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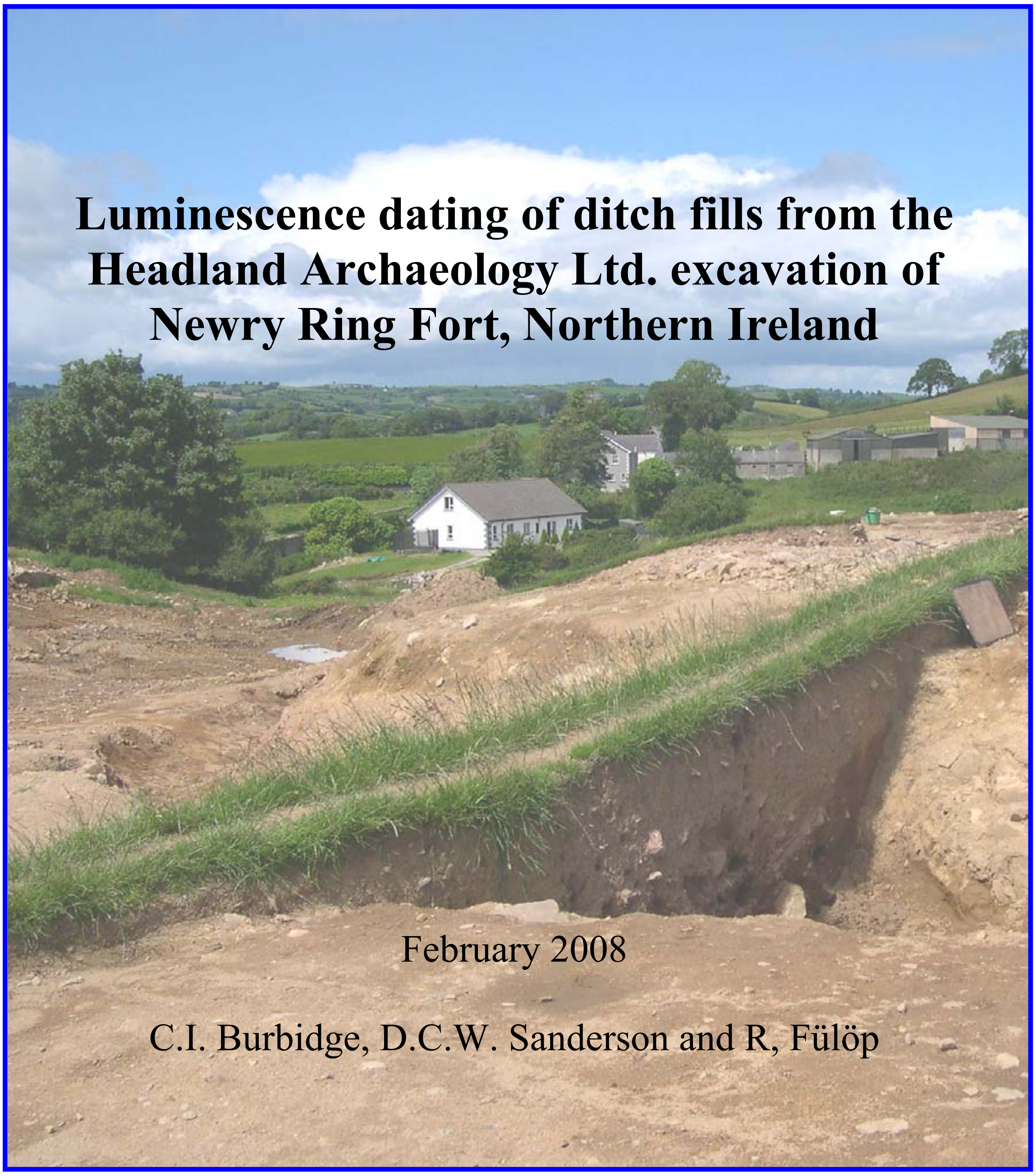

Luminescence dating of ditch fills from the Headland Archaeology Ltd. excavation of Newry Ring Fort, Northern Ireland

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Summary

This study supports a new investigation into the construction, occupation and utilisation history of a Mediaeval ring fort near Newry, southwest Northern Ireland (section 2). Optically stimulated luminescence (OSL) profiling and age determinations have been made for two sequences of sediments accumulated in the ring ditch surrounding the fort, and potential has been assessed for TL dating of a Souterrain-Ware sherd from a pit feature within the site complex (section 3). The archaeological significance of the age determinations has been reviewed in the light of the luminescence results and the samples' depositional contexts, to constrain the deposition/formation dates of the sampled sediments (section 6).

A total of 31 profiling (sections 5.1, 5.2) and 12 age (section 5.5) determinations were made. Profiling measurements were made using simplified equivalent dose determination procedures on polymineral coarse and hydrofluoric etched sand-sized mineral grains (sections 4.2.2). Dose rate determinations were made using thick source beta counting, high-resolution gamma spectrometry, field gamma spectrometry, measured water contents and calculated cosmic dose rates (sections 4.2.1 and 5.3). Equivalent dose determinations were made (sections 4.2.2, 5.4) using the OSL signals from sand sized grains of quartz separated from each sample.

The luminescence behaviour of the Newry Ringfort samples was generally very good. Profiling indicated variable levels of residual luminescence signal through the sections (sections 5.1, 5.2), but OSL on the etched fraction was found to be least affected, and measurements on fully prepared quartz for dating appeared even less so (sections 6.1, 6.2). Dose rates ranged from 2.6 to 3.9 mGy/a, De values from the dating samples ranged from 0.7 to 5.0 Gy. Estimates of sediment accumulation date ranged from 410AD to 1750AD (section 5.5). Uncertainties on the age estimates were commonly around 3%, but young samples with scattered equivalent dose distributions had estimated age uncertainties of up to 11%.

The external dose rate to the sherd was estimated to be 1.33 mGy/a ± 0.12 (sections 6.3, 7). Precision was limited by uncertainties in average water content during burial rather than heterogeneity in the gamma radiation field: providing the *range* of sediment radioactivity at a site can be assessed, and the average burial water contents of sherds excavated from it can be well constrained, then it is likely that sherds from around a site could be dated with sufficient precision to establish a broad chronology for Souterrain-Ware.

The earliest sediments in the ditch of the ringfort indicated that its construction predates the end of the 6th Century AD (sections 6.4, 7). These and other OSL age estimates indicated continued occupation until the mid 11th Century, or phases of occupation in the 7th, 9th and 11th Centuries. Results from the base of a colluvial soil sealing these layers indicate that the site was set to cultivation at or around the time of the Norman invasion of Ireland (1169AD), rather than in the post Mediaeval period. Abandonment of the ringfort must have occurred at the time of the invasion or in the century before it. Samples from throughout the colluvial soil also indicated that it continued to accumulate until at least the 18th Century, and probably into the 20th Century.

Contents

1. Introduction

This report is concerned with optically stimulated luminescence (OSL) investigations of sediment samples recovered from sequences of ditch fills, and dosimetric investigation of a pit feature, from a ring fort by Sheepbridge Junction on the route of improvements to the A1 north of Newry, Northern Ireland (54.216 N, 6.334 W; Figure 3.1). In the present report this will henceforth be termed “Newry Ringfort”.

2. Background

2.1. Context

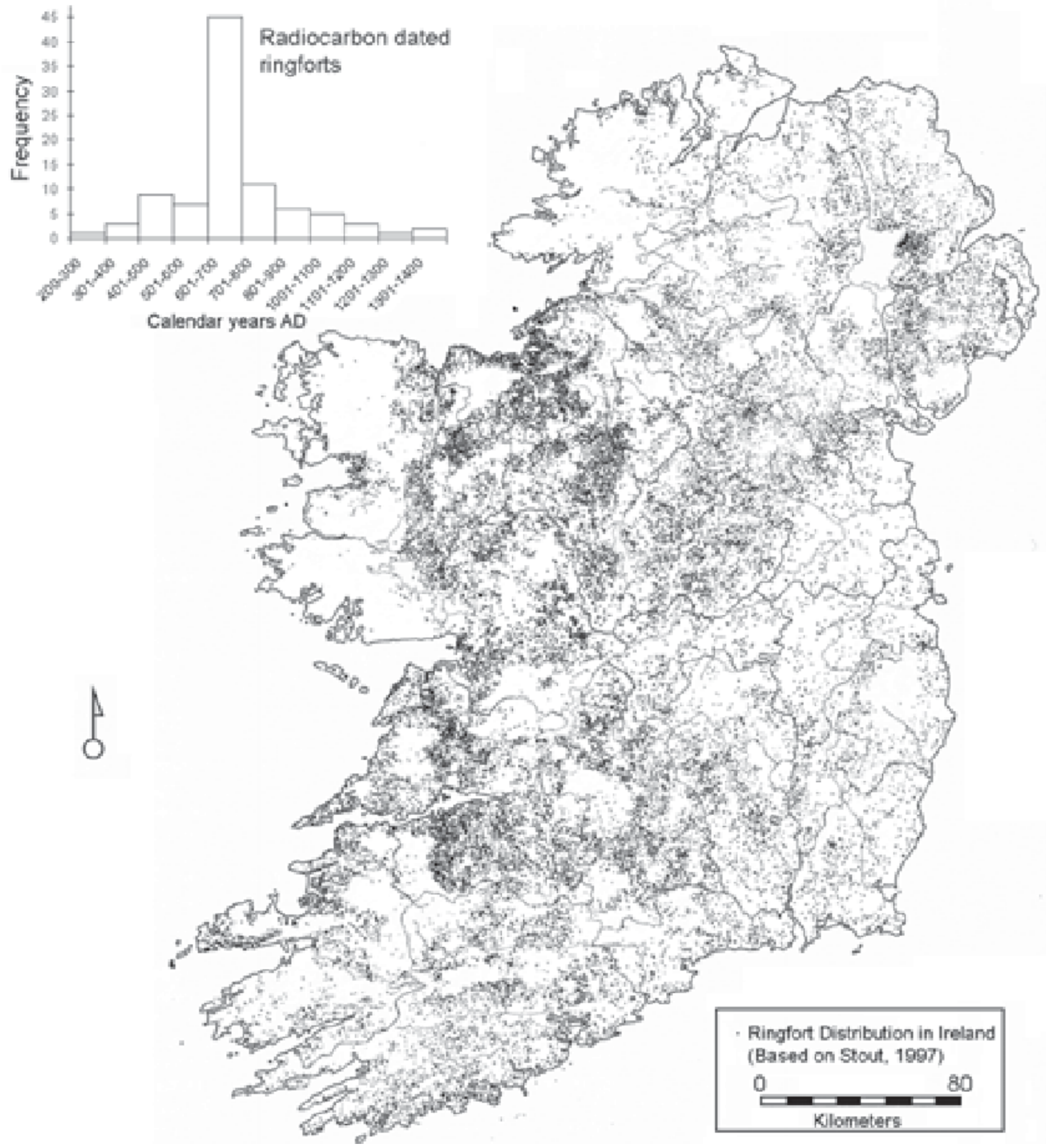
Ringforts distributed across the majority of Ireland are circular or sub-circular ditched enclosures. They thought to be “agricultural farmsteads built in a defensive form to offer protection against raiders and animal predators” (Legg and Taylor, 2006). Their construction is primarily associated with the Early Mediaeval period (450-1100 AD), prior to the Norman invasion of Ireland in 1169AD.

Reduced evidence of human activity in the Late Iron Age has been linked to a worsening of climate between around 300 BC and 250 AD. The subsequent increase in agricultural activity may have been a function of technological improvements (tools, farming practises, crop varieties, etc) as much as amelioration in climate, but increased food production appears to have led to population expansion, and hence increased competition for resources. Extant radiocarbon dates indicate that ringfort construction peaked in the 7^{th} Century AD (Figure 2.1).

Legg and Taylor (2006) found that ringforts are generally encountered on moderately fertile, well-drained soils on gently sloping land 80-150 m above sea level. In most of these respects Newry Ringfort appears typical: Although it is situated at lower altitude (~45 m a.s.l.), it lies on a granite knoll relatively high in a rolling landscape (see cover photo). Well-drained soils have developed from the weathered granite of the knoll, but substantial colluvial movement has left only thin soils on the top and produced deeper accumulations low on the sides of the knoll. Most in situ archaeological features within the site complex are therefore pits and niches.

The ditch enclosing the ringfort site complex is approximately 2 m deep x 4 m wide, although on steeper slopes little of the outer ditch bank is evident such that it functions as a steepening of the natural slope. The base of the ditch cuts into the weathered upper part of the granite bedrock. The ditch fills comprise sequences of colluvium, and palaeosols. These are thought to represent two phases of Mediaeval activity on the site: each phase destabilised the soil in the complex and led to its redeposition in the ditch (slope wash/ditch bank collapse), then a palaeosol formed in a subsequent period of stability. These sediments are sealed by a thicker layer of colluvial soil containing stone lines that lead to the bedrock wall forming the upper bank of the ditch. This is thought to be the consequence of Post-Mediaeval ploughing, possibly in the early 19^{th} Century AD.

Figure 2.1. Distribution of recorded ringforts in Ireland and frequency of construction per century based on 14C dating (from Legg and Taylor, 2006: based on Stout, 1997).



2.2. Aims

The principal aims of this study are to support an investigation into the construction, occupation and utilisation history of a Mediaeval ring fort in southwest Northern Ireland. The present study specifically aims to establish a sediment based OSL chronology for the accumulation of sediments in the ring ditch surrounding the fort, and to assess the potential for TL dating of a Souterrain-Ware sherd from a pit feature in terms of radiation dosimetry.

2.3. Luminescence dating of sediments

Optically stimulated luminescence originates as a consequence of energy deposited within sedimentary minerals in response to naturally occurring ionising radiation in the sample and its environment. By stimulating the minerals in the laboratory using lasers or other suitable light sources, part of this stored energy is released, resulting in luminescence which can be measured to quantify the radiation history of the sample. Luminescence signals can be erased either by heat or exposure to daylight, and for sedimentary materials exposure to light during transport phases acts as the zeroing mechanism. Enclosure of the sediment after final deposition protects it from light and allows the accumulation of luminescence signals that can be used for age estimation. The luminescence age is determined by combining luminescence determinations of the radiation dose equivalent to the signals recovered from the samples (the equivalent dose), with measurements of the radiation dosimetry of the sample and its environment (the dose rate). The natural dose rate comprises alpha, beta and gamma radiation produced by the decay of naturally occurring radionuclides (^{40}K, and the U and Th decay series), and cosmic radiation. The luminescence age is the quotient of equivalent dose over dose rate.

With sediment dating it is important to recognise that the luminescence age might represent an accumulated signal originating from many cycles of erosion, transport, bleaching and deposition. Only in the situation where undisturbed sediments are available and associated with effective zeroing at time of deposition can sediment dates be interpreted in terms of simple events. Photostimulation, or optical stimulation, targets readily reset luminescence signals, and regenerative procedures for determining the stored dose within single aliquots or mineral grains (Murray and Wintle, 2000) provided a means of assessing the homogeneity of doses within sediments. This approach can provide important information for diagnosing mixed sedimentary systems, and hence assists the interpretation of luminescence age determinations (Olley et al., 1998; 1999). It is also important to recognise that the dose rate values used for age estimation are based on contemporary measurements of the sample and its environment. These must be spatially representative, and expected variations in dose rate to the sample with time must be accounted for. Water absorbs radiation, so average water content during burial is estimated using the sample's water retention properties and by modelling it's hydrological history. Gross precipitation or leaching of radionuclides can be detected using gamma spectrometry and may require modelling based on the expected age of any movement.

It is probable that for the samples in the present study, the coarse hard mineral fraction, used for luminescence measurements, contains mineral grains weathered from bedrock in the late Pleistocene. It is likely that these were then reworked during soil formation by bioturbation and cultivation, and then redeposited through colluvial movement. Detailed examination of colluvially redeposited quartz grains weathered from granite bedrock has indicated that substantial residual signals may be retained (Heimsath et al., 2002). OSL studies applied to colluvial sediments have also met with mixed success (e.g. Prescott, 1997; Rees Jones and Tite, 1997). However, a number of fill sediments have been shown to be amenable to luminescence dating (e.g. Lang and Wagner, 1996; Rhodes et al., 2003), and OSL dating of sand-sized quartz grains from ditch fills has recently been applied successfully to the Bronze Age to Mediaeval site of Garretstown, Co. Meath (Rathbone, 2007).

The present report outlines the samples collected, the measurements undertaken, and the conclusions that can be drawn from the OSL results.

3. Sampling

Sampling was undertaken on the 26th-27th June 2007, by C. Burbidge and R. Fülöp (Burbidge et al., 2007). Fair copies of luminescence sampling forms are attached in Appendix A. Samples were taken from two cleaned sections through the fill of a ring ditch, on opposite sides of the enclosure.

Each section was sampled for luminescence profiling by excavating ~10 g loose sediment from behind the exposed material on the face of the section into light protected bags. These samples were taken from close to layer boundaries, and at ~10 cm intervals through thicker layers. The profiling samples were measured in field accommodation using a SUERC portable OSL reader, to assess the potential of the sediments for luminescence dating and to help select sampling locations (Burbidge et al., 2007).

Full luminescence dating samples were taken using stainless steel tubes (~200 g sediment), and additional sediment from the sampling location was collected in plastic pots (~200 g sediment) for laboratory gamma spectrometry measurements. The hole left by the sampling tube was then enlarged, and a field gamma spectrometry measurement recorded in situ.

Separate dosimetry samples were also taken, in plastic pots (~200 g sediment), from the fill and cover sediments of a relatively deep and narrow pit: a field gamma spectrometry measurement was made at the base of the pit.

16 profiling samples and 6 full dating samples were taken from Section 1 (Figure 3.2), 15 profiling samples and 6 full dating samples were taken from Section 2 (Figure 3.3), and two dosimetry samples were taken from Pit 1 (Figure 3.4).

Sampling details, including the labels assigned to each tube and bulk sample in the field, and the laboratory (SUTL) numbers assigned to each upon arrival at the SUERC luminescence dating laboratory, are summarised in Table 3.1 and Table 3.2.

Figure 3.1. Map showing location of Newry Ringfort on the route of improvements to the A1 between Beech Hill and Cloghogue (adapted from RoadsNI, www).

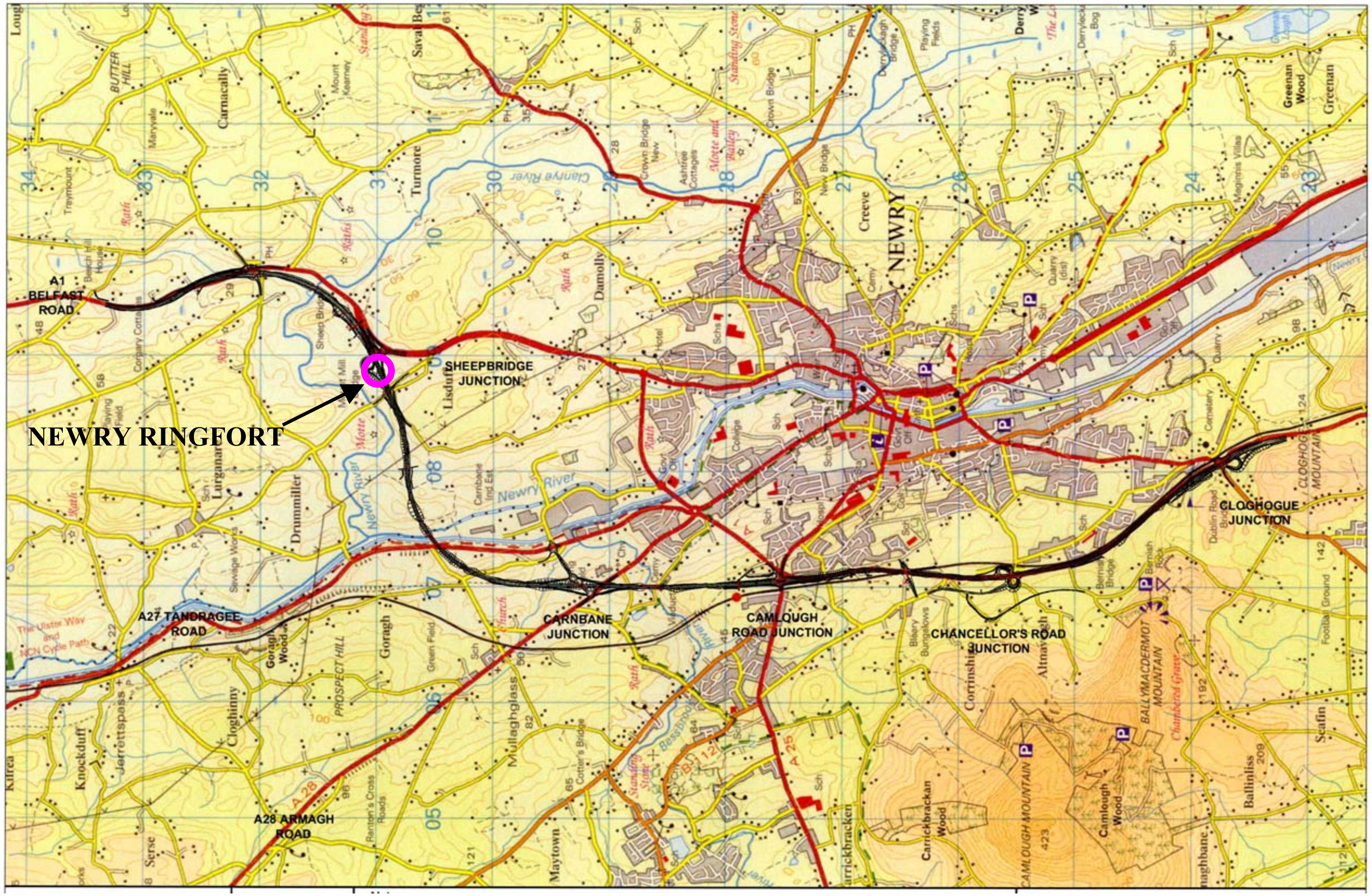


Figure 3.2. Newry Ring Fort Section 1 (South side of site, section faces East). Crosses indicate the locations from which samples were taken for luminescence profiling. Concentric circles represent locations from which full luminescence dating samples were taken, with associated field gamma spectrometry measurements. Layer numbers are related to site contexts in Table 3.1and Table 3.2.

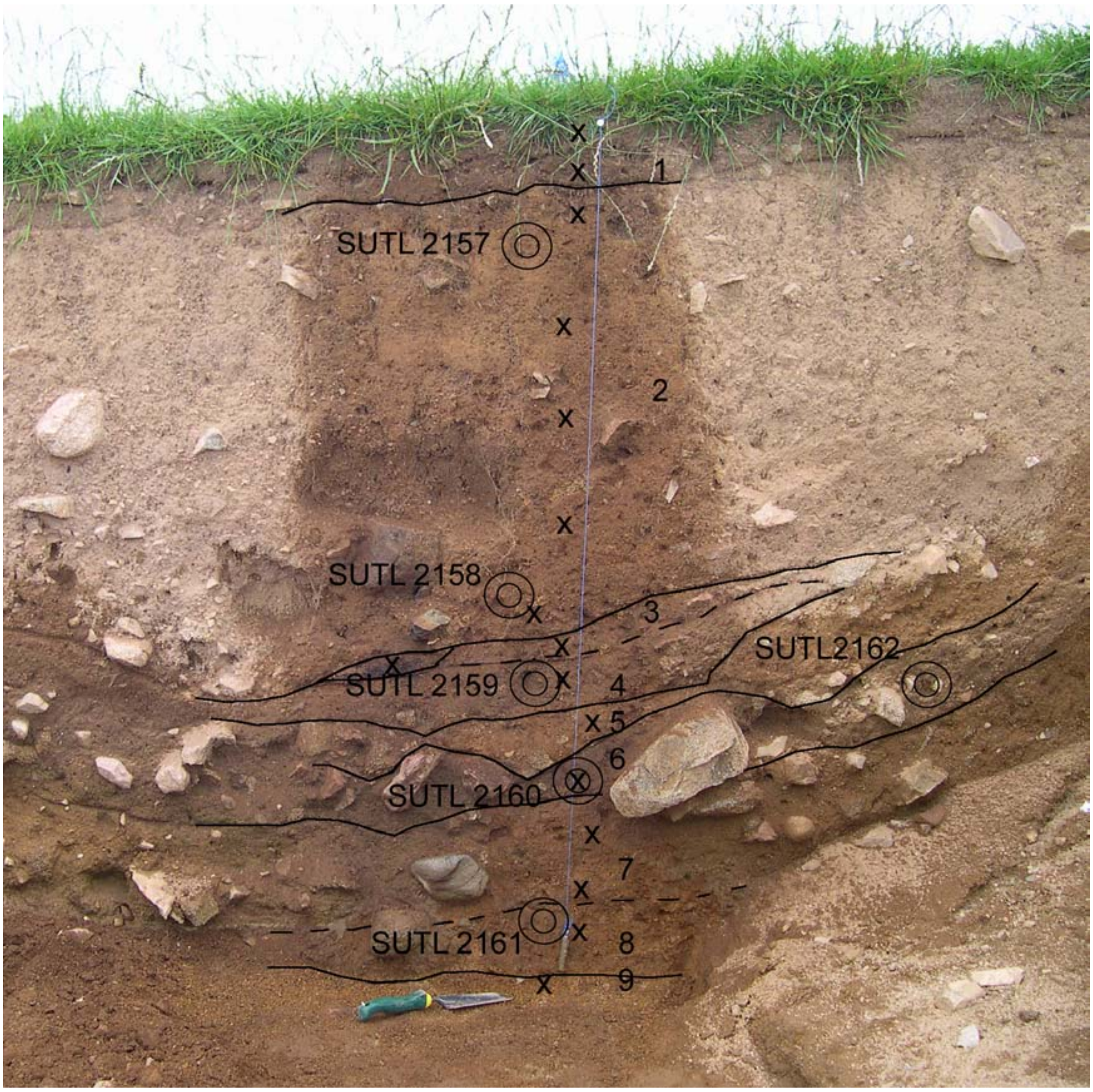


Figure 3.3. Newry Ring Fort Section 2 (West side of site, section faces South). Crosses indicate the locations from which samples were taken for luminescence profiling. Circles represent locations from which full luminescence dating samples were taken, with larger circles indicating the locations of associated field gamma spectrometry measurements. Layer numbers are related to site contexts in Table 3.1and Table 3.2.

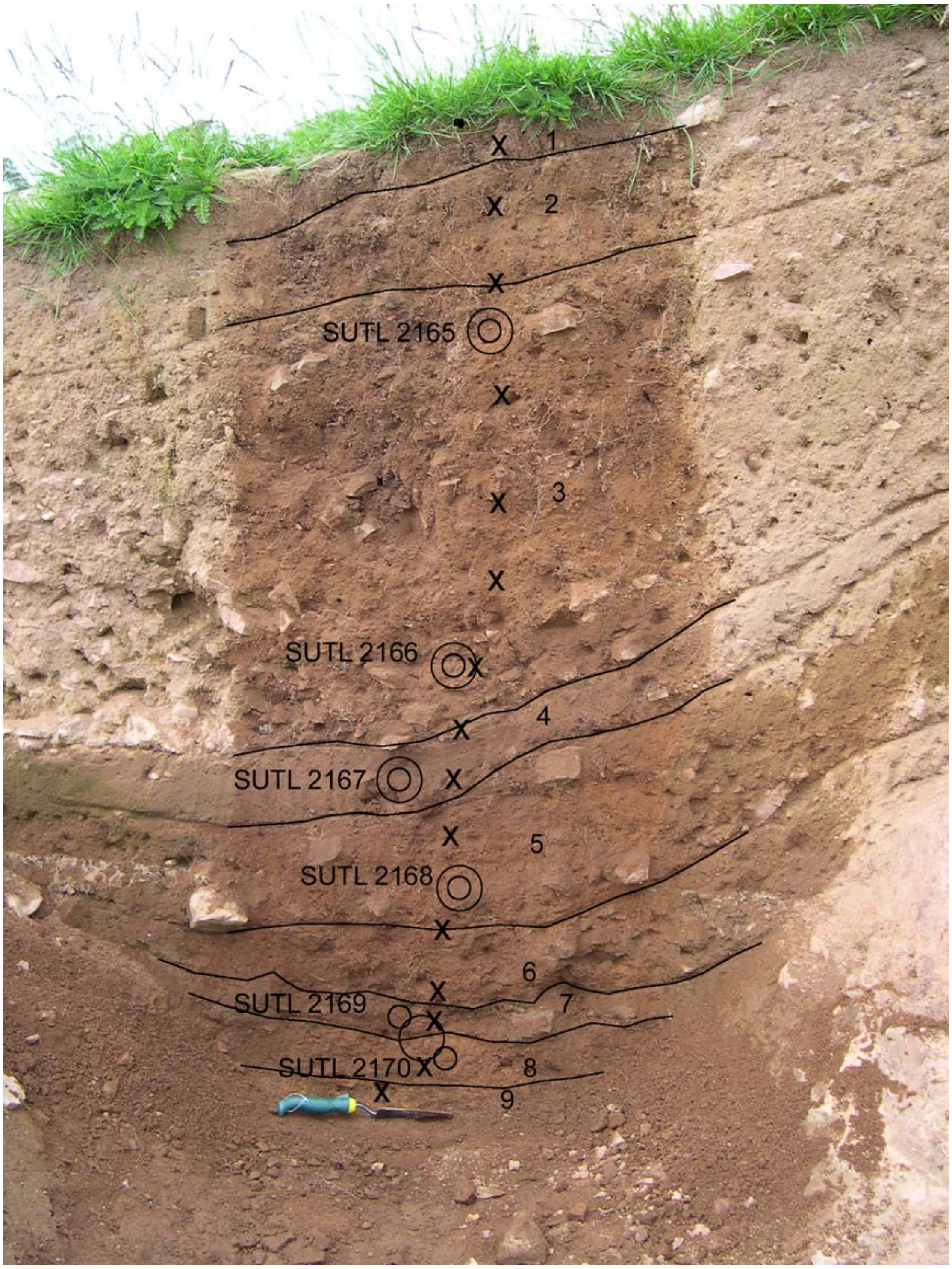


Figure 3.4. Newry Ring Fort Pit 1 (NW quarter of site complex within ring ditch). Illustrating pit location, shape, fill and cover sediments, and arrangement of gamma spectrometry measurement.

Table 3.1. Profiling sample locations, descriptions, and SUERC laboratory numbers

Sample Number				Depth	Context		
SUERC		Field	#	(cm)	Field	Site	Description
SUTL 2156	a	NEW S1	1	5	S1 Layer 1	20001	Modern topsoil. Reddish grey-brown, sandy, few stones
	b		2	11	1	20001	
	c		3	19	2	20629	
	d		4	39	2	20629	Light Red-Brown, many stones/clasts of all sizes to 20cm. Unclear colluvial stone lines coming from top of up-slope bank (bedrock). Colluvial soil, early C19?
	e		5	56	2	20629	
	f		6	79	2	20629	
	g		7	93	2	20629	
	h		8	99	3	20628	Red-brown soil lens, conforms to slope. V. silty fines, clasts < 5 cm.
	I		9	105	4	20628+7	Red brown soil similar to layer 3 but more loamy, less silty (cohesive). Conforms to slope. Colluvial accumulate associated with Late Mediaerval phase of site reuse?
	j		10	112	5	20626	Rubble layer with lt red-brown soil. Similar to layer 2
	k		11	124	6	20626	Dark red-brown soil in lee (downslope) of large stone. Silty, some clay but still plenty of small clasts and crystals from granite. Stabilisation following early occupation?
	l		12	134	7	20625	Red-brown soil, texture as layer 2, but partially conforms to slope. Fill associated with 1st phase of Mediaeval occupation?
	m		13	145	7	20625	
	n		14	154	8	20625	Red-brown soil, fewer clasts than layer 7. Initial fill following construction?
	o		15	164	9	N/A	Weathered Bed Rock – Granite
	p		16	105	3	20629	Ash/Org Lens. Dark grey-brown, silty
SUTL 2164	a	NEW S2	1	8	S2 Layer 1	20001	Modern topsoil. Reddish grey-brown, sandy, few stones
	b		2	17	2	20001	Rootzone, substrate as layer 3
	c		3	31	3	20029	
	d		4	48	3	20029	Light Red-Brown, many stones/clasts of all sizes to 20cm. Unclear colluvial stone lines coming from top of up-slope bank (bedrock). Colluvial soil, early C19?
	e		5	67	3	20029	
	f		6	80	3	20029	
	g		7	98	3	20029	
	h		8	107	4	20556	Dark red-brown, silty, some clay, few stones. Conforms to slope. Palaeosol - associated with Late Mediaeval phase of site reuse?
	I		9	116	4	20556	
	j		10	126	5	20555	Red brown soils similar to 2. Conforms to slope. Colluvial accumulate associated with Late Mediaeval phase of site reuse?
	k		11	143	5/6	20554/5	
	l		12	155	6	20554	
	m		13	161	7	20553/4	Dark red-brown soil in stone scatter/layer of small rubble. Silty, some clay but still plenty of small clasts and crystals from granite. Stabilisation following early occupation?
	n		14	171	8	20553	Red-brown soil, texture as layer2, but conforms to slope. Fill associated with 1st phase of Mediaeval occupation?
	o		15	180	9	N/A	Weathered Bed Rock – Granite

Table 3.2. Dating sample locations, descriptions, and SUERC laboratory numbers

Sample No. Lab' SUTL_	Field NEW_	Type	Sed. (g)	Lattitude Longtitude N	W	Depth (cm)	Site No.	Context Sediment	Constraints	Expected Relationships >	=	<
2156	S1 P1-16	Zlbs	~10 ea	54.216	-6.334	-	-	Whole section: topsoil to bedrock	Identify patterns in luminescence behaviour through the stratigraphy and aid selection of luminescence sampling locations.			
2157	S1#1	Tube + γ pot	117 146	54.216	-6.334	24	20629	Light Red-Brown, many stones/clasts of all sizes to 20cm. Unclear colluvial stone lines coming from top of up-slope bank (bedrock).	Constrain top of archaeological stratigraphy: end of C19? colluvial phase, associated with intensive agricultural activity		S2#1	S1#2
2158	S1#2	Tube + γ pot	139 128	54.216	-6.334	84			Base of colluvial/mixed layer.Constrain beginning of C19? colluvial phase, associated with intensive agricultural activity	S1#1	S2#2	S1#3
2159	S1#3	Tube + γ pot	118 168	54.216	-6.334	103	20628+7	Red-brown soil, conforms to slope. Loamy silt, clasts < 5 cm. Colluvial.	Constrain Late Mediaeval phase of site reuse: sealed by revetment used to widen natural causeway across ditch (c. 10 m away)	S1#2	S2#4	S1#4 S1#6
2160	S1#4	Tube + γ pot	123 170	54.216	-6.334	123	20626	Dark red-brown soil in lee (downslope) of large stone. Silty, some clay, many small clasts.	Palaeosol representing stabilisation following early Mediaeval phase: constrain initial period of Mediaeval site occupation.	S1#3	S2#5 S1#6	S1#5
2161	S1#5	Tube + γ pot	175 203	54.216	-6.334	148	20625	Red-brown soil, texture as 20629 but fewer clasts, partially conforms to slope.	Initial fill following ditch construction: constrain ditch construction and initial period of Mediaeval site occupation.	S1#4 S1#6	S2#6	
2162	S1#6	Tube + γ pot	150 164	54.216	-6.334	101	20626	As S1#4 but taken away from large stones on surface of section.	Palaeosol representing stabilisation following early Mediaeval phase: constrain initial period of Mediaeval site occupation.	S1#3	S2#5 S1#4	S1#5
2163a	Pit1#1a	γ pot	164	54.216	-6.334	-	-	Pink-purple granular plus silt/clay – appears either burnt or highly weathered.	Assess the potential for TL dating to improve constraint of the date of manufacture of a Souterraine Ware potsherd: presently "Mediaeval", i.e. ~500 to ~1500 AD			
2163b	Pit1#1b	γ pot	129	54.216	-6.334	-	-	Light red-brown silty sand (similar to ditch sediments)				
2164	S2 P1-15	Zlbs	~10 ea	54.216	-6.334	-	-	Whole section: topsoil to bedrock	Identify patterns in luminescence behaviour through the stratigraphy and aid selection of luminescence sampling locations.			
2165	S2#1	Tube + γ pot	129 182	54.216	-6.334	33	20029	Light Red-Brown, many stones/clasts of all sizes to 20cm. Unclear colluvial stone lines coming from top of up-slope bank (bedrock).	Constrain top of archaeological stratigraphy: end of C19? colluvial phase, associated with intensive agricultural activity		S1#1	S2#2
2166	S2#2	Tube + γ pot	130 212	54.216	-6.334	91			Base of colluvial/mixed layer.Constrain beginning of C19? colluvial phase, associated with intensive agricultural activity	S2#1	S1#2	S2#3
2167	S2#3	Tube + γ pot	126 161	54.216	-6.334	111	20556	Dark red-brown, silty, some clay, few stones. Conforms to slope.	Constrain Late Mediaeval phase of site reuse: sealed by revetment used to widen natural causeway across ditch (other side of site)	S2#2		S2#4
2168	S2#4	Tube + γ pot	156 218	54.216	-6.334	131	20555	Red brown soil similar to 20029: Light Red-Brown, many clasts of all sizes to 20cm.	Colluvial accumulate associated with Late Mediaeval phase of site reuse:Constrain phase of site reuse and accumulation rate	S2#3	S1#3	S2#5
2169	S2#5	Tube + γ pot	134 245	54.216	-6.334	157	20553/4	Dark red-brown soil in stone scatter/rubble layer. Silty, some clay, many small clasts.	Palaeosol representing stabilisation following early Mediaeval phase: constrain initial period of Mediaeval site occupation.	S2#4	S1#4 S1#6	S2#6
2170	S2#6	Tube + γ pot	166 195	54.216	-6.334	165	20553	Red-brown soil, similar to 20029, but conforms to slope.	Initial fill following ditch construction: constrain ditch construction and initial period of Mediaeval site occupation.	S2#5	S1#5	

4. Methods

4.1. Sample preparation

All sample handling and preparation was conducted under safelight conditions in the SUERC luminescence dating laboratories except where indicated.

