Regression analysis of exponential palaeodose growth curves

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When using palaeodosimetric dating methods, laboratory reconstruction of the palaeodose poses a key problem. As a rule, it is solved by the *additive dose* method, with extrapolation of the resulting experimental curve towards intersection with the x-axis. Given an experimental set of data (1)

$$\{D_A^{(i)}, I_i \equiv I(D_A^{(i)}); i = 1, \ldots n\} \quad (1)$$

where D_A is the laboratory additive does, and $I(D_A)$ the intensity of the TL peak or ESR spectrum signal, reconstruction of the accumulated dose DN is realised through a statistical regression analysis. This assumes optimum choice of the regressional functional dependence.

Supposing that fading involves a first order thermally activated process, the solving of the kinetic equations leads to the following functional shape for the intensity-dose relation (Hutt and Smirnov, 1982):

$$I(D_A) = I_o [1 - e^{-\beta(D_N + D_A)}] \quad (2)$$

where I_o and β are the parameters characterising the palaeo-dosimeter. Thus, (1) and (2) represent a non-linear three-parameter regression model I_o, β, D_N are the parameters to be estimated.

It would be more convenient to perform the regression analysis rewriting the equation (2) in the following way:

$$y(x) = a + be^{cx}$$

where $x \equiv D_A$ and $y(x) \equiv I(D_A)$.

From the condition $y(-D_N) = 0$ we obtain the value of the accumulated dose:

$$D_N = \frac{1}{c} \ln\left(-\frac{b}{a}\right)$$

The final model may be expressed as follows

$$y_i = f(\vec{\theta}; x_i) + \varepsilon_i, \quad i = 1, \ldots n$$

where y_i is the dependent variable, $\vec{\theta} = \{a,b,c\}$ is the estimated parameter vector, x_i is the independent variable, and $\vec{\varepsilon}$ is the random deviation vector. It is also assumed that x_i is error-free and that the random deviations are of normal distribution and uncorrelated,

i.e. $\quad \mathrm{cov}(\vec{\varepsilon}) \sim N(\vec{0}, \sigma^2 \vec{I})$.

The parameters a, b, c are estimated using the least squares method, when optimal choice of these parameters $\hat{\vec{\theta}} = \{\hat{a}, \hat{b}\ \hat{c}\}$ is determined by minimization of

$$S(a,b,c; x_i,y_i) = \sum_{i=1}^{n} (y_i - a - be^{cx_i})^2$$

The linearised Newton-Gauss method of minimization of $S(\vec{\theta}; x_i,y_i)$ is known from the literature (Berger et al, 1987). However, the linearisation procedure has some disadvantages. In some cases it leads to a slow convergence of the iterative processes and even to divergence.

The present paper proposes a straight minimisation method of $S(\vec{\theta}; x_i,y_i)$ by solving of the corresponding system of normal equations:

$$\left.\frac{\partial S}{\partial a}\right|_{\vec{\theta} = \hat{\vec{\theta}}} = -\sum_{i=1}^{n} 2(y_i - \hat{a} - \hat{b}e^{\hat{c}x_i}) = 0$$

$$\left.\frac{\partial S}{\partial b}\right|_{\vec{\theta} = \hat{\vec{\theta}}} = -\sum_{i=1}^{n} 2(y_i - \hat{a} - \hat{b}e^{\hat{c}x_i})e^{\hat{c}x_i} = 0$$

$$\left.\frac{\partial S}{\partial b}\right|_{\vec{\theta} = \hat{\vec{\theta}}} = -\sum_{i=1}^{n} 2(y_i - \hat{a} - \hat{b}e^{\hat{c}x_i})\hat{b}x_i e^{\hat{c}x_i} = 0$$

.... (3)

From the first two equations of the system (3) we have:

$$\hat{b} = \frac{\sum_{i=1}^{n} y_i e^{\hat{c}x_i} - \frac{1}{n}\sum_{i=1}^{n} e^{\hat{c}x_i} \sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} e^{2\hat{c}x_i} - \frac{1}{n}\left(\sum_{i=1}^{n} e^{\hat{c}x_i}\right)^2}$$

