JOURNAL OF QUATERNARY SCIENCE (2013) **28**(7) 647–652 ISSN 0267-8179. DOI: 10.1002/jqs.2669

Rapid Communication

Late Neanderthal occupation in North-West Europe: rediscovery, investigation and dating of a last glacial sediment sequence at the site of La Cotte de Saint Brelade, Jersey

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Received 2 June 2013; Revised 23 September 2013; Accepted 29 September 2013

ABSTRACT: In 2011, a programme of field research was undertaken to effect the stabilization of an unstable section in the West Ravine at the key Neanderthal occupation site of La Cotte de St Brelade on the Channel Island of Jersey. As part of this essential remedial work the threatened section was analysed to characterize its archaeological and palaeoenvironmental potential as well provide optically stimulated luminescence (OSL) dates. The work determined, through two concordant OSL dating programmes, that the section formed part of an extensive sequence of sedimentation spanning >105 to <48 ka. Furthermore, reanalysis of the archive determined that the sediment sequence examined contained the stratigraphic equivalent of deposits lying below those that have previously produced Neanderthal fossils. Through our work, we can now constrain these younger sediments to being younger than 48 ka. The combined results suggest that this sequence now represents the recovery of an extensive dataset, thought lost to science through complete excavation, which holds the potential to throw light on the disappearance of Neanderthal populations from the Atlantic-edge outpost on the north-west frontier of their world. Copyright © 2013 The Authors. *Journal of Quaternary Science* published by John Wiley & Sons Ltd on behalf of Quaternary Research Association

KEYWORDS: Jersey; La Cotte de Saint Brelade; Neanderthal; OSL dating.

Introduction

La Cotte de Saint Brelade (Figs. 1A, B and 2A) is a key site in north-west Europe for understanding the long-term behavioural development and extinction of Neanderthals. It is one of the world's most important Middle Palaeolithic sites, spanning approximately 200 000 years and it is the only site in the British Isles to have produced anatomical remains of late Neanderthals (Keith and Knowles, 1911; Stringer and Currant, 1986). Although excavation has occurred sporadically for at least 100 years, understanding of this site is patchy and imperfect. Indeed, little is known of the context or dating of these late Neanderthal remains. However, recent work in 2010/11 in the Western Ravine (Figs. 1C and 2) ascertained that a significant body of sediment is still preserved at the site that could potentially shed light on these issues. Unfortunately, this part of the site is poorly understood and at risk of erosion so in 2012 work was undertake n to sample and stabilise the at-risk sediments. This work represents the first formal investigation of the site since the early 1980s and the first conservation measure since work in the North Ravine at the end of McBurney's 1960s–1970s excavations (Callow and Cornford, 1986). It also represents the first modern attempt to provide a chronological framework for parts of the site most closely associated with the Neanderthal remains.

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Stratigraphy

The section examined by the authors in 2010/11 (Fig. 2B, C) lay on the north side of the West Ravine, immediately underlying the still extant remains of quarry rail tracks installed by Father Burdo in 1952 (Burdo, 1950–1958) (Figs. 2B and 3). These deposits were partially exposed along a relatively straight east–west axis for about 2.5 m. Although the general area was investigated during the research directed by Burdo in 1950–1952 (Burdo, 1951, 1952, 1953) his excavations were at a higher elevation than the extant section. Through examination of Burdo's plans and photographic archival material it has been established that Burdo's railway originally extended 12 m further to the west than our section and that head deposits flanked the south side of this railway along much of its length. We can therefore conclude that neither Burdo nor any other excavator had previously investigated the sequence recorded by us and that these deposits were buried beneath a talus of head deposits until some point in the past 50 years.

Eleven stratigraphic units were recorded extending from 7.94 to 12.44 m OD (Figs. 1C, 2B and 3; Table 1). All sediments dip in both a southerly and westerly direction; these directions of dip are consistent with previous observations (Burdo, 1960; McBurney and Callow, 1971; Callow, 1986). The lowermost observed unit (I) is a clast-supported, open matrix gravel that probably represents a phase of massive collapse of rock shattered from either the upper cliffs