4.1.1. Luminescence profiling samples

Field profiling measurements were made on subsamples of unprepared sediment, in a darkened room. In the laboratory the luminescence profiling samples were first wet sieved to isolate the 90-250 µm grain size fraction, which was treated with 1 M HCl for 10 minutes to dissolve carbonates. This material was subsampled (Polymineral coarse grains, "PMC"), and the rest was treated with 40% HF for 40 mins to dissolve less resistant minerals and leave a quartz-enriched sample, followed by 10 min HCL treatment to dissolve fluorides (Hydrofluoric-etched coarse grains, "HFC"). Each fraction was dried at 50°C, and dispensed onto the central part of 1 cm diameter, 0.25 mm thick stainless steel disks, using silicone oil for adhesion. Two such aliquots were made from each separated fraction (2 x PMC + 2 x HFC per sample).

4.1.2. Luminescence dating samples

Each sample was first subject to water content determination in the sampling tube. The tubes were unpacked and weighed with gauze taped over one end ("field"). They were then soaked in deionised water and reweighed ("saturated"), then allowed to drain at room temperature and reweighed ("drained upper limit"), and finally dried at 50°C and reweighed ("dry"). Sample material was then extracted from the tubes: potentially light exposed material from the ends was first removed, then the "core" was excavated for further measurements.

Around 100 g of the core material was weighed into HDPE pots for high-resolution gamma spectrometry (HRGS) measurement. The pots were sealed with epoxy resin and left for at least 4 weeks prior to measurement to allow equilibriation of ^{222}Rn daughters. After HRGS measurement the pots were opened and the sediment dry-sieved at 1 mm. 20 g of the less than 1 mm fraction was sub-sampled for thick source beta counting (TSBC) measurement. Following this, all the less than 1 mm material was recombined for processing to obtain a sand-sized quartz separate for equivalent dose determination.

Approximately 50 g of less than 1 mm material from the core of each sample tube was processed for luminescence measurements. With the object of separating sand-sized quartz grains from the bulk sediment, luminescence sub-samples were wet sieved to obtain 150-250 µm grains, which were treated with 1 M HCl for 10 minutes to dissolve carbonates: no strong reactions were observed. The treated material was centrifuged in heteropolytungstate solution (LST Fastfloat) at densities of 2.62 and 2.74 g/cm^3. The 2.62 - 2.74 g/cm^3 fraction was treated with 40% Hydrofluoric acid (HF) for 40 minutes, to dissolve less chemically resistant minerals with a similar density to quartz, and to etch the outer part of the quartz grains, which would have absorbed external alpha radiation during burial. The HF etched material was then treated with 1 M HCl for 10 minutes to dissolve any precipitated fluorides, and re-sieved at 150 µm with ultrasonic agitation to wash off any residual mineral dust. This etched quartz material was dried at 50°C, and dispensed in ~4 mg aliquots onto the central part of 1 cm diameter, 0.25 mm thick stainless steel disks, using silicone oil for adhesion. 16 disks were made per sample.

4.1.3. Dosimetry only samples

These samples were collected in HDPE pots for high-resolution gamma spectrometry (HRGS) measurement. The sediment was dried in the pots to determine field water content. 100 g subsamples were sealed in the pots with epoxy resin and left for at least 4 weeks prior to measurement to allow equilibriation of ^{222}Rn daughters. After HRGS measurement the pots were opened and the sediment dry-sieved at 1 mm. 20 g of the less than 1 mm fraction was sub-sampled for thick source beta counting (TSBC) measurement.

4.2. Measurements and determinations

4.2.1. Dose rate measurements and determinations

Dose rates were measured in the laboratory using High Resolution Gamma Spectrometry (HRGS) and Thick Source Beta Counting (TSBC). In-situ gamma spectra were measured using a Field Gamma Spectrometer (FGS) by C. Burbidge and R, Fülöp at time of sampling.

FGS measurements were made using a Health Physics Instruments Rainbow MCA with a 2"x 2" NaI probe. Prior to fieldwork, measurements were made using this system on the doped concrete reference pads at SUERC in order to provide cross-reference to dose-rate conversion factors established by Sanderson (1986), based on comparisons with TL dosimetry in doped blocks then at the Oxford and Risø luminescence laboratories. The spectra were calibrated to the 1457 keV peak from ^{40}K, then dose rates were determined from integral counts >450 keV, >1350 keV, and the energy integral (sum of counts times energy) across all the recorded spectrum. Using this approach yielded dose rates from the pads that were within errors of expected values (Appendix C.2). Field spectra were each measured for 10 mins in holes cut around the luminescence sampling positions using an overtube, and calibrated to the 1461 keV peak from ^{40}K before calculation of dose rates. The FGS measurement in the base of Pit 1 (Figure 3.4) was made similarly, but was estimated to have only 3pi (out of 4) solid angle of rock and sediment around it, the remainder being open to the sky and hence not contributing to the measurement. The measured gamma dose rate was therefore multiplied by 4/3 to estimate the dose rate to the probe if completely surrounded by the same materials.

HRGS measurements were performed using a 50% relative efficiency "n" type hyperpure Ge detector (EG&G Ortec Gamma-X) operated in a low background lead shield with a copper liner. Gamma ray spectra were recorded over the 30 keV to 3 MeV range from each sample, interleaved with background measurements and measurements from Shap Granite in the same geometries. Samples of c. 100g were counted for either 25 or 50 ks. The spectra were analysed to determine count rates from the major line emissions from ^{40}K (1457 keV), and from selected nuclides in the U decay series (^{234}Th, ^{226}Ra + ^{235}U, ^{214}Pb,^{214}Bi and ^{210}Pb) and the Th decay series (^{228}Ac, ^{212}Pb, ^{208}Tl) and their statistical counting uncertainties. Net rates and activity concentrations for each of these nuclides were determined relative to Shap Granite by weighted combination of the individual lines for each nuclide. The internal consistency of nuclide specific estimates for U and Th decay series nuclides was assessed relative to measurement precision, and weighted combinations used to estimate mean activity concentrations (in Bq kg^{-1}) and elemental concentrations (% K and ppm U, Th) for the parent activity. These data were used to determine infinite matrix dose rates for alpha, beta and gamma radiation.

Beta dose rates were also measured directly using the SUERC TSBC system (Sanderson, 1988). Sample count rates were determined with six replicate 600 s counts for each sample, bracketed by background measurements and sensitivity determinations using the SUERC Shap Granite secondary reference material. Infinite-matrix dose rates were calculated by scaling the net count rates of samples and reference material to the working beta dose rate of the Shap Granite (6.25±0.03 mGy a^{-1}). The estimated errors combine counting statistics, observed variance and the uncertainty on the reference value.

"Field", "saturated", and "drained upper limit" (DUL; Ratiff *et al*., 1983) values of water content (section 4.1) were calculated as fractions of dry sediment mass after subtracting the mass of the tube and gauze. The dose rate estimates were used in combination with the measured water contents, to determine the overall effective dose rates for age estimation. Since the sediments from Pit 1 (Figure 3.4) were not in situ when sampled they could be used for measurement of field water content but not saturated and DUL water contents: the assumed water contents for these samples were based on those for other samples with similar field water contents.

The cosmic dose rate is conventionally calculated rather than measured, without adjustment for sediment water content. The latitude, altitude and (sediment) depth dependencies of cosmic radiation, relevant to luminescence dating, are described by Prescott and Stephan (1982) and Prescott and Hutton (1988). In the present study, the latitude of each sample was approximated to the nearest degree, and altitude was approximated as 0.05 km for all. Surface cosmic dose rate was estimated using Prescott and Stephan (1982), Eqn. 1, with latitude dependent parameters read from Fig. 2. A representative value for the average burial depth of each sample since the luminescence signal was last zeroed, was estimated from depth at the time of sampling, geomorphological context, and approximate luminescence age. Depth was converted to mass-depth assuming sediment bulk density to be 1.6 g/cm^3, and a fit to the dose rate vs. depth data of Prescott and Hutton (1988) was used to calculate the cosmic dose rate at that depth. Uncertainties were calculated as: 5% plus the difference between cosmic dose rate at the depth of sampling, and that at the estimated average burial depth. Cosmic dose rate for the samples from Pit 1 were based on the depth of the potsherd with which the samples were associated (see sampling form in Appendix A).

4.2.2. Field luminescence measurements

Field profiling measurements were made using a SUERC portable OSL reader, equipped with blue LEDs emitting around 470 nm and a U340 detection filter pack to detect in the region 270-380 nm, while cutting out stimulating light. Samples were presented as loose bulk sediment in a 1.5” plastic petri dish, and the natural OSL signals were measured during optical stimulation with the blue diodes.

4.2.3. Laboratory luminescence measurements

All laboratory measurements were conducted using a Risø DA-15 automatic reader, equipped with a $^{90}Sr/^{90}Y$ β-source for irradiation, blue LEDs emitting around 470 nm and an infrared laser diode emitting around 830 nm for optical stimulation, and a U340 detection filter pack to detect in the region 270-380 nm, while cutting out stimulating light (Bøtter-Jensen *et al*., 2000).

The discs of quartz grains from the tube samples were subjected to a single aliquot regeneration (SAR) sequence (Murray and Wintle, 2000). According to this procedure, the OSL signal level from an individual disc is calibrated to provide an absorbed dose estimate using an interpolated dose-response curve, constructed by regenerating OSL signals by irradiation in the laboratory. This estimate is termed the equivalent dose (De), since it is the laboratory dose producing an equivalent signal to that observed from the natural sample. Sensitivity changes which may occur as a result of readout, irradiation and preheating (to remove unstable radiation-induced signals) are monitored using small test doses after each regenerative dose. Each measurement is standardised to the test dose response determined immediately after its readout, thus compensating for observed changes in sensitivity during the laboratory measurement sequence.

In a SAR sequence then, each disc is subject to a number of measurement cycles: Natural&Test (cycle 1), Regenerative&Test (cycle 2), Regenerative&Test (cycle 3), etc., where all that is varied is the regenerative dose. For the purposes of interpolation, the regenerative doses are chosen to encompass the likely value of the equivalent (natural) dose. A repeat dose point is included to check the ability of the SAR procedure to correct for laboratory-induced sensitivity changes, a zero dose point is included late in the sequence to check for recuperative signals, and a repeat point with infrared stimulation prior to the OSL measurement is included to check for non-quartz signal (“Recycling”, “Zero”, “IRRecycling”; Table 4.1). Quartz responds to blue light but generally not to infrared light, whereas other common minerals such as feldspars and zircon respond to both. Additionally, results may vary with the severity of the preheating employed: this is tested for by applying a range of preheats to different groups within the set of discs.

In the present study 16 discs per sample were measured using 4 discs each at 4 different preheats (Table 4.1). Regenerative doses of 0 to 10 Gy were applied to all samples (plus repeats etc.: cycles 1 to 8, Table 4.1).

Table 4.1. Quartz Single Aliquot Regenerative Sequence

		Measurement Cycle:	1	2	3	4	5	6	7	8
Aliquots	**Operation**	**Details**	Natural	Linear-spaced doses					Recycling	IR Recycling
1-16	Regenerative Dose	"X" Gy $^{90}Sr/^{90}Y$	no	4	0	1	7	10	4	4
1-4	Preheat	200°C for 30s	yes	yes	yes	yes	yes	yes	yes	yes
4-8	Preheat	220°C for 30s	yes	yes	yes	yes	yes	yes	yes	yes
9-12	Preheat	240°C for 30s	yes	yes	yes	yes	yes	yes	yes	yes
13-16	Preheat	260°C for 30s	yes	yes	yes	yes	yes	yes	yes	yes
1-16	Measurement	IRSL 120s at 50°C	no	no	no	no	no	no	no	yes
1-16	Measurement	OSL 60s at 125°C	yes	yes	yes	yes	yes	yes	yes	yes
1-16	Test Dose	"X" Gy $^{90}Sr/^{90}Y$	2	2	2	2	2	2	2	2
1-16	Test Preheat	160°C for 30s	yes	yes	yes	yes	yes	yes	yes	yes
1-16	Test Measurement	OSL 60s at 125°C	yes	yes	yes	yes	yes	yes	yes	yes

The laboratory profiling disks were measured using variants of the procedure described above (Table 4.2). The HFC fraction was measured using cycles 1 and 2 of the SAR protocol (Table 4.1) but with the same preheats for all aliquots, i.e. the natural cycle plus a single regenerative cycle. The PMC fraction was measured using IRSL and TL as well as OSL, but without test dose monitors. IRSL was measured first: this accesses signal from feldspars (and other minerals), but not generally from quartz. OSL was measured second: this accesses optically bleachable signals from quartz and feldspar (etc.). TL was measured last: this also accesses signals that are less optically sensitive. Comparison of the three signals can aid interpretation of residuality (e.g. Burbidge *et al.*, 2007). In the present study regenerative doses of 10 Gy and test doses of 2 Gy were used in profiling measurements (Table 4.2).

Table 4.2. Profiling measurement sequences

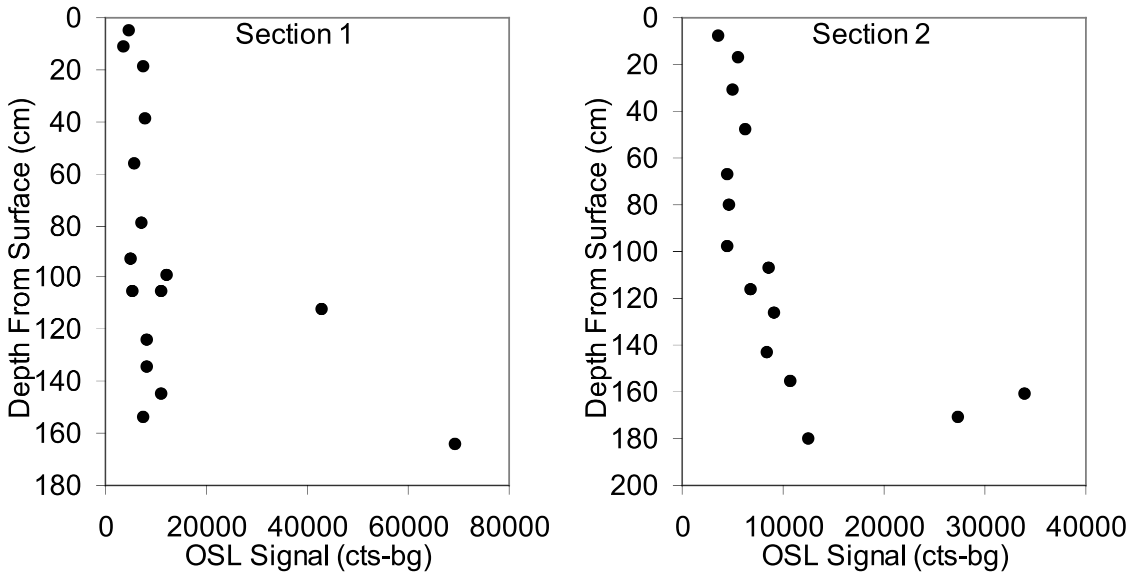
HFC		**PMC**	
Operation	Details	Operation	Details
Natural Sample	-	Natural Sample	-
Preheat	220°C for 30s	Preheat	220°C for 30s
Measurement	OSL 60s at 125°C	Measurement	IRSL 60s at 50°C
Test Dose	2 Gy $^{90}Sr/^{90}Y$	Measurement	OSL 30s at 125°C
Test Preheat	160°C for 30s	Measurement	TL 500°C @ 5°C/s
Test Measurement	OSL 60s at 125°C	Regenerative Dose	10 Gy $^{90}Sr/^{90}Y$
Regenerative Dose	10 Gy $^{90}Sr/^{90}Y$	Preheat	220°C for 30s
Preheat	220°C for 30s	Measurement	IRSL 60s at 50°C
Measurement	OSL 60s at 125°C	Measurement	OSL 30s at 125°C
Test Dose	2 Gy $^{90}Sr/^{90}Y$	Measurement	TL 500°C @ 5°C/s
Test Preheat	160°C for 30s		
Test Measurement	OSL 60s at 125°C		

5. Results

5.1. Field Profiling

Very high signals, indicative of geological residuals, were recorded from the samples from layer 5 and layer 9 in section 1, and layer 8 in section 2 (Figure 5.1). The remainder of the samples gave signals an order of magnitude lower, indicating that these samples contain potentially archaeologically relevant signals. Other features in the data are: 1/ the decrease in signal with depth through the disturbed uppermost archaeological layer (~20-~100 cm), which may indicate minor residual signals in the upper parts of this layer; 2/ the discontinuity at ~100 cm depth, at the boundary between the disturbed upper archaeological layer (lower signal) and the palaeosol below it (higher signal), and 3/ gradual increase in signal with depth below this.

Figure 5.1. Newry Ringfort field profiling results.



5.2. Laboratory Profiling

Laboratory luminescence profiling results are shown in,
Figure 5.2 and Figure 5.3.

1/ The luminescence sensitivity of the samples varies little through the archaeological stratigraphy or between the sections, indicating that all samples have similar mineralogy. However, the sensitivity of the lowermost samples was consistently lower than the others. These samples were taken directly from weathered bedrock.
2/ The values of equivalent dose estimated using OSL measurements are all less than 10 Gy, and tend to gradually increase with depth. Assuming a dose rate of ~2 mGy/a indicates that all these sediments contain signals that were reset in the second half of the Holocene and therefore have the potential to yield archaeologically relevant age estimates.
3/ The values of equivalent dose estimated using IRSL measurements are often higher and are more scattered, while those estimated using TL are much higher. Those estimated using IRSL and TL measurements tend to fluctuate more markedly up and

down the section: higher values are found in both sections between 20 and 60 cm, 100 and 120 cm, and 140 and 180 cm. These signals appear to have been less well reset during redeposition than the OSL signal, but they indicate that less severe residuals may be present in the OSL signal in these sediments.

4/ Patterns in the field profiling measurements are more similar to the IRSL and TL results from the PMC prepared fraction measured in the laboratory, than to OSL on the HFC fraction.

Figure 5.2. Newry Ringfort Section 1 laboratory profiling results.

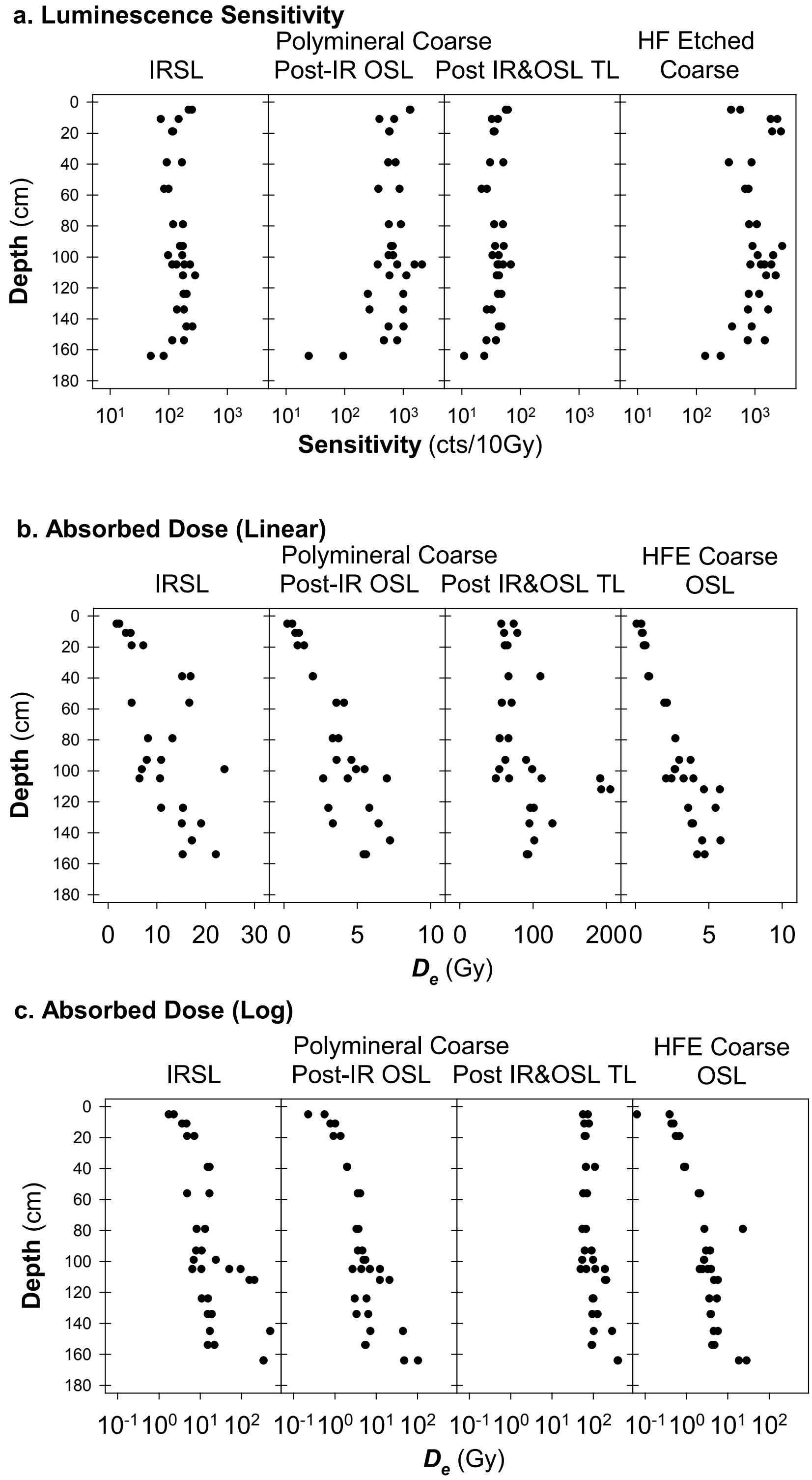
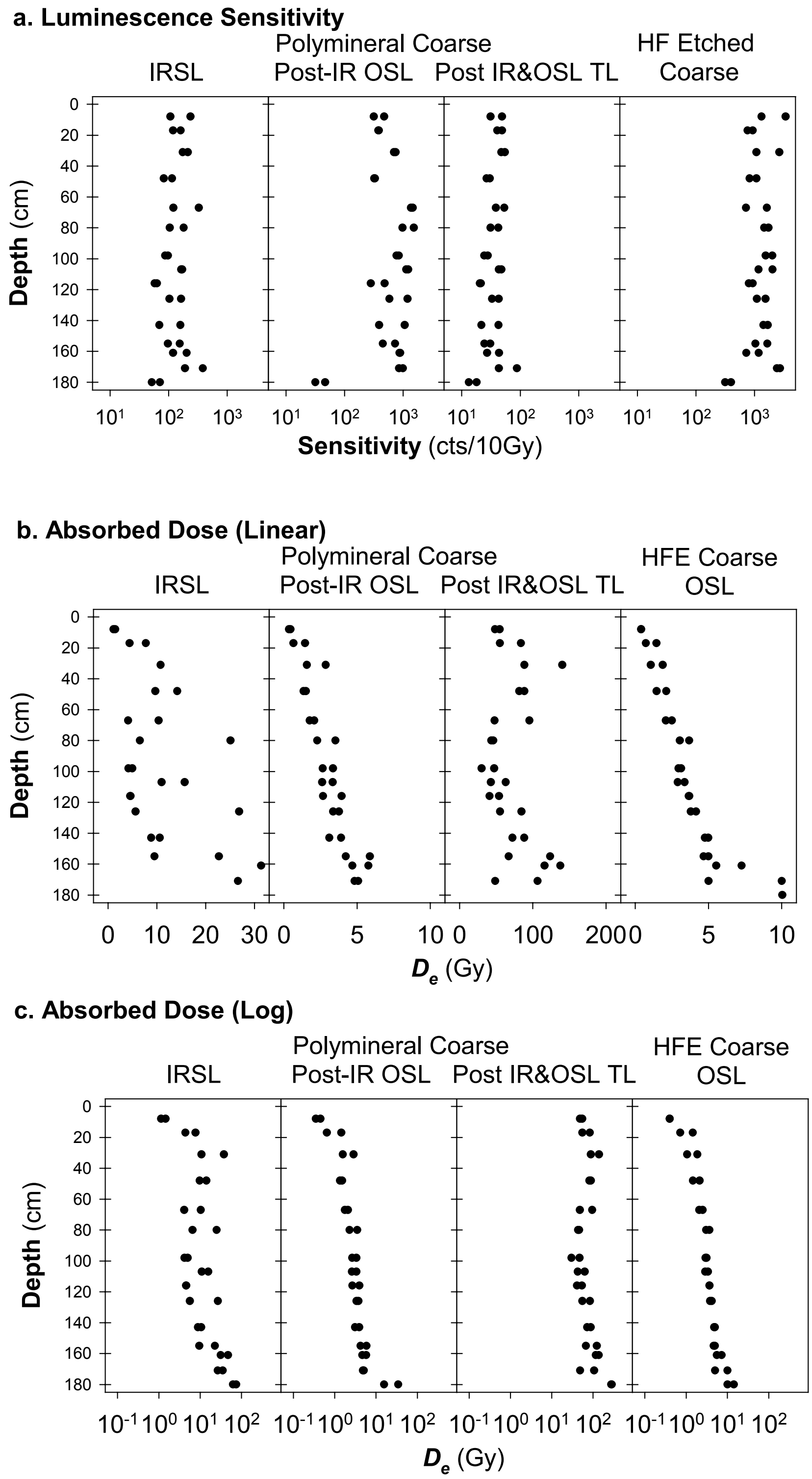


Figure 5.3. Newry Ringfort Section 2 laboratory profiling results.



5.3. Dose rates

HGRS results are shown in Table 5.1, both as activity concentrations (i.e. disintegrations per second per kilogram) and as equivalent parent element concentrations (in % and ppm), based in the case of U and Th on combining nuclide specific data assuming decay series equilibrium. K concentrations ranged from 2.3 to 3.9 %, the mean was 2.7 % ± 0.4. U concentrations ranged from 1.9 to 3.5 ppm, the mean was 2.3 ppm ± 0.5. Th concentrations ranged from 5.5 to 8.5 ppm, the mean was 6.6 ppm ± 0.8. For comparison, "typical" values are 1 % K, 1 ppm U, and 3 ppm Th (Adamiec and Aitken, 1998). The concentration ratio Th/U is also listed in Table 5.1, to indicate the relative contribution of Th and U to the samples' dose rates. The "typical" context noted above has a concentration ratio of 3/1 (equivalent to an activity ratio of 1/1). Th/U concentration ratios for the present samples ranged from 1.8 to 3.8, with a mean value of 3.0 ± 0.5.

Infinite matrix alpha, beta and gamma dose rates from HGRS are listed in Table 5.2, with in-situ gamma dose rates from FGS, infinite matrix beta dose rates from TSBC, and the ratio of beta dose rates from TSBC/HGRS. In-situ gamma dose rate (FGS) to the dated samples ranged from 0.8 to 1.1 mGy/a, with a mean of 0.95 mGy/a ± 0.1, but that in Pit 1 was 1.74 mGy/a. Gamma dose rate measured on a dry sample in the laboratory (HGRS) ranged from 1.1 to 1.7 mGy/a, the mean was 1.3 mGy/a ± 0.2. Beta dose rate from HGRS ranged from 2.4 to 3.9 mGy/a, the mean was 2.8 mGy/a ± 0.4. Beta dose rate from TSBC ranged from 2.7 to 3.5 mGy/a, the mean was 2.9 mGy/a ± 0.2. Alpha dose rate (HGRS) ranged from 9 to 14 mGy/a, the mean was 11 mGy/a ± 2. The ratio of beta dose rates from TSBC and HGRS ranged from 0.88 to 1.14, the mean was 1.04 mGy/a ± 0.07.

Effective dose rates to the HF etched 200 µm quartz grains used for equivalent dose determination in the present study are listed in Table 5.3, with water content measurements and the assumed values used for calculation of effective dose rate. Etching removes the external alpha contribution to the dose rate (so these are not tabluated), and 14 % of the beta dose rate. Cosmic dose rates are as calculated (section 4.2.1), gamma dose rates are corrected for water content, while beta dose rates are corrected for etching and water content.

Field water content, as a fraction of dry sediment mass, ranged from 0.12 to 0.29, the mean was 0.20 ± 0.05. Saturated water content ranged from 0.33 to 0.53, the mean was 0.45 ± 0.08. The drained upper limit (DUL) of water content ranged from 0.16 to 0.50, the mean was 0.39 ± 0.10. Given the freely draining nature of the sediments and the measured water contents, the average water content during burial was assumed to lie between the measured field and DUL values. Assumed values for average water content during burial were estimated accordingly, and used for age determinations. These ranged from 0.18 to 0.40, the mean was 0.28 ± 0.07.

The ratio of gamma dose rates from FGS and HGRS for the dated samples, after adjustment for assumed levels of water content, ranged from 0.82 to 1.02 with a mean of 0.94 ± 0.06. However, FGS results from Pit 1 were higher than the HGRS dose rates: the ratios were 1.75 for SUTL 2163a and 1.28 for SUTL 2163b, indicating that the base and/or walls of the pit were more radioactive than the fill and cover sediments.

Effective beta dose rate ranged from 1.55 to 2.55 mGy/a, the mean was 1.89 mGy/a ± 0.26. Effective gamma dose rate ranged from 0.74 to 1.31 mGy/a, the mean was 0.94 mGy/a ± 0.15. Effective cosmic dose rate ranged from 0.20 to 0.27 mGy/a, the mean was 0.22 mGy/a ± 0.02. On average, the beta contribution to overall dose rate was 62 %, the gamma contribution was 31 %, and the cosmic contribution was 7 %.

Table 5.1. Activity and equivalent concentrations of K, U and Th, determined by HRGS

SUTL	Activity Concentration			Equivalent Concentration[a,b]			
No.	K (Bq/kg)	U (Bq/kg)	Th (Bq/kg)	K (%)	U (ppm)	Th (ppm)	Th/U
2157	731 ± 25	23.6 ± 2.1	24.1 ± 1.7	2.36 ± 0.08	1.91 ± 0.17	5.94 ± 0.41	3.11 ± 0.35
2158	709 ± 18	28.0 ± 1.3	25.0 ± 0.9	2.29 ± 0.06	2.27 ± 0.11	6.16 ± 0.21	2.71 ± 0.16
2159	727 ± 25	24.6 ± 2.3	25.9 ± 1.8	2.35 ± 0.08	1.99 ± 0.19	6.39 ± 0.46	3.20 ± 0.38
2160	779 ± 18	29.5 ± 1.4	24.7 ± 0.8	2.52 ± 0.06	2.39 ± 0.11	6.10 ± 0.20	2.56 ± 0.14
2161	860 ± 26	22.9 ± 2.0	22.6 ± 1.6	2.78 ± 0.08	1.86 ± 0.16	5.57 ± 0.40	3.00 ± 0.34
2162	770 ± 18	23.1 ± 1.2	25.1 ± 0.8	2.49 ± 0.06	1.87 ± 0.10	6.19 ± 0.20	3.32 ± 0.20
2163a	896 ± 26	24.3 ± 2.1	22.3 ± 1.6	2.90 ± 0.08	1.97 ± 0.17	5.50 ± 0.40	2.80 ± 0.32
2163b	1200 ± 23	43.4 ± 2.1	26.0 ± 0.9	3.88 ± 0.07	3.51 ± 0.17	6.41 ± 0.23	1.82 ± 0.11
2165	888 ± 26	25.0 ± 2.1	30.2 ± 1.7	2.87 ± 0.08	2.03 ± 0.17	7.45 ± 0.43	3.68 ± 0.37
2166	816 ± 19	28.3 ± 1.4	27.6 ± 0.9	2.64 ± 0.06	2.29 ± 0.11	6.81 ± 0.22	2.97 ± 0.18
2167	819 ± 26	35.3 ± 3.0	27.2 ± 2.2	2.65 ± 0.08	2.86 ± 0.25	6.71 ± 0.54	2.35 ± 0.28
2168	909 ± 19	24.6 ± 1.3	30.4 ± 0.9	2.94 ± 0.06	1.99 ± 0.10	7.50 ± 0.22	3.76 ± 0.23
2169	807 ± 27	35.8 ± 3.0	34.6 ± 2.1	2.61 ± 0.09	2.90 ± 0.25	8.52 ± 0.52	2.94 ± 0.31
2170	893 ± 20	28.0 ± 1.4	29.7 ± 0.9	2.89 ± 0.06	2.27 ± 0.11	7.32 ± 0.22	3.22 ± 0.19
Shap	1370 ± 10	148.2 ± 7.4	115.6 ± 1.1	4.43 ± 0.03	12.00 ± 0.06	28.50 ± 0.26	2.38 ± 0.02

a. Conversion factors based on OECD (1994): 40K: 309.3 Bq/kg/%K, 238U: 12.35 Bq/kg/ppmU, 232Th: 4.057 Bq/kg/ppmTh.

b. Shap granite reference, working values based on HRGS relative to CANMET and NBL standards by Sanderson (1986).