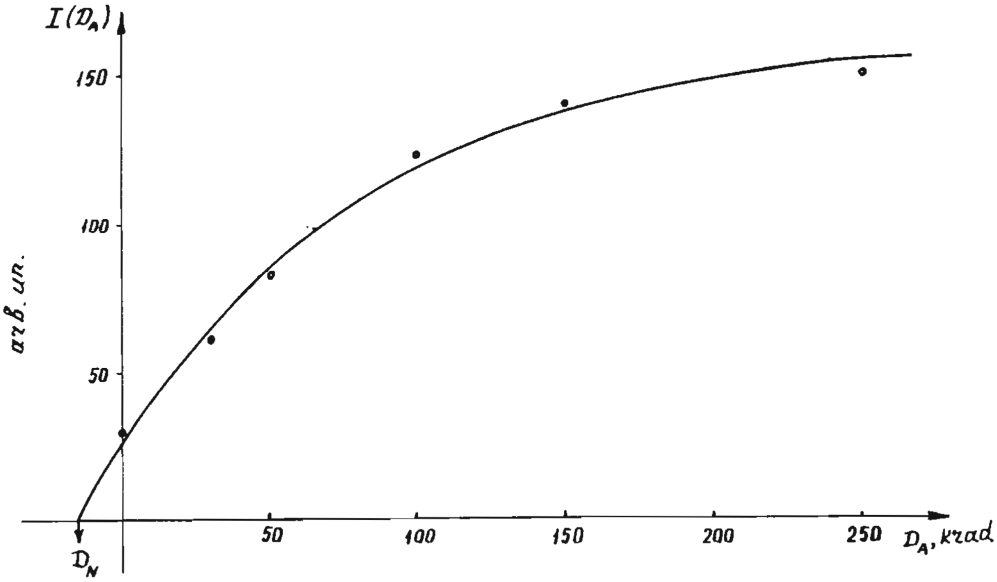
$$\hat{a} = \frac{1}{n}\sum_{i=1}^{n} y_i - \frac{\hat{b}}{n}\sum_{i=1}^{n} e^{\hat{c}x_i}$$

..... (4)

Inserting (4) into the third equation of the system (3) we obtain the equation for $\hat{c}$:

$$F(\hat{a}, \hat{b}, \hat{c}; x_i, y_i) = 0 \quad (5)$$

Non-linear equation (5) can be solved numerically by means of the Newton-Raphson iteration method:



$$\hat{c}_K = \hat{c}_{K-1} - \frac{F(\hat{c}_{K-1})}{F'(\hat{c}_{K-1})}, \quad K = 1, \dots ; \tag{6}$$

where $\hat{c}_o$ is the initial approximation and

$$F'(c) \equiv \frac{\partial F}{\partial c} + \frac{\partial F}{\partial a}\frac{\partial a}{\partial c} + \frac{\partial F}{\partial b}\frac{\partial b}{\partial c}$$

Calculating the derivatives included in $F'(\hat{c}_{K-1})$ by means of the system of equations (4) we entirely determine the calculation scheme of the iterative procedure. The termination of the iterative process (6) is based on the natural proximity condition of consequent estimates for $\hat{c}$:

$$|(\hat{c}_{K^*}) - (\hat{c}_{K^*-1})| \leq \varepsilon$$

The proposed calculation scheme is realised in the form of a BASIC programme. The working results of the programme are presented in the figure, where the regression dependence is shown by the solid line, and the experimental data by dots.

A linearised procedure for the approximate estimation of error in the accumulated dose can be carried out in the following way. Denoting with $V(y_i)$ the variance of y_i:

$$V(y_i) = \frac{1}{m_i - 1} \sum_{j=1}^{m_i} (y_{ij} - \bar{y}_i)^2 \quad i = 1, \dots\dots n;$$

$$\text{where } \bar{y}_i = \frac{1}{m_i} \sum_{j=1}^{m_i} (y_{ij} - y_i)^2 \quad i = 1, \dots n;$$

and m_i is the number of repeated measurements of value y_i. Writing the accumulated dose in a Taylor series in powers of $\delta y_i \equiv y_i - \bar{y}_i$, and confining ourselves to linear terms:

$$\delta_{D_N} = \sum_{i=1}^{n} \left(\frac{\partial f}{\partial a}\frac{\partial a}{\partial y_i} + \frac{\partial f}{\partial b}\frac{\partial b}{\partial y_i} + \frac{\partial f}{\partial c}\frac{\partial c}{\partial y_i}\right)\partial y_i, \tag{7}$$

where

$$f = D_N = \frac{1}{c} \ln\left(\frac{b}{a}\right),$$

$$a = a(x_i, y_i), \quad b = b(x_i, y_i), \quad c = c(x_i, y_i);$$

$$\delta_{D_N} = f(a,b,c) - f(\hat{a}, \hat{b}, \hat{c})$$

and the derivatives of function f are determined at the point of

$$\hat{\theta} = \{ \hat{a}(x_i, \bar{y}_i), \hat{b}(x_i, \bar{y}_i), \hat{c}(x_i, \bar{y}_i) \}.$$

A linearized procedure for the approximation estimate of error in the accumulated dose can be acrried out by using the law of propagation of errors (Mandel, 1964):

$$V(D_N) = \sum_{i=1}^{n} \left(\frac{\partial D_N}{\partial a}\frac{\partial a}{\partial y_i} + \frac{\partial D_N}{\partial b}\frac{\partial b}{\partial y_i} + \frac{\partial D_N}{\partial c}\frac{\partial c}{\partial y_i}\right)^2 V(y_i)$$

where $V(D_N)$ is the variance of D_N and $V(y_i)$ is the variance in the value of y_i evaluated using replicate measurements at the same dose x_i.