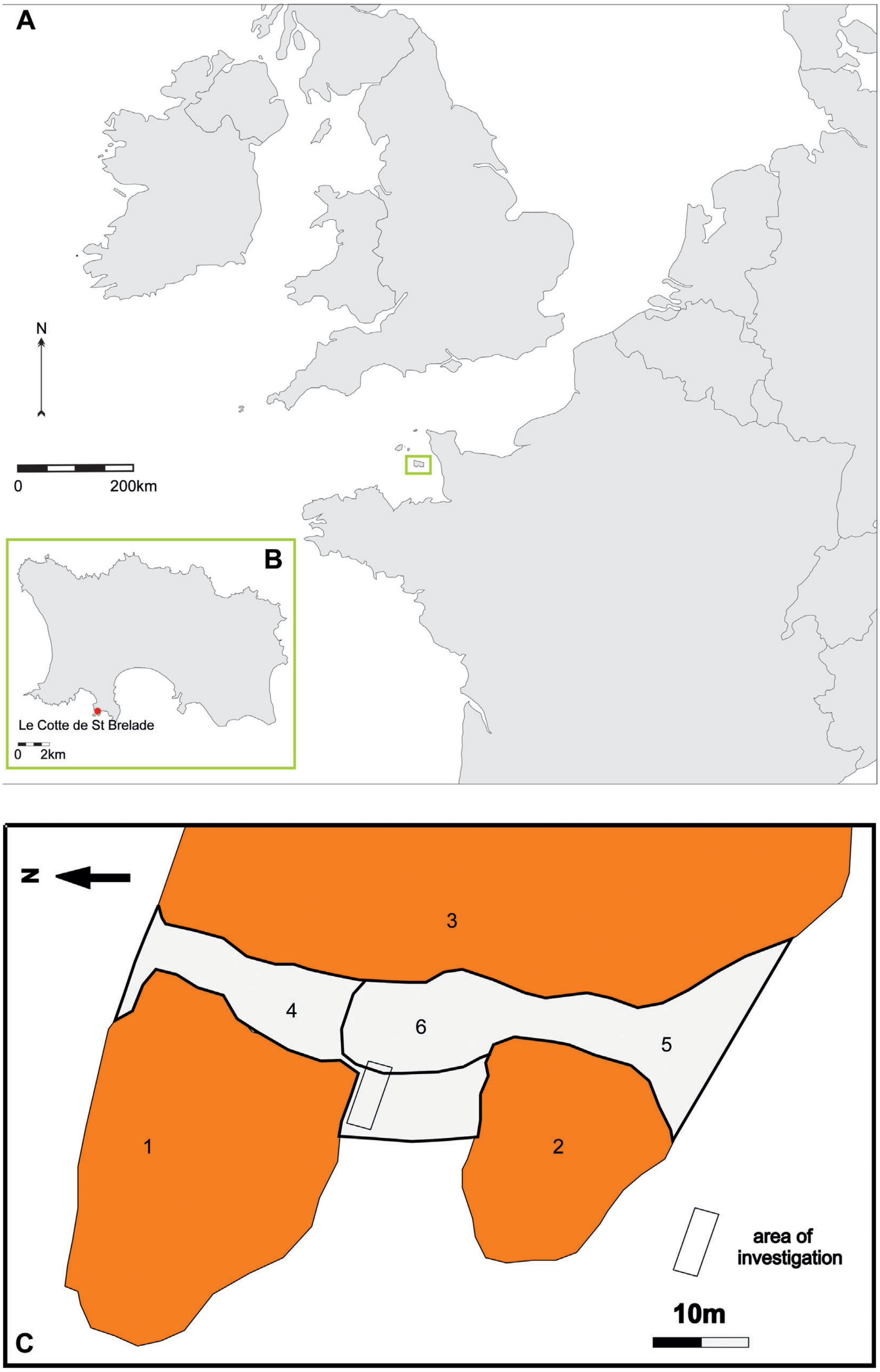

Figure 1. (A) Jersey and the English Channel/La Manche. (B) La Cotte and Jersey outline map. (C) Site plan of La Cotte (based on Callow and Cornford, 1986). Key: 1, North Pinnacle; 2, South Pinnacle; 3, East Wall; 4, North Ravine; 5, South Ravine; 6, central site. This figure is available in colour online at wileyonlinelibrary.com.