Table 5.2. Insitu gamma dose rate measured using FGS, and infinite matrix dose rates determined by HRGS and TSBC in the laboratory.

SUTL	FGS, In-Situ[a]	HRGS, Dry [b]			TSBC, Dry [c]	TSBC/HRGS
No.	Gamma (mGy/a)	Alpha (mGy/a)	Beta (mGy/a)	Gamma (mGy/a)	Beta (mGy/a)	Beta Ratio
2157	0.79 ± 0.02	9.70 ± 0.56	2.41 ± 0.07	1.09 ± 0.03	2.76 ± 0.06	1.14 ± 0.04
2158	0.82 ± 0.02	10.86 ± 0.34	2.41 ± 0.05	1.13 ± 0.02	2.75 ± 0.06	1.14 ± 0.04
2159	0.89 ± 0.03	10.26 ± 0.62	2.42 ± 0.07	1.12 ± 0.04	2.68 ± 0.06	1.11 ± 0.04
2160	0.86 ± 0.02	11.14 ± 0.34	2.62 ± 0.05	1.20 ± 0.02	2.89 ± 0.06	1.11 ± 0.03
2161	0.96 ± 0.03	9.28 ± 0.54	2.74 ± 0.07	1.17 ± 0.03	2.89 ± 0.06	1.05 ± 0.04
2162	0.89 ± 0.03	9.77 ± 0.31	2.52 ± 0.05	1.13 ± 0.02	2.73 ± 0.06	1.08 ± 0.03
2163a	*1.74 ± 0.08*	9.54 ± 0.56	2.85 ± 0.07	1.21 ± 0.03	2.79 ± 0.06	0.98 ± 0.03
2163b	*1.74 ± 0.08*	14.49 ± 0.50	3.92 ± 0.07	1.67 ± 0.03	3.46 ± 0.07	0.88 ± 0.02
2165	1.02 ± 0.04	11.14 ± 0.56	2.89 ± 0.08	1.31 ± 0.04	3.11 ± 0.07	1.07 ± 0.04
2166	0.99 ± 0.03	11.41 ± 0.36	2.72 ± 0.05	1.25 ± 0.02	2.69 ± 0.07	0.99 ± 0.03
2167	1.00 ± 0.04	12.89 ± 0.79	2.81 ± 0.08	1.31 ± 0.04	2.81 ± 0.06	1.00 ± 0.04
2168	1.04 ± 0.04	11.08 ± 0.34	2.95 ± 0.05	1.32 ± 0.02	3.00 ± 0.07	1.02 ± 0.03
2169	1.07 ± 0.03	14.36 ± 0.78	2.83 ± 0.08	1.40 ± 0.04	2.98 ± 0.07	1.05 ± 0.04
2170	1.07 ± 0.03	11.72 ± 0.35	2.94 ± 0.06	1.33 ± 0.02	2.88 ± 0.06	0.98 ± 0.03

a. Values in italics measured in 3pi geometry: measured values multiplied by 4/3±0.1/3 to give 4pi dose rate

b. Based on Dose Rate conversion factors from Aitken (1983). c. Relative to Shap granite reference (Sanderson, 1986).

Table 5.3. Water contents and effective dose rates

SUTL	Water Content (frn. of dry mass)				Gamma, Assumed WC		Effective Dose Rate (mGy/a)		
No.	Field	Sat.	DUL	Assumed[a]	FGS (mGy/a)	HGRS (mGy/a)	Beta[b]	Gamma[c]	Cosmic[d]
2157	0.13	0.51	0.42	0.28 ± 0.10	0.68 ± 0.06	0.83 ± 0.09	1.72 ± 0.04	0.74 ± 0.06	0.27 ± 0.03
2158	0.21	0.48	0.44	0.32 ± 0.08	0.74 ± 0.09	0.83 ± 0.07	1.65 ± 0.03	0.79 ± 0.06	0.23 ± 0.04
2159	0.28	0.53	0.49	0.38 ± 0.08	0.79 ± 0.06	0.78 ± 0.07	1.55 ± 0.01	0.79 ± 0.04	0.22 ± 0.03
2160	0.21	0.48	0.44	0.33 ± 0.08	0.85 ± 0.08	0.87 ± 0.08	1.75 ± 0.01	0.86 ± 0.05	0.21 ± 0.03
2161	0.18	0.33	0.30	0.24 ± 0.04	0.90 ± 0.04	0.92 ± 0.05	1.95 ± 0.04	0.91 ± 0.03	0.20 ± 0.03
2162	0.12	0.36	0.32	0.22 ± 0.07	0.80 ± 0.05	0.90 ± 0.06	1.85 ± 0.01	0.84 ± 0.05	0.22 ± 0.03
2163a	0.21	-	-	*0.32 ± 0.10*	1.55 ± 0.15	0.89 ± 0.10	1.81 ± 0.11	1.08 ± 0.27	0.23 ± 0.01
2163b	0.23	-	-	*0.34 ± 0.10*	1.54 ± 0.15	1.20 ± 0.13	2.29 ± 0.25	1.35 ± 0.16	0.23 ± 0.01
2165	0.12	0.46	0.38	0.25 ± 0.09	0.89 ± 0.08	1.01 ± 0.10	2.05 ± 0.02	0.94 ± 0.06	0.26 ± 0.04
2166	0.21	0.50	0.43	0.32 ± 0.08	0.88 ± 0.07	0.91 ± 0.08	1.74 ± 0.09	0.89 ± 0.05	0.22 ± 0.04
2167	0.23	0.50	0.45	0.34 ± 0.08	0.89 ± 0.07	0.95 ± 0.08	1.77 ± 0.08	0.91 ± 0.05	0.22 ± 0.03
2168	0.17	0.35	0.39	0.28 ± 0.08	0.92 ± 0.07	1.00 ± 0.08	1.98 ± 0.08	0.96 ± 0.05	0.21 ± 0.03
2169	0.29	0.51	0.50	0.40 ± 0.07	0.96 ± 0.07	0.96 ± 0.08	1.74 ± 0.03	0.96 ± 0.05	0.20 ± 0.03
2170	0.20	0.33	0.16	0.18 ± 0.01	1.10 ± 0.04	1.11 ± 0.02	2.19 ± 0.11	1.11 ± 0.02	0.20 ± 0.03

a. Assumed water content = (Field + DUL)/2 ± |Assumed - Field|/2^0.5, values in italics predicted from other samples with similar field values

b. Calculated using the weighted mean of the effective beta dose rates measured using HRGS and TSBC: effective beta dose rate = 0.9*infinite beta dose rate/(1+1.25*water content). 0.9 is the average beta attenuation in a 200 micron silicate grain (Mejdahl, 1979).

c. Calculated using the weighted mean of the gamma dose rates corrected for assumed water content measured using HRGS and FGS: Effective gamma dose rate = gamma dose rate/(1+1.14*WCassumed-WCas-measured). WCas-measured = Field for FGS, = 0 for HGRS

For the energies found in a typical sedimentary matrix, water absorbs approximately 1.25 times more beta, and 1.14 times more gamma radiation per unit mass than do silicates (Aitken, 1985).

d. Calculated from latitude, altitude, and estimated average depth during burial, using the data of Prescott and Stephan (1982) and Prescott and Hutton (1988).

5.4. Single aliquot equivalent dose determinations

Sample averaged values relating to the aliquots and measurements used for equivalent dose determination are listed in Table 5.4: aliquot by aliquot breakdowns can be found in Appendix D.

The average mass of 150-250 µm grains on each disk was 4.5 mg, equivalent to c. 400 grains. The average sensitivity of the OSL signal from these samples to radiation ranged from 98 to 610 cps/mg/Gy, the mean was 420 cps/mg/Gy ± 146. With repeated SAR measurement cycles, this sensitivity changed to between 1.4 and 1.8 times the starting values, the mean being 1.6 ± 0.1 times. With respect to the internal checks on SAR performance: average recycling ratio for each sample ranged between 0.97 and 1.04, with a mean of 1.02 ± 0.02, and the effect of IRSL exposure on this ratio was to produce a range of 0.96 to 1.06, with a mean of 1.02 ± 0.03. Average zero dose response as a fraction of the recycling dose response ranged from –0.002 to 0.021, the mean was 0.011 ± 0.007. This indicates residual signals due to accumulated charge transfer during the SAR run equivalent to 0.04 ± 0.03 Gy. This is an insignificant fraction of the equivalent doses determined in the present study.

For equivalent dose determination, data from single aliquot regenerative dose measurements were analysed using the Risø Analyst programme, which fitted individual dose response curves and estimated equivalent dose values for each of the 16 disks per sample. A saturating exponential curve was fitted to all the measured points except the “IRRecycling” point (cycle 8, Table 4.1). No consistent patterns of variation in De with preheat were apparent (Appendix D). Results from all 16 disks were used in the estimation of central De values.

Arithmetic mean De values are listed for each sample in Table 5.4, with the “external” uncertainty on the mean value (standard deviation divided by the square root of the number of disks), the standard deviation of the dataset, and “internal uncertainty” on the mean value (errors propagated through the calculation of the mean). The mean De values range from 0.7 to 5.0 Gy, the average is 3.0 Gy ± 1.3.

However, examination of the distributions of results from individual aliquots (Appendix D) indicated that some of the mean values were affected by scatter in the data. The luminescence sensitivity of the Newry samples was relatively high, so uncertainties on De values for individual aliquots were relatively low: errors propagated from integral counts and interpolation were commonly less than 2% of the De values (Appendix D). Scatter in samples’ De distributions could not in general be explained by measured uncertainties (indicating that it was “genuine”), so the “H15 Robust Mean” (RSC, 2001) was used to estimate a central De value for each sample. The H15 Robust Mean estimate is calculated iteratively by down weighting data outwith 1.5 standard deviations, but weighting data equally within this range. This yields a central estimate that is less sensitive to outliers than the arithmetic mean, and is still associated with a standard error estimate (unlike e.g. the Median).

Table 5.4. Equivalent dose determination: samples and results

SUTL No.	Reader Risø	N	Ali. Mass (mg)[a]	Sensitivity (cps/mg/Gy)[a]	Sensitivity Change (frn.)[a]	Recycling Ratio[a]	Post IRSL Ratio[a]	Zero Dose Ratio[a]	Mean De[a,b,c] (Gy) σ/N$^{1/2}$	σ	pe	Robust Mean De[b,d] Type	N	(Gy) se	σ	se /σ	Notes[e]
2157	1	16	3.0 ± 0.8	98 ± 99	1.65 ± 0.11	1.04 ± 0.01	1.03 ± 0.01	0.007 ± 0.001	0.73 ± 0.04	0.14	0.00	H15 mean	16	0.71 ± 0.03	0.13	0.25	>
2158	1	16	4.5 ± 0.2	350 ± 30	1.65 ± 0.13	1.02 ± 0.01	1.01 ± 0.01	0.007 ± 0.001	2.21 ± 0.04	0.17	0.01	H15 mean	16	2.20 ± 0.04	0.17	0.25	=
2159	1	16	2.2 ± 0.1	331 ± 41	1.42 ± 0.08	1.02 ± 0.01	1.03 ± 0.01	0.003 ± 0.002	2.51 ± 0.06	0.22	0.02	H15 mean	16	2.51 ± 0.06	0.23	0.25	=
2160	2	16	5.8 ± 0.4	441 ± 30	1.80 ± 0.13	1.02 ± 0.01	0.99 ± 0.01	0.021 ± 0.002	3.09 ± 0.26	1.06	0.01	H15 mean	16	2.95 ± 0.19	0.75	0.25	=
2161	2	16	6.5 ± 0.2	610 ± 92	1.67 ± 0.07	1.03 ± 0.01	1.00 ± 0.01	0.014 ± 0.002	3.65 ± 0.07	0.28	0.01	H15 mean	16	3.68 ± 0.04	0.17	0.25	=
2162	2	16	3.7 ± 0.1	350 ± 44	1.61 ± 0.07	1.04 ± 0.01	1.02 ± 0.01	0.017 ± 0.003	3.34 ± 0.12	0.49	0.02	H15 mean	16	3.30 ± 0.12	0.46	0.25	>
2165	1	16	not measured		1.72 ± 0.13	0.97 ± 0.03	0.96 ± 0.05	-0.002 ± 0.018	1.04 ± 0.17	0.70	0.12	H15 mean	16	0.91 ± 0.10	0.39	0.25	>
2166	1	16	4.0 ± 0.2	399 ± 38	1.54 ± 0.09	1.03 ± 0.01	1.03 ± 0.01	0.005 ± 0.001	2.42 ± 0.03	0.14	0.01	H15 mean	16	2.44 ± 0.03	0.11	0.25	=
2167	1	16	5.1 ± 0.2	417 ± 34	1.46 ± 0.08	1.01 ± 0.00	1.01 ± 0.00	0.009 ± 0.001	3.28 ± 0.07	0.27	0.01	H15 mean	16	3.27 ± 0.07	0.26	0.25	=
2168	2	16	5.2 ± 0.2	466 ± 53	1.66 ± 0.07	1.02 ± 0.01	1.06 ± 0.01	0.019 ± 0.002	4.55 ± 0.10	0.39	0.02	H15 mean	16	4.54 ± 0.10	0.39	0.25	=
2169	2	16	4.0 ± 0.2	597 ± 42	1.55 ± 0.08	1.01 ± 0.01	1.04 ± 0.01	0.014 ± 0.001	4.75 ± 0.18	0.74	0.02	H15 mean	16	4.65 ± 0.13	0.51	0.25	>
2170	2	16	4.9 ± 0.3	561 ± 50	1.73 ± 0.12	1.02 ± 0.01	1.06 ± 0.01	0.015 ± 0.002	4.97 ± 0.09	0.34	0.02	H15 mean	16	4.96 ± 0.09	0.35	0.25	=

a. Values = arithmetic means. Errors = σ/N$^{1/2}$, σ = standard deviation, N = number of aliquots

b. Errors incorporate additional 2% source calibration uncertainty

c. pe = propagated error. Propagated through the calculation of the mean from measurement uncertainties for each aliquot

d. Robust Mean: H15 mean (and σ) calculated iteratively by reducing the weight of data outwith 1.5 σ (RSC, 2001)

e. =/</>: Weighted Central De appears to be representative/an underestimate/an overestimate

5.5. Age estimates

Listed in Table 5.5 are the sums of the effective beta, gamma and cosmic dose rates and the weighted central equivalent dose estimates. Age values were calculated as equivalent dose divided by dose rate, and converted to calendar dates. The precision to which all values are quoted is based on the rounding of associated uncertainties to 1 significant figure.

14 sets of dose rates, and 12 equivalent doses and hence 12 OSL ages were determined. Dose rate ranges from 2.6 to 3.9 mGy/a, the average is 3.0 mGy/a ± 0.4. De values range from 0.7 to 5.0 Gy, the average is 3.0 Gy ± 1.3. Age estimates for these samples range from 0.26 to 1.6 ka, with an average of 1.0 ka ± 0.4. Uncertainties on the age estimates are quoted at 1se. The age uncertainties range from 0.01 to 0.07 ka, the average is 0.04 ka ± 0.02. These values equate to 2 to 11 % uncertainty.

Table 5.5. Dose rates, equivalent doses, ages and calendar dates

Sample Number SUERC	Field	Total Dose Rate (mGy/a)	Equivalent Dose (Gy)	Age (ka)[a]	% error	Calendar Date[b] AD/BC	Notes[c] De	DR
SUTL 2157	NEW S1#1	2.73 ± 0.08	0.71 ± 0.03	0.26 ± 0.01	5	1750 AD ± 10	>	
SUTL 2158	NEW S1#2	2.67 ± 0.08	2.20 ± 0.04	0.83 ± 0.03	3	1180 AD ± 30	=	
SUTL 2159	NEW S1#3	2.56 ± 0.06	2.51 ± 0.06	0.98 ± 0.03	3	1030 AD ± 30	=	=
SUTL 2160	NEW S1#4	2.82 ± 0.06	2.95 ± 0.19	1.04 ± 0.07	7	960 AD ± 70	=	=
SUTL 2161	NEW S1#5	3.06 ± 0.06	3.68 ± 0.04	1.20 ± 0.03	2	800 AD ± 30	=	=
SUTL 2162	NEW S1#6	2.91 ± 0.06	3.30 ± 0.12	1.13 ± 0.05	4	870 AD ± 50	>	
SUTL 2163a	NEW Pit1#1a	3.12 ± 0.29	not measured					
SUTL 2163b	NEW Pit1#1b	3.87 ± 0.30	not measured					=
SUTL 2165	NEW S2#1	3.24 ± 0.08	0.91 ± 0.10	0.28 ± 0.03	11	1730 AD ± 30	>	
SUTL 2166	NEW S2#2	2.85 ± 0.11	2.44 ± 0.03	0.85 ± 0.03	4	1150 AD ± 30	=	=
SUTL 2167	NEW S2#3	2.90 ± 0.10	3.27 ± 0.07	1.13 ± 0.04	4	880 AD ± 40	=	=
SUTL 2168	NEW S2#4	3.15 ± 0.10	4.54 ± 0.10	1.44 ± 0.05	4	570 AD ± 50	=	
SUTL 2169	NEW S2#5	2.91 ± 0.07	4.65 ± 0.13	1.60 ± 0.06	4	410 AD ± 60	>	=
SUTL 2170	NEW S2#6	3.50 ± 0.12	4.96 ± 0.09	1.42 ± 0.05	4	590 AD ± 50	=	

a. Ages in ka before 2007 AD b. Errors rounded to 1 significant figure, values rounded accordingly
c. =/</>: equivalent dose / dose rate appears to be representative/an underestimate/an overestimate

6. Discussion

6.1. Profiling

Profiling measurements are basic assessments of sensitivity and absorbed dose (De), with greater spatial resolution than practical or necessary for full dating measurements (Burbidge *et al.*, 2007).

Lack of variation in luminescence sensitivity between the sections or through the stratigraphy at Newry Ringfort, except for the lowermost samples from weathered bedrock, indicates that all archaeological samples have similar hard mineralogy. However, since the archaeological sediments are expected to have been derived from the local bedrock, lower sensitivity in the samples from the bases of the sections indicates that reworking has enhanced luminescence sensitivity.

Field profiling (OSL signal intensity from raw sediment) indicated three main phases in the accumulation of the Newry Ringfort sequences: geological age material at the base, older archaeological material below 100 cm in each section, followed by a discontinuity and younger material above.

Laboratory profiling (approximate equivalent dose determination using OSL, IRSL and TL on prepared fractions) indicated gradual accumulation through the sequences rather than distinct phases, but with scatter to high values of equivalent dose in the lower and mid sections, and a pulse of older sediment in the colluvial accumulation of the upper sections. However, this variability was most evident in IRSL and TL on the polymineral fraction, and less evident in OSL measurements both on polyminerals and etched (quartz enhanced) material. TL signals are much less sensitive to resetting through daylight exposure than the optical signals, and IRSL signals can require prolonged exposure to reset them, whereas OSL signals are particularly sensitive to the UV component of daylight. OSL equivalent dose estimates in the samples from the modern turf line ranged from 0.06 to 0.56 Gy. For IRSL this was 1.1 to 2.3 Gy and for TL it was 49 to 73 Gy. The progressively higher residual signals in IRSL and TL compared to OSL in the Newry Ringfort samples indicates that in many parts of the sequence the mineral grains were only exposed to light relatively briefly during colluvial transport and redeposition. Further, although the OSL signals appear to have been largely reset prior to redeposition, the IRSL and TL results indicate greater potential for residual signals in layers 2 (upper), 4, 5, 7 and 9 of section 1, and layers 2, 3 (upper), 4 (upper), 5, 7, 8 and 9 of section 2.

6.2. Equivalent dose

The sand sized grains of quartz extracted from the Newry Ringfort samples generally performed well in terms of equivalent dose determination. Internal checks on the performance of the SAR protocol indicated reproducible behaviour through the sequences of laboratory measurements, no significant infrared stimulable signal components, and no significant signal recuperation effects. Scatter in the equivalent doses determined from each set of 16 aliquots was commonly symmetrical and less than 3%, indicating that the OSL signals in the grains from these samples is likely to have been reset around the same time. Some scatter to high values was identified in the distributions from four samples (SUTL 2157, 2162, 2165, 2169), indicating that not all the quartz grains in these samples had their OSL signals reset at the same time. These samples were from the top and bottom of the sections – sediments for which profiling had indicated the presence of residual luminescence signals. In these cases the equivalent dose relating to the event of interest (redeposition in the ditch) may have been overestimated: the magnitude of any effect on the age estimates is discussed in section 6.4. Higher than average scatter, albeit symmetrical, was also observed from sample SUTL 2160.

6.3. Dose rate

Three methods were used for dose rate determination in the present study: field gamma spectrometry, high resolution gamma spectrometry, and thick source beta counting. These measure dose rate from different sizes/geometries of sample in different conditions. Comparison between the results therefore provides indications of any effects on dose rate arising from sediment inhomogeneity and/or disequilibrium in the U and Th series. HRGS also facilitates limited examination of radioactive equilibrium within each measurement.

The ratio of thorium to uranium in the Newry Ringfort samples was similar to that expected (i.e. around 3), indicating that very severe movement of radionuclides during the burial period of the samples was unlikely. Examination of HGRS results from individual radioisotopes in the ^{238}U series indicates that while ^{226}Ra is generally close to equilibrium with the post ^{222}Rn isotopes, ^{210}Pb and ^{234}Th are sometimes significantly different from the remainder of the series (Table 6.1). Variation in ^{234}Th activity concentrations relative to the rest of the decay series is considered indicative of past Uranium movement, in which case Radium is also likely to have been mobile. Variation in ^{210}Pb activity concentrations relative to the rest of the decay series are likely to indicate ^{222}Rn movement in the last few decades. However, no consistent pattern was evident in this set of samples, and ^{210}Pb and ^{234}Th are the least securely determined isotopes in the U series (low energy, low intensity gamma emissions). Therefore, no modelling of the effects of this variability on dose rates was conducted, but the "=" signs in the notes on dosimetry in Table 5.5 were omitted for these samples to indicate that the dose rate determinations are less secure in terms of disequilibrium than for the others.

With respect to the effects of sediment inhomogeneity, the sediments associated with the dating samples from Newry Ringfort yielded consistent dose rate estimates from the three types of measurement made in different geometries: gamma dose rates from FGS (in situ, ~ 200 kg field of view) and HRGS (sealed subsample from tube, unsieved, ~ 100 g), and beta dose rates from HRGS and TSBC (unsealed subsample from tube, <1 mm, 20 g). One may therefore be confident that the overall dose rate estimates for the dated samples are spatially representative.

The situation is more complex for the location of the potsherd recovered from Pit 1 however. FGS in the base of the pit yielded a gamma dose rate of 1.55 mGy/a, while HGRS yielded 0.89 mGy/a for the pit fill (SUTL 2163a) and 1.20 mGy/a for the pit cover sediment (Table 5.3). The high value from FGS is thought to reflect greater radioactivity in the (granite) base of the pit, or its walls, than in the fill or cover sediments. The sherd was recovered from within the pit fill sediment, but close to the boundary between pit fill and pit cover, around 20 cm from the pit's walls and base (see sampling form in Appendix A). The gamma dose rate at the boundary between two sedimentary layers of different radioactivity is the average of the two activities, while 5 cm into one of the layers the split is approximately 60:40 in favour of that layer, and only around 5 % of the gamma dose rate from radionuclides in natural sediments will be deposited beyond 20 cm from the source (Aitken, 1985, Appendix H). The gamma dose rate to the potsherd is therefore likely to be 1.10 mGy/a ± 0.12. If the sherd were in fact 5 cm into the cover sediment instead of the pit fill, the dose rate calculated in this way would be 1.04 mGy/a, so in this case geometric uncertainties are less than those propagated from the measured values (Table 5.3). Uncertainties in the measured values are largely a function of the uncertainty in water content for these samples. This analysis indicates that provided the beta dose rate from the sherd itself can be accurately determined (by e.g. TSBC), then the external dose rate including cosmic radiation will be 1.33 mGy/a ± 0.12, and that measured gamma inhomogeneity in its surroundings is unlikely to limit the precision of a luminescence age determination. However, uncertainty in estimating the average burial water content has limited the precision of this estimate to ±10%, and unless the average burial water content of the potsherd itself can be better constrained (for internal dose rate estimation), the uncertainty on any luminescence age estimate for the sherd is also likely to be around ±10%.

Table 6.1. Activity concentrations for the isotopes in the ^{238}U series measured using HRGS

SUTL No.	Activity Concentration (Bq/kg) ^{234}Th	^{226}Ra	^{214}Pb	^{214}Bi	^{210}Pb	Notes[a]
2157	51.2 ± 4.2	34.8 ± 7.7	22.2 ± 2.1	23.4 ± 2.0	5.7 ± 12.0	^{234}Th
2158	58.4 ± 6.3	45.0 ± 5.9	25.3 ± 1.6	28.5 ± 2.0	18.7 ± 8.4	^{234}Th^{226}Ra
2159	22.3 ± 0.4	33.3 ± 8.0	24.0 ± 2.3	24.4 ± 3.0	40.7 ± 13.6	
2160	31.8 ± 8.0	27.1 ± 5.2	29.1 ± 0.2	30.0 ± 1.2	31.9 ± 8.8	
2161	39.5 ± 6.9	13.8 ± 7.3	22.1 ± 4.1	23.6 ± 1.9	33.9 ± 12.5	
2162	16.7 ± 6.0	26.5 ± 5.3	25.1 ± 0.2	21.0 ± 2.6	5.0 ± 8.2	^{210}Pb
2163a	17.3 ± 4.9	20.3 ± 7.3	23.7 ± 1.1	25.3 ± 2.9	57.9 ± 13.3	^{210}Pb
2163b	49.5 ± 3.5	43.9 ± 6.0	42.0 ± 0.2	44.1 ± 2.0	47.5 ± 9.8	
2165	35.2 ± 4.0	28.4 ± 7.4	25.5 ± 0.2	22.6 ± 1.8	34.1 ± 12.2	^{234}Th
2166	34.7 ± 7.2	30.1 ± 5.5	28.0 ± 0.3	28.3 ± 1.7	19.8 ± 8.7	
2167	41.3 ± 4.5	40.7 ± 8.6	35.9 ± 0.1	33.0 ± 2.4	38.3 ± 14.1	
2168	18.7 ± 1.6	28.9 ± 5.5	25.1 ± 0.7	24.0 ± 1.1	23.8 ± 8.7	^{234}Th
2169	35.9 ± 7.1	46.3 ± 8.6	35.2 ± 0.6	36.4 ± 3.9	22.4 ± 13.0	
2170	43.3 ± 4.0	27.8 ± 5.4	27.6 ± 0.2	26.5 ± 0.7	45.6 ± 9.5	^{234}Th
Mean	35.4 ± 5.9	31.9 ± 4.2	27.9 ± 2.6	27.9 ± 2.8	30 ± 6.9	

a. Note of values outwith 2 se of the weighted mean across the full series (table 5.1)

6.4. Ages

OSL age estimates from the tube samples (Table 5.5) are plotted vs. depth from the surface of each section in Figure 6.1. Also plotted are "apparent age" estimates calculated from the HFC profiling data and dose rate values interpolated from those determined for the tube samples. The "apparent age" estimates from profiling agree well with the results from the tube samples and add to the interpretation of the deposits' accumulation:

1/ The full dating results appear rather less affected by scatter (to high values) than the profiling results, but elevated scatter in the profiling tends to correspond with slightly higher or more variable results from the dating samples. Note that the IRSL and TL profiling results indicate more strongly the layers that were exposed to less daylight prior to redeposition (section 6.1): OSL measurements on the quartz fraction appear to approximate the date of redeposition most closely at this site.

2/ When viewed on a millennial scale accumulation of the sequences was gradual (c. 1.25 mm/a in Section 1; c. 1.0 mm/a in Section 2), but there is some evidence for pulses or phases of rapid accumulation on a centennial scale: of the initial fill in Section 2 (layers 8 to 5), and of the lower part of the thick colluvial plough soil in both sections (Section 1 Layer 3, Section 2, Layer 2).

3/ The ditch fills at the base of Section 2, layers 5 to 8, accumulated around 580AD±50. The sample from layer 7 yielded an older result than this but this is thought to represent the redeposition of material with residual luminescence signal. Construction of the ditch is therefore likely to predate the end of the 6th Century AD, placing establishment of the site in the rising limb of the wave of ringfort construction (Figure 2.1).

4/ The palaeosol sealing the initial fills in Section 2 dated to 880AD ± 40.

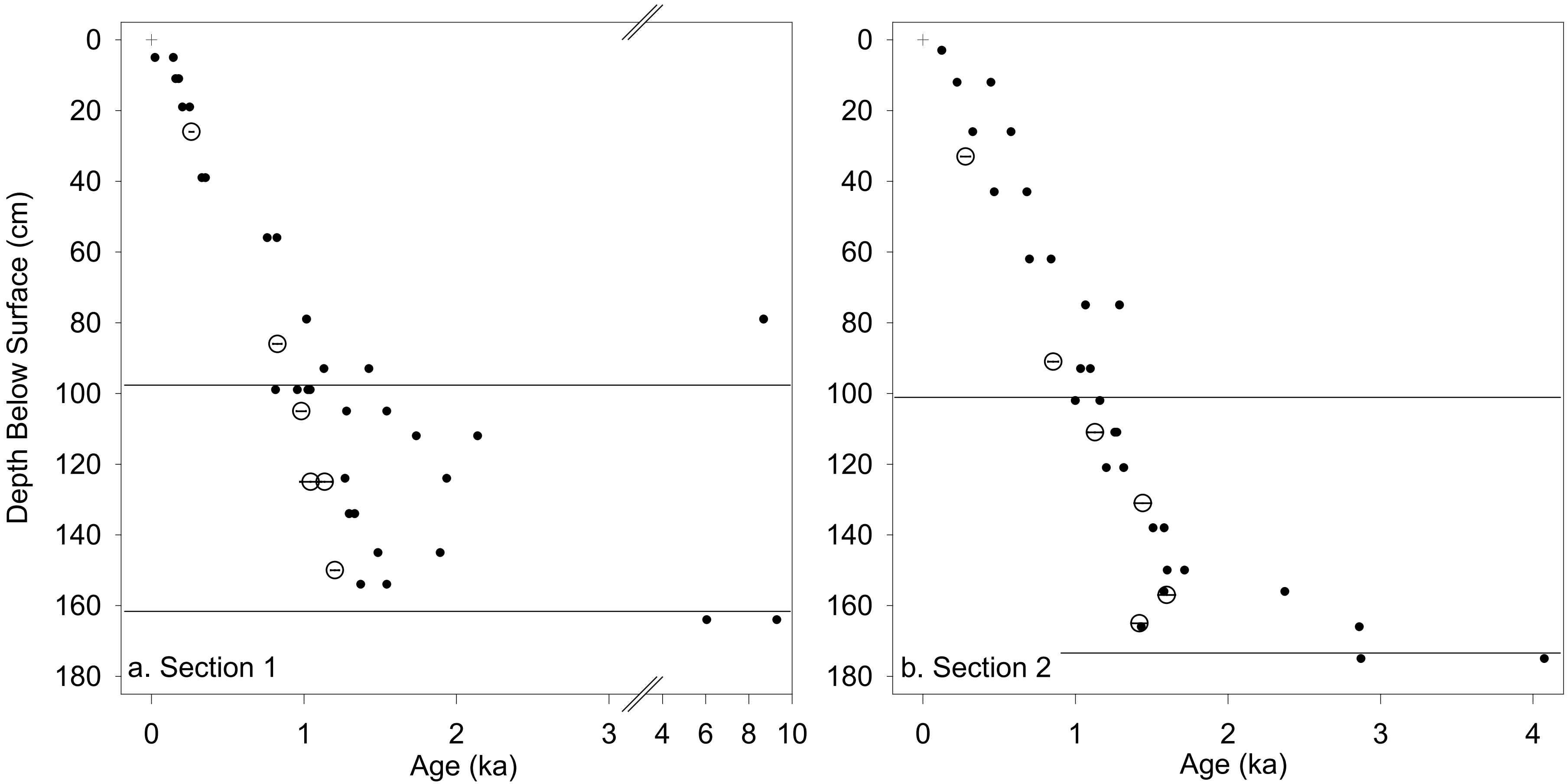
5/ The ditch fills at the base of Section 1 post-date those of Section 2 but appear to have accumulated around the time the upper palaeosol in that section formed. They indicate accumulation from the early 9th Century to the mid 10th Century (800AD±30 – 960AD±70). The second sample from layer 6 yielded a late 9th Century date, but this is thought to represent the redeposition of material with residual luminescence signal.

6/ The upper palaeosol in Section 1 yielded a date of 1030AD±30, constraining the upper phase of accumulation related to site occupation in this section to the mid 10th to mid 11th Centuries AD.

7/ OSL determinations from the colluvial plough soil in the upper part of both sections indicate its accumulation between the second half of the 12th Century and the mid 18th Century. Although profiling indicates a phase of rapid accumulation at the base of this layer (through the redeposition of older material), the dating results from the two sections are identical within errors, are younger than those from the layers below them, and follow the same trend in age vs. depth as those below them. Combined with the profiling results, and assuming that the colluvial accumulate is the result of tillage, they indicate that the Newry Ringfort site was set to arable cultivation by 1165AD±22. The Norman invasion of Ireland occurred in 1169, so if the site changed usage as a consequence of the imposition of Norman rule it is likely to have happened within a couple of decades. However, the OSL age estimates for this horizon do not preclude transition of the site to agricultural usage shortly before the invasion.