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PR. Reviewed by A.D. Franklin

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Notices

E-mail Address update

Michael Short of the Radioisotope Unit, Hong Kong writes to inform AnTL subscribers that the Laboratory may now be reached via BITNET using the following address:
HRXRSMA @HKUCC.BITNET

Meetings

6th International Specialist Seminar on TL and ESR Dating. 2-6 July 1990, Clermont Ferrand, France.
Further details: TL+ESR, Lab. de Physique Corpusculaire, F-63177 Aubiere, Cedex, France.

5th Nordic Conference on the Application of Scientific Methods in Archaeology. Stockholm 20-24 September 1990.
Further details: Stockholms Universitet, Arkeologiska Forskningslaboratoriet, Greens Villa, S-106 91 Stockholm.

Time and Environment - A PACT Seminar, Helsinki, Finland September. 25-28 1990
Further details: The Dating laboratory, University of Helsinki, Snellmaninkatu, Finland.

NB All of the above meetings are now in the final stages of preparation.

Ancient TL SUPPLEMENT

Date List

March 1990 Issue 3

1. This list includes dates for fired materials of archaeological interest, submitted to *Ancient TL* during 1989 for which sufficient information has been supplied. Readers are referred to earlier issues of the Date List for a fuller description of the structure of entries.

2. Application forms are available from the Editor, who will be pleased to advise on data compilation; laboratories wishing to submit dates for which the current date entry specification is not suitable should write to him. The application forms may be supplied on either paper or magnetic media.

3. A separate summary of all Part 1 entries published so far will be available for general archaeological circulation during 1990.

4. A specification for *Luminescence Sediment Age* entries is now being formulated. Suggestions for the form of the Entry Specification are welcomed and should be sent to to the Editor by 1st May 1990.

Laboratory: [*name*]	**Date Entry Specification**	**Entry:** [*entry number*]

PART I

Site: [*Name*] **Location:** [*Region, country*] **Grid Ref.:** [*National map reference*]

Site Description: [*Brief description of period and nature of site*]

Dates/Ages:

			Lab. Ref.	**Material**	**Archaeological Ref.**
[*Type*]	[*Type*]	[*Lab. abbrev.*]			
TL Context / Single	Date / Age	800 AD ± 50 (Dur87TLfg)	100-1/6	pottery	ABC-1a

[*Overall error*] [*Test year*] [*Technique*] [*Sample ref.*] [*Dated material*] [*Context reference*]

— **TL Context Components:** [*Details of component TL dates/ages used to derive Context Date/Age*] —

Archaeological Evidence: [*Excavator's brief description of context(s)*]

Site Director: [*Full name and institutional postal address*]

Reports: [*Details of excavation and laboratory reports*]

PART II

Section A. TL Measurements

1. **min.**([*mineral*]) **tech.**([*technique*]; [*grain size range, gsr*] µm)
   Data tabulated for each sample:
2. **P** = [*value*] ± s.e. Gy **2a. I/P** = [*value*] **3. Slopes** [2nd/1st: [*value*] ± s.e.]
4. [*Type of plateau*] **Plateau** [± [*value*] %; [T_1 - T_2]]

4a. **Peak** [@ [*value*] °C ; [*heating rate*]°/s; [*pre-heat details if applicable*]]

5. **Stability**[[*interval*, T_1 - T_2]; [*period*]; [*storage T* °C]; [*result* ; [*value*] ± [*value*]%]]
6. *a* value = [*value*] , or *b* value = [*value*]

Section B. Dose-rate Measurements

Data tabulated for each sample:

1. **Total Effective Dose-rate** = [*value*] ± s.e. mGy/a [α = [*value*]% [*method*];
   ß = [*value*]% [*method*]; γ = [*value*] % [*method*]; cos(mic) = [*value*] % [*method*]]
2. **Radon** [± [*value*] % [*method*]]
3. **Water** [Sample ([*value*] ± s.e. %); (Burial) Environment ([*value*] ± s.e. %)]