or overhanging roof arches. Given the coarse nature of this body of sediments it may well represent an episode of extreme cold when freeze–thaw resulted in shattering of bedrock faces. The sequence of overlying fine-grained sediments (Units II–V) exhibits considerable lateral variation in texture with a marked fining in grain size from west to east. This body of sediments appears to be derived from decaying granite (producing a fine granitic sand) washing downslope into a hollow. Wetter parts of the hollow appear to be dominated by increasingly clayey sediment (Unit IV and parts of Unit III) eastwards. It is possible that textural differences are associated with either changing source areas for sediment, or wetter environments in pools and puddles, accumulating within a hummocky terrain formed by a series of fan-like features building against the ravine wall. The contrast with the underlying sediment of Unit I suggests probable amelioration of climate. Following deposition of the granitic sands, finer grained clays and silts dominate the upper parts of the sequence (albeit with large angular fragments of granite throughout) (Units VI, VII and IX).

Figure 2. (A) View of La Cotte from the west looking into Western Ravine. (B) Intact stratigraphy beneath Burdo's railway tracks in the Western Ravine. (C) Sampled sediments to the east of railway track in the Western Ravine. This figure is available in colour online at wileyonlinelibrary.com.

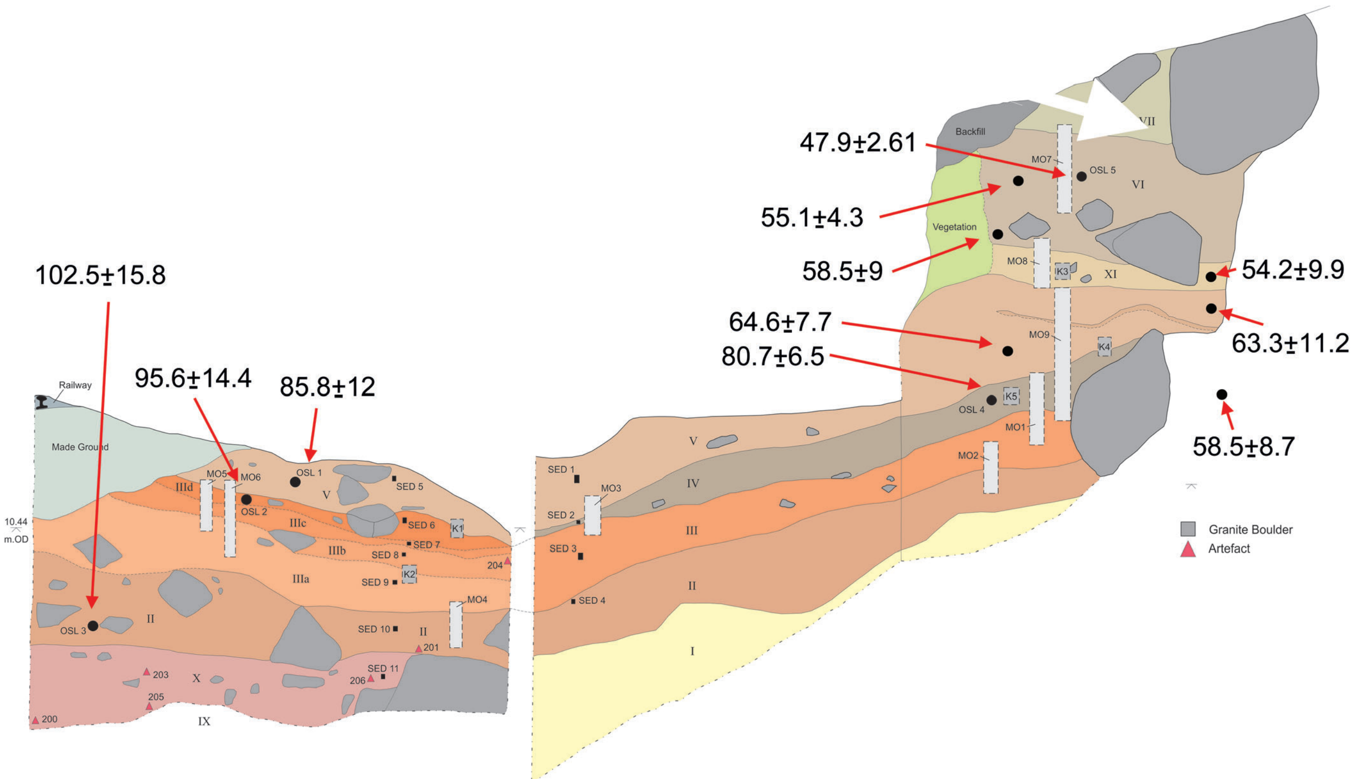

Figure 3. Stratigraphy sampled in the Western Ravine showing the position and ages of OSL dates. This figure is available in colour online at wileyonlinelibrary.com.