8/ The profiling results and the full dating results from the upper part of the colluvial plough soil indicate that accumulation continued through the following centuries. This indicates that the site remained under cultivation, at least sporadically. Scatter in the equivalent dose distributions from both of the younger samples from the colluvium indicated that these results may overestimate the time since the upper part of the layer accumulated or was last reworked by ploughing. It is considered likely that the scatter in these results has been produced by continued mixing of the soil by ploughing, bioturbation, or simply colluvial heave, into the 20th Century: the profiling samples from the modern turf line yielded apparent ages between 30 and 280 years, but trends in the full dating results from this layer are consistent with zero age at zero depth. As such the modern topsoil may simply represent the most recent component of this colluvial accumulate.

Figure 6.1. Age vs depth for the tube samples from Sections 1 (a) and 2 (b), shown as empty circles with error bars. Also shown as smaller solid circles are "apparent ages" calculated from HFC profiling data by interpolating the dose rates estimated for the tube samples. Depth coordinates have been adjusted slightly from those recorded in order to match the sequences of dating and profiling samples, and those for samples across the section face from the main line of sampling have been adjusted to their stratigraphic level (see Figure 3.2 and Figure 3.3). Horizontal lines indicate the boundaries between substrate/layered ditch fill and layered ditch fill/unstructured colluvium.



7. Conclusions

The present study supports a new investigation into the construction, occupation and utilisation history of a Mediaeval ring fort in southwest Northern Ireland. The results describe the history of sedimentary accumulation in the ditch encircling the fort, they provide a terminus ante quem for the establishment of the ringfort, date its early Mediaeval occupation, constrain its abandonment, and indicate the nature of site usage afterwards. This information has been integrated with relevant external evidence to aid the interpretation of the sediment luminescence chronostratigraphy.

Dosimetric constraints on the potential for luminescence dating of a Souterrain-Ware sherd recovered from a pit within the site complex have also been assessed, and the external dose rate to the sherd has been estimated. The external dose rate to the sherd was estimated to be 1.33 mGy/a ± 0.12. Inhomogeneity of the gamma radiation field around this sherd was found to be less important for luminescence age determination than constraining the average water content of the sediments and/or the sherd during its burial. Depending on the range of water contents supported by the sherd, this would limit the precision of an age estimate to around ±10%. This would be sufficient to broadly assess the place of the present sherd in the site chronology. These results imply that providing the *range* of sediment radioactivity at a site can be assessed, and the average burial water contents of sherds excavated from it can be well constrained, then it is likely that sherds from around a site could be dated with sufficient precision to establish a broad chronology for Souterrain-Ware. However, for high precision determinations, intact, sealed samples of sediment and sherd combined with in situ dosimetry would be required.

The earliest sediments in the ditch of the ringfort date to 580AD±50. Construction of the ditch is therefore likely to predate the end of the 6th Century AD. These and other OSL age estimates from series of ditch fill layers indicate continued occupation until the mid 11th Century, but might be interpreted as phases of occupation in the 7th, 9th and 11th Centuries. These occupation related deposits were sealed by a colluvial soil, thought to have been produced by ploughing of the site from the early 19th century. The OSL results from the base of this soil (average = 1165AD±22) indicate that the initiation of ploughing actually occurred at or around the time of the Norman invasion of Ireland (1169AD), i.e. around a century after the last occupation related deposits accumulated (1030AD±30), rather than in the post Mediaeval period. The ringfort itself must therefore have been abandoned at the time of the invasion or in the century before it. Samples from throughout the colluvial soil also indicated that it continued to accumulate until at least the 18th Century, and probably into the 20th Century. This implies cultivation, at least sporadically, through the last 800 years.

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Appendix A: Sample Forms

Site Code: NEW **Site Name:** **Newry Ring Fort**	**Date** **260607**	**Context No** **Section 1** **Profiling**	**Sample No** **Field: S1 P1-16** **Lab: SUTL2156**
Description of sampling location :		**Sketch of surrounding area**	

Profile down section through ring ditch

No.	DfS	LfP	Layer	Description	Site Context
1	5	4	1	Modern topsoil. Reddish grey-brown, sandy, few stones	20001
2	11	4	1		20001
3	19	4	2	Light Red-Brown, many stones/clasts of all sizes to 20cm. Unclear colluvial stone lines coming from top of up-slope bank (bedrock). Colluvial soil, early C19?	20629
4	39	5	2		20629
5	56	4	2		20629
6	79	5	2		20629
7	93	10	2		20629
8	99	5	3	Red-brown soil lens, conforms to slope. V. silty fines, clasts < 5 cm. Palaeosol - associated with Late Mediaeval phase of site reuse?	20628
9	105	4	4	Red brown soil similar to layer 3 but more loamy, less silty (cohesive). Conforms to slope. Colluvial accumulate associated with Late Mediaerval phase of site reuse?	20628+27
10	112	-2	5	Rubble layer with lt red-brown soil. Similar to layer 2	20626
11	124	0	6	Dark red-brown soil in lee (downslope) of large stone. Silty, some clay but still plenty of small clasts and crystals from granite. Stabilisation following early occupation?	20626
12	134	-2	7	Red-brown soil, texture as layer 2, but partially conforms to slope. Fill associated with 1st phase of Mediaeval occupation?	20625
13	145	-1	7		20625
14	154	0	8	Red-brown soil, fewer clasts than layer 7. Initial fill following construction?	20625
15	164	6	9	Weathered Bed Rock – Granite	N/A
16	105	37	3	Ash/Org Lens. Dark grey-brown, silty	20629

7.1.1.1 (DfS = depth from surface, LfP = left from plumb line)

		Photo No:	
Gamma Dosimetry	**Reading**	**Assoc. Sample**	**Ref No**
Details:			
N/A			
Description of Sample:			
Zip lock bag ~ 10g + Petri dish for portable OSL ~10g. Sediment excavated from behind exposed face of section using a stainless steel tube, and deposited in a pre-labelled zip lock bag while protected from light inside a larger black bag.			
Nature of Dating Problem:			
Identify patterns in luminescence behaviour through the stratigraphy: discontinuities, boundaries, presence of geological-age material etc. Aid selection of luminescence sampling locations.			

Completed By	**Checked By**	**Date**
CIB & RF	M. Black	270607

Site Code: NEW Site Name: Newry Ring Fort	Date 270607	Context: Section 1, layer 2 Site No. 20629	Sample No Field: S1#1 Lab: SUTL2157

Description of sampling location :	Sketch of surrounding area
Top of colluvial/mixed layer. Top of archaeological stratigraphy Light Red-Brown, many stones/clasts of all sizes to 20cm. Unclear colluvial stone lines coming from top of up-slope bank (bedrock). Sealed by layer 1 (20001): modern topsoil (turf line & rootzone) . Reddish grey-brown, sandy, few stones Seals layer 3 (20628): Red-brown soil lens, conforms to slope. V. silty fines, clasts < 5 cm. Palaeosol - associated with Late Mediaerval phase of site reuse? Depth from surface (cm): 24 Left of plumb line (cm): 12 Top of layer (cm): 10 Bottom of layer (cm): 70 Clasts: 11 cm from nearest, 10 cm diameter	See fig.1
	Photo No:

Gamma Dosimetry	Reading	Assoc. Sample	Ref No
	Spec1		

Details:

Hole depth 29 cm into 60 cm thick baulk, top of hole 20 cm from ground surface.
4pi.
>450keV: 22374cts/600s

Description of Sample:

Stainless Steel Tube (~200g sediment) + Lab' Gamma Pot (~200g sediment)

Nature of Dating Problem:

Constrain end of C19? colluvial phase, associated with intensive agricultural activity
Should post-date S1#2 and equal S1#1

Completed By	Checked By	Date
CIB & RF	M Black (Headland)	270607

<table>
<tr><td>Site Code: NEW
Site Name:
Newry Ring Fort</td><td colspan="2">Date
270607</td><td colspan="2">Context:
Section 1, layer 2
Site No. 20629</td><td>Sample No
Field: S1#2
Lab: SUTL2158</td></tr>
<tr><td colspan="3">Description of sampling location :</td><td colspan="3">Sketch of surrounding area</td></tr>
<tr><td colspan="3" rowspan="2">Base of colluvial/mixed layer.
Light Red-Brown, many stones/clasts of all sizes to 20cm. Unclear colluvial stone lines coming from top of up-slope bank (bedrock).
Sealed by layer 1 (20001): modern topsoil (turf line & rootzone) . Reddish grey-brown, sandy, few stones
Seals layer 3 (20628): Red-brown soil lens, conforms to slope. V. silty fines, clasts < 5 cm. Palaeosol - associated with Late Mediaerval phase of site reuse?

Depth from surface (cm): 84
Left of plumb line (cm): ?
Top of layer (cm): 73
Bottom of layer (cm): 12
Clasts: 12 cm from nearest, 7 cm diameter</td><td colspan="3">See fig.1</td></tr>
<tr><td colspan="3">Photo No:</td></tr>
<tr><td rowspan="2">Gamma Dosimetry</td><td colspan="2">Reading</td><td colspan="2">Assoc. Sample</td><td>Ref No</td></tr>
<tr><td colspan="2">Spec2</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="6">Details:</td></tr>
<tr><td colspan="6">Hole depth 30 cm into 60 cm thick baulk.
4pi. Granite rock close to side of hole
>450keV: 23645cts/600s</td></tr>
<tr><td colspan="6">Description of Sample:</td></tr>
<tr><td colspan="6">Stainless Steel Tube (~200g sediment) + Lab’ Gamma Pot (~200g sediment)</td></tr>
<tr><td colspan="6">Nature of Dating Problem:</td></tr>
<tr><td colspan="6">Constrain beginning of C19? colluvial phase, associated with intensive agricultural activity
Should pre-date S1#1, post-date S1#3 and equal S2#2</td></tr>
<tr><td>Completed By</td><td colspan="3">Checked By</td><td colspan="2">Date</td></tr>
<tr><td>CIB & RF</td><td colspan="3">M Black (Headland)</td><td colspan="2">270607</td></tr>
</table>

Site Code: NEW Site Name: Newry Ring Fort	Date 270607	Context: Section 1, layer 4 Site No. 20628+7	Sample No Field: S1#3 Lab: SUTL2159

Description of sampling location :	**Sketch of surrounding area**
Red brown soil similar to layer 3 but more loamy, less silty (cohesive). Conforms to slope. Colluvial accumulate underlying palaeolandsurface? Sealed by layer 3 (20628): Red-brown soil lens, conforms to slope. V. silty fines, clasts < 5 cm. Palaeosol - associated with Late Mediaerval phase of site reuse? Seals layer 5 (20626): Rubble layer with lt red-brown soil. Similar to layer 2 Depth from surface (cm): 103 Left of plumb line (cm): 11 Top of layer (cm): 8 Bottom of layer (cm): 20 Clasts: 12 cm from nearest, 20 cm diameter	See fig.1 **Photo No:**

Gamma Dosimetry	**Reading**	**Assoc. Sample**	**Ref No**
	Spec3		

Details:

Hole depth 28 cm into 60 cm thick baulk.
4pi. Granite rock in side of hole.
>450keV: 25307cts/600s

Description of Sample:

Stainless Steel Tube (~200g sediment) + Lab' Gamma Pot (~200g sediment)

Nature of Dating Problem:

Colluvial accumulate associated with Late Mediaeval phase of site reuse: revetment used to widen natural causeway across ditch was built on top of this layer (c. 10 m away): Constrain Late Mediaeval phase of site reuse
Should pre-date S1#2, post-date S1#4 and S1#6, and equal S2#4

Completed By	**Checked By**	**Date**
CIB & RF	M Black (Headland)	270607

Site Code: NEW Site Name: Newry Ring Fort	Date 270607	Context: Section 1, layer 6 Site No. 20626	Sample No Field: S1#4 Lab: SUTL2160

Description of sampling location :	**Sketch of surrounding area**
Dark red-brown soil in lee (downslope) of large stone. Silty, some clay but still plenty of small clasts and crystals from granite. Sealed by layer 5 (20626): Rubble layer with lt red-brown soil. Similar to layer 2 Seals layer 7 (20625): Red-brown soil, texture as layer 2, but partially conforms to slope. Fill associated with 1st phase of Mediaeval occupation? Depth from surface (cm): 123 Left of plumb line (cm): 5 Top of layer (cm): 3 Bottom of layer (cm): 5 Clasts: 6 cm from nearest, 23 cm diameter	See fig.1 **Photo No:**

Gamma Dosimetry	**Reading**	**Assoc. Sample**	**Ref No**
	Spec4		

Details:

Hole depth 20 cm into 60 cm thick baulk.
3.9pi. Granite rock in all sides of hole & limited depth of hole.
\>450keV: 21575cts/600s: 4pi = 22128cts/600s

Description of Sample:

Stainless Steel Tube (~200g sediment) + Lab' Gamma Pot (~200g sediment) + Clast (~200g granite)

Nature of Dating Problem:

Palaeosol representing ground stabilisation following early Mediaeval occupation phase: i.e. following excavation of ditch and initial colluvial infill phase.
Constrain initial period of Mediaval site occupation.
Should pre-date S1#3, post-date S1#5, and equal S1#6 and S2#5

Completed By	**Checked By**	**Date**
CIB & RF	M Black (Headland)	270607

Site Code: NEW Site Name: Newry Ring Fort	Date 270607	Context: Section 1, layer 8 Site No. 20625	Sample No Field: S1#5 Lab: SUTL2161

Description of sampling location :	**Sketch of surrounding area**
Red-brown soil, fewer clasts than layer 7. Sealed by layer 7 (20625): Red-brown soil, texture as layer2, but partially conforms to slope. Fill associated with 1st phase of Mediaeval occupation? Seals layer 9: Weathered bedrock (granite) Depth from surface (cm): 148 Left of plumb line (cm): 4 Top of layer (cm): 9 Bottom of layer (cm): 8 Clasts: 11 cm from nearest, 15 cm diameter Bedrock 10 cm Granite.	See fig.1
	Photo No:

Gamma Dosimetry	**Reading**	**Assoc. Sample**	**Ref No**
	Spec5		

Details:

Hole depth 30 cm into 60 cm thick baulk.
4pi. Bedrock 10 cm.
>450keV: 27776cts/600s

Description of Sample:

Stainless Steel Tube (~200g sediment) + Lab' Gamma Pot (~200g sediment) + Clast (~200g granite)

Nature of Dating Problem:

Initial fill following ditch construction: associated with Early Mediaeval occupation phase?
Constrain ditch construction and initial period of Mediaeval site occupation.
Should pre-date S1#4 and S1#6, and equal S2#6

Completed By	Checked By	Date
CIB & RF	M Black (Headland)	270607

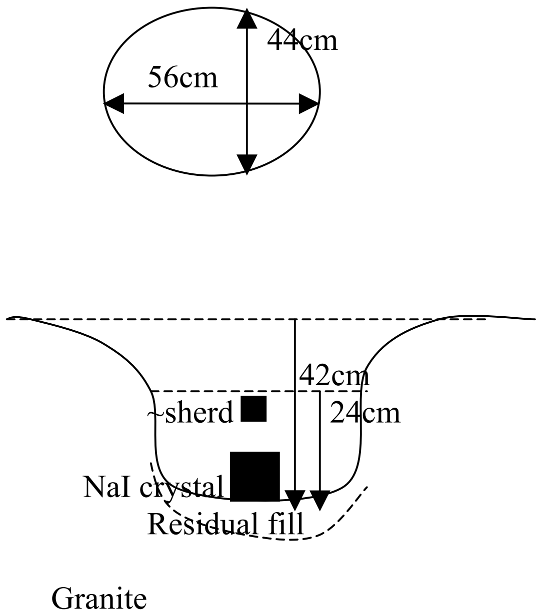
<table>
<tr><td colspan="2">Site Code: NEW
Site Name:
Newry Ring Fort</td><td>Date
270607</td><td colspan="2">Context:
Section 1, layer 6
Site No. 20626</td><td>Sample No
Field: S1#6
Lab: SUTL2162</td></tr>
<tr><td colspan="3">Description of sampling location :</td><td colspan="3">Sketch of surrounding area</td></tr>
<tr><td colspan="3" rowspan="2">Dark red-brown soil away from large stones on surface of section. Silty, some clay but still plenty of small clasts and crystals from granite.

Sealed by layer 4 (20627&8): Red brown soil similar to layer 3 but more loamy, less silty (cohesive). Conforms to slope. Colluvial accumulate underlying palaeolandsurface?

Seals layer 7 (20625): Red-brown soil, texture as layer2, but partially conforms to slope. Fill associated with 1st phase of Mediaeval occupation?

Depth from surface (cm): 101
Left of plumb line (cm): -63 (i.e. to right)
Top of layer (cm):
Bottom of layer (cm):
Clasts: no large ones within 30 cm</td><td colspan="3">See fig.1</td></tr>
<tr><td colspan="3">Photo No:</td></tr>
<tr><td rowspan="2">Gamma Dosimetry</td><td colspan="2">Reading</td><td colspan="2">Assoc. Sample</td><td>Ref No</td></tr>
<tr><td colspan="2">Spec6</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="6">Details:</td></tr>
<tr><td colspan="6">Hole depth 30 cm into 60 cm thick baulk.
4pi.
>450keV: 26181 cts/600s
(implies ~ 3.3pi or less granite (!) around spec4)</td></tr>
<tr><td colspan="6">Description of Sample:</td></tr>
<tr><td colspan="6">Stainless Steel Tube (~200g sediment) + Lab’ Gamma Pot (~200g sediment)</td></tr>
<tr><td colspan="6">Nature of Dating Problem:</td></tr>
<tr><td colspan="6">Palaeosol representing ground stabilisation following early Mediaeval occupation phase: i.e. following excavation of ditch and initial colluvial infill phase.
Constrain initial period of Mediaval site occupation.
Should pre-date S1#3, post-date S1#5, and equal S1#4 and S2#5</td></tr>
<tr><td colspan="2">Completed By</td><td colspan="2">Checked By</td><td colspan="2">Date</td></tr>
<tr><td colspan="2">CIB & RF</td><td colspan="2">M Black (Headland)</td><td colspan="2">270607</td></tr>
</table>

Site Code: NEW **Site Name:** **Newry Ring Fort**	**Date** **270607**	**Context:** **Pit 1** **Site No. ?**	**Sample No** **Field: Pit1#1** **Lab: SUTL2163**

Description of sampling location :	**Sketch of surrounding area**
Previously excavated pit in granite bedrock within site complex (inside ditch), in which a Souteraine-ware sherd was found. Gamma pot samples were taken of the fill sediment (SUTL2163a) and the cover sediment (SUTL2163b), with a view to using them to help reconstruct the radiation environment of the sherd. A field gamma spectrometry measurement was made in the middle of the pit. The base of the pit appeared similar to the fill sediment described below. Fill sediment: pink-purple granular plus silt/clay – appears either burnt or highly weathered. Sherd was in upper fill. Cover sediment: light red-brown silty sand (similar to ditch sediments)	and see fig.3 
	Photo No:

Gamma Dosimetry	**Reading**	**Assoc. Sample**	**Ref No**
	Spec7		

Details:

See diagram
~3pi.
>450keV: 37524 cts/600s: 4pi ~ 50032 cts/600s

Description of Sample:

2 x Lab' Gamma Pot (~200g sediment each)

Nature of Dating Problem:

A Souterraine-ware sherd was found in the middle of this relatively deep and narrow pit, and is being sent for typological analysis. Sediment samples and a gamma spectrometry measurement were taken to help assess the sherd's radiation environment in case it is decided to use this as a test case for the utility of TL dating Souterraine Ware. This pottery is generally non-diagnostic except in that it is associated with the whole of the Mediaeval period: i.e. ~500 to ~1500 AD. TL dating might therefore be used to constrain usage phases of Souterraine ware within this period.

Completed By	**Checked By**	**Date**
CIB & RF	M Black (Headland)	270607

Site Code: NEW Site Name: Newry Ring Fort	Date 260607	Context No Section 2 Profiling	Sample No Field: S2 P1-15 Lab: SUTL2164
Description of sampling location :		**Sketch of surrounding area**	

Profile down section through ring ditch

No.	DfS	RfP	Layer	Description	Site Context
1	8	5	1	Modern topsoil. Reddish grey-brown, sandy, few stones	20001
2	17	6	2	Rootzone, substrate as layer 3	20001
3	31	7	3	Light Red-Brown, many stones/clasts of all sizes to 20cm. Unclear colluvial stone lines coming from top of up-slope bank (bedrock). Colluvial soil, early C19?	20029
4	48	9	3		20029
5	67	10	3		20029
6	80	10	3		20029
7	98	9	3		20029
8	107	6	4	Dark red-brown, silty, some clay, few stones. Conforms to slope. Palaeosol - associated with Late Mediaerval phase of site reuse?	20556
9	116	6	4		20556
10	126	6	5	Red brown soils similar to 2. Conforms to slope. Colluvial accumulate associated with Late Mediaerval phase of site reuse?	20555
11	143	6	5/6		20554/5
12	155	6	6		20554
13	161	4	7	Dark red-brown soil in stone scatter/layer of small rubble. Silty, some clay but still plenty of small clasts and crystals from granite. Stabilisation following early occupation?	Interface 20554-3
14	171	3	8	Red-brown soil, texture as layer2, but conforms to slope. Fill associated with 1st phase of Mediaeval occupation?	20553
15	180	-5	9	Weathered Bed Rock – Granite	N/A

7.1.1.2 (DfS = depth from surface, RfP = right from plumb line)

		Photo No:	
Gamma Dosimetry	**Reading**	**Assoc. Sample**	**Ref No**

Details:

N/A

Description of Sample:

Zip lock bag ~ 10g + Petri dish for portable OSL ~10g. Sediment excavated from behind exposed face of section using a stainless steel tube, and deposited in a pre-labelled zip lock bag while protected from light inside a larger black bag.

Nature of Dating Problem:

Identify patterns in luminescence behaviour through the stratigraphy: discontinuities, boundaries, presence of geological-age material etc.
Aid selection of luminescence sampling locations.

Completed By	Checked By	Date
CIB & RF	M. Black	270607

Site Code: NEW **Site Name:** **Newry Ring Fort**	**Date** **270607**	**Context:** **Section 2, layer 3** **Site No. 20029**	**Sample No** **Field: S2#1** **Lab: SUTL2165**

Description of sampling location :	**Sketch of surrounding area**
Top of colluvial/mixed layer. Top of archaeological stratigraphy Light Red-Brown, many stones/clasts of all sizes to 20cm. Unclear colluvial stone lines coming from top of up-slope bank (bedrock). Sealed by layer 2 (20001): modern rootzone in substrate similar to layer 3. Reddish grey-brown, sandy, few stones Seals layer 4 (20556): Dark red-brown, silty, some clay, few stones. Conforms to slope. Palaeosol - associated with Late Mediaerval phase of site reuse? Depth from surface (cm): 33 Right of plumb line (cm): 5 Top of layer (cm): 9 Bottom of layer (cm): 64 Clasts: 11 cm from nearest, 10 cm diameter	See fig 2.
	Photo No:

Gamma Dosimetry	**Reading**	**Assoc. Sample**	**Ref No**
	Spec12		

Details:

Hole depth 30 cm into 60 cm thick baulk, top of hole 20 cm from ground surface.
4pi.
>450keV: 28532 cts/600s

Description of Sample:

Stainless Steel Tube (~200g sediment) + Lab' Gamma Pot (~200g sediment)

Nature of Dating Problem:

Constrain end of C19? colluvial phase, associated with intensive agricultural activity
Should post-date S2#2 and equal S1#1

Completed By	**Checked By**	**Date**
CIB & RF	M Black (Headland)	270607

Site Code: NEW Site Name: Newry Ring Fort	Date 270607	Context: Section 2, layer 3 Site No. 20029	Sample No Field: S2#2 Lab: SUTL2166

Description of sampling location :	Sketch of surrounding area
Base of colluvial/mixed layer. Light Red-Brown, many stones/clasts of all sizes to 20cm. Unclear colluvial stone lines coming from top of up-slope bank (bedrock). Sealed by layer 2 (20001): modern rootzone in substrate similar to layer 3. Reddish grey-brown, sandy, few stones Seals layer 4 (20556): Dark red-brown, silty, some clay, few stones. Conforms to slope. Palaeosol - associated with Late Mediaerval phase of site reuse? Depth from surface (cm): 91 Right of plumb line (cm): 2 Top of layer (cm): 66 Bottom of layer (cm): 10 Small clasts around sample	See fig 2
	Photo No:

Gamma Dosimetry	Reading	Assoc. Sample	Ref No
	Spec11		

Details:

Hole depth 30 cm into 60 cm thick baulk.
4pi. Granite rock in end of hole
>450keV: 27907 cts/600s

Description of Sample:

Stainless Steel Tube (~200g sediment) + Lab' Gamma Pot (~200g sediment)

Nature of Dating Problem:

Constrain beginning of C19? colluvial phase, associated with intensive agricultural activity
Should pre-date S2#1, post-date S2#3, and equal S1#2.

Completed By	Checked By	Date
CIB & RF	M Black (Headland)	270607

Site Code: NEW **Site Name:** **Newry Ring Fort**	**Date** **270607**	**Context:** **Section 2, layer 4** **Site No. 20556**	**Sample No** **Field: S2#3** **Lab: SUTL2167**

Description of sampling location :	**Sketch of surrounding area**
Dark red-brown, silty, some clay, few stones. Conforms to slope. Palaeosol - associated with Late Mediaeval phase of site reuse? Sealed by layer 3 (20029): Light Red-Brown, many stones/clasts of all sizes to 20cm. Unclear colluvial stone lines coming from top of up-slope bank (bedrock). Seals layer 5 (20626): Red brown soil similar to layer 2. Conforms to slope. Colluvial accumulate associated with Late Mediaerval phase of site reuse? Depth from surface (cm): 111 Right of plumb line (cm): -5 Top of layer (cm): 6 Bottom of layer (cm): 6 Clasts: 0 cm from nearest, 6 cm long	See fig 2
	Photo No:

Gamma Dosimetry	**Reading**	**Assoc. Sample**	**Ref No**
	Spec10		

Details:

Hole depth 26 cm into 60 cm thick baulk.
4pi.
>450keV: 28379 cts/600s

Description of Sample:

Stainless Steel Tube (~200g sediment) + Lab' Gamma Pot (~200g sediment)

Nature of Dating Problem:

Palaeosol associated with (stabilisation following?) Late Mediaeval phase of site reuse: revetment used to widen natural causeway across ditch was built on top of this layer (other side of site): Constrain Late Mediaeval phase of site reuse.
Should pre-date S2#2, post-date S2#4.

Completed By	**Checked By**	**Date**
CIB & RF	M Black (Headland)	270607

Site Code: NEW **Site Name:** **Newry Ring Fort**	**Date** **270607**	**Context:** **Section 2, layer 5** **Site No. 20555**	**Sample No** **Field: S2#4** **Lab: SUTL2168**

Description of sampling location :	**Sketch of surrounding area**
Red brown soil similar to layer 2: Light Red-Brown, many stones/clasts of all sizes to 20cm. Conforms to slope. Colluvial accumulate underlying palaeolandsurface? Sealed by layer 4 (20556): Dark red-brown, silty, some clay, few stones. Conforms to slope. Palaeosol - associated with Late Mediaeval phase of site reuse? Seals layer 6 (20554): similar to layer 5. Depth from surface (cm): 131 Right of plumb line (cm): 5 Top of layer (cm): 19 Bottom of layer (cm): 11 Clasts: 4 cm from nearest, 5 cm diameter	See fig 2
	Photo No:

Gamma Dosimetry	**Reading**	**Assoc. Sample**	**Ref No**
	Spec9		

Details:

Hole depth 29 cm into 60 cm thick baulk.
4pi. Nearest gamma spec holes are 11 & 13 cm away, edge to edge.
>450keV: 29100 cts/600s

Description of Sample:

Stainless Steel Tube (~200g sediment) + Lab' Gamma Pot (~200g sediment)

Nature of Dating Problem:

Colluvial accumulate associated with Late Mediaeval phase of site reuse:
Constrain Late Mediaeval phase of site reuse and accumulation rate during this period
Should pre-date S2#3, post-date S2#5 and equal S1#3

Completed By	**Checked By**	**Date**
CIB & RF	M Black (Headland)	270607

<table>
<tr><td>Site Code: NEW
Site Name:
Newry Ring Fort</td><td>Date
270607</td><td colspan="2">Context:
Section 2, layer 7
Site No. Interface 20553-20554</td><td>Sample No
Field: S2#5
Lab: SUTL2169</td></tr>
<tr><td colspan="3">Description of sampling location :</td><td colspan="2">Sketch of surrounding area</td></tr>
<tr><td colspan="3" rowspan="2">Dark red-brown soil in stone scatter/layer of small rubble. Silty, some clay but still plenty of small clasts and crystals from granite. Stabilisation following early occupation?
Sealed by layer 6 (20554): Red brown soil similar to layer 2: Light Red-Brown, many stones/clasts of all sizes to 20cm. Conforms to slope. Colluvial accumulate underlying palaeolandsurface?
Seals layer 8 (20553): Red-brown soil, texture as layer 2, but conforms to slope. Fill associated with 1st phase of Mediaeval occupation?
Depth from surface (cm): 157
Right of plumb line (cm): 0
Top of layer (cm): 1
Bottom of layer (cm): 1
Layer packed with clasts, none above and below</td><td colspan="2">See fig 2</td></tr>
<tr><td colspan="2">Photo No:</td></tr>
<tr><td rowspan="2">Gamma Dosimetry</td><td colspan="2">Reading</td><td>Assoc. Sample</td><td>Ref No</td></tr>
<tr><td colspan="2">Spec8</td><td>Clast S2#5</td><td></td></tr>
<tr><td colspan="5">Details:</td></tr>
<tr><td colspan="5">Due to proximity of S2#6, a single gamma spectrometry hole was opened between the two – taking in the edges of both sample holes.
Hole depth 30 cm into 60 cm thick baulk.
4pi. Clasts all around upper part of hole – layer 7.
>450keV: 30891 cts/600s</td></tr>
<tr><td colspan="5">Description of Sample:</td></tr>
<tr><td colspan="5">Stainless Steel Tube (~200g sediment) + Lab’ Gamma Pot (~200g sediment) + Clast (~200g granite)</td></tr>
<tr><td colspan="5">Nature of Dating Problem:</td></tr>
<tr><td colspan="5">Palaeosol representing ground stabilisation following early Mediaeval occupation phase: i.e. following excavation of ditch and initial colluvial infill phase.
Constrain initial period of Mediaval site occupation.
Should pre-date S2#4, post-date S2#6, and equal S1#4 and S1#6</td></tr>
<tr><td>Completed By</td><td colspan="2">Checked By</td><td colspan="2">Date</td></tr>
<tr><td>CIB & RF</td><td colspan="2">M Black (Headland)</td><td colspan="2">270607</td></tr>
</table>

Site Code: NEW **Site Name:** **Newry Ring Fort**	**Date** **270607**	**Context:** **Section 2, layer 8** **Site No. 20553**	**Sample No** **Field: S2#6** **Lab: SUTL2170**

Description of sampling location :	**Sketch of surrounding area**
Red-brown soil, texture as layer2, but conforms to slope. Fill associated with 1st phase of Mediaeval occupation? Sealed by layer 7 (20553-20554): Dark red-brown soil in stone scatter/layer of small rubble. Silty, some clay but still plenty of small clasts and crystals from granite. Stabilisation following early occupation? Seals layer 9: Weathered bedrock (granite) Depth from surface (cm): 165 Right of plumb line (cm): 13 Top of layer (cm): 3 Bottom of layer (cm): 3 Clasts: 3 cm from nearest, in rocky palaeosol (layer 7) Bedrock ~10 cm, Granite.	See fig 2 **Photo No:**

Gamma Dosimetry	**Reading**	**Assoc. Sample**	**Ref No**
	Spec8		

Details:

Due to proximity of S2#5, a single gamma spectrometry hole was opened between the two – taking in the edges of both sample holes.
Hole depth 30 cm into 60 cm thick baulk. Clasts all around upper part of hole – layer 7.
Rock in end of hole, 8 cm from edge of hole to bedrock.
4pi. >450keV: 30891 cts/600s

Description of Sample:

Stainless Steel Tube (~200g sediment) + Lab' Gamma Pot (~200g sediment)

Nature of Dating Problem:

Initial fill following ditch construction: associated with Early Mediaeval occupation phase?
Constrain ditch construction and initial period of Mediaeval site occupation.
Should pre-date S2#5, and equal S1#5