Section C. Error [[*Procedure* : *eA76 or specify other*]]

Section D. TL Age

Data tabulated for each sample:
TL Age[± [*random error*]; ± [*overall accuracy*]]

Special Remarks: [*Details of entries with * or any other additional information*]

KEY TO ABBREVIATIONS

STANDARD METHODS/TECHNIQUES/PROCEDURES

i	Inclusion	pd	Pre-dose	*a* Plat	Age plateau
fg	Fine-grain	MA	Multiple activation	*d* Plat	Dose plateau
mmi	Multi-mineral	ADD	Additive dose proc.	*s* Plat	TL Signal plateau
		Sb	Sensitivity baseline		
α-c	Alpha counting	FPh	Flame Photometry	TLD	TL dosimetry
AAS	Atomic absorption	NAA	Neutron Activation Analysis	XRF	X-ray fluorescence
β-c	Beta counting	PXE	PIXIE		
CAP	Capsule	SPEC	Spectrometer (SpEC = portable)		
Non-standard	AutoR	Auto regeneration	PTTL	Photo-transferred TL	

MINERALS & ETC.

cal	Calcite	Nf	Sodium feldspar	*	Other
ft	Flint	p	Polymineral	-	Not applicable
f	Feldspar	q	Quartz	e	Equivalent to (used as prefix)
Af	Unsep. alkali feldspar	z	Zircon		
Kf	Potassium feldspar	por	Porcelain	a	Year

Terms: I, P, *a* , *b*, A, S_N, S_o, TAC: as defined in the literature.

Laboratory: Oxford	Entry: 31

Site: Orp-le-grand **Location:** Brabant, Belgium **Grid Ref.:** 50° 41'40"N 4° 58'23"E.
Site Description: Open air site, buried in upper part of loess in plateau situation.

Dates				Lab. Ref.	Material	Archaeological Reference
TL Single Ages:	13.7	; ±1.7 ka	(Ox88TLfg)	245a3	burnt flint	OP1145/79
	13.1	; ±1.4		245a5		OP1164/26
	12.9	; ±1.5		245b1		OP1221/48
	12.1	; ±1.3		245b2		OP1133/79
	11.8	; ±1.2		245b4		OP1185/29

Archaeological Evidence: Magdalenian; as the chronological succession of the different Magdalenian groups in Western Europe is poorly understood these dates can be accpeted as a good indication of the age of the Magdalenian of Orp.

Site Director: Prof. Dr P.M. Vermeersch. Catholic University of Leuven, Redingenstraat, 16 bis, 3000 Leuven, Belgium.

Reports: Vermeersch, P.M., Symens, N., Vynckier, P., Gijselings, G., Lauwers, R. (1987) Orp, site Magdalenien de plein air (comm.de Orp Jauche). *Archaeologia Belgica*, 111, 7-56.

PART II
TECHNICAL SPECIFICATION

Section A. TL Measurements

1. Min(ft) tech.(fg; 1 - 8μm)

Sample Ref.	P ± s.e. (Gy)	I/P	Slopes	s Plateau	Peak	Stability	a val.
245a3	22.0 ± 1.5	0	-	± 3%; 300-350°	350°; 5°/s;	300 - 350°; 0.5 a; 18°; 100 ± 3%	0.09
245a5	22.5 ± 1.5	0	-	± 3%; 325-375°	350°; 5°/s;	325 - 375°; "	0.08
245b1	19.7 ± 1.3	0	-	± 5%; 350-425°	375°; 5°/s;	350 - 425°; "	0.06
245b2	22.6 ± 1.5	0	-	± 3%; 300-375°	350°; 5°/s;	300 - 375°; "	0.07
245b4	20.8 ± 1.3	0	-	± 3%; 300-375°	350°; 5°/s;	300 - 375°; "	0.05

Section B. Dose-rate Measurements

Sample Ref.	Total Eff. Dose-rate	Dose-rate Components α	β	γ	cos.	Radon	Water Sample	Env.
	mGy/a	%	%	%	%	%	%	%
245a3	1.60 ± 0.10	12	9	71	8	0 ± 5	0 ± 2	12 ± 3
245a5	1.71 ± 0.11	12	13	66	9	"	"	"
245b1	1.53 ± 0.10	8	12	71	9	"	"	"
245b2	1.86 ± 0.11	16	19	58	7	"	"	"
245b4	1.76 ± 0.11	13	18	61	8	"	"	"
Method		α-c	α-c FPh	CAP SPEC	SpEC	α-c		

Section C. Error [eA76]

Section D. TL Age

Sample Ref.	TL Age ka	Errors Random ka	Errors Overall ka
245a3	13.7	-	1.7
245a5	13.1	-	1.4
245b1	12.9	-	1.5
245b2	12.1	-	1.3
245b4	11.8	-	1.2

Laboratory: Oxford	Entry: 32

Site: Nine Mile Water **Location:** Nether Wallop, Hampshire, UK. **Grid Ref.:** SU 307345
Site Description: Raised mound adjoining Wallop Brook, on westerly edge of water meadow system.