Table 1. Units and stratigraphy from railway cutting section in Western Ravine.

Unit and Description	Inferred environments of deposition
VII. Mid to dark brown clay–silt	Slope wash fans grading downslope into pools and puddles under mild climate. Occasional catastrophic collapses.
VI. Grey brown sandy silt	Slope wash fans grading downslope into pools and puddles under mild climate. Occasional catastrophic collapses.
XI. Dark brown to yellowish brown gravel	Slope wash fans grading downslope into pools and puddles under mild climate. Occasional catastrophic collapses.
V. Mid brown to reddish brown sandy silt to salty sand	Slope wash fans grading downslope into pools and puddles under mild climate.
IV. Very dark brown bedded clay–silt and sandy clay–silt.	Slope wash fans grading downslope into pools and puddles under mild climate.
III d. Pale yellow–red slightly gravelly sand	Slope wash fans grading downslope into pools and puddles under mild climate.
III c. Pale brownish yellow and reddish brown laminated fine to medium sand	
III b. Pale brown to yellowish red fine gravel	
III a. Red brown homogenous sandy silt to silty sand	
II. Dark brown very coarse to medium sand	Slope wash fans grading downslope into pools and puddles under mild climate.
X. Reddish brown gravel	Slope wash fans grading downslope into pools and puddles under mild climate.
IX. Mid brown clay–silt with some sand	Slope wash fans grading downslope into pools and puddles under mild climate.
Very poorly sorted, clast-supported gravel	Freeze–thaw dominating in cold environment with collapse of rock walls/roof

Comparison with the published works (Burdo, 1960; McBurney and Callow, 1971; Callow, 1986) indicate that the sediments present are probably the lateral downslope equivalent of units observed by Burdo along the northernmost edge of the west ravine (Burdo, 1960; see Supporting information, Table S1). It is probable that units IX, X, II and III are the lateral equivalent of 7A (a reddish brown gritty sand), unit IV corresponds to 6 (described as a brown peaty soil), while units V and XI equate to 5A (a coarse gritty sand). This places the deposits studied within the Stage IV (layers 6.2–9) sediments of Callow (1986, p. 64).

Archaeological artefacts from the excavated sections

Ten flakes were excavated from Units I–III and Unit X; most are flint, bar individual chert and quartz examples, and generally exhibit at least some edge damage, indicative of probable reworking. A single core fragment was also recovered from loess-rich deposits above our section at 14.9 m OD. Technologically speaking, all are compatible with Middle Palaeolithic reduction strategies; the core fragment appears to have been subject to discoidal exploitation in its final phase, while two flakes have facetted platforms – commensurate with controlled flaking techniques, such as Levallois or discoidal flaking.

Although restricted, it is notable that artefacts were only recovered from deposits already observed to contain artefacts, and in similar condition to the larger, existing assemblages: Callow notes the presence of derived artefacts within his layer 8.1 (Callow, 1986, Table 7.1). The condition of our artefacts might also suggest reworking. No artefacts were recovered from Burdo's overlying layers 6 and 5A (Burdo, 1960, pp. 23–25), and similarly, no material was recovered from the equivalents of these layers during our excavations. The single core fragment from 14.9 m OD (loess-rich deposits) is interesting, as it does not exhibit edge damage indicative of movement, and is of a dark, lustrous flint uncommon in the older deposits at La Cotte, but well represented among the later Neanderthal archaeology from the site.

Dating

Twelve sediment samples were collected from key deposits within the section featured in Fig. 3 for dating by optically stimulated luminescence (OSL). The results are shown in Table 2 and presented graphically by unit against the marine isotope stratigraphy in Fig. 4. Luminescence measurements were made on sand-sized quartz (180–255 μm) grains extracted by standard preparation procedures conducted under filtered laboratory lighting. All the samples were measured in automated Risø TL-DA-15 readers (Bøtter-Jensen, 1997; Bøtter-Jensen et al., 2000, 2002) fitted with blue LED stimulation units and using a single aliquot regenerative-dose (SAR) post-IR blue OSL measurement protocol (Murray and Wintle, 2000; Banerjee *et al.*, 2001; Wintle and Murray, 2006). Additional information is presented in the Supporting information, Appendix S1 and Fig. S1.