Completed By	**Checked By**	**Date**
CIB & RF	M Black (Headland)	270607

Appendix B. Sample preparation and measurement

Sample Number SUERC	Field	Sample Type	Associated Sample Type	Measured Material: Retained unprocessed Sample From	Mass (g)	Sample From	Mass (g)	For measurement Sample From	Mass (g)	Gamma spectrometry Sample From	Sed. (g)	Sealed date	Measured date	Det.	Beta Ctg Sample From	Dry Sieved (g) <1mm	>1mm	Meas. (g)	<1mm date	Luminescence Sample From	Mass (g)
SUTL 2156	NEW S1 P1-16	Zlbs		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Zlbs	~10
SUTL 2157	NEW S1#1	Tube	gamma pot	tube ends	18.2	gamma pot	-	core of tube	98.8	for meas.	98.8	051007	221007	3	gam. spec.	56.8	42.7	20	11107	B.Ctg <1mm	56.8
SUTL 2158	NEW S1#2	Tube	gamma pot	tube ends	28.5	gamma pot	-	core of tube	110.2	for meas.	100.0	051007	221007	3	gam. spec.	59.2	32.8	20	11107	B.Ctg <1mm	59.2
SUTL 2159	NEW S1#3	Tube	gamma pot	tube ends	25.7	gamma pot	-	core of tube	92.4	for meas.	92.4	051007	231007	3	gam. spec.	50.2	36.2	20	11107	B.Ctg <1mm	50.2
SUTL 2160	NEW S1#4	Tube	gamma pot	tube ends	19.6	gamma pot	-	core of tube	103.6	for meas.	103.6	051007	231007	3	gam. spec.	57.5	45.4	20	11107	B.Ctg <1mm	57.5
SUTL 2161	NEW S1#5	Tube	gamma pot	tube ends	17.0	gamma pot	-	core of tube	158.1	for meas.	100.0	051007	241007	3	gam. spec.	52.5	47.1	20	11107	B.Ctg <1mm	52.5
SUTL 2162	NEW S1#6	Tube	gamma pot	tube ends	48.3	gamma pot	-	core of tube	102.1	for meas.	102.1	051007	241007	3	gam. spec.	47.9	54.0	20	21107	B.Ctg <1mm	47.9
SUTL 2163a	NEW Pit1#1a	gamma pot		-	-	gamma pot	65.0	gamma pot	100.0	for meas.	100	051007	251007	3	gam. spec.	49.5	50.7	20	21107	-	-
SUTL 2163b	NEW Pit1#1b	gamma pot		-	-	gamma pot	31.1	gamma pot	100.0	for meas.	100	051007	251007	3	gam. spec.	49.7	50.3	20	21107	-	-
SUTL 2164	NEW S2 P1-15	Zlbs		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Zlbs	~10
SUTL 2165	NEW S2#1	Tube	gamma pot	tube ends	26.5	gamma pot	-	core of tube	102.4	for meas.	102.4	051007	291007	3	gam. spec.	44.9	57.2	20	21107	B.Ctg <1mm	44.9
SUTL 2166	NEW S2#2	Tube	gamma pot	tube ends	22.7	gamma pot	-	core of tube	107.6	for meas.	107.6	051007	291007	3	gam. spec.	58.8	41.3	20	21107	B.Ctg <1mm	58.8
SUTL 2167	NEW S2#3	Tube	gamma pot	tube ends	37.6	gamma pot	-	core of tube	88.6	for meas.	88.6	051007	301007	3	gam. spec.	68.3	20	20	21107	B.Ctg <1mm	68.3
SUTL 2168	NEW S2#4	Tube	gamma pot	tube ends	28.2	gamma pot	-	core of tube	128.1	for meas.	100	051007	301007	3	gam. spec.	59.6	40.6	20	21107	B.Ctg <1mm	59.6
SUTL 2169	NEW S2#5	Tube	gamma pot	tube ends	37.8	gamma pot	-	core of tube	96.1	for meas.	96.1	051007	311007	3	gam. spec.	62	34.4	20	21107	B.Ctg <1mm	62
SUTL 2170	NEW S2#6	Tube	gamma pot	tube ends	28.3	gamma pot	-	core of tube	138.0	for meas.	100	051007	311007	3	gam. spec.	54.2	45.6	20	21107	B.Ctg <1mm	54.2

	mass (g)	error (g)
pot	1.105	0.004

Sample SUTL	Luminescence Sample Prep: Lumin Subsample (g)	Wet Sieved (microns) date	<150 (g)	150-250 (g)	">250" (g)	150-250 micron 10 min 1M HCl date	(g)	reaction	Density separation (g/cm3) retained (g)	for Sep. (g)	date	<2.62 (g) inc pot	2.62-2.74 (g) inc pot	>2.74 (g) inc pot
2156	~10	171207	direct to HCl	direct to HCl	-	171207	direct to HF	-	-	-	-	-	-	-
2157	56.8	61107	4.9	direct to HCl	19.5	71107	direct to d sep	n	3.165	direct to d sep	71107	1.88	direct to HF	1.2
2158	59.2	61107	8.6	direct to HCl	21.9	71107	direct to d sep	n	3.91	direct to d sep	71107	1.86	direct to HF	1.16
2159	50.2	61107	7.3	direct to HCl	21.2	71107	direct to d sep	n	4.03	direct to d sep	71107	1.86	direct to HF	1.14
2160	57.5	61107	4.6	direct to HCl	23.5	71107	direct to d sep	n	3.1	direct to d sep	71107	1.9	direct to HF	1.25
2161	52.5	61107	6.8	direct to HCl	21.6	71107	direct to d sep	n	2.07	direct to d sep	71107	1.99	direct to HF	1.33
2162	47.9	61107	5.6	direct to HCl	19.3	71107	direct to d sep	n	2.61	direct to d sep	71107	1.88	direct to HF	1.15
2163a	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2163b	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2164	~10	191207	direct to HCl	direct to HCl	-	191207	direct to HF	-	-	-	-	-	-	-
2165	44.9	61107	6.3	direct to HCl	21.30	71107	direct to d sep	n	2.87	direct to d sep	71107	1.91	direct to HF	1.14
2166	58.8	61107	5.1	direct to HCl	28.00	71107	direct to d sep	n	2.97	direct to d sep	71107	1.96	direct to HF	1.24
2167	68.3	61107	7.7	direct to HCl	27.20	71107	direct to d sep	n	4.49	direct to d sep	71107	2.16	direct to HF	1.21
2168	59.6	61107	3.5	direct to HCl	25.00	71107	direct to d sep	n	3.64	direct to d sep	71107	2.07	direct to HF	1.21
2169	62	61107	3.5	direct to HCl	20.40	71107	direct to d sep	n	3.43	direct to d sep	71107	1.88	direct to HF	1.25
2170	54.2	61107	4.6	direct to HCl	23.80	71107	direct to d sep	n	3.18	direct to d sep	71107	1.88	direct to HF	1.32

Sample	2.62-2.74 g/cm3 40min 40% HF, HCl & Resieve					Disks				Measurement			
SUTL	date	Retained (g) inc pot	Split for HF (g) inc pot	HF <150 (g) inc pot	HF>150 (g) inc pot	Set 1 date	number	Set 2 date	number	Set 1 date	file	Set 2 date	file
2156	171207	PMC	direct to HF	HFC not weighed		181207	2x16 HFC	181207	2x16 PMC	181207	new1hfc.bin	181207	new1pmc.bin
2157	81107	-	direct to HF	1.13	1.24	81107	16	-	-	91107	newry1.bin	-	-
2158	81107	-	direct to HF	1.13	1.21	81107	16	-	-	91107	newry1.bin	-	-
2159	81107	-	direct to HF	1.13	1.15	81107	16	-	-	91107	newry1.bin	-	-
2160	81107	-	direct to HF	1.18	1.31	81107	16	-	-	91107	newry2.bin	-	-
2161	81107	-	direct to HF	1.14	1.28	81107	16	-	-	91107	newry2.bin	-	-
2162	81107	-	direct to HF	1.13	1.19	81107	16	-	-	91107	newry2.bin	-	-
2163a	-	-	-	-	-	-	-	-	-	-	-	-	-
2163b	-	-	-	-	-	-	-	-	-	-	-	-	-
2164	191207	PMC	direct to HF	HFC not weighed		201207	2x15 HFC	201207	2x15 PMC	201207	new2hfc.bin	201207	new2pmc.bin
2165	81107	-	direct to HF	1.12	1.12	91107	16	-	-	121107	newry3.bin	-	-
2166	81107	-	direct to HF	1.14	1.2	91107	16	-	-	121107	newry3.bin	-	-
2167	81107	-	direct to HF	1.14	1.22	91107	16	-	-	121107	newry3.bin	-	-
2168	81107	-	direct to HF	1.14	1.23	91107	16	-	-	151107	newry4.bin	-	-
2169	81107	-	direct to HF	1.15	1.2	91107	16	-	-	151107	newry4.bin	-	-
2170	81107	-	direct to HF	1.17	1.22	91107	16	-	-	151107	newry4.bin	-	-

Appendix C. Dosimetry

C.1. Thick source beta counting

Run	978	File	11107		Date	11107	
HV	6.60				Threshold	0.45	
Sample	2157				Mass (g)	20	
	Observed		Rolling Average				
Standard (cps)	3.493 .+/-	0.054	3.454 .+/-		0.014		
Background (cps)	0.739 .+/-	0.014	0.749 .+/-		0.003		
Sensitivity (mGy/a/cps)	2.267 .+/-	0.051	2.309 .+/-		0.026		
Sample	counts	1128	1198	1174	1137	1166	1194
	time	600	600	600	600	600	600
	cps	1.880	1.997	1.957	1.895	1.943	1.990
Mean gross rate (cps)	1.944 .+/-	0.020	(SD/rtN)	0.023	(poisson error)		
cps (false if value > 3SD different from mean)		1.880	1.997	1.957	1.895	1.943	1.990
Mean gross rate (cps)	1.944 .+/-	0.020	(SD/rtN)	0.023	(poisson error)		
Net rate (cps)	1.194 .+/-	0.023	(poisson error)				
Beta dose rate (Gy/ka)	2.758 .+/-	0.063					

Run	979	File	11107		Date	11107	
HV	6.60				Threshold	0.45	
Sample	2158				Mass (g)	20	
	Observed		Rolling Average				
Standard (cps)	3.493 .+/-	0.054	3.454 .+/-		0.014		
Background (cps)	0.739 .+/-	0.014	0.749 .+/-		0.003		
Sensitivity (mGy/a/cps)	2.267 .+/-	0.051	2.309 .+/-		0.026		
Sample	counts	1186	1158	1191	1187	1144	1121
	time	600	600	600	600	600	600
	cps	1.977	1.930	1.985	1.978	1.907	1.868
Mean gross rate (cps)	1.941 .+/-	0.019	(SD/rtN)	0.023	(poisson error)		
cps (false if value > 3SD different from mean)		1.977	1.930	1.985	1.978	1.907	1.868
Mean gross rate (cps)	1.941 .+/-	0.019	(SD/rtN)	0.023	(poisson error)		
Net rate (cps)	1.191 .+/-	0.023	(poisson error)				
Beta dose rate (Gy/ka)	2.751 .+/-	0.063					

Run	980	File	11107		Date	11107	
HV	6.60				Threshold	0.45	
Sample	2159				Mass (g)	20	
	Observed		Rolling Average				
Standard (cps)	3.493 .+/-	0.054	3.454 .+/-		0.014		
Background (cps)	0.739 .+/-	0.014	0.749 .+/-		0.003		
Sensitivity (mGy/a/cps)	2.267 .+/-	0.051	2.309 .+/-		0.026		
Sample	counts	1201	1130	1152	1155	1141	1100
	time	600	600	600	600	600	600
	cps	2.002	1.883	1.920	1.925	1.902	1.833
Mean gross rate (cps)	1.911 .+/-	0.023	(SD/rtN)	0.023	(poisson error)		
cps (false if value > 3SD different from mean)		2.002	1.883	1.920	1.925	1.902	1.833
Mean gross rate (cps)	1.911 .+/-	0.023	(SD/rtN)	0.023	(poisson error)		
Net rate (cps)	1.161 .+/-	0.023	(poisson error)				
Beta dose rate (Gy/ka)	2.682 .+/-	0.062					

Run	981	File	11107		Date	11107	
HV	6.60				Threshold	0.45	
Sample	2160				Mass (g)	20	
	Observed		Rolling Average				
Standard (cps)	3.493 .+/-	0.054	3.454 .+/-		0.014		
Background (cps)	0.739 .+/-	0.014	0.749 .+/-		0.003		
Sensitivity (mGy/a/cps)	2.267 .+/-	0.051	2.309 .+/-		0.026		
Sample	counts	1189	1288	1245	1107	1178	1198
	time	600	600	600	600	600	600
	cps	1.982	2.147	2.075	1.845	1.963	1.997
Mean gross rate (cps)	2.001 .+/-	0.042	(SD/rtN) 0.024		(poisson error)		
cps (false if value > 3SD different from mean)		1.982	2.147	2.075	1.845	1.963	1.997
Mean gross rate (cps)	2.001 .+/-	0.042	(SD/rtN)	0.024	(poisson error)		
Net rate (cps)	1.252 .+/-	0.024	(poisson error)				
Beta dose rate (Gy/ka)	2.891 .+/-	0.064					

Run	982	File	11107		Date	11107	
HV	6.60				Threshold	0.45	
Sample	2161				Mass (g)	20	
	Observed		Rolling Average				
Standard (cps)	3.493 .+/-	0.054	3.454 .+/-		0.014		
Background (cps)	0.739 .+/-	0.014	0.749 .+/-		0.003		
Sensitivity (mGy/a/cps)	2.267 .+/-	0.051	2.309 .+/-		0.026		
Sample	counts	1241	1248	1211	1174	1146	1176
	time	600	600	600	600	600	600
	cps	2.068	2.080	2.018	1.957	1.910	1.960
Mean gross rate (cps)	1.999 .+/-	0.028	(SD/rtN) 0.024		(poisson error)		
cps (false if value > 3SD different from mean)		2.068	2.080	2.018	1.957	1.910	1.960
Mean gross rate (cps)	1.999 .+/-	0.028	(SD/rtN)	0.024	(poisson error)		
Net rate (cps)	1.249 .+/-	0.024	(poisson error)				
Beta dose rate (Gy/ka)	2.885 .+/-	0.064					

Run	983	File	21107		Date	21107	
HV	6.60				Threshold	0.45	
Sample	2162				Mass (g)	20	
	Observed		Rolling Average				
Standard (cps)	3.458 .+/-	0.038	3.455 .+/-		0.014		
Background (cps)	0.720 .+/-	0.010	0.747 .+/-		0.003		
Sensitivity (mGy/a/cps)	2.280 .+/-	0.040	2.306 .+/-		0.026		
Sample	counts	1163	1160	1182	1141	1171	1131
	time	600	600	600	600	600	600
	cps	1.938	1.933	1.970	1.902	1.952	1.885
Mean gross rate (cps)	1.930 .+/-	0.013	(SD/rtN) 0.023		(poisson error)		
cps (false if value > 3SD different from mean)		1.938	1.933	1.970	1.902	1.952	1.885
Mean gross rate (cps)	1.930 .+/-	0.013	(SD/rtN)	0.023	(poisson error)		
Net rate (cps)	1.183 .+/-	0.023	(poisson error)				
Beta dose rate (Gy/ka)	2.729 .+/-	0.062					

Run	984		File	21107		Date	21107	
HV	6.60					Threshold	0.45	
Sample	2163a					Mass (g)	20	
	Observed			Rolling Average				
Standard (cps)	3.458	.+/-	0.038	3.455	.+/-	0.014		
Background (cps)	0.720	.+/-	0.010	0.747	.+/-	0.003		
Sensitivity (mGy/a/cps)	2.280	.+/-	0.040	2.306	.+/-	0.026		
Sample	counts		1189	1153	1148	1184	1180	1183
	time		600	600	600	600	600	600
	cps		1.982	1.922	1.913	1.973	1.967	1.972
Mean gross rate (cps)	1.955	.+/-	0.012	(SD/rtN)	0.023	(poisson error)		
cps (false if value > 3SD different from mean)			1.982	1.922	1.913	1.973	1.967	1.972
Mean gross rate (cps)	1.955	.+/-	0.012	(SD/rtN)	0.023	(poisson error)		
Net rate (cps)	1.208	.+/-	0.024	(poisson error)				
Beta dose rate (Gy/ka)	2.786	.+/-	0.063					

Run	985		File	21107		Date	21107	
HV	6.60					Threshold	0.45	
Sample	2163b					Mass (g)	20	
	Observed			Rolling Average				
Standard (cps)	3.458	.+/-	0.038	3.455	.+/-	0.014		
Background (cps)	0.720	.+/-	0.010	0.747	.+/-	0.003		
Sensitivity (mGy/a/cps)	2.280	.+/-	0.040	2.306	.+/-	0.026		
Sample	counts		1396	1364	1333	1314	1336	1224
	time		600	600	600	600	600	600
	cps		2.327	2.273	2.222	2.190	2.227	2.040
Mean gross rate (cps)	2.213	.+/-	0.040	(SD/rtN)	0.025	(poisson error)		
cps (false if value > 3SD different from mean)			2.327	2.273	2.222	2.190	2.227	FALSE
Mean gross rate (cps)	2.248	.+/-	0.024	(SD/rtN)	0.027	(poisson error)		
Net rate (cps)	1.501	.+/-	0.028	(poisson error)				
Beta dose rate (Gy/ka)	3.462	.+/-	0.074					

Run	986		File	21107		Date	21107	
HV	6.60					Threshold	0.45	
Sample	2165					Mass (g)	20	
	Observed			Rolling Average				
Standard (cps)	3.458	.+/-	0.038	3.455	.+/-	0.014		
Background (cps)	0.720	.+/-	0.010	0.747	.+/-	0.003		
Sensitivity (mGy/a/cps)	2.280	.+/-	0.040	2.306	.+/-	0.026		
Sample	counts		1284	1291	1233	1207	1295	1228
	time		600	600	600	600	600	600
	cps		2.140	2.152	2.055	2.012	2.158	2.047
Mean gross rate (cps)	2.094	.+/-	0.026	(SD/rtN)	0.024	(poisson error)		
cps (false if value > 3SD different from mean)			2.140	2.152	2.055	2.012	2.158	2.047
Mean gross rate (cps)	2.094	.+/-	0.026	(SD/rtN)	0.024	(poisson error)		
Net rate (cps)	1.347	.+/-	0.024	(poisson error)				
Beta dose rate (Gy/ka)	3.107	.+/-	0.066					

Run	987	File	21107		Date	21107		
HV	6.60				Threshold	0.45		
Sample	2166				Mass (g)	20		
	Observed		Rolling Average					
Standard (cps)	3.458 .+/-	0.038	3.455 .+/-		0.014			
Background (cps)	0.720 .+/-	0.010	0.747 .+/-		0.003			
Sensitivity (mGy/a/cps)	2.280 .+/-	0.040	2.306 .+/-		0.026			
Sample	counts	1200	1166	1153	1141	1133	1147	
	time	600	600	600	600	600	600	
	cps	2.000	1.943	1.922	1.902	1.888	1.912	
Mean gross rate (cps)	1.928 .+/-	0.016	(SD/rtN)	0.023	(poisson error)			
cps (false if value > 3SD different from mean)		FALSE	1.943	1.922	1.902	1.888	1.912	
Mean gross rate (cps)	1.913 .+/-	0.009	(SD/rtN)	0.025	(poisson error)			
Net rate (cps)	1.167 .+/-	0.025	(poisson error)					
Beta dose rate (Gy/ka)	2.691 .+/-	0.066						

Run	988	File	21107		Date	21107		
HV	6.60				Threshold	0.45		
Sample	2167				Mass (g)	20		
	Observed		Rolling Average					
Standard (cps)	3.458 .+/-	0.038	3.455 .+/-		0.014			
Background (cps)	0.720 .+/-	0.010	0.747 .+/-		0.003			
Sensitivity (mGy/a/cps)	2.280 .+/-	0.040	2.306 .+/-		0.026			
Sample	counts	1188	1129	1197	1232	1170	1162	
	time	600	600	600	600	600	600	
	cps	1.980	1.882	1.995	2.053	1.950	1.937	
Mean gross rate (cps)	1.966 .+/-	0.024	(SD/rtN)	0.023	(poisson error)			
cps (false if value > 3SD different from mean)		1.980	1.882	1.995	2.053	1.950	1.937	
Mean gross rate (cps)	1.966 .+/-	0.024	(SD/rtN)	0.023	(poisson error)			
Net rate (cps)	1.219 .+/-	0.024	(poisson error)					
Beta dose rate (Gy/ka)	2.812 .+/-	0.063						

Run	989	File	21107		Date	21107	
HV	6.60				Threshold	0.45	
Sample	2168				Mass (g)	20	
	Observed		Rolling Average				
Standard (cps)	3.458 .+/- 0.038		3.455 .+/-		0.014		
Background (cps)	0.720 .+/- 0.010		0.747 .+/-		0.003		
Sensitivity (mGy/a/cps)	2.280 .+/- 0.040		2.306 .+/-		0.026		
Sample	counts	1310	1253	1209	1201	1242	1232
	time	600	600	600	600	600	600
	cps	2.183	2.088	2.015	2.002	2.070	2.053
Mean gross rate (cps)	2.069 .+/- 0.027		(SD/rtN)	0.024	(poisson error)		
cps (false if value > 3SD different from mean)		FALSE	2.088	2.015	2.002	2.070	2.053
Mean gross rate (cps)	2.046 .+/- 0.016		(SD/rtN)	0.026	(poisson error)		
Net rate (cps)	1.299 .+/- 0.026		(poisson error)				
Beta dose rate (Gy/ka)	2.996 .+/- 0.069						

Run	990	File	21107		Date	21107	
HV	6.60				Threshold	0.45	
Sample	2169				Mass (g)	20	
	Observed		Rolling Average				
Standard (cps)	3.458 .+/- 0.038		3.455 .+/-		0.014		
Background (cps)	0.720 .+/- 0.010		0.747 .+/-		0.003		
Sensitivity (mGy/a/cps)	2.280 .+/- 0.040		2.306 .+/-		0.026		
Sample	counts	1239	1220	1236	1167	1221	1200
	time	600	600	600	600	600	600
	cps	2.065	2.033	2.060	1.945	2.035	2.000
Mean gross rate (cps)	2.023 .+/- 0.018		(SD/rtN)	0.024	(poisson error)		
cps (false if value > 3SD different from mean)		2.065	2.033	2.060	FALSE	2.035	2.000
Mean gross rate (cps)	2.039 .+/- 0.012		(SD/rtN)	0.026	(poisson error)		
Net rate (cps)	1.292 .+/- 0.026		(poisson error)				
Beta dose rate (Gy/ka)	2.980 .+/- 0.069						

Run	991	File	21107		Date	21107	
HV	6.60				Threshold	0.45	
Sample	2170				Mass (g)	20	
	Observed		Rolling Average				
Standard (cps)	3.458 .+/- 0.038		3.455 .+/-		0.014		
Background (cps)	0.720 .+/- 0.010		0.747 .+/-		0.003		
Sensitivity (mGy/a/cps)	2.280 .+/- 0.040		2.306 .+/-		0.026		
Sample	counts	1182	1196	1225	1211	1220	1157
	time	600	600	600	600	600	600
	cps	1.970	1.993	2.042	2.018	2.033	1.928
Mean gross rate (cps)	1.998 .+/- 0.018		(SD/rtN)	0.024	(poisson error)		
cps (false if value > 3SD different from mean)		1.970	1.993	2.042	2.018	2.033	1.928
Mean gross rate (cps)	1.998 .+/- 0.018		(SD/rtN)	0.024	(poisson error)		
Net rate (cps)	1.251 .+/- 0.024		(poisson error)				
Beta dose rate (Gy/ka)	2.885 .+/- 0.064						

C.2. High resolution gamma spectrometry

					Background		Shap Granite 100 g			
					Mass (g)	0	Mass (g)	100		
					Total time (ks)	1515	Total time (ks)	250	Net	
		Half Life	**Energy** (keV)	**Intensity**	Wt Mean rate (cts/ks)	Error	Wt Mean rate (cts/ks)	Error	Rate (cts/ks)	error
Potassium	40-K	1.28e9a	1460.8	0.107	7.86	0.13	120.61	0.79	112.75	0.80
Uranium series	238-U	4.47e9a								
	234-Th	24.1d	62	0.0402	33.41	0.19	55.56	0.73	22.15	0.76
			92.6	0.054	38.71	0.24	64.48	0.89	25.77	0.92
	226-Ra (235-U)	1599a	185.99	0.0328	21.34	0.19	55.91	0.73	34.58	0.75
	214-Pb	26.8m	241.91	0.0745						
			295.2	0.191	3.26	0.13	68.50	0.66	65.24	0.67
			351.9	0.369	4.17	0.16	125.09	0.87	120.92	0.88
	214-Bi	19.9m	609.3	0.468	4.97	0.18	98.21	0.83	93.25	0.85
			1120.28	0.154	1.01	0.09	20.63	0.41	19.62	0.42
			1238	0.06098	0.52	0.08	7.35	0.33	6.82	0.34
			1764.5	0.162	1.89	0.09	17.29	0.35	15.40	0.36
			2204	0.052	0.76	0.10	5.65	0.34	4.89	0.36
	210-Pb	22a	45	0.045	4.50	0.10	15.60	0.41	11.10	0.42
Thorium Series	232-Th	1.405e10a								
	228-Ac	6.15h	338.7	0.12	1.79	0.13	34.71	0.56	32.92	0.58
			911.3	0.29	2.40	0.14	38.91	0.60	36.51	0.62
			964.84	0.0545						
			969.16	0.17458	6.33	0.22	34.37	0.78	28.04	0.81
	224-Ra	3.62d	240.987	0.0397						
	212-Pb	10.64h	238.625	0.434	13.71	0.32	229.50	1.42	215.79	1.45
	212-Bi	1.01h	727.2	0.0675	0.55	0.16	10.66	0.57	10.11	0.59
	208-Tl	3.06m	277.358	0.0637	1.10	0.12	7.63	0.45	6.53	0.46
			583.19	0.851	3.70	0.19	57.11	0.75	53.41	0.78
			860.56	0.126	-1.12	0.16	5.21	0.53	6.33	0.56
			2614.5	0.999	5.27	0.14	25.35	0.60	20.08	0.62

Detector	#3															
Sample	**2157**															
Filename	2157															
Roi file	G3nov07															
Date	21/10/07															
Time (ks)	25.00															
Mass (g)	98.8				Net		Specific		Concentration		Within	WM calcs				
	Counts	error	Rate	error	Rate	error	Activity	error		error	2 err of					
			(cts/ks)		(cts/ks)		(Bq/kg)				WM ?					
							K		%K							
40-K	1682	48	67.28	1.92	59.42	1.92	731	25	2.36	0.08						
238-U							238U		ppm eU	error		x/sigma^2	1/sigma	sum		
234-Th	1004	43	40.16	1.72	6.75	1.73	46	12	3.70	0.97	TRUE	0.32	0.01	full	11.27	0.48
	1215	53	48.60	2.12	9.89	2.13	58	13	4.66	1.03	FALSE	0.35	0.01	preRn	1.26	0.03
226-Ra (23	734	43	29.36	1.72	8.02	1.73	35	8	2.82	0.63	TRUE	0.58	0.02	postRn	10.01	0.45
214-Pb																
	283	31	11.32	1.24	8.06	1.25	19	3	1.50	0.24	TRUE	2.04	0.11			
	599	41	23.96	1.64	19.79	1.65	25	2	1.99	0.19	TRUE	4.30	0.18			
214-Bi	480	43	19.20	1.72	14.23	1.73	23	3	1.85	0.24	TRUE	2.52	0.11			
	102	21	4.08	0.84	3.07	0.84	23	7	1.90	0.53	TRUE	0.54	0.02			
	12	19	0.48	0.76	-0.04	0.76	-1	-17	-0.08	-1.36	FALSE	0.00	0.00			
	126	19	5.04	0.76	3.15	0.77	31	8	2.48	0.62	TRUE	0.53	0.02			
	48	21	1.92	0.84	1.16	0.85	36	26	2.88	2.11	TRUE	0.05	0.00			
210-Pb	123	22	4.92	0.88	0.42	0.89	6	12	0.46	0.97	TRUE	0.04	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	223	31	8.92	1.24	7.13	1.25	25	4	6.24	1.10	TRUE	1.27	0.05	full	14.40	0.60
	268	35	10.72	1.40	8.32	1.41	27	5	6.57	1.12	TRUE	1.30	0.05			
	302	49	12.08	1.96	5.75	1.97	24	8	5.91	2.03	TRUE	0.35	0.01			
224-Ra																
212-Pb	1494	75	59.76	3.00	46.05	3.02	25	2	6.15	0.41	TRUE	9.08	0.36			
212-Bi	81	36	3.24	1.44	2.69	1.45	31	17	7.67	4.15	TRUE	0.11	0.00			
208-Tl	80	28	3.20	1.12	2.10	1.13	38	20	9.28	5.01	TRUE	0.09	0.00			
	335	43	13.40	1.72	9.70	1.73	21	4	5.24	0.94	TRUE	1.47	0.07			
	-30	37	-1.20	1.48	-0.08	1.49	-1	-28	-0.35	-6.78	FALSE	0.00	0.00			
	203	20	8.12	0.80	2.85	0.81	17	5	4.10	1.17	TRUE	0.74	0.04			

Sample		Specific Activi		Concentration		Dose Rates (mGy/a)					
		(Bq/kg)		(% or ppm)		Alpha	error	Beta	error	Gamma	error
Full Series	K	731	25	2.36	0.08			1.96	0.0664	0.56949	0.02
WM	U	23.61	2.095	1.912	0.17	5.31	0.47	0.28	0.0248	0.21965	0.02
	Th	24.1	1.673	5.939	0.41	4.39	0.30	0.17	0.0118	0.30528	0.02
					Total	9.70	0.56	2.41	0.0718	1.09441	0.03
Thfull/Ufull				3.11							
Pre 222Rn	U	42.01	33.43	3.402	2.71	9.45	7.52	0.50	0.3956	0.3909	0.31
Post 222Rn	U	22.37	2.235	1.812	0.18	5.04	0.50	0.26	0.0264	0.2082	0.02
Difference		19.63	33.51	1.59	2.71	4.42	7.54	0.23	0.40	0.18	0.31

Detector	#3															
Sample	**2158**															
Filename	2158															
Roi file	G3nov07															
Date	21/10/07															
Time (ks)	50.00															
Mass (g)	100				Net		Specific		Concentration		Within	WM calcs				
	Counts	error	Rate (cts/ks)	error	Rate (cts/ks)	error	Activity (Bq/kg)	error		error	2 err of WM ?					
							K		%K							
40-K	3311	67	66.22	1.34	58.36	1.35	709	18	2.29	0.06						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	2046	62	40.92	1.24	7.51	1.25	50	9	4.07	0.71	FALSE	0.65	0.01	full	20.99	0.75
	2527	76	50.54	1.52	11.83	1.54	68	10	5.51	0.77	FALSE	0.75	0.01	preRn	2.71	0.05
226-Ra (23	1592	62	31.84	1.24	10.50	1.26	45	6	3.64	0.47	FALSE	1.31	0.03	postRn	18.28	0.70
214-Pb																
	660	44	13.20	0.88	9.94	0.89	23	2	1.83	0.19	FALSE	4.18	0.19			
	1321	58	26.42	1.16	22.25	1.17	27	2	2.21	0.16	TRUE	6.90	0.25			
214-Bi	1149	62	22.98	1.24	18.01	1.25	29	2	2.32	0.20	TRUE	4.72	0.16			
	253	32	5.06	0.64	4.05	0.65	31	5	2.48	0.42	TRUE	1.15	0.04			
	139	28	2.78	0.56	2.26	0.57	49	13	3.97	1.03	TRUE	0.30	0.01			
	214	28	4.28	0.56	2.39	0.57	23	6	1.86	0.45	TRUE	0.73	0.03			
	54	32	1.08	0.64	0.32	0.65	10	20	0.79	1.59	TRUE	0.03	0.00			
210-Pb	295	31	5.90	0.62	1.40	0.63	19	8	1.51	0.68	TRUE	0.26	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	407	44	8.14	0.88	6.35	0.89	22	3	5.49	0.78	TRUE	2.24	0.10	full	29.11	1.17
	469	48	9.38	0.96	6.98	0.97	22	3	5.45	0.76	TRUE	2.30	0.10			
	678	68	13.56	1.36	7.23	1.38	30	6	7.35	1.41	TRUE	0.91	0.03			
224-Ra																
212-Pb	3090	108	61.80	2.16	48.09	2.18	26	1	6.35	0.30	TRUE	17.80	0.69			
212-Bi	170	51	3.40	1.02	2.85	1.03	33	12	8.03	2.94	TRUE	0.23	0.01			
208-Tl	130	39	2.60	0.78	1.50	0.79	27	14	6.55	3.47	TRUE	0.13	0.01			
	693	61	13.86	1.22	10.16	1.23	22	3	5.42	0.66	TRUE	3.03	0.14			
	87	49	1.74	0.98	2.86	0.99	52	19	12.87	4.66	TRUE	0.15	0.00			
	496	28	9.92	0.56	4.65	0.58	27	3	6.60	0.84	TRUE	2.32	0.09			

Sample		Specific Activi (Bq/kg)		Concentration (% or ppm)		Dose Rates (mGy/a) Alpha	error	Beta	error	Gamm	error
Full Series	K	709	18	2.29	0.06			1.90	0.0477	0.553	0.01
WM	U	28.03	1.335	2.27	0.11	6.31	0.30	0.33	0.0158	0.261	0.01
	Th	24.98	0.858	6.157	0.21	4.55	0.16	0.18	0.006	0.316	0.01
					Total	10.86	0.34	2.41	0.0506	1.13	0.02
Thfull/Ufull				2.71							
Pre 222Rn	U	51.05	18.83	4.135	1.52	11.49	4.24	0.60	0.2228	0.475	0.18
Post 222Rn	U	26.27	1.437	2.128	0.12	5.91	0.32	0.31	0.017	0.244	0.01
Difference		24.78	18.88	2.01	1.53	5.58	4.25	0.29	0.22	0.23	0.18

Detector	#3															
Sample	**2159**															
Filename	2159															
Roi file	G3nov07															
Date	22/10/07															
Time (ks)	25.00															
Mass (g)	92.4				Net		Specific		Concentration		Within	WM calcs				
	Counts	error	Rate (cts/ks)	error	Rate (cts/ks)	error	Activity (Bq/kg)	error		error	2 err of WM ?					
							K		%K							
40-K	1578	46	63.12	1.84	55.26	1.84	727	25	2.35	0.08						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	914	42	36.56	1.68	3.15	1.69	23	12	1.85	1.00	TRUE	0.15	0.01	full	10.58	0.43
	1055	51	42.20	2.04	3.49	2.05	22	13	1.76	1.04	TRUE	0.13	0.01	preRn	0.80	0.03
226-Ra (23	713	42	28.52	1.68	7.18	1.69	33	8	2.70	0.65	TRUE	0.52	0.02	postRn	9.79	0.40
214-Pb																
	284	31	11.36	1.24	8.10	1.25	20	3	1.61	0.26	TRUE	1.91	0.10			
	605	41	24.20	1.64	20.03	1.65	27	3	2.15	0.21	TRUE	4.04	0.15			
214-Bi	440	41	17.60	1.64	12.63	1.65	22	3	1.76	0.25	TRUE	2.35	0.11			
	119	22	4.76	0.88	3.75	0.88	31	7	2.48	0.60	TRUE	0.56	0.02			
	50	19	2.00	0.76	1.48	0.76	35	18	2.81	1.47	TRUE	0.11	0.00			
	113	18	4.52	0.72	2.63	0.73	27	8	2.22	0.62	TRUE	0.46	0.02			
	77	17	3.08	0.68	2.32	0.69	76	23	6.16	1.89	FALSE	0.14	0.00			
210-Pb	183	23	7.32	0.92	2.82	0.93	41	14	3.30	1.10	TRUE	0.22	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	189	30	7.56	1.20	5.77	1.21	22	5	5.40	1.14	TRUE	1.03	0.05	full	14.01	0.54
	216	34	8.64	1.36	6.24	1.37	21	5	5.27	1.16	TRUE	0.97	0.05			
	358	48	14.32	1.92	7.99	1.93	36	9	8.79	2.14	TRUE	0.47	0.01			
224-Ra																
212-Pb	1417	74	56.68	2.96	42.97	2.98	25	2	6.14	0.43	TRUE	8.16	0.33			
212-Bi	48	36	1.92	1.44	1.37	1.45	17	18	4.18	4.43	TRUE	0.05	0.00			
208-Tl	91	27	3.64	1.08	2.54	1.09	49	21	12.00	5.18	TRUE	0.11	0.00			
	417	42	16.68	1.68	12.98	1.69	30	4	7.50	0.98	TRUE	1.91	0.06			
	-4	35	-0.16	1.40	0.96	1.41	19	28	4.67	6.88	TRUE	0.02	0.00			
	267	20	10.68	0.80	5.41	0.81	34	5	8.31	1.27	TRUE	1.28	0.04			

