

1.2 In total, six subsamples, three from each of the two locations, were selected for testing. Tests were made using infrared stimulated luminescence (IRSL) in which the dominant emissions are from feldspars within the silt-sized (2-10 μ m) fraction selected for measurement. Dates were obtained for the three samples from the pit/well; the sediments from beneath the sarsen stones were incompletely bleached and no dates were determined.

2. Methodology

Location 1

2.1 A monolith was taken of the colluvium at the top of the section beneath Group I Sarsen stones (contexts 628 and 698). The flint layer prevented a second monolith being taken and lower samples were taken in film canisters knocked into the section.

Samples taken:

<i>Sample number</i>	<i>Distance from top of section</i>	<i>Notes</i>	<i>Context</i>
6	0.13m to top of monolith	0.50m monolith	628 & 698
7	0.66m	canister	698
8	0.79m	canister	698
9	0.87m	canister	698

2.2 Subsamples were taken in the laboratory under subdued red light conditions.

2.3 Samples were extracted from the film canisters under subdued red light conditions by slicing through both sediment and canister at the top and bottom. The ends of the sample which had been exposed to light were discarded and the central portion used for luminescence measurements. Samples for dose-rate measurements were collected in a separate bag at the time of sampling from the section. Sample 255-8 was very dry and crumbly and not possible to subsample.

2.4 When sampling from the monolith, the sediment which had been exposed to light during sampling was removed and five subsamples were taken:

255-6-5	@ 50 – 80mm from top of monolith.
255-6-15	@ 0.13 – 0.15m.
255-6-25	@ 0.25 – 0.27m.
255-6-35	@ 0.35 – 0.37m.
255-6-45	@ 0.45 – 0.47m.

- 2.5 Three sub-samples were selected for luminescence testing: 255-6-5, 255-6-45 and 255-9.

Location 2

- 2.6 Two monoliths taken from the section of the pond [630] (contexts 614 and 744) with 19 cm overlap.

Samples taken:

<i>Sample number</i>	<i>Distance from top of section</i>	<i>Notes</i>	<i>Context</i>
10	70mm to top of monolith	50 cm monolith	614
11	0.48m to top of monolith	50 cm monolith	614 & 744

- 2.7 When sampling from the monolith, the sediment which had been exposed to light during sampling was removed. Three sub-samples were taken from sample 255-10 and two samples from 255-11:

255-10-12	@ 0.10 – 0.12m from top of monolith	context 614
255-10-30	@ 0.29 – 0.31m	context 614
255-10-45	@ 0.43 – 0.45m	context 614
255-11-25	@ 0.23 – 0.26m from top of monolith	context 614
255-11-45	@ 0.38 – 0.42m	context 744S

- 2.8 Three sub-samples (255-10-12, 255-10-30, 255-10-45) were selected for luminescence testing. The lower sub-samples (255-11-25 and 255-11-45) were considered too dry and crumbly for reliable sampling.

Luminescence Measurements

- 2.9 The subsamples were dried at 105°C and sieved to isolate material of <90 µm diameter. The <90 µm fraction was treated with H₂O₂ for 24h to remove organic material and then with 15% HCl at 50°C for 24h to remove carbonates. Material of 2 - 10 µm grain size was extracted by settling in a 20 cm column of 0.01N sodium oxalate for 20 minutes, pouring off the suspension and settling this in a 20 cm column of 0.01N sodium oxalate for 4 hours. The 2-10 µm material collects at the bottom of the column during this settling. After recovering and drying this material, it was deposited by settling in acetone onto abraded 10 mm diameter aluminium discs. This provides a monolayer of material, with approximately 2 mg per aliquot.

- 2.10 Measurements were made in a Risø TL-DA-12 automated reader. Laboratory beta doses were administered by a calibrated ⁹⁰Sr/⁹⁰Y beta source mounted on the reader and alpha doses by an external calibrated ²⁴¹Am foil. Infrared stimulation was provided by an array of IR diodes within the reader. The luminescence was detected by an EMI photomultiplier with a Schott BG39 filter used to isolate the blue luminescence from the stimulating IR light.

- 2.11 Aliquots were normalised by a 1s exposure to infrared light; correction was subsequently made for depletion of the signal due to this normalisation measurement. The palaeodose was determined from measurements made using the additive dose technique (Aitken 1985). Following irradiation, aliquots were preheated to 220°C for 10 minutes to remove the component of the signal unstable over archaeological time scales. IR stimulation of 250 s duration was sufficient to reduce the signal to within 5% of the background signal. The background, comprising photomultiplier dark count and breakthrough from the IR diodes, was measured by an extended (2000 s) stimulation of one aliquot.