Dose rate calculations are based on the concentration of radioactive elements (K, Th and U) within the samples as well as complementary field γ-ray spectroscopy measurements using a 3 × 3-inch NaI (Ti) detector (EG&G Ortec micronomad) calibrated against the Oxford blocks (Rhodes and Schwenninger, 2007). The beta dose rates were derived from outsourced ICP-MS/OES and ICP-MS/AES analyses carried out by Prof. R. Ellam at the Scottish Universities Environmental Research Centre (SUERC) and Actlabs in Canada. No *in situ* spectroscopy measurements could be obtained for four of the samples due to unsuitable measurement conditions. In these cases, the gamma dose rates were derived from the radioisotope concentrations determined by the laboratory-based elemental analyses. For two further sets of samples (X5290 and X5380 as well as X5381 and X5382), considered near replicates, the external dose rate was obtained from only one of the sample pairs. In the absence of field spectroscopy data, a uniform medium for gamma rays was assumed and although the calculated total dose rate for these samples was consistent with the results obtained for the other samples in the series, potential uncertainty in the calculation of the external gamma dose rate cannot be excluded. Despite the granitic nature of the local bedrock geology and hence the relatively high environmental dose rates (~3 mGy a^{-1}) recorded throughout the sequence (Table 2), none of the samples was found to suffer significantly from signal saturation. However, clear evidence for this was noted for a small number of aliquots, probably because of individual grains retaining a geological signal following *in situ* weathering of detrital rocky debris embedded within the sediment. There is some uncertainty on the appropriate burial depth to be used in the age calculations, due to the complex history of

Table 2. Radioactivity data, equivalent dose (D_e) measurements and OSL age estimates.

Sample field code	Sample laboratory code	Radioisotopes* K (%)	Th (p.p.m.)	U (p.p.m.)	Field water (%)	External γ-dose rate (Gy ka^{-1})†	Total dose rate (Gy ka^{-1})‡	D_e (Gy)	Age (ka)§
COT11-1	X5286	2.39	12.5	4.5	19–25	–	3.23 ± 0.18	277.55 ± 35.09	85.8 ± 12.0
COT11-2	X5287	1.92	8.1	2.8	9–15	–	2.71 ± 0.16	259.49 ± 35.63	95.6 ± 14.4
COT11-3	X5288	2.27	13.0	5.8	14–20	–	3.64 ± 0.20	373.50 ± 53.58	102.5 ± 15.8
COT11-4	X5289	2.22	10.8	5.6	23–29	–	3.04 ± 0.18	245.17 ± 12.17	80.7 ± 6.5
COT11-5¶	X5290	1.60	11.8	6.3	26–36	1.92 ± 0.10	3.41 ± 0.15	163.53 ± 4.34	47.9 ± 2.6
COT11-6¶	X5380	1.58	11.8	6.3	20–30	(1.92 ± 0.10)	3.55 ± 0.16	195.30 ± 12.18	55.1 ± 4.3
COT11-7A¶	X5381	1.51	9.5	6.1	21–31	1.45 ± 0.07	2.97 ± 0.14	173.60 ± 25.29	58.5 ± 9.0
COT11-7B¶	X5382	1.36	9.4	7.7	21–31	(1.45 ± 0.07)	3.03 ± 0.14	169.90 ± 70.60	56.2 ± 23.4
COT11-8	X5383	1.28	8.7	8.1	21–31	1.01 ± 0.11	2.65 ± 0.16	143.87 ± 24.59	54.2 ± 9.9
COT11-9	X5384	1.61	16.7	6.1	19–29	1.15 ± 0.06	2.86 ± 0.14	184.76 ± 19.82	64.6 ± 7.7
COT11-10	X5385	2.03	9.0	5.4	16–26	1.38 ± 0.07	3.21 ± 0.16	203.12 ± 43.14	63.3 ± 11.2
COT11-11	X5386	2.06	7.8	6.5	20–30	1.45 ± 0.07	3.27 ± 0.16	191.18 ± 26.69	58.5 ± 8.7