Dates				Lab. Ref.	Material	Archaeological Reference
TL Context Age:	4240	; ±380 a	(Ox88TLfg)	260f	burnt flint	TL Pit layer 2
TL Context Comps:	4050	; ± 400		260f1		
	4350	; ± 430		260f3		
	4190	; ± 410		260f6		
	4230	; ± 420		260f9		
	4380	; ± 430		260f13		

Archaeological Evidence: Excavation revealed a sequence of topsoil overlying burnt flint sealing a fine grey/white deposit. Pottery at the base of the topsoil has been dated to the 12th/13th Centuries. There are however some I.A. sherds and the extent of burnt flint is unknown. A pre-I.A. date is therefore expected. The molluscan analysis needs to be completed before further comment can be made.

Site Director: Diane Williams, Department of Archaeology, University College, P.O. Box 78, Cardiff CF1 1XL.

Reports: D. Williams, in preparation.

PART II
TECHNICAL SPECIFICATION

Section A. TL Measurements

1. Min(ft) tech.(fg; 1 - 8μm)

Sample Ref.	P ± s.e. (Gy)	I/P	Slps	s Plateau	Peak	Stability	a val.
260f1	2.55 ± 0.20	0	-	± 5%; 325-375°	350°; 5°/s; -	325 - 375°; 0.5 a; 18°; 100 ±3%	0.13
260f3	3.92 ± 0.35	0	-	± 3%; 350-400°	"	350 - 400°; "	0.20
260f6	2.60 ± 0.20	0	-	± 5%; 325-400°	"	325 - 400°; "	0.11
260f9	2.75 ± 0.20	0	-	± 3%; 325-400°	"	325 - 400°; "	0.06
260f13	3.02 ± 0.20	0	-	± 5%; 350-425°	"	350 - 425°; "	0.11

Section B. Dose-rate Measurements

Sample Ref.	Total Eff. Dose-rte	Dose-rate Components α	β	γ	cos.	Radon	Water Sample	Env.
	mGy/a	%	%	%	%	%	%	%
260f1	0.63 ± 0.06	14	18	46	22	0 ± 3	0 ± 2	20 ± 5
260f3	0.90 ± 0.08	38	14	33	15	"	"	"
260f6	0.62 ± 0.06	18	13	47	22	"	"	"
260f9	0.65 ± 0.06	12	22	45	21	"	"	"
260f13	0.69 ± 0.06	16	22	42	20	"	"	"
Method		α-c	α-c FPh	CAP SPEC	SpEC			

Section C. Error [eA76]

Section D. TL Age

Sample Ref.	TL Age a	Errors Random a	Errors Overall a
260f3	4050	-	400
260f3	4350	-	430
260f6	4190	-	410
260f9	4230	-	420
260f13	4380	-	430

Laboratory: Oxford — **Entry: 33**

Site: Jels 2
Location: The site is at 'Jels-lakes' near the town of Jels in the southern part of Jutland, Denmark.
Grid Ref.: M3608
Site Description: A small hunters camp belonging to the Hamburgian Culture.

Dates				Lab.Ref.	Material	Archaeological Reference
TL Context Age:	10.2	; ±0.9 ka	(Ox88TLfg)	600a	burnt flint	HAM 1610 Oksenvad sogn 204
TL Context Comps:	9.4	; ± 1.1		600a1		2203
	10.8	; ± 1.0		600a3		2287

Archaeological Evidence: A very artefact-rich hunters camp belonging to the Hamburgian Culture. (12-13000 B.P.) A few Mesolithic artefacts were found within the excavation area. The TL date is not in agreement with the archaeological dating.

Site Director: Jorgen Holm, Haderslev Museum, Dalgade 7, 6100 Haderslev, Denmark. Flemming Rieck, Skibshistorisk Laboratorium, Frederiksborgvej 63, 4000 Roskilde, Denmark.

Reports: Holm J., and Rieck, F. (1987) Die Hamburger Kultur in Dänemark, *Archaologisches Korrespondenzblatt*, 17, 151-165.