Sample		Specific Activi (Bq/kg)		Concentration (% or ppm)		Dose Rates (mGy/a) Alpha	error	Beta	error	Gamm	error
Full Series	K	727	25	2.35	0.08			1.95	0.0679	0.566	0.02
WM	U	24.63	2.327	1.995	0.19	5.54	0.52	0.29	0.0275	0.229	0.02
	Th	25.92	1.85	6.388	0.46	4.72	0.34	0.18	0.013	0.328	0.02
					Total	10.26	0.62	2.42	0.0744	1.124	0.04
Thfull/Ufull				3.20							
Pre 222Rn	U	28.34	35.47	2.295	2.87	6.38	7.98	0.34	0.4197	0.264	0.33
Post 222Rn	U	24.37	2.49	1.973	0.20	5.48	0.56	0.29	0.0295	0.227	0.02
Difference		3.98	35.56	0.32	2.88	0.89	8.00	0.05	0.42	0.04	0.33

Detector	#3															
Sample	**2160**															
Filename	2160															
Roi file	G3nov07															
Date	22/10/07															
Time (ks)	50.00															
Mass (g)	103.6				Net		Specific		Concentration		Within	WM calcs				
	Counts	error	Rate	error	Rate	error	Activity	error		error	2 err of					
			(cts/ks)		(cts/ks)		(Bq/kg)				WM ?					
							K		%K							
40-K	3716	69	74.32	1.38	66.46	1.39	779	18	2.52	0.06						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	1837	60	36.74	1.20	3.33	1.22	21	8	1.74	0.64	TRUE	0.34	0.02	full	21.58	0.73
	2335	75	46.70	1.50	7.99	1.52	44	9	3.59	0.71	TRUE	0.58	0.01	preRn	1.92	0.07
226-Ra (23	1394	60	27.88	1.20	6.54	1.22	27	5	2.19	0.42	TRUE	0.99	0.04	postRn	19.67	0.67
214-Pb																
	835	46	16.70	0.92	13.44	0.93	29	3	2.39	0.20	TRUE	4.61	0.16			
	1430	59	28.60	1.18	24.43	1.19	29	2	2.34	0.16	TRUE	7.03	0.24			
214-Bi	1214	61	24.28	1.22	19.31	1.23	30	2	2.40	0.20	TRUE	5.08	0.17			
	296	33	5.92	0.66	4.91	0.67	36	5	2.90	0.42	TRUE	1.31	0.04			
	94	28	1.88	0.56	1.36	0.57	28	12	2.30	0.97	TRUE	0.20	0.01			
	239	27	4.78	0.54	2.89	0.55	27	5	2.17	0.43	TRUE	0.96	0.04			
	71	31	1.42	0.62	0.66	0.63	19	18	1.56	1.49	TRUE	0.06	0.00			
210-Pb	349	33	6.98	0.66	2.48	0.67	32	9	2.59	0.71	TRUE	0.41	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	485	44	9.70	0.88	7.91	0.89	27	3	6.60	0.75	TRUE	2.87	0.11	full	30.74	1.24
	545	50	10.90	1.00	8.50	1.01	26	3	6.40	0.77	TRUE	2.66	0.10			
	770	67	15.40	1.34	9.07	1.36	36	5	8.90	1.35	FALSE	1.20	0.03			
224-Ra																
212-Pb	2941	107	58.82	2.14	45.11	2.16	23	1	5.75	0.28	TRUE	17.72	0.76			
212-Bi	83	51	1.66	1.02	1.11	1.03	12	11	3.02	2.81	TRUE	0.09	0.01			
208-Tl	186	39	3.72	0.78	2.62	0.79	45	14	11.04	3.39	TRUE	0.24	0.01			
	844	61	16.88	1.22	13.18	1.23	28	3	6.79	0.64	TRUE	4.02	0.15			
	-4	51	-0.08	1.02	1.04	1.03	18	18	4.52	4.51	TRUE	0.05	0.00			
	481	31	9.62	0.62	4.35	0.64	24	4	5.96	0.89	TRUE	1.88	0.08			

Sample		Specific Activi		Concentration		Dose Rates (mGy/a)					
		(Bq/kg)		(% or ppm)		Alpha	error	Beta	error	Gamm	error
Full Series	K	779	18	2.52	0.06			2.09	0.0482	0.607	0.01
WM	U	29.46	1.365	2.386	0.11	6.63	0.31	0.35	0.0162	0.274	0.01
	Th	24.75	0.805	6.1	0.20	4.51	0.15	0.17	0.0057	0.314	0.01
					Total	11.14	0.34	2.62	0.0512	1.195	0.02
Thfull/Ufull				2.56							
Pre 222Rn	U	29.15	15.21	2.361	1.23	6.56	3.42	0.34	0.18	0.271	0.14
Post 222Rn	U	29.49	1.5	2.389	0.12	6.64	0.34	0.35	0.0177	0.274	0.01
Difference		-0.34	15.29	-0.03	1.24	-0.08	3.44	0.00	0.18	0.00	0.14

Detector	#3
Sample	**2161**
Filename	2161
Roi file	G3nov07
Date	23/10/07
Time (ks)	25.00
Mass (g)	100

	Counts	error	Rate (cts/ks)	error	Net Rate (cts/ks)	error	Specific Activity (Bq/kg)	error	Concentration	error	Within 2 err of WM ?	WM calcs				
							K		%K							
40-K	1965	50	78.60	2.00	70.74	2.00	860	26	2.78	0.08						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	949	43	37.96	1.72	4.55	1.73	30	12	2.46	0.95	TRUE	0.22	0.01	full	11.35	0.49
	1185	53	47.40	2.12	8.69	2.13	50	13	4.05	1.02	FALSE	0.32	0.01	preRn	0.80	0.03
226-Ra (23	614	42	24.56	1.68	3.22	1.69	14	7	1.12	0.59	TRUE	0.26	0.02	postRn	10.55	0.46
214-Pb																
	253	29	10.12	1.16	6.86	1.17	16	3	1.26	0.22	FALSE	2.03	0.13			
	660	41	26.40	1.64	22.23	1.65	27	2	2.21	0.20	TRUE	4.57	0.17			
214-Bi	520	42	20.80	1.68	15.83	1.69	25	3	2.04	0.24	TRUE	2.85	0.11			
	98	21	3.92	0.84	2.91	0.84	22	6	1.78	0.53	TRUE	0.52	0.02			
	31	20	1.24	0.80	0.72	0.80	16	17	1.26	1.42	TRUE	0.05	0.00			
	100	20	4.00	0.80	2.11	0.80	20	8	1.64	0.63	TRUE	0.33	0.02			
	3	24	0.12	0.96	-0.64	0.97	-19	-29	-1.57	-2.37	FALSE	-0.02	0.00			
210-Pb	176	23	7.04	0.92	2.54	0.93	34	12	2.75	1.01	TRUE	0.22	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	234	30	9.36	1.20	7.57	1.21	27	4	6.55	1.05	TRUE	1.46	0.05	full	13.90	0.62
	211	35	8.44	1.40	6.04	1.41	19	4	4.71	1.10	TRUE	0.96	0.05			
	338	48	13.52	1.92	7.19	1.93	30	8	7.31	1.97	TRUE	0.46	0.02			
224-Ra																
212-Pb	1400	75	56.00	3.00	42.29	3.02	23	2	5.58	0.40	TRUE	8.48	0.37			
212-Bi	40	36	1.60	1.44	1.05	1.45	12	17	2.96	4.09	TRUE	0.04	0.00			
208-Tl	80	27	3.20	1.08	2.10	1.09	37	19	9.17	4.78	TRUE	0.10	0.00			
	334	44	13.36	1.76	9.66	1.77	21	4	5.15	0.95	TRUE	1.41	0.07			
	-1	36	-0.04	1.44	1.08	1.45	20	27	4.86	6.54	TRUE	0.03	0.00			
	224	20	8.96	0.80	3.69	0.81	21	5	5.24	1.16	TRUE	0.96	0.05			

Sample		Specific Activity		Concentration		Dose Rates (mGy/a)					
		(Bq/kg)		(% or ppm)		Alpha	error	Beta	error	Gamm	error
Full Series	K	860	26	2.78	0.08			2.31	0.0692	0.67	0.02
WM	U	22.93	2.02	1.857	0.16	5.16	0.45	0.27	0.0239	0.213	0.02
	Th	22.595	1.626	5.569	0.40	4.12	0.30	0.16	0.0115	0.286	0.02
					Total	9.28	0.54	2.74	0.0741	1.169	0.03
Thfull/Ufull				3.00							
Pre 222Rn	U	24.61	30.73	1.993	2.49	5.54	6.92	0.29	0.3636	0.229	0.29
Post 222Rn	U	22.81	2.162	1.847	0.18	5.13	0.49	0.27	0.0256	0.212	0.02
Difference		1.81	30.81	0.15	2.49	0.41	6.93	0.02	0.36	0.02	0.29

Detector	#3															
Sample	**2162**															
Filename	2162															
Roi file	G3nov07															
Date	23/10/07															
Time (ks)	50.00															
Mass (g)	102.1				Net		Specific		Concentration		Within	WM calcs				
	Counts	error	Rate (cts/ks)	error	Rate (cts/ks)	error	Activity (Bq/kg)	error		error	2 err of WM ?					
							K		%K							
40-K	3627	69	72.54	1.38	64.68	1.39	770	18	2.49	0.06						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	1860	60	37.20	1.20	3.79	1.22	25	8	2.01	0.65	TRUE	0.38	0.02	full	19.38	0.84
	2004	74	40.08	1.48	1.37	1.50	8	8	0.62	0.68	TRUE	0.11	0.01	preRn	1.44	0.07
226-Ra (23	1382	60	27.64	1.20	6.30	1.22	26	5	2.14	0.43	TRUE	0.95	0.04	postRn	17.94	0.78
214-Pb																
	734	45	14.68	0.90	11.42	0.91	25	2	2.06	0.19	TRUE	4.41	0.17			
	1248	57	24.96	1.14	20.79	1.15	25	2	2.02	0.15	TRUE	7.14	0.29			
214-Bi	904	61	18.08	1.22	13.11	1.23	20	2	1.65	0.18	TRUE	4.29	0.21			
	144	31	2.88	0.62	1.87	0.63	14	5	1.12	0.38	TRUE	0.63	0.05			
	143	28	2.86	0.56	2.34	0.57	50	12	4.02	1.01	FALSE	0.32	0.01			
	235	27	4.70	0.54	2.81	0.55	26	5	2.14	0.43	TRUE	0.93	0.03			
	112	28	2.24	0.56	1.48	0.57	44	17	3.56	1.40	TRUE	0.15	0.00			
210-Pb	244	31	4.88	0.62	0.38	0.63	5	8	0.40	0.66	FALSE	0.07	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	406	44	8.12	0.88	6.33	0.89	22	3	5.36	0.76	TRUE	2.28	0.10	full	30.70	1.22
	551	48	11.02	0.96	8.62	0.97	27	3	6.59	0.75	TRUE	2.88	0.11			
	537	70	10.74	1.40	4.41	1.42	18	6	4.39	1.41	TRUE	0.54	0.03			
224-Ra																
212-Pb	3198	107	63.96	2.14	50.25	2.16	26	1	6.50	0.29	TRUE	19.22	0.73			
212-Bi	110	50	2.20	1.00	1.65	1.01	18	11	4.56	2.81	TRUE	0.14	0.01			
208-Tl	66	38	1.32	0.76	0.22	0.77	4	13	0.94	3.29	TRUE	0.02	0.01			
	738	61	14.76	1.22	11.06	1.23	23	3	5.78	0.65	TRUE	3.36	0.14			
	-35	51	-0.70	1.02	0.42	1.03	8	18	1.85	4.56	TRUE	0.02	0.00			
	483	28	9.66	0.56	4.39	0.58	25	3	6.10	0.82	TRUE	2.24	0.09			

Sample		Specific Activi (Bq/kg)		Concentration (% or ppm)		Dose Rates (mGy/a) Alpha	error	Beta	error	Gamm	error
Full Series	K	770	18	2.49	0.06			2.07	0.0487	0.6	0.01
WM	U	23.05	1.19	1.867	0.10	5.19	0.27	0.27	0.0141	0.215	0.01
	Th	25.13	0.819	6.194	0.20	4.58	0.15	0.18	0.0058	0.318	0.01
					Total	9.77	0.31	2.52	0.051	1.133	0.02
Thfull/Ufull				3.32							
Pre 222Rn	U	22.04	15.33	1.785	1.24	4.96	3.45	0.26	0.1814	0.205	0.14
Post 222Rn	U	23.14	1.29	1.874	0.10	5.21	0.29	0.27	0.0153	0.215	0.01
Difference		-1.10	15.39	-0.09	1.25	-0.25	3.46	-0.01	0.18	-0.01	0.14

Detector #3
Sample **2163a**
Filename 2163a
Roi file G3nov07
Date 24/10/07
Time (ks) 25.00
Mass (g) 100

	Counts	error	Rate (cts/ks)	error	Net Rate (cts/ks)	error	Specific Activity (Bq/kg)	error	Concentration	error	Within 2 err of WM ?	WM calcs				
							K		%K							
40-K	2039	50	81.56	2.00	73.70	2.00	896	26	2.90	0.08						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	925	43	37.00	1.72	3.59	1.73	24	12	1.94	0.94	TRUE	0.18	0.01	full	11.67	0.48
	1012	52	40.48	2.08	1.77	2.09	10	12	0.82	0.98	TRUE	0.07	0.01	preRn	0.63	0.03
226-Ra (23	652	42	26.08	1.68	4.74	1.69	20	7	1.65	0.59	TRUE	0.38	0.02	postRn	11.05	0.45
214-Pb																
	366	31	14.64	1.24	11.38	1.25	26	3	2.09	0.25	TRUE	2.65	0.10			
	565	41	22.60	1.64	18.43	1.65	23	2	1.83	0.19	TRUE	4.20	0.19			
214-Bi	503	44	20.12	1.76	15.15	1.77	24	3	1.95	0.25	TRUE	2.56	0.11			
	103	22	4.12	0.88	3.11	0.88	23	7	1.90	0.55	TRUE	0.51	0.02			
	32	19	1.28	0.76	0.76	0.76	16	17	1.33	1.35	TRUE	0.06	0.00			
	127	18	5.08	0.72	3.19	0.73	31	7	2.48	0.58	TRUE	0.60	0.02			
	85	19	3.40	0.76	2.64	0.77	80	24	6.47	1.95	FALSE	0.14	0.00			
210-Pb	221	24	8.84	0.96	4.34	0.96	58	13	4.69	1.08	FALSE	0.33	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	141	30	5.64	1.20	3.85	1.21	14	4	3.33	1.05	FALSE	0.75	0.06	full	13.61	0.61
	248	34	9.92	1.36	7.52	1.37	24	4	5.87	1.07	TRUE	1.26	0.05			
	327	50	13.08	2.00	6.75	2.01	28	8	6.86	2.05	TRUE	0.40	0.01			
224-Ra																
212-Pb	1402	75	56.08	3.00	42.37	3.02	23	2	5.59	0.40	TRUE	8.49	0.37			
212-Bi	105	36	4.20	1.44	3.65	1.45	42	17	10.29	4.12	TRUE	0.15	0.00			
208-Tl	69	27	2.76	1.08	1.66	1.09	29	19	7.25	4.76	TRUE	0.08	0.00			
	329	44	13.16	1.76	9.46	1.77	20	4	5.05	0.95	TRUE	1.39	0.07			
	0	36	0.00	1.44	1.12	1.45	21	27	5.06	6.54	TRUE	0.03	0.00			
	256	22	10.24	0.88	4.97	0.89	29	5	7.06	1.28	TRUE	1.06	0.04			

Sample		Specific Activi (Bq/kg)		Concentration (% or ppm)		Dose Rates (mGy/a) Alpha	error	Beta	error	Gamm	error
Full Series	K	896	26	2.90	0.08			2.40	0.0695	0.698	0.02
WM	U	24.31	2.083	1.969	0.17	5.47	0.47	0.29	0.0246	0.226	0.02
	Th	22.33	1.641	5.504	0.40	4.07	0.30	0.16	0.0116	0.283	0.02
					Total	9.54	0.56	2.85	0.0746	1.207	0.03
Thfull/Ufull				2.80							
Pre 222Rn	U	19.02	30.39	1.54	2.46	4.28	6.84	0.23	0.3595	0.177	0.28
Post 222Rn	U	24.70	2.236	2	0.18	5.56	0.50	0.29	0.0265	0.23	0.02
Difference		-5.68	30.47	-0.46	2.47	-1.28	6.86	-0.07	0.36	-0.05	0.28

Detector	#3															
Sample	**2163b**															
Filename	2163b															
Roi file	G3nov07															
Date	24/10/07															
Time (ks)	50.00															
Mass (g)	100				Net		Specific		Concentration		Within	WM calcs				
	Counts	error	Rate (cts/ks)	error	Rate (cts/ks)	error	Activity (Bq/kg)	error		error	2 err of WM ?					
							K		%K							
40-K	5330	80	#####	1.60	98.74	1.61	1200	23	3.88	0.07						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	2006	64	40.12	1.28	6.71	1.29	45	9	3.63	0.73	TRUE	0.56	0.01	full	20.75	0.48
	2412	78	48.24	1.56	9.53	1.58	55	10	4.44	0.77	TRUE	0.61	0.01	preRn	2.39	0.05
226-Ra (23	1579	64	31.58	1.28	10.24	1.29	44	6	3.55	0.49	TRUE	1.22	0.03	postRn	18.37	0.43
214-Pb																
	1094	50	21.88	1.00	18.62	1.01	42	3	3.42	0.25	TRUE	4.28	0.10			
	1914	64	38.28	1.28	34.11	1.29	42	3	3.38	0.21	TRUE	6.02	0.14			
214-Bi	1665	67	33.30	1.34	28.33	1.35	45	3	3.65	0.25	TRUE	4.59	0.10			
	327	33	6.54	0.66	5.53	0.67	42	6	3.38	0.45	TRUE	1.38	0.03			
	179	30	3.58	0.60	3.06	0.60	66	14	5.37	1.12	TRUE	0.34	0.01			
	306	28	6.12	0.56	4.23	0.57	41	6	3.29	0.48	TRUE	1.18	0.03			
	90	32	1.80	0.64	1.04	0.65	32	20	2.55	1.60	TRUE	0.08	0.00			
210-Pb	403	35	8.06	0.70	3.56	0.71	48	10	3.85	0.79	TRUE	0.49	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	523	46	10.46	0.92	8.67	0.93	30	3	7.50	0.82	TRUE	2.77	0.09	full	28.22	1.09
	455	51	9.10	1.02	6.70	1.03	21	3	5.23	0.81	TRUE	1.97	0.09			
	589	74	11.78	1.48	5.45	1.50	22	6	5.54	1.53	TRUE	0.59	0.03			
224-Ra																
212-Pb	3114	111	62.28	2.22	48.57	2.24	26	1	6.41	0.30	TRUE	17.07	0.66			
212-Bi	148	52	2.96	1.04	2.41	1.05	28	12	6.79	2.99	TRUE	0.19	0.01			
208-Tl	75	39	1.50	0.78	0.40	0.79	7	14	1.75	3.45	TRUE	0.04	0.01			
	782	64	15.64	1.28	11.94	1.29	26	3	6.37	0.70	TRUE	3.23	0.12			
	-34	53	-0.68	1.06	0.44	1.07	8	20	1.98	4.83	TRUE	0.02	0.00			
	517	29	10.34	0.58	5.07	0.60	29	4	7.20	0.87	TRUE	2.36	0.08			

Sample		Specific Activi (Bq/kg)		Concentration (% or ppm)		Dose Rates (mGy/a) Alpha	error	Beta	error	Gamm	error
Full Series	K	1200	23	3.88	0.07			3.22	0.0611	0.935	0.02
WM	U	43.35	2.089	3.511	0.17	9.76	0.47	0.51	0.0247	0.403	0.02
	Th	25.99	0.921	6.406	0.23	4.73	0.17	0.18	0.0065	0.329	0.01
					Total	14.49	0.50	3.92	0.0662	1.668	0.03
Thfull/Ufull				1.82							
Pre 222Rn	U	46.48	19.47	3.764	1.58	10.46	4.38	0.55	0.2304	0.432	0.18
Post 222Rn	U	42.98	2.34	3.481	0.19	9.67	0.53	0.51	0.0277	0.4	0.02
Difference		3.50	19.61	0.28	1.59	0.79	4.41	0.04	0.23	0.03	0.18

Detector #3
Sample **2165**
Filename 2165
Roi file G3nov07
Date 28/10/07
Time (ks) 25.00
Mass (g) 102.40

	Counts	error	Rate (cts/ks)	error	Net Rate (cts/ks)	error	Specific Activity (Bq/kg)	error	Concentration	error	Within 2 err of WM ?	WM calcs				
							K		%K							
40-K	2067	52	82.68	2.08	74.82	2.08	888	26	2.87	0.08						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	991	44	39.64	1.76	6.23	1.77	41	12	3.29	0.95	TRUE	0.29	0.01	full	12.15	0.49
	1098	54	43.92	2.16	5.21	2.17	29	12	2.37	1.00	TRUE	0.19	0.01	preRn	1.01	0.03
226-Ra (23	703	43	28.12	1.72	6.78	1.73	28	7	2.30	0.60	TRUE	0.52	0.02	postRn	11.14	0.45
214-Pb																
	366	32	14.64	1.28	11.38	1.29	25	3	2.04	0.25	TRUE	2.58	0.10			
	641	41	25.64	1.64	21.47	1.65	26	2	2.08	0.19	TRUE	4.61	0.18			
214-Bi	476	43	19.04	1.72	14.07	1.73	22	3	1.77	0.24	TRUE	2.59	0.12			
	122	22	4.88	0.88	3.87	0.88	29	7	2.31	0.54	TRUE	0.64	0.02			
	25	21	1.00	0.84	0.48	0.84	10	18	0.82	1.45	TRUE	0.03	0.00			
	101	19	4.04	0.76	2.15	0.77	20	7	1.63	0.59	TRUE	0.38	0.02			
	62	21	2.48	0.84	1.72	0.85	51	25	4.12	2.05	TRUE	0.08	0.00			
210-Pb	178	23	7.12	0.92	2.62	0.93	34	12	2.77	0.99	TRUE	0.23	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	276	33	11.04	1.32	9.25	1.33	32	5	7.81	1.13	TRUE	1.51	0.05	full	17.38	0.57
	287	37	11.48	1.48	9.08	1.49	28	5	6.92	1.14	TRUE	1.31	0.05			
	277	52	11.08	2.08	4.75	2.09	19	8	4.71	2.08	TRUE	0.27	0.01			
224-Ra																
212-Pb	1743	79	69.72	3.16	56.01	3.18	29	2	7.22	0.42	TRUE	10.23	0.35			
212-Bi	144	37	5.76	1.48	5.21	1.49	58	17	14.34	4.17	TRUE	0.20	0.00			
208-Tl	51	27	2.04	1.08	0.94	1.09	16	19	4.01	4.64	TRUE	0.05	0.00			
	487	45	19.48	1.80	15.78	1.81	33	4	8.22	0.95	TRUE	2.24	0.07			
	36	34	1.44	1.36	2.56	1.37	46	25	11.27	6.13	TRUE	0.07	0.00			
	290	21	11.60	0.84	6.33	0.85	36	5	8.77	1.20	TRUE	1.50	0.04			

Sample		Specific Activi (Bq/kg)		Concentration (% or ppm)		Dose Rates (mGy/a) Alpha	error	Beta	error	Gamm	error
Full Series	K	888	26	2.87	0.08			2.38	0.0704	0.692	0.02
WM	U	25.04	2.061	2.028	0.17	5.64	0.46	0.30	0.0244	0.233	0.02
	Th	30.24	1.741	7.455	0.43	5.51	0.32	0.21	0.0123	0.383	0.02
					Total	11.14	0.56	2.89	0.0755	1.308	0.04
Thfull/Ufull				3.68							
Pre 222Rn	U	31.33	31.1	2.537	2.52	7.05	7.00	0.37	0.3679	0.292	0.29
Post 222Rn	U	24.59	2.207	1.992	0.18	5.53	0.50	0.29	0.0261	0.229	0.02
Difference		6.74	31.18	0.55	2.52	1.52	7.02	0.08	0.37	0.06	0.29

Detector	#3
Sample	**2166**
Filename	2166
Roi file	G3nov07
Date	28/10/07
Time (ks)	50.00
Mass (g)	100.00

	Counts	error	Rate (cts/ks)	error	Net Rate (cts/ks)	error	Specific Activity (Bq/kg)	error	Concentration	error	Within 2 err of WM ?	WM calcs				
							K		%K							
40-K	3750	70	75.00	1.40	67.14	1.41	816	19	2.64	0.06						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	1860	61	37.20	1.22	3.79	1.24	25	8	2.05	0.68	TRUE	0.36	0.01	full	20.11	0.71
	2333	75	46.66	1.50	7.95	1.52	46	9	3.70	0.73	TRUE	0.56	0.01	preRn	1.91	0.06
226-Ra (23	1418	61	28.36	1.22	7.02	1.24	30	6	2.44	0.45	TRUE	0.99	0.03	postRn	18.20	0.65
214-Pb																
	767	46	15.34	0.92	12.08	0.93	27	3	2.22	0.20	TRUE	4.29	0.16			
	1368	60	27.36	1.20	23.19	1.21	28	2	2.30	0.17	TRUE	6.68	0.24			
214-Bi	1101	64	22.02	1.28	17.05	1.29	27	2	2.19	0.20	TRUE	4.44	0.16			
	240	31	4.80	0.62	3.79	0.63	29	5	2.32	0.40	TRUE	1.16	0.04			
	143	28	2.86	0.56	2.34	0.57	51	13	4.11	1.03	TRUE	0.31	0.01			
	252	27	5.04	0.54	3.15	0.55	30	6	2.45	0.45	TRUE	1.00	0.03			
	80	32	1.60	0.64	0.84	0.65	25	20	2.06	1.60	TRUE	0.07	0.00			
210-Pb	299	32	5.98	0.64	1.48	0.65	20	9	1.60	0.71	TRUE	0.26	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	529	45	10.58	0.90	8.79	0.91	31	3	7.60	0.80	TRUE	2.93	0.09	full	30.90	1.12
	440	50	8.80	1.00	6.40	1.01	20	3	4.99	0.79	FALSE	1.95	0.10			
	750	68	15.00	1.36	8.67	1.38	36	6	8.81	1.42	TRUE	1.08	0.03			
224-Ra																
212-Pb	3212	109	64.24	2.18	50.53	2.20	27	1	6.67	0.30	TRUE	18.28	0.68			
212-Bi	55	52	1.10	1.04	0.55	1.05	6	12	1.55	2.97	TRUE	0.04	0.01			
208-Tl	158	39	3.16	0.78	2.06	0.79	36	14	8.99	3.49	TRUE	0.18	0.00			
	877	62	17.54	1.24	13.84	1.25	30	3	7.38	0.68	TRUE	3.94	0.13			
	35	51	0.70	1.02	1.82	1.03	33	19	8.19	4.72	TRUE	0.09	0.00			
	540	30	10.80	0.60	5.53	0.62	32	4	7.85	0.90	TRUE	2.40	0.08			

Sample		Specific Activi (Bq/kg)		Concentration (% or ppm)		Dose Rates (mGy/a) Alpha	error	Beta	error	Gamm	error
Full Series	K	816	19	2.64	0.06			2.19	0.0506	0.636	0.01
WM	U	28.33	1.409	2.294	0.11	6.38	0.32	0.34	0.0167	0.264	0.01
	Th	27.63	0.894	6.81	0.22	5.03	0.16	0.19	0.0063	0.35	0.01
					Total	11.41	0.36	2.72	0.0537	1.249	0.02
Thfull/Ufull				2.97							
Pre 222Rn	U	32.16	16.85	2.604	1.36	7.24	3.79	0.38	0.1994	0.299	0.16
Post 222Rn	U	27.98	1.537	2.266	0.12	6.30	0.35	0.33	0.0182	0.26	0.01
Difference		4.18	16.92	0.34	1.37	0.94	3.81	0.05	0.20	0.04	0.16

Detector #3
Sample **2167**
Filename 2167
Roi file G3nov07
Date 29/10/07
Time (ks) 25.00
Mass (g) 88.60

	Counts	error	Rate (cts/ks)	error	Net Rate (cts/ks)	error	Specific Activity (Bq/kg)	error	Concentration	error	Within 2 err of WM ?	WM calcs				
							K		%K							
40-K	1689	45	67.56	1.80	59.70	1.81	819	26	2.65	0.08						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	992	43	39.68	1.72	6.27	1.73	47	13	3.83	1.08	TRUE	0.27	0.01	full	11.62	0.33
	1101	53	44.04	2.12	5.33	2.13	35	14	2.80	1.13	TRUE	0.18	0.01	preRn	0.99	0.02
226-Ra (23	744	43	29.76	1.72	8.42	1.73	41	9	3.30	0.70	TRUE	0.55	0.01	postRn	10.62	0.31
214-Pb																
	429	32	17.16	1.28	13.90	1.29	36	4	2.88	0.30	TRUE	2.52	0.07			
	756	42	30.24	1.68	26.07	1.69	36	3	2.92	0.24	TRUE	4.12	0.11			
214-Bi	604	43	24.16	1.72	19.19	1.73	34	4	2.79	0.29	TRUE	2.72	0.08			
	101	21	4.04	0.84	3.03	0.84	26	7	2.09	0.59	TRUE	0.48	0.02			
	22	20	0.88	0.80	0.36	0.80	9	20	0.71	1.60	TRUE	0.02	0.00			
	138	19	5.52	0.76	3.63	0.77	39	9	3.19	0.69	TRUE	0.54	0.01			
	39	19	1.56	0.76	0.80	0.77	27	26	2.22	2.13	TRUE	0.04	0.00			
210-Pb	176	23	7.04	0.92	2.54	0.93	38	14	3.10	1.14	TRUE	0.19	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	229	31	9.16	1.24	7.37	1.25	29	5	7.19	1.23	TRUE	1.18	0.04	full	12.52	0.46
	199	35	7.96	1.40	5.56	1.41	20	5	4.90	1.24	TRUE	0.78	0.04			
	281	49	11.24	1.96	4.91	1.97	23	9	5.63	2.27	TRUE	0.27	0.01			
224-Ra																
212-Pb	1536	77	61.44	3.08	47.73	3.10	29	2	7.11	0.47	TRUE	8.01	0.28			
212-Bi	76	35	3.04	1.40	2.49	1.41	32	18	7.92	4.50	TRUE	0.10	0.00			
208-Tl	36	27	1.44	1.08	0.34	1.09	7	22	1.68	5.36	TRUE	0.01	0.00			
	423	43	16.92	1.72	13.22	1.73	32	4	7.96	1.05	TRUE	1.78	0.06			
	-35	35	-1.40	1.40	-0.28	1.41	-6	-29	-1.42	-7.16	FALSE	-0.01	0.00			
	183	22	7.32	0.88	2.05	0.89	13	6	3.29	1.43	FALSE	0.40	0.03			

Sample		Specific Activi (Bq/kg)		Concentration (% or ppm)		Dose Rates (mGy/a) Alpha	error	Beta	error	Gamm	error
Full Series	K	819	26	2.65	0.08			2.20	0.0698	0.638	0.02
WM	U	35.27	3.037	2.857	0.25	7.94	0.68	0.42	0.0359	0.328	0.03
	Th	27.21	2.173	6.706	0.54	4.96	0.40	0.19	0.0153	0.345	0.03
					Total	12.89	0.79	2.81	0.08	1.311	0.04
Thfull/Ufull				2.35							
Pre 222Rn	U	40.97	41.31	3.318	3.35	9.22	9.30	0.48	0.4888	0.381	0.38
Post 222Rn	U	34.82	3.278	2.82	0.27	7.84	0.74	0.41	0.0388	0.324	0.03
Difference		6.15	41.44	0.50	3.36	1.38	9.33	0.07	0.49	0.06	0.39

Detector	#3
Sample	**2168**
Filename	2168
Roi file	G3nov07
Date	29/10/07
Time (ks)	50.00
Mass (g)	100.00

	Counts	error	Rate (cts/ks)	error	Net Rate (cts/ks)	error	Specific Activity (Bq/kg)	error	Concentration	error	Within 2 err of WM ?	WM calcs				
							K		%K							
40-K	4133	71	82.66	1.42	74.80	1.43	909	19	2.94	0.06						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	1827	62	36.54	1.24	3.13	1.25	21	8	1.69	0.69	TRUE	0.29	0.01	full	19.03	0.77
	2077	75	41.54	1.50	2.83	1.52	16	9	1.32	0.71	TRUE	0.21	0.01	preRn	1.46	0.06
226-Ra (23	1404	61	28.08	1.22	6.74	1.24	29	6	2.34	0.45	TRUE	0.96	0.03	postRn	17.57	0.71
214-Pb																
	688	45	13.76	0.90	10.50	0.91	24	2	1.93	0.19	TRUE	4.16	0.17			
	1266	59	25.32	1.18	21.15	1.19	26	2	2.10	0.16	TRUE	6.75	0.26			
214-Bi	1014	62	20.28	1.24	15.31	1.25	24	2	1.97	0.19	TRUE	4.44	0.18			
	179	31	3.58	0.62	2.57	0.63	19	5	1.57	0.39	TRUE	0.83	0.04			
	89	28	1.78	0.56	1.26	0.57	27	12	2.21	1.00	TRUE	0.18	0.01			
	240	28	4.80	0.56	2.91	0.57	28	6	2.27	0.46	TRUE	0.87	0.03			
	64	33	1.28	0.66	0.52	0.67	16	20	1.28	1.64	TRUE	0.04	0.00			
210-Pb	314	32	6.28	0.64	1.78	0.65	24	9	1.92	0.71	TRUE	0.31	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	460	45	9.20	0.90	7.41	0.91	26	3	6.41	0.80	TRUE	2.49	0.10	full	33.41	1.10
	646	50	12.92	1.00	10.52	1.01	33	3	8.21	0.80	TRUE	3.14	0.09			
	805	69	16.10	1.38	9.77	1.40	40	6	9.93	1.44	TRUE	1.18	0.03			
224-Ra																
212-Pb	3384	110	67.68	2.20	53.97	2.22	29	1	7.13	0.30	TRUE	19.04	0.66			
212-Bi	158	51	3.16	1.02	2.61	1.03	30	12	7.36	2.94	TRUE	0.21	0.01			
208-Tl	163	39	3.26	0.78	2.16	0.79	38	14	9.43	3.49	TRUE	0.19	0.00			
	932	63	18.64	1.26	14.94	1.27	32	3	7.97	0.69	TRUE	4.11	0.13			
	-21	52	-0.42	1.04	0.70	1.05	13	19	3.15	4.75	TRUE	0.03	0.00			
	598	29	11.96	0.58	6.69	0.60	39	4	9.50	0.88	FALSE	3.01	0.08			