*Measurements were made on dried, homogenized and powdered material by ICP-MS/AES with an assigned systematic uncertainty of ± 5%. Dry beta dose rates calculated from these activities were adjusted for the measured field water content expressed as a percentage of the dry mass of the sample. †Based on *in situ* measurements using a portable γ-ray spectrometer (EG&G Ortec micronomad) equipped with a 3 × 3-inch NaI (Tl) scintillator crystal and calibrated against the Oxford calibration blocks (Rhodes and Schwenninger, 2007). No field spectroscopy measurements are available for samples OSL 1–4. For these samples, calculation of the external dose rate is based on the concentrations of radioisotopes within the sediment. ‡Dose rate calculations are based on Aitken (1985). These incorporated beta attenuation factors (Mejdahl, 1979), dose rate conversion factors (Adamiec and Aitken, 1998) and an absorption coefficient for the water content (Zimmerman, 1971). The contribution of cosmic radiation to the total dose rate was calculated as a function of latitude, altitude, burial depth and average over-burden density based on data by Prescott and Hutton (1994). §Age estimates are reported at 1σ (68% confidence interval) and include a systematic instrument uncertainty of 3% to allow for possible bias associated with the calibration of the laboratory beta source. ¶OSL samples 6 as well as 7B are near replicates of samples 5 and 7A taken from the same stratigraphic units (e.g. units VI and VI base). γ-Ray spectroscopy measurements were made at the location of samples 5 and 7A and the same external gamma dose rate was applied to the replicate samples 6 and 7B (the data in parentheses). OSL age estimates are reported at 1σ (68% confidence interval) and include a systematic instrument uncertainty of 3% to allow for possible bias associated with the calibration of the laboratory beta source.

deposition and erosion at the site. Because of the relatively large thickness of the overburden (>5 m), it would seem reasonable to assume that the effect of the cosmic dose rate on the calculated dates is likely to be minimal. The dose rate calculations are based on a static stratigraphic model but, as the dating results seem to indicate, there could have been relatively long periods where the overburden was not sufficient to assume infinite matrix conditions. A more sophisticated model might be more appropriate and could be developed in the context of future investigations. In a similar way, it is important to note that the age estimates presented here also assume secular equilibrium of the decay series. No checks for disequilibrium have been made but we intend to conduct more advanced luminescence and dosimetric investigations (i.e. single grain dating, feldspar dating and high-resolution gamma spectrometry) as part of a detailed forthcoming programme of work.

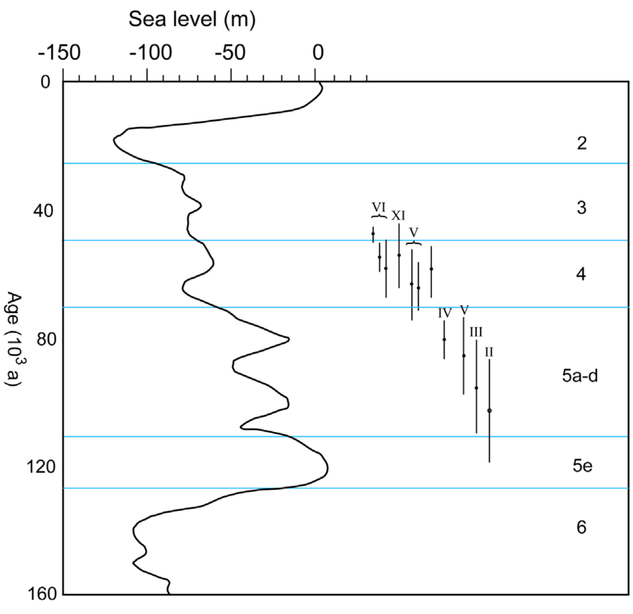

Figure 4. Marine isotope curve (based on Waelbroeck *et al.*, 2002) and OSL dates for La Cotte.

The sequences and their relationship to the Neanderthal remains

The deposits exposed in the railway section (Fig. 3) are stratigraphically below those from which human fossils were recovered at the beginning of the 20th century (Burdo, 1960). These consist of 13 Neanderthal teeth from a single individual, and an occipital fragment from a juvenile human skull (Stringer and Currant, 1986). The teeth were excavated together from a deposit located in the north ravine at 19.12 m OD (McBurney and Callow, 1971, p. 181) that consisted of a 'black soil' rich in poorly consolidated faunal remains containing lithic artefacts, structured hearths, ash and carbonized wood (Nicolle and Sinel, 1910, 1912; Keith and Knowles, 1911). In contrast, the occipital fragment was recovered from loessic head located in the north-east corner of the west ravine at 26.5 m OD.