PART II
TECHNICAL SPECIFICATION

Section A. TL Measurements

1. Min(ft) tech.(fg ; 1 - 8μm)

Sample Ref.	P ± s.e. (Gy)	I/P	Slps	s Plateau	Peak	Stability	a val.
600a1	4.25 ± 0.50	0	-	± 5%; 325-400°	375°; 5°/s;	325-400°; 0.5a; 18°; 100 ±3%	0.15
600a3	5.50 ± 0.50	0	-	± 5%; 325-400°	375°; 5°/s;	325-400°; "	0.04

Section B. Dose-rate Measurements

Sample Ref.	Total Eff. Dose-rte	Dose-rate Components α	β	γ	cos.	Radon	Water Sample	Env.
	mGy/a	%	%	%	%	%	%	%
600a1	0.45 ± 0.07	10	10	51	29	0 ± 5	0 ± 2	18 ± 6
600a3	0.51 ± 0.07	10	20	45	25	"	"	"
Method		α-c	α-c FPh	SPEC	SPEC			

Section C. Error [eA76]

Section D. TL Age

Sample Ref.	TL Age ka	Errors Random ka	Overall ka.
600a1	9.4	-	1.1
600a3	10.8	-	1.0

Laboratory: Oxford — **Entry: 34**

Site: Jels 1
Location: The site is at 'Jels-lakes' near the town of Jels in the southern part of Jutland, Denmark.
Grid Ref.: M 3608
Site Description: A small hunters camp belonging to the Hamburgian Culture.

Dates				Lab. Ref.	Material	Archaeological Reference
TL Context Age:	12.40	; ±1.60 ka	(Ox84TLfg)	600g(25)	burnt flint	HAM 1356
TL Context Comps:	12.85	; ±1.95		600g(25)i		47.2
	12.10	; ±1.80		600g(25)ii		1625
	12.25	; ±1.80		600g(25)iii		1686

Archaeological Evidence: In N.Germany similar sites are dated by C-14 to the Bolling interstadial, ie 12-13000 B.P.

Site Director: Jorgen Holm, Haderslev Museum, Dalgade 7, 6100 Haderslev, Denmark. Flemming Rieck, Skibshistorisk Laboratorium, Frederiksborgvej 63, 4000 Roskilde, Denmark.

Reports: Holm J., and Rieck, F. (1987) Die Hamburger Kultur in Dänemark, *Archaologisches Korrespondenzblatt*, 17, 151-165.

PART II
TECHNICAL SPECIFICATION

Section A. TL Measurements

1. Min(ft) tech.(fg ; 1 - 8μm)

Sample Ref.	P ± s.e. (Gy)	I/P	Slps	s Plateau	Peak	Stability	a val.
g(25)i	8.7 ± 0.5	0	-	± 5%; 325-400°	350°; 5°/s;	325 - 400°; 0.5 a; 18°; 100 ±3%	0.030
g(25)ii	9.6 ± 0.5	0	-	± 5%; 325-400°	375°; 5°/s;	325 - 400°; 0.5 a; "	0.095
g(25)iii	9.7 ± 0.5	0	-	± 5%; 325-400°	375°; 5°/s;	325 - 400°; 0.5 a; "	0.095

Section B. Dose-rate Measurements

Sample Ref.	Total Eff. Dose-rte	Dose-rate Components α	β	γ	cos.	Radon	Water Sample	Env.
	mGy/a	%	%	%	%	%	%	%
g(25)i	0.68 ± 0.08	4	13	65	18	-	0 ± 2	*
g(25)ii	0.80 ± 0.10	7	23	55	15	-	"	*
g(25)iii	0.80 ± 0.10	7	23	55	15	-	"	*
Method		α-c	α-c FPh	SPEC	SPEC			

Section C. Error [eA76]

Section D. TL Age

Sample Ref.	TL Age ka	Errors Random ka	Overall ka.
g(25)i	12.85	-	1.95
g(25)ii	12.10	-	1.80
g(25)iii	12.25	-	1.80

Special Remarks:
* Environmental dose-rate were determined by V. Mejdahl, Risø National Laboratory using a portable gamma-ray spectrometer.

Laboratory: Oxford	Entry: 35

Site: West Overton
Location: River valley bottom in Upper Kennet, North Farm, West Overton, Wiltshire., UK.
Grid Ref.: SU /135686
Site Description: Cremation hearth.