Dose rate measurements

- 2.12 Laboratory measurements using beta TL dosimetry (Bailiff 1982) and thick source alpha counting were used to calculate the annual dose. No radon loss was detected using thick source alpha counting of sealed and unsealed samples from any of the samples tested and secular equilibrium has been assumed. The ‘as-dug’ water content and the organic content of the sediments were measured in the laboratory by successive heatings to 105°C, 500°C and 900°C. The total dose rate was corrected for both the water and the organic content of the sediments.

Age calculation

- 2.13 The luminescence age is determined from the Age Equation:

- $$\text{Luminescence Age (years)} = \frac{\text{Palaeodose (Gy)}}{\text{Dose rate (Gy / year)}}$$

3. Quantifications

- 3.1 In total, six subsamples, three from each of the two locations, were selected for testing.

4. Provenance

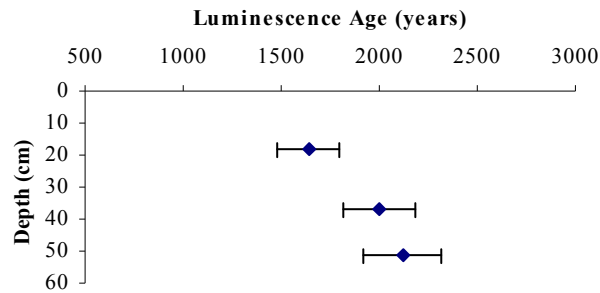
Location 1

- 4.1 Three sub-samples of sediment beneath the sarsen stones were tested: from 0.38m (255-6-25), 0.58m (255-6-45) and 0.87m (255-9) below the top of the section. Subsample 255-6-25 was from fine sediments above the layer of medium-sized (<8 cm) flints; while subsample 255-6-45 was from just below this flint layer. Sub-sample 255-9 was from the manganese stained layer.

- 4.2 Palaeodoses of ~150 Gy and ~300 Gy were obtained for sub-samples 255-6-25 and 255-6-45, indicating ages in excess of 50 ka for both samples. This, together with the younger date for the lower sample (255-9), suggests that the sediments were not well bleached at the time of deposition and no further measurements were made on these samples. A palaeodose of ~40 Gy was obtained for 255-9, indicating an age of 13 – 19 ka. The luminescence age for 255-9 may reflect the time of deposition, but this cannot be tested and no further measurements were made on this sample.

Location 2

- 4.3 Sub-samples from 0.18m, 0.37m and 0.51m below the top of the section of the pit/well were selected for dating. The section was c1m deep but, unfortunately, samples taken from the lower part of the section were unsuitable for luminescence dating being very dry and crumbly.



- 4.4 The dates for the upper part of the fill indicate a gradual silting up of the pond and give a terminus ante quem of 120 BC \pm 200 for the start of infilling.

5. Conservation

- 5.1 No conservation is necessary.

6. Comparative material

- 6.1 The luminescence date is given with associated errors at the 68% level of confidence. Both the random error and the overall error are quoted; the random error should be used for inter-comparison of the luminescence dates while the overall error should be used in comparison with independent dating evidence.

7. Potential for further work

- 7.1 The Luminescence dates have potential to add to the corpus of dating evidence, but little potential to answer the research aims.

8. Bibliography

- Aitken, MJ, 1985, *Thermoluminescence Dating*, Academic Press, London.
- Bailiff, IK, 1982, 'Beta-TLD apparatus for small samples' *PACT*, **6**, 72-76.

Table 1: Assessment of Dating

Sample ref.	Luminescence date ± random error ± overall error		
255-10-12	AD 360	± 140	± 160
255-10-30	AD 0	± 140	± 180
255-10-45	120 BC	± 140	± 200

Sample ref.	Palaeodose P (Gy)	Total Dose Rate (mGy/a)	Dose rate components (%)				Water content (%)	Organic content (%)	a-value
			α	β	γ	cosmic			
255-10-12	5.28 ± 0.24	3.20 ± 0.09	25	42	28	5	19 ± 2	3.8 ± 0.4	0.096 ± 0.008
255-10-30	5.51 ± 0.33	2.77 ± 0.08	28	38	29	5	19 ± 2	4.5 ± 0.5	0.093 ± 0.008
255-10-45	7.06 ± 0.38	3.33 ± 0.09	30	39	26	5	20 ± 2	3.1 ± 0.3	0.119 ± 0.009