Significantly, the deposits containing the teeth sloped from the north ravine into the western ravine in a south-westerly direction, thus following the same geometry as those encountered in the railway section (Burdo, 1960). The downslope equivalent of this unit was recorded by Burdo 5 m south of the northern edge of the western ravine, overlying the corollaries of sediment bodies identified in the railway section (Table S1). Here they were located between 15.4 and 13.9 m OD, which suggests that their equivalent would be *c*. 2 m above the top of the railway section. Indeed, the intact deposits above the railway section may be the equivalent of these deposits. It is therefore highly likely that this unit is still extant in the west ravine. Conversely, the skull fragment originates from units which are stratigraphically above and exhibit a different geometry from those containing the teeth. These sloped within the western ravine along a north-westerly axis (Callow, 1986) and represent part of the final phase of head deposition within the ravine system (Burdo, 1960).

Discussion

Dating of the sediments in the Western Ravine indicated that this part of the La Cotte sequence accumulated between the middle of Marine Isotope Stage (MIS) 5 and the earliest parts of MIS 3. These results therefore constrain the potential age range of the human fossils from La Cotte de St Brelade that are stratigraphically above those described and dated from the railway section, and must therefore have been deposited after 48 ka. Furthermore, as the skull fragment was recovered from a stratigraphically distinct and later phase of deposition within the ravine system, there is likely to be a significant chronological gap between the fossils. Some indication of the potential age of the final phase of head deposition within the La Cotte fissure system is indicated by an OSL age estimate obtained for these deposits in the southern fissure, which has provided an estimate of 25.7 ± 3.0 ka (J.-L. Schwenninger, unpublished data).

Before this investigation it was considered impossible to contextualize the La Cotte Neanderthals due to the complete excavation of the sedimentary unit from which they were excavated. Our work demonstrates that in the West Ravine a hitherto unrecorded sequence appears to exist that contains the stratigraphic equivalent of the Neanderthal fossil levels. The dating evidence has shown that these levels exist as part of a deep sequence spanning MIS 5–2, with the lower portion now constrained to between 105 and 48 ka. The Neanderthal fossils are now shown to be of critical interest and their age may well turn out to sit close to or within the period in which Neanderthal populations were replaced in Northern Europe by Anatomically Modern Humans.

Supporting Information

Additional supporting information can be found in the online version of this article:

Table S1. Correlations between our excavations and previous excavations at La Cotte.
Figure S1. Natural OSL decay curve and sensitivity-corrected dose–response curve (inset) for a single aliquot of sample OSL 11. The OSL characteristics of this aliquot are typical of those recorded for quartz from La Cotte de Saint Brelade. The natural signal (open triangle) is projected onto the dose–response curve using an exponential plus linear function to estimate the equivalent dose (D_e) by interpolation.
Appendix S1. Additional information on dating.

Acknowledgements. We would like to thank the Natural Environment Research Council for the award of a NERC Urgency award (NE/J012394/1) to cover field and laboratory work at the site. Grateful thanks are extended to the site's owners, the Société Jersiaise, for access to the site and for fruitful discussion on the site with John Clarke (President of the Société) and Dr John Renouf; to Jersey Heritage for tremendous support in carrying out fieldwork, especially to their archaeologist Olga Finch and conservator Neil Mahrer; to the States of Jersey Department of Planning and Environment for guiding the work; and also to Anne Best, Ralph Nichols, Jersey Digimap and the Jersey Coastguard. We thank NERC for their guidance and valued support. Thanks also go to Jo Dullaghan, Louise Rayner and Dominic Perring at the Institute of Archaeology for administering the application and project; and to the Leverhulme Trust-funded AHOB3 project for funding the second set of OSL dates and supporting B.S.'s involvement. Grateful thanks are also extended to Clive Gamble, Chris Stringer and John McNabb for their continued advice and encouragement, and to James Cole and Karen Rubens for help in the fieldwork. Finally we would like to thank the two reviewers for their valuable comments on this paper.

Abbreviations. MIS, Marine Isotope Stage; OSL, optically stimulated luminescence.

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