Dates				Lab. Ref.	Material	Archaeological Reference
TL Context Age:	3030	; ± 250 a	(Ox88TLfg)	727f	burnt flint	Long Meadow Pit D
TL Context Comps:	3090	; ± 275		727(I)		
	2870	; ± 270		727(II)		
	3130	; ± 280		727(IV)		

Archaeological evidence: Bronze age (probably Deverel-Rimbury) pot, up-turned over a human cremation. It was in a buried soil covered by alluvium. The charcoal in the pot is C-14 dated to 3020 ± 70 BP (OxA-1348).

Site Director: J. G. Evans, Department of Archaeology, University College , PO Box 78, Cardiff CF1 1XL, UK.

Reports: For related C-14 date see *Archaeometry*, 29(2), 1987 pp 294-295 (Also forthcoming date list of AMS lab).

PART II
TECHNICAL SPECIFICATION

Section A. TL Measurements

1. Min(ft) tech.(fg ; 1 - 8µm)

Sample Ref.	P ± s.e. (Gy)	I/P	Slps	s Plateau	Peak	Stability	a val.
727(I)	2.38 ± 0.30	0	-	± 3%; 325-400°	375°; 5°/s; -	325 - 400°; 0.5a; 18°; 100 ±3%	0.10
727(II)	2.38 ± 0.30	0	-	± 3%; 325-375°	350°; 5°/s; -	325 - 375°; "	0.08
727(IV)	2.38 ± 0.30	0	-	± 3%; 325-375°	350°; 5°/s; -	325 - 375°; "	0.10

Section B. Dose-rate Measurements

Sample Ref.	Total Eff. Dose-rte	Dose-rate Components α	β	γ	cos.	Radon	Water Sample	Env.
	mGy/a	%	%	%	%	%	%	%
727(I)	0.77 ± 0.05	16	12	55	17	0 ± 3	0 ± 2	32 ± 3
727(II)	0.83 ± 0.05	16	17	51	16	"	"	"
727(IV)	0.76 ± 0.05	14	12	56	18	"	"	"
Method		α-c	α-c FPh	CAP SpEC	SpEC	α-c		

Section C. Error [eA76]

Section D. TL Age

Sample Ref.	TL Age a	Errors Random a	Overall a.
727(I)	3090	-	275
727(II)	2870	-	270
727(IV)	3130	-	280

Laboratory: Oxford	Entry: 36

Site: Bagaggera.
Location: Merate village, Lecco region, Lombardy, N. Italy.
Grid Ref.: F.32 Como. 45°42'54" N., 9°23'18" E, 260 m above sea level.
Site Description: Pleistocene terrace.

Dates				Lab. Ref.	Material	Archaeological Reference
TL Single Age:	60.5	; ±7.5 ka	(Ox89TLfg)	750f	burnt flint	282

Archaeological Evidence: Burned flint from a Mousterian level at the base of an Upper Pleistocene loess, 40 m thick; at the top of weathered fluviatile Middle Pleistocene sand and gravel.

Site Director: Prof. Mauro Cremaschi, Dipartimento di Scienze della Terra, Via Mangiagalli 20133 Milano, Italy.

Reports: Preliminary reports in:
Cremaschi M., Orombelli G., Salloway J.C. (1985) Quaternary stratigraphy and soil development at the S. border of the Central Alps (Italy): the Bagaggera sequence. *Riv. It. Paleont. Strat.*, 90(4), 565 - 603.
Cremaschi M. (1987).Paleosols and Vetusols in the central Po Plain (N.Italy). Thesis, University of Amsterdam, Unicopli, Milano. pp1-360. Definitive report in preparation.

PART II
TECHNICAL SPECIFICATION

Section A. TL Measurements

1. Min(ft) tech.(1 - 8 µm)

Sample Ref.	P ± s.e. (Gy)	I/P	Slps	s Plateau	Peak	Stability	a val
750f	99.8 ± 5.0	0	-	± 3%; 375-450°	375°; 5°/s;-	375-400°; 0.5a; 18°; 100 ±3%	0.10

Section B. Dose-rate Measurements

Sample Ref.	Total Eff. Dose-rte	Dose-rate Components α	β	γ	cos.	Radon	Water Sample	Env.
	mGy/a	%	%	%	%	%	%	%
750f	1.65 ± 0.16	7	11	75	7	0 ± 5	0 ± 2	28 ± 7
Method		α-c	α-c FPh	SPEC	SPEC	α-c		

Section C. Error [eA76]

Section D. TL Age

Sample Ref.	TL Age ka	Errors Random ka	Overall ka.
750f	60.5	-	7.5

Laboratory: Oxford	Entry: 37

Site: Three Ways Wharf.
Location: 101-105 Oxford Road, Uxbridge, Middlesex, UK.
Grid Ref.: TQ 052 846
Site Description: Multiperiod site composed of a Late Glacial flint and bone scatter and an early Mesolithic flint and bone scatter.