Sample		Specific Activi		Concentration		Dose Rates (mGy/a)					
		(Bq/kg)		(% or ppm)		Alpha	error	Beta	error	Gamm	error
Full Series	K	909	19	2.94	0.06			2.44	0.0523	0.708	0.02
WM	U	24.62	1.293	1.993	0.10	5.54	0.29	0.29	0.0153	0.229	0.01
	Th	30.43	0.911	7.5	0.22	5.54	0.17	0.21	0.0064	0.386	0.01
					Total	11.08	0.34	2.95	0.0549	1.323	0.02
Thfull/Ufull				3.76							
Pre 222Rn	U	24.30	16.67	1.968	1.35	5.47	3.75	0.29	0.1972	0.226	0.16
Post 222Rn	U	24.64	1.402	1.996	0.11	5.55	0.32	0.29	0.0166	0.229	0.01
Difference		-0.34	16.72	-0.03	1.35	-0.08	3.76	0.00	0.20	0.00	0.16

Detector	#3															
Sample	**2169**															
Filename	2169															
Roi file	G3nov07															
Date	30/10/07															
Time (ks)	25.00															
Mass (g)	91.60				Net		Specific		Concentration		Within	WM calcs				
	Counts	error	Rate (cts/ks)	error	Rate (cts/ks)	error	Activity (Bq/kg)	error		error	2 err of WM ?					
							K		%K							
40-K	1718	48	68.72	1.92	60.86	1.92	807	27	2.61	0.09						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	926	44	37.04	1.76	3.63	1.77	26	13	2.15	1.05	TRUE	0.16	0.01	full	11.83	0.33
	1153	54	46.12	2.16	7.41	2.17	47	14	3.77	1.12	TRUE	0.24	0.01	preRn	1.02	0.02
226-Ra (23	781	44	31.24	1.76	9.90	1.77	46	9	3.75	0.70	TRUE	0.62	0.01	postRn	10.80	0.31
214-Pb																
	426	33	17.04	1.32	13.78	1.33	34	4	2.77	0.30	TRUE	2.47	0.07			
	773	43	30.92	1.72	26.75	1.73	36	3	2.90	0.24	TRUE	4.16	0.12			
214-Bi	627	45	25.08	1.80	20.11	1.81	35	4	2.83	0.29	TRUE	2.69	0.08			
	150	22	6.00	0.88	4.99	0.88	41	8	3.33	0.62	TRUE	0.71	0.02			
	66	20	2.64	0.80	2.12	0.80	50	19	4.06	1.57	TRUE	0.13	0.00			
	115	21	4.60	0.84	2.71	0.84	28	9	2.30	0.73	TRUE	0.35	0.01			
	95	18	3.80	0.72	3.04	0.73	101	25	8.14	2.05	FALSE	0.16	0.00			
210-Pb	151	22	6.04	0.88	1.54	0.89	22	13	1.82	1.05	TRUE	0.13	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	240	32	9.60	1.28	7.81	1.29	30	5	7.38	1.22	TRUE	1.21	0.04	full	16.47	0.48
	323	34	12.92	1.36	10.52	1.37	36	5	8.96	1.18	TRUE	1.60	0.04			
	400	48	16.00	1.92	9.67	1.93	44	9	10.73	2.16	TRUE	0.57	0.01			
224-Ra																
212-Pb	1777	78	71.08	3.12	57.37	3.14	34	2	8.27	0.46	TRUE	9.59	0.29			
212-Bi	118	36	4.72	1.44	4.17	1.45	52	18	12.83	4.51	TRUE	0.16	0.00			
208-Tl	101	28	4.04	1.12	2.94	1.13	57	22	14.01	5.43	TRUE	0.12	0.00			
	418	44	16.72	1.76	13.02	1.77	31	4	7.58	1.04	TRUE	1.74	0.06			
	56	34	2.24	1.36	3.36	1.37	67	28	16.51	6.94	TRUE	0.08	0.00			
	316	22	12.64	0.88	7.37	0.89	46	6	11.42	1.41	FALSE	1.41	0.03			

Sample		Specific Activi (Bq/kg)		Concentration (% or ppm)		Dose Rates (mGy/a) Alpha	error	Beta	error	Gamm	error
Full Series	K	807	27	2.61	0.09			2.17	0.0717	0.629	0.02
WM	U	35.84	3.03	2.902	0.25	8.07	0.68	0.42	0.0359	0.333	0.03
	Th	34.57	2.099	8.52	0.52	6.30	0.38	0.24	0.0148	0.438	0.03
					Total	14.36	0.78	2.83	0.0815	1.401	0.04
Thfull/Ufull				2.94							
Pre 222Rn	U	41.59	40.69	3.368	3.30	9.36	9.16	0.49	0.4814	0.387	0.38
Post 222Rn	U	35.37	3.274	2.865	0.27	7.96	0.74	0.42	0.0387	0.329	0.03
Difference		6.22	40.82	0.50	3.31	1.40	9.19	0.07	0.48	0.06	0.38

Detector	#3
Sample	**2170**
Filename	2170
Roi file	G3nov07
Date	30/10/07
Time (ks)	50.00
Mass (g)	100.00

	Counts	error	Rate (cts/ks)	error	Net Rate (cts/ks)	error	Specific Activity (Bq/kg)	error	Concentration	error	Within 2 err of WM ?	WM calcs				
							K		%K							
40-K	4069	72	81.38	1.44	73.52	1.45	893	20	2.89	0.06						
238-U							238U		ppm eU	error		x/sigm	1/sigm	sum		
234-Th	1955	62	39.10	1.24	5.69	1.25	38	9	3.08	0.70	TRUE	0.51	0.01	full	20.42	0.73
	2365	76	47.30	1.52	8.59	1.54	49	9	4.00	0.75	FALSE	0.58	0.01	preRn	2.05	0.06
226-Ra (23	1391	60	27.82	1.20	6.48	1.22	28	5	2.25	0.44	TRUE	0.95	0.03	postRn	18.37	0.67
214-Pb																
	765	46	15.30	0.92	12.04	0.93	27	3	2.21	0.20	TRUE	4.28	0.16			
	1342	59	26.84	1.18	22.67	1.19	28	2	2.25	0.16	TRUE	6.79	0.24			
214-Bi	1097	61	21.94	1.22	16.97	1.23	27	2	2.18	0.19	TRUE	4.72	0.18			
	226	32	4.52	0.64	3.51	0.65	26	5	2.15	0.41	TRUE	1.03	0.04			
	76	29	1.52	0.58	1.00	0.58	22	13	1.75	1.04	TRUE	0.13	0.01			
	230	27	4.60	0.54	2.71	0.55	26	5	2.11	0.44	TRUE	0.88	0.03			
	62	31	1.24	0.62	0.48	0.63	15	19	1.18	1.54	TRUE	0.04	0.00			
210-Pb	396	34	7.92	0.68	3.42	0.69	46	10	3.70	0.77	TRUE	0.50	0.01			
232-Th							232Th		ppm eTh	error				sum		
228-Ac	424	44	8.48	0.88	6.69	0.89	23	3	5.79	0.78	TRUE	2.36	0.10	full	32.97	1.11
	653	48	13.06	0.96	10.66	0.97	34	3	8.32	0.77	TRUE	3.44	0.10			
	678	71	13.56	1.42	7.23	1.44	30	6	7.35	1.47	TRUE	0.84	0.03			
224-Ra																
212-Pb	3441	110	68.82	2.20	55.11	2.22	30	1	7.28	0.30	TRUE	19.39	0.66			
212-Bi	226	52	4.52	1.04	3.97	1.05	45	12	11.19	3.03	TRUE	0.30	0.01			
208-Tl	193	39	3.86	0.78	2.76	0.79	49	14	12.05	3.52	TRUE	0.24	0.00			
	962	63	19.24	1.26	15.54	1.27	34	3	8.29	0.69	TRUE	4.26	0.13			
	13	51	0.26	1.02	1.38	1.03	25	19	6.21	4.69	TRUE	0.07	0.00			
	484	29	9.68	0.58	4.41	0.60	25	4	6.26	0.86	TRUE	2.07	0.08			

Sample		Specific Activi (Bq/kg)		Concentration (% or ppm)		Dose Rates (mGy/a) Alpha	error	Beta	error	Gamm	error
Full Series	K	893	20	2.89	0.06			2.40	0.0527	0.696	0.02
WM	U	28.05	1.374	2.272	0.11	6.31	0.31	0.33	0.0163	0.261	0.01
	Th	29.71	0.901	7.323	0.22	5.41	0.16	0.21	0.0064	0.376	0.01
					Total	11.72	0.35	2.94	0.0555	1.334	0.02
Thfull/Ufull				3.22							
Pre 222Rn	U	34.38	16.81	2.784	1.36	7.74	3.78	0.41	0.1989	0.32	0.16
Post 222Rn	U	27.49	1.496	2.226	0.12	6.19	0.34	0.33	0.0177	0.256	0.01
Difference		6.90	16.88	0.56	1.37	1.55	3.80	0.08	0.20	0.06	0.16

C.3. Field Gamma Spectrometry

File	:	e:\rainbow\new1.asc					
Live	time	(s)	600				
Energy	calibration	coefficients					
	b1=	43.25188					
	b2=	2.931298					
	b3=	0					
E	=	450	keV	in	Ch		138
Integrated	counts,	count	rates	(cps)			
Total	spectrum	:	57759	96.265			
E>450	keV	:	24649	41.08167			
E>1350	keV	:	4740	7.9			
Energy	integral	:	3.23E+07	keV			
Energy	deposition	rate	:	53816	keV/s		
Mean	energy	per	photon	detected	:		559.0401
Dose	Rate	(mGy/a)	-	>450		0.801093	4.14E-02
Dose	Rate	(mGy/a)	-	>1350		0.84135	4.13E-02
Dose	rate	(mGy/a)	-	energy		0.825537	4.14E-02

File	:	e:\rainbow\new2.asc					
Live	time	(s)	600				
Energy	calibration	coefficients					
	b1=	19.77891					
	b2=	2.96144					
	b3=	0					
E	=	450	keV	in	Ch		145
Integrated	counts,	count	rates	(cps)			
Total	spectrum	:	61702	102.8367			
E>450	keV	:	24937	41.56167			
E>1350	keV	:	4818	8.03			
Energy	integral	:	3.32E+07	keV			
Energy	deposition	rate	:	55272.59	keV/s		
Mean	energy	per	photon	detected	:		537.4794
Dose	Rate	(mGy/a)	-	>450		0.810453	4.19E-02
Dose	Rate	(mGy/a)	-	>1350		0.855195	4.20E-02
Dose	rate	(mGy/a)	-	energy		0.847882	4.26E-02

File	:	e:\rainbow\new3.asc					
Live	time	(s)	600				
Energy	calibration	coefficients					
	b1=	41.48875					
	b2=	2.887218					
	b3=	0					
E	=	450	keV	in	Ch		141
Integrated	counts,	count	rates	(cps)			
Total	spectrum	:	65479	109.1317			
E>450	keV	:	27329	45.54833			
E>1350	keV	:	5417	9.028333			
Energy	integral	:	3.64E+07	keV			
Energy	deposition	rate	:	60624.69	keV/s		
Mean	energy	per	photon	detected	:		555.5187
Dose	Rate	(mGy/a)	-	>450		0.888193	4.59E-02
Dose	Rate	(mGy/a)	-	>1350		0.961518	4.70E-02
Dose	rate	(mGy/a)	-	energy		0.929983	4.67E-02

File	:	e:\rainbow\new4.asc				
Live	time	(s)	600			
Energy	calibration	coefficients				
	b1=	21.28536				
	b2=	2.858561				
	b3=	0				
E	=	450	keV	in	Ch	149
Integrated	counts,	count	rates	(cps)		
Total	spectrum	:	65254	108.7567		
E>450	keV	:	25933	43.22167		
E>1350	keV	:	5072	8.453333		
Energy	integral	:	3.45E+07	keV		
Energy	deposition	rate	:	57522.52	keV/s	
Mean	energy	per	photon	detected	:	528.9103
Dose	Rate	(mGy/a)	-	>450	0.842823	4.35E-02
Dose	Rate	(mGy/a)	-	>1350	0.90028	4.41E-02
Dose	rate	(mGy/a)	-	energy	0.882395	0.044293

File	:	e:\rainbow\new5.asc				
Live	time	(s)	600			
Energy	calibration	coefficients				
	b1=	0.639442				
	b2=	2.946291				
	b3=	0				
E	=	450	keV	in	Ch	152
Integrated	counts,	count	rates	(cps)		
Total	spectrum	:	72452	120.7533		
E>450	keV	:	28087	46.81167		
E>1350	keV	:	5688	9.48		
Energy	integral	:	3.78E+07	keV		
Energy	deposition	rate	:	62945.28	keV/s	
Mean	energy	per	photon	detected	:	521.2716
Dose	Rate	(mGy/a)	-	>450	0.912828	4.71E-02
Dose	Rate	(mGy/a)	-	>1350	1.00962	4.93E-02
Dose	rate	(mGy/a)	-	energy	0.965581	4.85E-02

File	:	e:\rainbow\new6.asc				
Live	time	(s)	600			
Energy	calibration	coefficients				
	b1=	39.95509				
	b2=	2.872818				
	b3=	0				
E	=	450	keV	in	Ch	142
Integrated	counts,	count	rates	(cps)		
Total	spectrum	:	66510	110.85		
E>450	keV	:	27496	45.82667		
E>1350	keV	:	5301	8.835		
Energy	integral	:	3.65E+07	keV		
Energy	deposition	rate	:	60799.41	keV/s	
Mean	energy	per	photon	detected	:	548.4837
Dose	Rate	(mGy/a)	-	>450	0.89362	4.61E-02
Dose	Rate	(mGy/a)	-	>1350	0.940928	4.60E-02
Dose	rate	(mGy/a)	-	energy	0.932663	0.046816

File	:	e:\rainbow\new7.asc					
Live	time	(s)	600				
Energy	calibration	coefficients					
	b1=	63.55224					
	b2=	2.865672					
	b3=	0					
E	=	450	keV	in	Ch		134
Integrated	counts,	count	rates	(cps)			
Total	spectrum	:	92352	153.92			
E>450	keV	:	42158	70.26333			
E>1350	keV	:	7860	13.1			
Energy	integral	:	5.39E+07	keV			
Energy	deposition	rate	:	89809.99	keV/s		
Mean	energy	per	photon	detected	:		583.4848
Dose	Rate	(mGy/a)	-	>450		1.370135	0.07058
Dose	Rate	(mGy/a)	-	>1350		1.39515	6.74E-02
Dose	rate	(mGy/a)	-	energy		1.377685	6.92E-02

File	:	e:\rainbow\new8.asc					
Live	time	(s)	600				
Energy	calibration	coefficients					
	b1=	7.306108					
	b2=	2.938776					
	b3=	0					
E	=	450	keV	in	Ch		150
Integrated	counts,	count	rates	(cps)			
Total	spectrum	:	80018	133.3633			
E>450	keV	:	31643	52.73833			
E>1350	keV	:	6399	10.665			
Energy	integral	:	4.23E+07	keV			
Energy	deposition	rate	:	70435.65	keV/s		
Mean	energy	per	photon	detected	:		528.1485
Dose	Rate	(mGy/a)	-	>450		1.028398	5.31E-02
Dose	Rate	(mGy/a)	-	>1350		1.135823	0.055183
Dose	rate	(mGy/a)	-	energy		1.080483	0.054236

File	:	e:\rainbow\new9.asc					
Live	time	(s)	600				
Energy	calibration	coefficients					
	b1=	41.88752					
	b2=	2.946291					
	b3=	0					
E	=	450	keV	in	Ch		138
Integrated	counts,	count	rates	(cps)			
Total	spectrum	:	74150	123.5833			
E>450	keV	:	31883	53.13833			
E>1350	keV	:	6348	10.58			
Energy	integral	:	4.21E+07	keV			
Energy	deposition	rate	:	70214.59	keV/s		
Mean	energy	per	photon	detected	:		568.1558
Dose	Rate	(mGy/a)	-	>450		1.036198	5.35E-02
Dose	Rate	(mGy/a)	-	>1350		1.12677	5.48E-02
Dose	rate	(mGy/a)	-	energy		1.077092	5.41E-02

File	:	e:\rainbow\new10.asc					
Live	time	(s)	600				
Energy	calibration	coefficients					
	b1=	45.27269					
	b2=	2.909091					
	b3=	0					
E	=	450	keV	in	Ch		139
Integrated	counts,	count	rates	(cps)			
Total	spectrum	:	72485	120.8083			
E>450	keV	:	30920	51.53333			
E>1350	keV	:	6056	10.09333			
Energy	integral	:	4.10E+07	keV			
Energy	deposition	rate	:	68379.36	keV/s		
Mean	energy	per	photon	detected	:		566.0153
Dose	Rate	(mGy/a)	-	>450		1.0049	5.18E-02
Dose	Rate	(mGy/a)	-	>1350		1.07494	0.052323
Dose	rate	(mGy/a)	-	energy		1.048939	5.27E-02

File	:	e:\rainbow\new11.asc					
Live	time	(s)	600				
Energy	calibration	coefficients					
	b1=	13.77144					
	b2=	2.992208					
	b3=	0					
E	=	450	keV	in	Ch		145
Integrated	counts,	count	rates	(cps)			
Total	spectrum	:	71465	119.1083			
E>450	keV	:	29406	49.01			
E>1350	keV	:	5951	9.918333			
Energy	integral	:	3.90E+07	keV			
Energy	deposition	rate	:	64958.14	keV/s		
Mean	energy	per	photon	detected	:		545.3702
Dose	Rate	(mGy/a)	-	>450		0.955695	4.93E-02
Dose	Rate	(mGy/a)	-	>1350		1.056302	5.14E-02
Dose	rate	(mGy/a)	-	energy		0.996458	5.00E-02

File	:	e:\rainbow\new12.asc					
Live	time	(s)	600				
Energy	calibration	coefficients					
	b1=	8.429333					
	b2=	3.015707					
	b3=	0					
E	=	450	keV	in	Ch		146
Integrated	counts,	count	rates	(cps)			
Total	spectrum	:	73499	122.4983			
E>450	keV	:	29906	49.84333			
E>1350	keV	:	6136	10.22667			
Energy	integral	:	3.98E+07	keV			
Energy	deposition	rate	:	66407.26	keV/s		
Mean	energy	per	photon	detected	:		542.1075
Dose	Rate	(mGy/a)	-	>450		0.971945	5.02E-02
Dose	Rate	(mGy/a)	-	>1350		1.08914	0.05299
Dose	rate	(mGy/a)	-	energy		1.018687	5.11E-02

C.4. Cosmic dose rate

Sample Number SUERC	Field	Approx. Latitude N	Prescott & Stephan (1982) Parameters for Eqn. 1[a.] Read from Fig. 2 *F*	*J*	*H*	Approx. Altitude (km)	Surface Cosmic Dose Rate (Gy/ka)	Depth below surface (cm)[b.]	Present Cosmic Dose Rate (Gy/ka)[c,d]	Representative Values (Est. from context and age) Depth below surface Estimation	Estimated (cm)	Cosmic Dose Rate (Gy/ka)[c,d,e]
SUTL 2157	NEW S1#1	54	0.24	0.77	4.10	0.05	0.294	24	0.24	.=present/2	12	0.27 ± 0.03
SUTL 2158	NEW S1#2	54	0.24	0.77	4.10	0.05	0.294	84	0.20	.=present/2	42	0.22 ± 0.04
SUTL 2159	NEW S1#3	54	0.24	0.77	4.10	0.05	0.294	103	0.19	.=present/2	52	0.22 ± 0.03
SUTL 2160	NEW S1#4	54	0.24	0.77	4.10	0.05	0.294	123	0.19	.=present/2	62	0.21 ± 0.03
SUTL 2161	NEW S1#5	54	0.24	0.77	4.10	0.05	0.294	148	0.18	.=present/2	74	0.20 ± 0.03
SUTL 2162	NEW S1#6	54	0.24	0.77	4.10	0.05	0.294	101	0.19	.=present/2	51	0.22 ± 0.03
SUTL 2163a	NEW Pit1#1a	54	0.24	0.77	4.10	0.05	0.294	*20*	0.25	.=present*2	40	0.23 ± 0.01
SUTL 2163b	NEW Pit1#1b	54	0.24	0.77	4.10	0.05	0.294	*20*	0.25	.=present*2	40	0.23 ± 0.01
SUTL 2165	NEW S2#1	54	0.24	0.77	4.10	0.05	0.294	33	0.23	.=present/2	17	0.26 ± 0.04
SUTL 2166	NEW S2#2	54	0.24	0.77	4.10	0.05	0.294	91	0.20	.=present/2	46	0.22 ± 0.04
SUTL 2167	NEW S2#3	54	0.24	0.77	4.10	0.05	0.294	111	0.19	.=present/2	56	0.21 ± 0.03
SUTL 2168	NEW S2#4	54	0.24	0.77	4.10	0.05	0.294	131	0.19	.=present/2	66	0.21 ± 0.03
SUTL 2169	NEW S2#5	54	0.24	0.77	4.10	0.05	0.294	157	0.18	.=present/2	79	0.20 ± 0.03
SUTL 2170	NEW S2#6	54	0.24	0.77	4.10	0.05	0.294	165	0.18	.=present/2	83	0.20 ± 0.03

a. Cosmic dose rate as a fn. of altitude = K*(F+J*exp(h/H)): h = altitude (km) (Prescott & Stephan, 1982)

b. Depth values in normal text were quoted in fieldwork notes, those in italics were inferred from photos and notes

c. Sediment bulk density assumed = 1.6 g/cm^3

d. Cosmic dose rate as a fn. of depth =0.08*EXP(-0.02*(d*1.6))+0.21*EXP(-0.0007*(d*1.6)+0.00000008*(d*1.6)^2): d = mass depth (g/cm2), parameters from fit to data in Prescott and Hutton (1988)

e. Estimated error = 5%Dcrep. + |Dcpresent-Dcrep.|

C.5. Water content

Sample Number SUERC	Sample Number Field	Subsample for Water Content Determinations: Sample From	"InSitu" date	Mass inc.T&G (g)	Sat. Soak date	Mass inc.T&G (g)	DUL Drip Dry date	Mass inc.T&G (g)	Dry date	Mass inc.T&G (g)	Tube + Gauze (g)	Water Content as Mass Fraction: ISWC/ Dry Sed	SatWC/ Dry Sed	DULWC/ Dry Sed	Expected Burial (IS+DUL)/2
SUTL 2157	NEW S1#1	all, in tube	110907	348.7	110907	392.6	160907	381.6	041007	332.9	215.7	0.13	0.51	0.42	0.28 ± 0.10
SUTL 2158	NEW S1#2	all, in tube	110907	385.3	110907	423.9	160907	417.5	041007	356.8	217.8	0.21	0.48	0.44	0.32 ± 0.08
SUTL 2159	NEW S1#3	all, in tube	110907	367.8	110907	398.4	160907	393.5	041007	335.1	216.7	0.28	0.53	0.49	0.38 ± 0.08
SUTL 2160	NEW S1#4	all, in tube	110907	366.7	110907	399.6	160907	394.6	041007	340.3	217.2	0.21	0.48	0.44	0.33 ± 0.08
SUTL 2161	NEW S1#5	all, in tube	110907	424.9	110907	450.9	160907	446.9	041007	393.6	218.1	0.18	0.33	0.30	0.24 ± 0.04
SUTL 2162	NEW S1#6	all, in tube	110907	386.4	110907	421.9	160907	415.9	041007	367.8	217.8	0.12	0.36	0.32	0.22 ± 0.07
SUTL 2163a	NEW Pit1#1a	all, in pot	280607	218.2	-	-	-	-	170707	183.8	20	*0.21*	-	-	*0.32* ± *0.10*
SUTL 2163b	NEW Pit1#1b	all, in pot	280607	178.3	-	-	-	-	170707	149.0	20	*0.23*	-	-	*0.34* ± *0.10*
SUTL 2165	NEW S2#1	all, in tube	110907	363.0	110907	406.2	160907	396.8	041007	347.2	218.3	0.12	0.46	0.38	0.25 ± 0.09
SUTL 2166	NEW S2#2	all, in tube	110907	374.3	110907	412.7	160907	403.6	041007	347.2	217	0.21	0.50	0.43	0.32 ± 0.08
SUTL 2167	NEW S2#3	all, in tube	110907	372.1	110907	406.4	160907	399.8	041007	343.5	217.2	0.23	0.50	0.45	0.34 ± 0.08
SUTL 2168	NEW S2#4	all, in tube	110907	398.2	110907	427.6	160907	433.4	041007	372.4	216.3	0.17	0.35	0.39	0.28 ± 0.08
SUTL 2169	NEW S2#5	all, in tube	110907	390.2	110907	418.2	160907	417.2	041007	351.0	218.1	0.29	0.51	0.50	0.40 ± 0.07
SUTL 2170	NEW S2#6	all, in tube	110907	416.6	110907	439.1	160907	410.1	041007	384.1	217.6	0.20	0.33	0.16	0.18 ± 0.01

Appendix D. Equivalent dose determinations

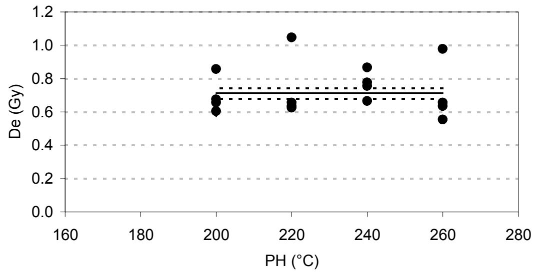
Sample SUTL 2157
Date 91107 to 121107
Reader Riso 1
Source Calibration 0.1007 ± 0.0017 Gy/s
Regenerative Dose Sequence (Gy)

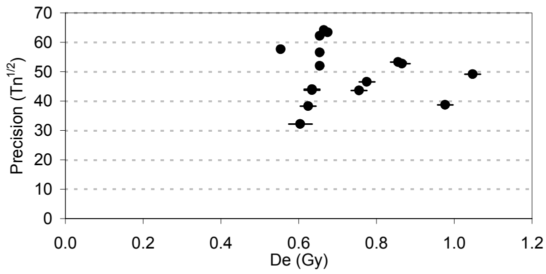
Dn	D1	D2	D3	D4	D5	D6	D7	D8	D9
0.00	4.02	0.00	1.00	7.04	10.06	4.02	4.02	0.00	0.00

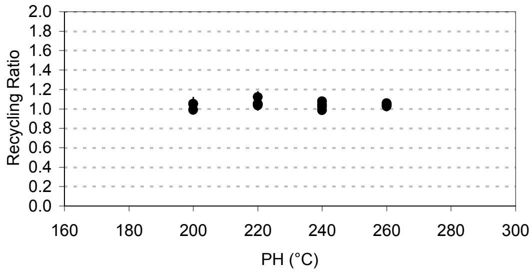
Test Dose (Gy) 2.00

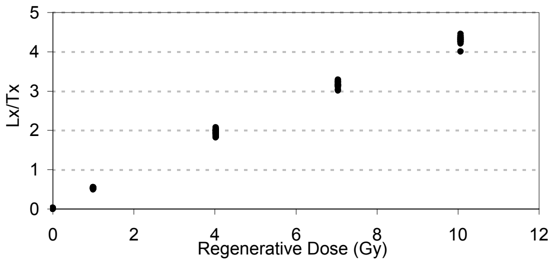
Measurement	Signal	Background
OSL 60s@125°C, 240Cl	11-30	191-230
IRSL 120s@50°C, 240C	11-30	191-230

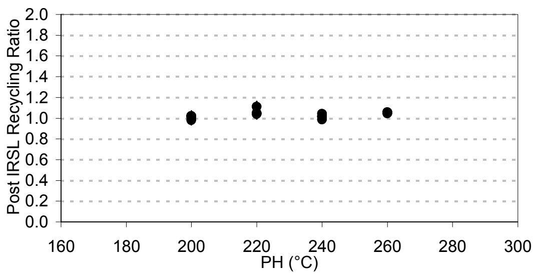
Aliquot	Preheat	Aliquot Mass	Sensitivity (cps/	Change	Dose Response		Recycling Point 4.02	Gy	Post IRSL 4.02	Gy	Zero Dose 0.00	Gy	Equivalent Dose		AMC Robust Statistics V1.(	
	(°C/30s)	(g)	mg/Gy)	(frn.)	D0 (Gy)	Err	ratio	error	ratio	error	ratio	error	(Gy)	error	ROBUST STATISTICS SU	
															Estimate	*Estimate value*
1	200	6.6	215	1.2	23	2.9	1.05	0.04	1.02	0.04	0.000	0.007	0.856	0.020	*Median*	0.65971
2	200	-2.1	-953	1.2	27	2.8	1.05	0.03	1.02	0.03	0.000	0.005	0.675	0.010	*A15 mea*	0.68239
3	200	4.7	340	1.0	24	2.8	0.99	0.04	0.98	0.04	0.005	0.005	0.655	0.010	*H15 mea*	0.7127
4	200	-2.0	-258	1.3	21	3.8	1.05	0.07	1.00	0.07	0.018	0.012	0.604	0.030	*MAD*	0.04532
5	220	-3.2	-229	1.4	20	2.4	1.12	0.05	1.11	0.05	0.005	0.008	0.624	0.020	*MADe*	0.0672
6	220	4.8	199	1.5	34	6.7	1.04	0.05	1.04	0.05	0.005	0.008	0.635	0.020	*sMAD*	0.0672
7	220	4.3	449	1.5	22	1.7	1.05	0.03	1.05	0.03	0.001	0.004	0.655	0.010	*H15 Std*	0.12717
8	220	-2.2	-548	1.0	25	3.6	1.05	0.05	1.04	0.05	0.008	0.007	1.047	0.020		
9	240	4.3	251	1.6	20	1.9	1.08	0.04	1.01	0.04	0.008	0.005	0.776	0.020		
10	240	4.6	446	1.8	26	1.9	1.04	0.03	1.04	0.03	0.006	0.003	0.665	0.010		
11	240	4.4	216	2.0	24	2.7	1.02	0.04	1.02	0.04	0.011	0.006	0.755	0.020		
12	240	8.0	173	2.0	22	1.8	0.99	0.03	0.99	0.03	0.009	0.004	0.866	0.020		
13	260	4.0	336	2.2	30	2.9	1.05	0.03	1.05	0.03	0.007	0.003	0.655	0.010		
14	260	4.0	414	2.2	27	2.2	1.04	0.03	1.06	0.03	0.008	0.003	0.554	0.010		
15	260	4.6	210	2.3	24	2.3	1.06	0.04	1.04	0.04	0.007	0.005	0.635	0.020		
16	260	2.4	311	2.2	21	2.0	1.02	0.04	1.05	0.04	0.007	0.005	0.977	0.020		
													n =	16	n =	16
Mean		3.0	98	1.6	24.3		1.04		1.03		0.007	Mean	0.727	Internal	H15 mean	0.713
SD		3.4	395	0.4	3.9		0.03		0.03		0.004	SD	0.141	Error	H15 Std Dev	0.127
SD/rtN		0.8	99	0.1	1.0		0.01		0.01		0.001	SD/rtN	0.035	0.004	SD/rtN	0.032
%err		29	101	7	4		1		1		16	%err	5		%err	4

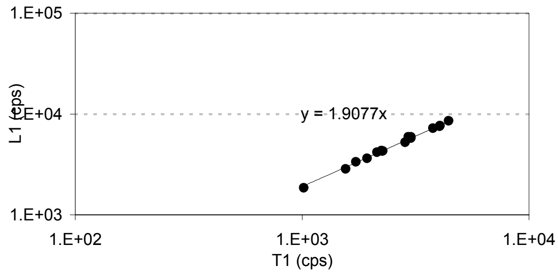


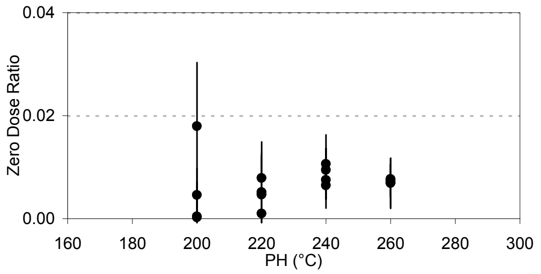


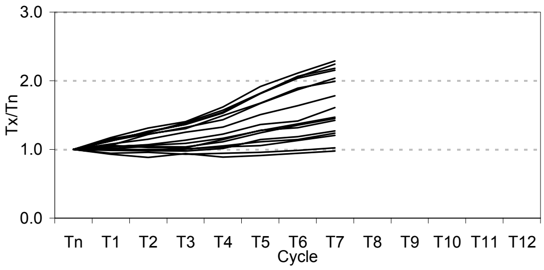












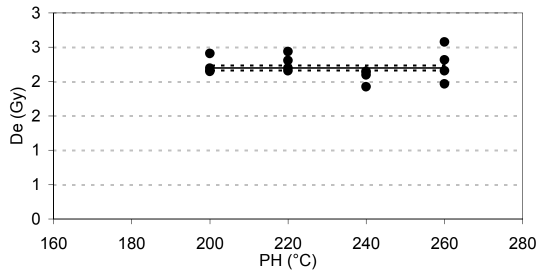
Sample SUTL 2158
Date 91107 to 121107
Reader Riso 1
Source Calibration 0.1007 ± 0.0017 Gy/s
Regenerative Dose Sequence (Gy)

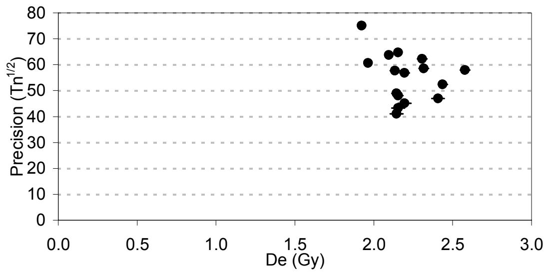
Dn	D1	D2	D3	D4	D5	D6	D7	D8	D9
0.00	4.02	0.00	1.00	7.04	10.06	4.02	4.02	0.00	0.00

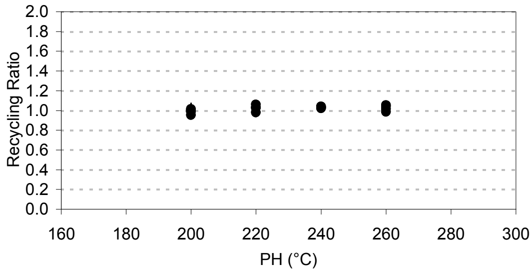
Test Dose (Gy) 2.00

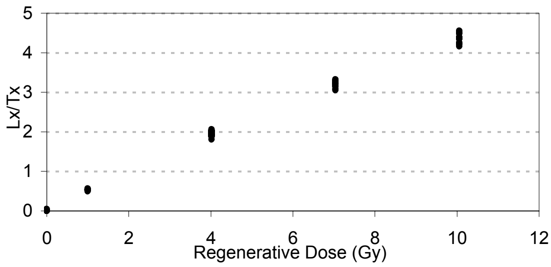
Measurement	Signal	Background
OSL 60s@125°C, 240Cl	11-30	191-230
IRSL 120s@50°C, 240C	11-30	191-230