Dates			Lab.Ref.	Material	Archaeological Reference
TL Single Age:	8000 ; ±800 a	(Ox89TLfg)	772f1	burnt flint	UX88VIII E23/NO2/D/3 343 SF64

Archaeological Evidence: Scatter A contained c.700 pieces of flint with some affinity to the 'Long Blade' late glacial period, with associated fauna of reindeer and horse. This latter dated by C-14 to 10270 ± 100 B.P. (OxA1778) and 10010 ± 120 B.P. (OxA1902). Scatter C produced c.7000 pieces of struck flint and c.2000 fragments of bone. The lithic assemblage is early Mesolithic and fauna is dominated by red deer. The dated sample is from this assemblage contained within argillic sediments deposited by gentle overbank flooding. The flint work is dated typologically to the early Mesolithic (expected to date to ca 9000 BP). *JSCL*

Site Director: John S.C. Lewis, Dept. of Greater London Archaeology, Museum of London, Town Mission Hall, Mission Square, Pottery Road, Brentford, Middlesex TW8 0SD, UK.

Reports: Lewis, J. S. C. (1989) Excavations at Three Ways Warf. *Mesolithic Miscellany*, **10**.
Lewis, J. S. C. (1990) Excavations at Three Ways Warf. Proc. 'The Late Glacial of N.W. Europe' (ed N. Barton), Dept. External Studies, Oxford University September 1989. In press.

PART II
TECHNICAL SPECIFICATION

Section A. TL Measurements

1. Min(ft) tech.(fg; 1 - 8μm)

Sample Ref.	P ± s.e. (Gy)	I/P	Slps	*s* Plateau	Peak	Stability	a val.
772f1	9.6 ± 0.6	0	-	± 5%; 325-400°	375°; 5°/s;	325-400°; 0.5 a; 18°; 100 ±3%	0.10

Section B. Dose-rate Measurements

Sample Ref.	Total Eff. Dose-rate	Dose-rate Components α	β	γ	cos.	Radon	Water Sample	Env.
	mGy/a	%	%	%	%	%	%	%
772f1	1.2 ± 0.2	10	8	71	11	0 ± 5	0 ± 2	30 ± 8
Method		α-c	α-c FPh	SPEC	SpEC	α-c		

Section C. Error [eA76]

Section D. TL Age

Sample Ref.	TL Age ka	Errors Random ka	Overall ka.
772f1	8.0	-	0.8

Laboratory: Oxford	Entry: 38

Site: Bir Sahara, BS-1
Location: Bir Sahara East Depression in south western Egypt.
Grid Ref.: 22°52' N, 28°50' E
Site Description: Middle Palaeolithic. Samples are from buried layers above an occupation horizon.

Dates			Lab. Ref.	Material	Archaeological Reference
TL Single Ages:	105.4 ; ±10.5 ka	(Ox88TLqi)	506a	burnt quartz	BS1TR965, V.H.73 upper layer
	108.6 ; ±10.6 ka	(Ox88TLqi)	506b		lower layer

Archaeological Evidence: Large concentration of artefacts (approx. 230 per m^2) of Levallois technique core and flakes; also highly denticulate tool assemblage.

Site Director: Fred Wendorf, Dept of Anthropology, Southern Methodist University, Dallas, Texas 75275, USA.

Reports: Wendorf, F., and Schild, R. (1980) *Prehistory of the Eastern Sahara*. Academic Press, New York.

PART II
TECHNICAL SPECIFICATION

Section A. TL Measurements

1. Min(q) tech.(inc; 90 - 150μm)

Sample Ref.	P ± s.e. (Gy)	I/P	Slps	*s* Plateau	Peak	Stability
506a	310 ± 30	0	1.05 ± 0.05	± 3%; 325-375°	350°; 5°/s;	-
506b	304 ± 30	0	1.05 ± 0.05	"	"	-

Section B. Dose-rate Measurements

Sample Ref.	Total Eff. Dose-rte	Dose-rate Components α	β	γ	cos.	Radon	Water Sample	Env.
	mGy/a	%	%	%	%	%	%	%
506a	2.94 ± 0.44	-	62	34	4	0 ± 5%	5 ± 5	7 ± 5
506b	2.80 ± 0.42	-	57	39	4	"	"	"
Method		-	α–c FPh	SPEC	SpEC	α–c		

Section C. Error [eA76]

Section D. TL Age

Sample Ref.	TL Age a	Errors Random a	Overall a.
506a	105.4	-	10.5
506b	108.6	-	10.6