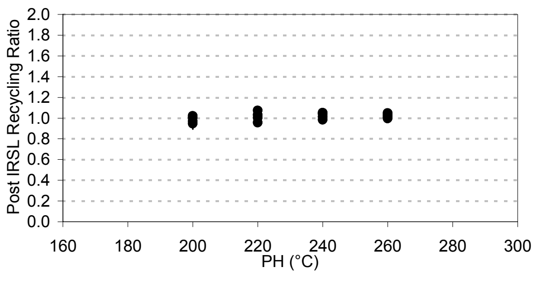
Aliquot	Preheat	Aliquot	Sensitivity		Dose Response		Recycling Point		Post IRSL		Zero Dose		Equivalent Dose		AMC Robust Statistics V1.(		
		Mass	(cps/	Change			4.02	Gy	4.02	Gy	0.00	Gy					
	(°C/30s)	(g)	mg/Gy)	(frn.)	D0 (Gy)	Err	ratio	error	ratio	error	ratio	error	(Gy)	error	ROBUST STATISTICS SU		
17	200	5.1	216	1.2	21	2.6	0.99	0.04	1.00	0.04	-0.002	-0.008	2.407	0.040	*Estimate*	*Estimate*	*Paramei*
18	200	4.6	351	1.1	23	2.3	0.95	0.03	0.97	0.03	0.005	0.005	2.196	0.030	*Median*	2.15538	
19	200	4.8	176	1.2	23	4.3	1.02	0.06	0.95	0.05	0.011	0.011	2.145	0.040	*A15 mea*	2.17512	c=1.5: C
20	200	4.3	487	1.1	25	2.3	1.00	0.03	1.02	0.03	0.003	0.004	2.155	0.020	*H15 mea*	2.2007	c=1.5: C
21	220	5.0	231	1.3	25	3.2	1.03	0.04	1.03	0.04	0.009	0.006	2.155	0.030	*MAD*	0.05036	
22	220	4.0	484	1.5	25	2.0	1.06	0.03	1.07	0.03	0.003	0.003	2.306	0.030	*MADe*	0.07466	
23	220	5.2	195	1.5	28	4.4	1.02	0.04	1.00	0.04	0.007	0.007	2.196	0.040	*sMAD*	0.07466	
24	220	4.2	327	1.0	23	2.7	0.98	0.04	0.96	0.04	0.005	0.005	2.437	0.030	*H15 Std*	0.16534	c=1.5: C
25	240	5.1	326	2.0	22	1.6	1.02	0.03	0.98	0.03	0.003	0.003	2.135	0.030			
26	240	4.6	611	1.6	12	13.9	1.04	0.02	1.01	0.02	0.008	0.002	1.924	0.020			
27	240	5.4	375	1.9	21	1.3	1.03	0.03	1.04	0.03	0.005	0.003	2.095	0.020			
28	240	4.9	244	1.6	35	5.3	1.03	0.04	1.05	0.04	0.005	0.005	2.145	0.030			
29	260	3.8	441	2.7	25	1.6	1.02	0.03	1.01	0.03	0.005	0.002	2.578	0.030			
30	260	4.8	383	2.4	36	3.5	1.04	0.03	1.03	0.03	0.024	0.003	1.964	0.020			
31	260	2.8	333	2.2	31	4.2	0.98	0.04	1.00	0.04	0.013	0.005	2.155	0.040			
32	260	4.1	417	2.1	21	1.3	1.05	0.03	1.05	0.03	0.010	0.003	2.317	0.030			
													n =	16		n =	16
Mean		4.5	350	1.6	24.8		1.02		1.01		0.007	Mean	2.207	Internal		H15 mean	2.201
SD		0.7	121	0.5	6.0		0.03		0.04		0.006	SD	0.168	Error		H15 Std Dev	0.165
SD/rtN		0.2	30	0.1	1.5		0.01		0.01		0.001	SD/rtN	0.042	0.008		SD/rtN	0.041
%err		4	9	8	6		1		1		20	%err	2			%err	2

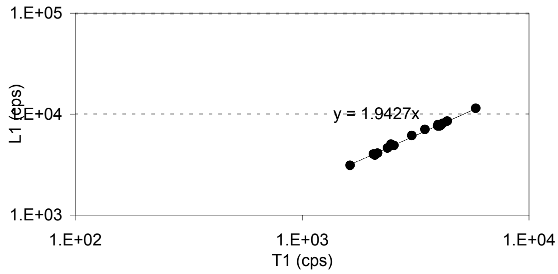


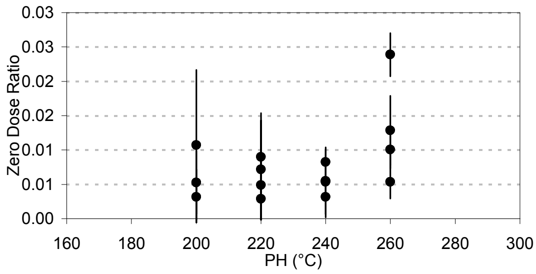


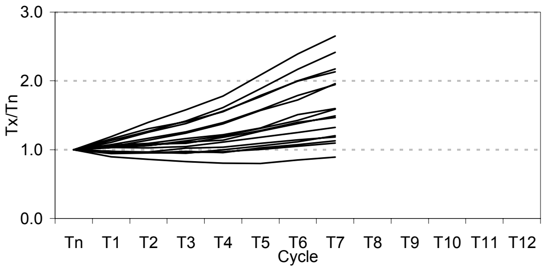












Sample SUTL 2159
Date 91107 to 121107
Reader Riso 1
Source Calibration 0.1007 ± 0.0017 Gy/s
Regenerative Dose Sequence (Gy)

Dn	D1	D2	D3	D4	D5	D6	D7	D8	D9
0.00	4.02	0.00	1.00	7.04	10.06	4.02	4.02	0.00	0.00

Test Dose (Gy) 2.00

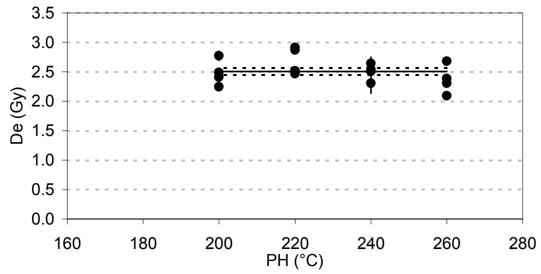
Measurement	Signal	Background
OSL 60s@125°C, 240Cl	11-30	191-230
IRSL 120s@50°C, 240C	11-30	191-230

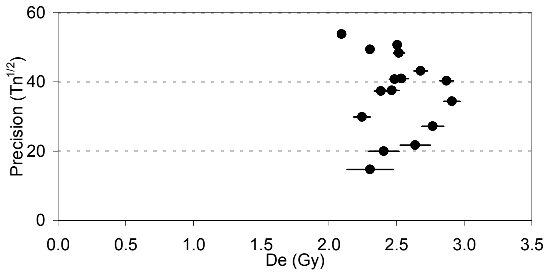
Aliquot	Preheat (°C/30s)	Aliquot Mass (g)	Sensitivity (cps/ mg/Gy)	Sensitivity Change (frn.)	Dose Response D0 (Gy)	Dose Response Err	Recycling Point 4.02 Gy ratio	Recycling Point error	Post IRSL 4.02 Gy ratio	Post IRSL error	Zero Dose 0.00 Gy ratio	Zero Dose error	Equivalent Dose (Gy)	Equivalent Dose error
33	200	1.1	404	1.1	30	9.2	0.97	0.07	0.97	0.07	0.010	0.014	2.246	0.060
34	200	2.2	168	1.4	21	4.5	0.99	0.07	0.99	0.07	0.002	0.014	2.770	0.081
35	200	1.6	518	1.0	24	3.5	1.04	0.05	1.03	0.05	-0.003	-0.007	2.488	0.040
36	200	1.5	132	1.2	27	12.7	1.02	0.13	1.02	0.12	-0.022	-0.028	2.407	0.111
37	220	2.6	449	1.1	16	1.3	1.00	0.04	1.03	0.04	0.001	0.005	2.518	0.040
38	220	2.4	292	1.4	19	2.3	1.00	0.05	1.01	0.05	0.001	0.008	2.468	0.050
39	220	2.6	312	1.3	22	3.0	1.08	0.05	1.06	0.05	0.005	0.008	2.870	0.050
40	220	2.7	218	1.3	23	3.8	1.03	0.06	1.07	0.06	0.002	0.009	2.911	0.060
41	240	2.9	441	1.8	25	2.3	1.04	0.03	1.03	0.03	0.007	0.004	2.508	0.030
42	240	3.0	79	1.4	17	4.2	1.03	0.11	1.06	0.11	-0.008	-0.023	2.639	0.111
43	240	2.2	380	1.5	18	1.8	1.04	0.05	1.02	0.04	0.005	0.006	2.538	0.050
44	240	1.7	63	1.8	24	11.9	1.08	0.17	1.15	0.18	0.014	0.038	2.306	0.171
45	260	2.5	577	2.0	31	3.0	1.03	0.03	1.05	0.03	0.002	0.003	2.095	0.030
46	260	2.1	580	1.8	29	3.0	0.98	0.03	1.01	0.03	0.008	0.004	2.306	0.030
47	260	2.5	372	1.6	22	2.2	1.00	0.04	0.93	0.04	0.006	0.005	2.679	0.050
48	260	2.2	316	1.0	19	2.7	0.96	0.05	0.99	0.06	0.009	0.008	2.387	0.050
												n =	16	
Mean		2.2	331	1.4	23.0		1.02		1.03		0.003	Mean	2.509	Internal
SD		0.5	165	0.3	4.6		0.03		0.05		0.008	SD	0.225	Error
SD/rtN		0.1	41	0.1	1.2		0.01		0.01		0.002	SD/rtN	0.056	0.018
%err		6	12	5	5		1		1		81	%err	2	

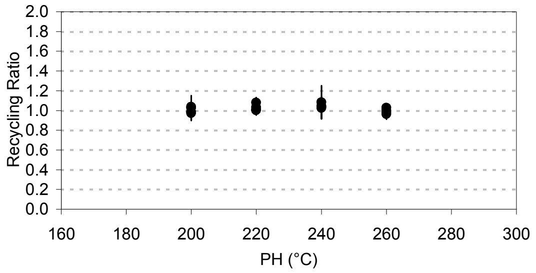
AMC Robust Statistics V1.(

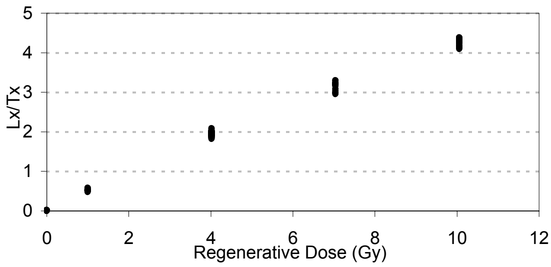
ROBUST STATISTICS SU		
Estimate	*Estimate*	*Paramet*
Median	2.49782	
A15 mea	2.507	c=1.5: C
H15 mea	2.50772	c=1.5: C
MAD	0.16115	
MADe	0.23892	
sMAD	0.23892	
H15 Std	0.23405	c=1.5: C

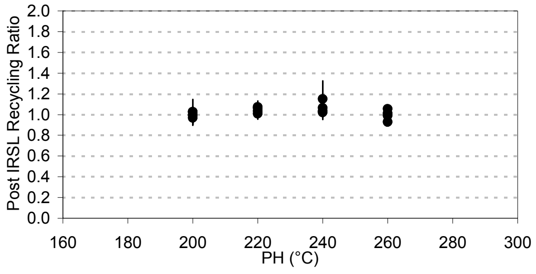
n =	16
H15 mean	2.508
H15 Std Dev	0.234
SD/rtN	0.059
%err	2

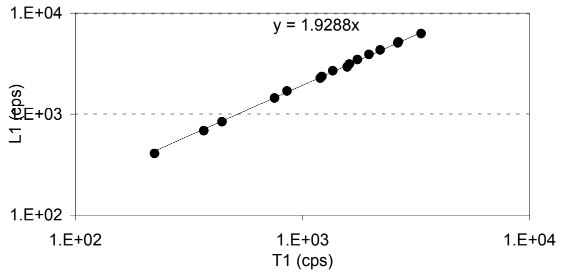


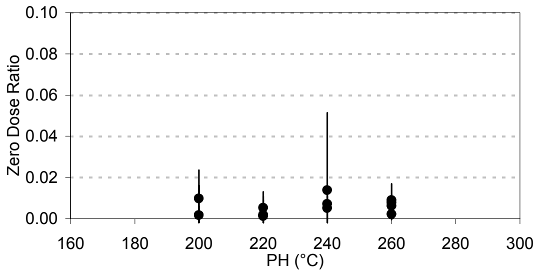


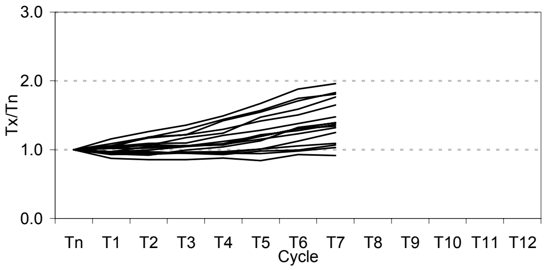












Sample SUTL 2160
Date 91107 to 151107
Reader Riso 2
Source Calibration 0.0936 ± 0.001 Gy/s
Regenerative Dose Sequence (Gy)

Dn	D1	D2	D3	D4	D5	D6	D7	D8	D9
0.00	3.77	0.02	0.96	6.57	9.38	3.77	3.77	0.02	0.02

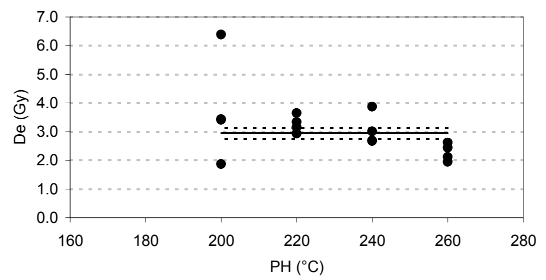
Test Dose (Gy) 1.89

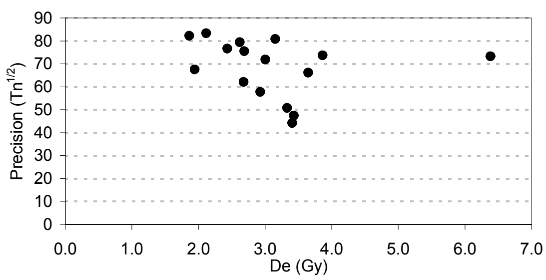
Measurement	Signal	Background
OSL 60s@125°C, 240Cl	11-30	191-230
IRSL 120s@50°C, 240C	11-30	191-230

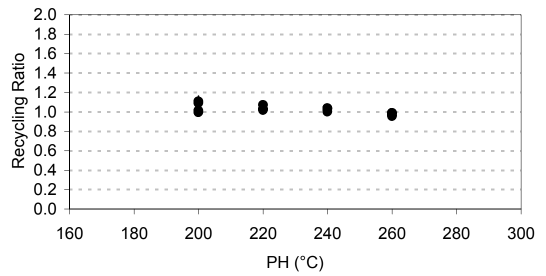
Aliquot	Preheat (°C/30s)	Aliquot Mass (g)	Sensitivity (cps/ mg/Gy)	Change (frn.)	Dose Response D0 (Gy)	Err	Recycling Point 3.77 Gy ratio	error	Post IRSL 3.77 Gy ratio	error	Zero Dose 0.00 Gy ratio	error	Equivalent Dose (Gy)	error
1	200	3.5	338	1.6	20	2.3	1.09	0.05	1.02	0.04	0.015	0.008	3.435	0.056
2	200	5.2	686	1.1	23	1.8	0.99	0.03	0.97	0.02	0.007	0.004	1.863	0.019
3	200	4.6	615	1.2	27	2.7	1.01	0.03	0.99	0.03	0.011	0.005	6.383	0.066
4	200	2.4	429	1.1	16	1.9	1.11	0.06	1.04	0.05	0.013	0.010	3.407	0.066
5	220	4.6	501	1.3	36	5.4	1.02	0.03	0.97	0.03	0.015	0.005	3.650	0.037
6	220	7.4	466	1.6	23	1.7	1.03	0.02	1.01	0.02	0.013	0.004	3.154	0.028
7	220	5.1	267	1.4	25	3.7	1.03	0.04	1.04	0.04	0.022	0.008	3.332	0.056
8	220	6.1	288	1.6	25	2.9	1.07	0.04	1.03	0.03	0.022	0.007	2.930	0.037
9	240	7.9	380	2.5	24	1.5	1.04	0.02	1.00	0.02	0.029	0.003	2.686	0.028
10	240	7.2	398	1.9	19	1.2	1.03	0.03	1.01	0.02	0.023	0.004	3.866	0.037
11	240	6.2	328	2.1	21	1.8	1.00	0.03	0.96	0.03	0.032	0.005	2.677	0.037
12	240	6.9	395	1.9	20	1.4	1.03	0.03	0.99	0.02	0.020	0.004	3.004	0.028
13	260	6.3	581	2.4	20	1.0	0.97	0.02	0.96	0.02	0.024	0.002	2.115	0.019
14	260	5.9	525	2.4	21	1.1	0.99	0.02	0.97	0.02	0.030	0.003	2.434	0.028
15	260	7.0	475	2.2	30	2.2	0.96	0.02	0.94	0.02	0.030	0.003	2.621	0.028
16	260	6.3	382	2.6	19	1.1	0.99	0.02	0.97	0.02	0.035	0.004	1.947	0.028
												n =	16	
Mean		5.8	441	1.8	23.0		1.02		0.99		0.021	Mean	3.094	Internal
SD		1.5	119	0.5	4.9		0.04		0.03		0.008	SD	1.059	Error
SD/rtN		0.4	30	0.1	1.2		0.01		0.01		0.002	SD/rtN	0.265	0.010
%err		6	7	7	5		1		1		10	%err	9	

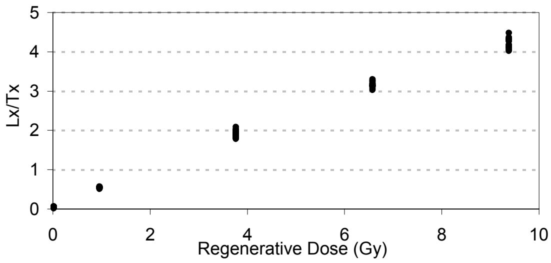
AMC Robust Statistics V1.(

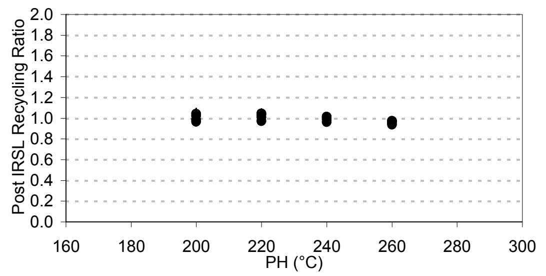
ROBUST STATISTICS SU	
Estimate	*Estimate value*
Median	2.96705
A15 mea	2.947
H15 mea	2.947
MAD	0.45395
MADe	0.67303
sMAD	0.67303
H15 Std	0.74774
n =	16
H15 mean	2.947
H15 Std Dev	0.748
SD/rtN	0.187
%err	6

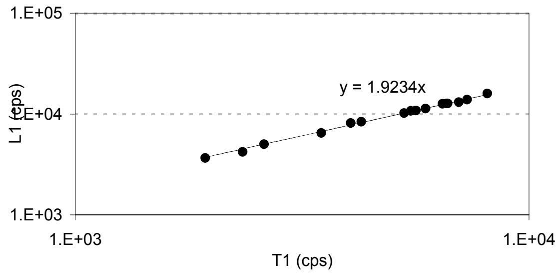


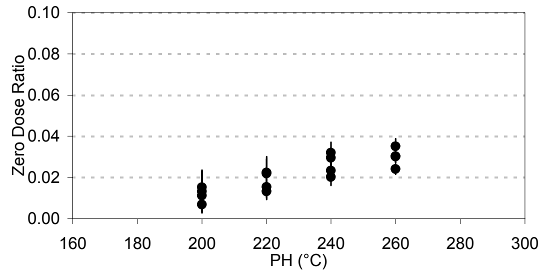


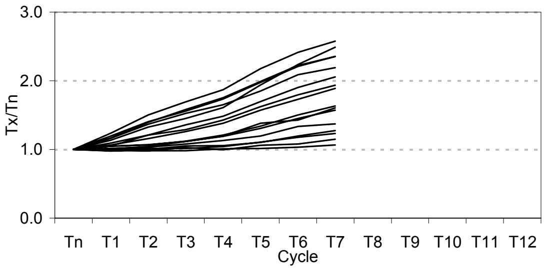












Sample SUTL 2161
Date 91107 to 151107
Reader Riso 2
Source Calibration 0.0936 ± 0.001 Gy/s
Regenerative Dose Sequence (Gy)

Dn	D1	D2	D3	D4	D5	D6	D7	D8	D9
0.00	3.77	0.02	0.96	6.57	9.38	3.77	3.77	0.02	0.02

Test Dose (Gy) 1.89

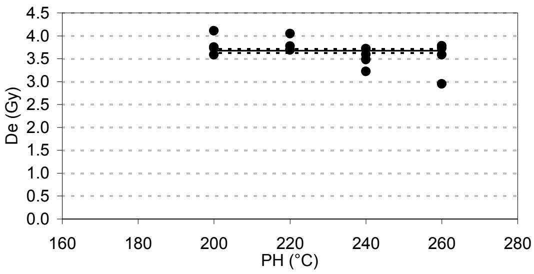
Measurement	Signal	Background
OSL 60s@125°C, 240Cl	11-30	191-230
IRSL 120s@50°C, 240C	11-30	191-230

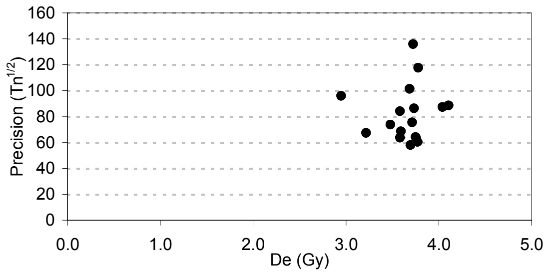
Aliquot	Preheat	Aliquot Mass	Sensitivity (cps/	Change	Dose Response		Recycling Point 3.77	Gy	Post IRSL 3.77	Gy	Zero Dose 0.00	Gy	Equivalent Dose	
	(°C/30s)	(g)	mg/Gy)	(frn.)	D0 (Gy)	Err	ratio	error	ratio	error	ratio	error	(Gy)	error
17	200	8.9	466	1.3	21	1.5	1.03	0.02	0.99	0.02	0.008	0.004	4.109	0.037
18	200	7.4	289	1.2	29	4.1	1.03	0.04	0.98	0.03	0.010	0.006	3.585	0.047
19	200	6.1	646	1.3	23	1.5	1.02	0.02	1.00	0.02	0.002	0.003	3.735	0.028
20	200	7.9	275	1.3	27	3.7	1.00	0.03	0.97	0.03	0.013	0.006	3.753	0.047
21	220	6.3	280	1.5	20	2.0	1.05	0.04	1.04	0.04	0.023	0.007	3.697	0.047
22	220	6.0	672	1.6	21	1.2	1.03	0.02	1.01	0.02	0.012	0.003	4.043	0.028
23	220	6.9	278	1.7	25	2.7	1.02	0.03	0.99	0.03	0.016	0.006	3.772	0.047
24	220	6.4	847	1.6	24	1.3	1.05	0.02	1.03	0.02	0.005	0.002	3.735	0.028
25	240	5.7	504	1.6	22	1.6	1.07	0.03	1.03	0.02	0.014	0.004	3.482	0.037
26	240	6.6	456	1.9	25	1.8	1.04	0.02	1.01	0.02	0.015	0.003	3.716	0.037
27	240	6.0	412	1.6	18	1.2	1.05	0.03	1.00	0.03	0.015	0.004	3.594	0.037
28	240	6.4	374	2.0	18	1.0	1.06	0.03	1.00	0.03	0.020	0.004	3.220	0.037
29	260	5.8	1257	1.8	24	0.9	1.03	0.01	1.01	0.01	0.018	0.002	3.781	0.019
30	260	6.2	783	2.3	20	0.8	1.00	0.02	0.98	0.02	0.018	0.002	2.948	0.019
31	260	6.2	1573	1.9	27	1.0	1.05	0.01	1.00	0.01	0.013	0.001	3.725	0.019
32	260	5.7	654	2.0	17	0.7	1.00	0.02	0.95	0.02	0.031	0.003	3.585	0.028
												n =	16	
Mean		6.5	610	1.7	22.5		1.03		1.00		0.014	Mean	3.652	Internal
SD		0.9	367	0.3	3.6		0.02		0.02		0.007	SD	0.276	Error
SD/rtN		0.2	92	0.1	0.9		0.01		0.01		0.002	SD/rtN	0.069	0.009
%err		3	15	4	4		1		1		12	%err	2	

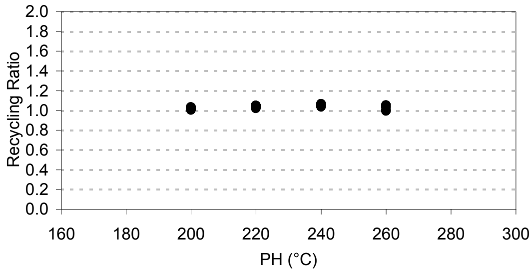
AMC Robust Statistics V1.(

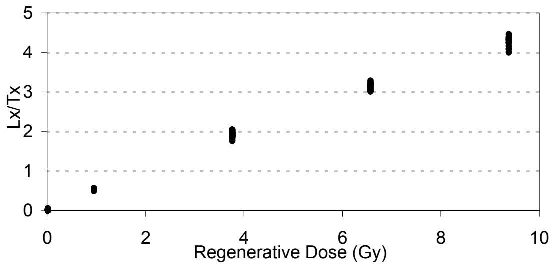
ROBUST STATISTICS SU		
Estimate	*Estimate*	*Paramet*
Median	3.70647	
A15 mea	3.67606	c=1.5: C
H15 mea	3.67606	c=1.5: C
MAD	0.0936	
MADe	0.13877	
sMAD	0.13877	
H15 Std	0.16742	c=1.5: C

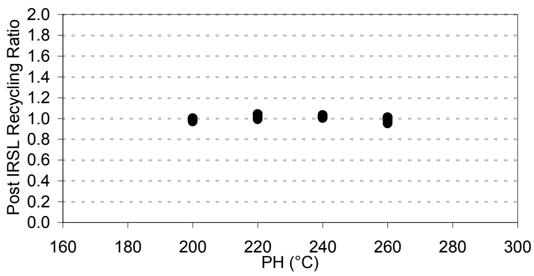
n =	16
H15 mean	3.676
H15 Std Dev	0.167
SD/rtN	0.042
%err	1

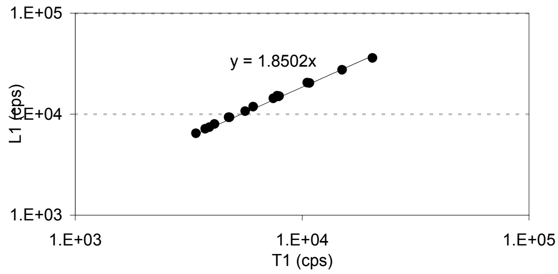


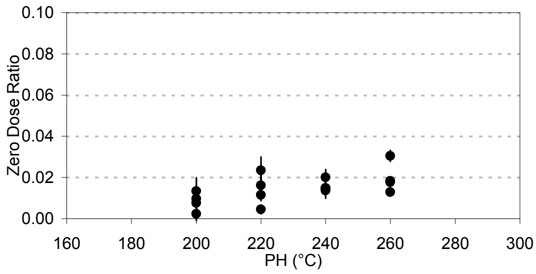


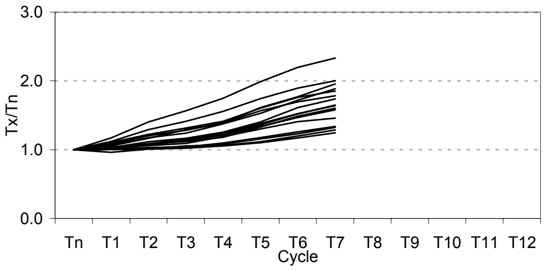












Sample SUTL 2162
Date 91107 to 151107
Reader Riso 2
Source Calibration 0.0936 ± 0.001 Gy/s
Regenerative Dose Sequence (Gy)

Dn	D1	D2	D3	D4	D5	D6	D7	D8	D9
0.00	3.77	0.02	0.96	6.57	9.38	3.77	3.77	0.02	0.02

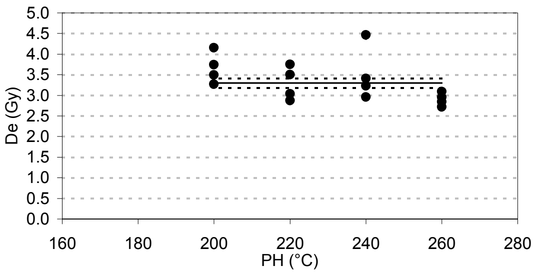
Test Dose (Gy) 1.89

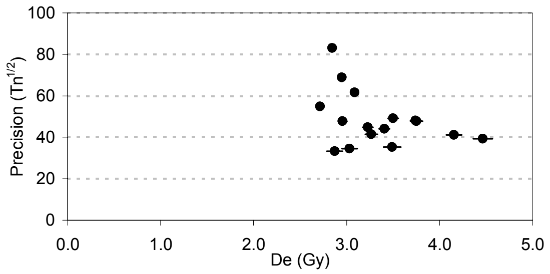
Measurement	Signal	Background
OSL 60s@125°C, 240Cl	11-30	191-230
IRSL 120s@50°C, 240C	11-30	191-230

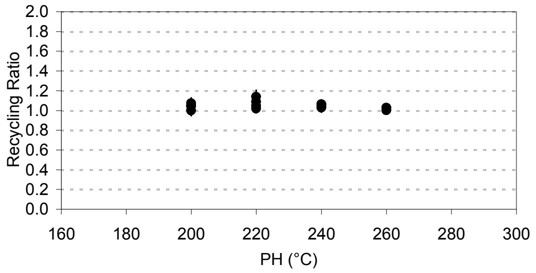
Aliquot	Preheat	Aliquot Mass	Sensitivity (cps/	Change	Dose Response		Recycling Point 3.77 Gy		Post IRSL 3.77 Gy		Zero Dose 0.00 Gy		Equivalent Dose	
	(°C/30s)	(g)	mg/Gy)	(frn.)	D0 (Gy)	Err	ratio	error	ratio	error	ratio	error	(Gy)	error
33	200	3.4	360	1.3	28	4.6	1.05	0.04	1.04	0.04	0.015	0.008	3.744	0.056
34	200	2.9	227	1.1	18	3.8	1.04	0.08	1.03	0.08	0.037	0.016	3.491	0.094
35	200	3.5	260	1.5	24	4.4	1.07	0.06	1.06	0.06	0.004	0.012	3.267	0.066
36	200	3.6	248	1.5	20	3.2	1.00	0.05	1.01	0.05	0.011	0.011	4.156	0.084
37	220	4.9	246	1.7	20	2.3	1.02	0.04	0.96	0.04	0.014	0.008	3.753	0.066
38	220	3.0	424	1.6	21	2.4	1.09	0.04	1.05	0.04	0.010	0.007	3.501	0.056
39	220	4.2	149	2.0	19	3.1	1.14	0.07	1.09	0.06	0.034	0.015	3.033	0.084
40	220	3.3	177	1.7	17	2.9	1.05	0.07	1.00	0.06	0.022	0.013	2.873	0.084
41	240	4.4	274	1.8	19	1.8	1.06	0.04	1.05	0.04	0.017	0.007	2.958	0.047
42	240	3.4	239	2.0	29	5.6	1.04	0.05	1.00	0.05	0.041	0.011	4.465	0.103
43	240	3.1	331	1.4	27	4.4	1.03	0.05	1.02	0.04	0.007	0.008	3.407	0.056
44	240	3.9	273	1.8	36	6.7	1.06	0.04	1.04	0.04	0.016	0.007	3.229	0.056
45	260	3.7	677	2.1	26	1.9	1.00	0.02	0.97	0.02	0.010	0.003	2.948	0.028
46	260	3.9	407	1.3	18	1.5	1.02	0.04	0.98	0.03	0.013	0.005	2.714	0.037
47	260	3.7	543	1.7	17	1.0	1.03	0.03	1.01	0.03	0.016	0.004	3.089	0.037
48	260	4.8	759	1.4	25	1.7	1.00	0.02	0.98	0.02	0.010	0.002	2.845	0.028
													n =	16
Mean		3.7	350	1.6	22.8		1.04		1.02		0.017	Mean	3.342	Internal
SD		0.6	175	0.3	5.3		0.04		0.03		0.011	SD	0.493	Error
SD/rtN		0.1	44	0.1	1.3		0.01		0.01		0.003	SD/rtN	0.123	0.016
%err		4	13	4	6		1		1		15	%err	4	

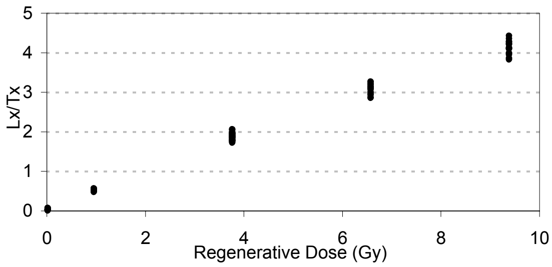
AMC Robust Statistics V1.(

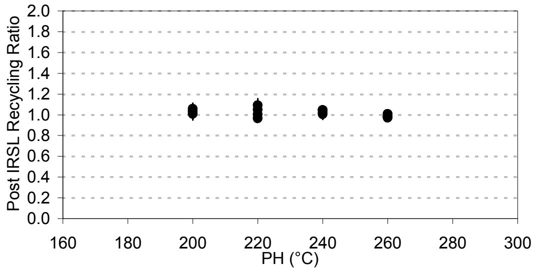
ROBUST STATISTICS SU		
Estimate	*Estimate*	*Paramei*
Median	3.24784	
A15 mea	3.29119	c=1.5: C
H15 mea	3.29927	c=1.5: C
MAD	0.29483	
MADe	0.43712	
sMAD	0.43712	
H15 Std	0.46069	c=1.5: C
n =	16	
H15 mean	3.299	
H15 Std Dev	0.461	
SD/rtN	0.115	
%err	3	

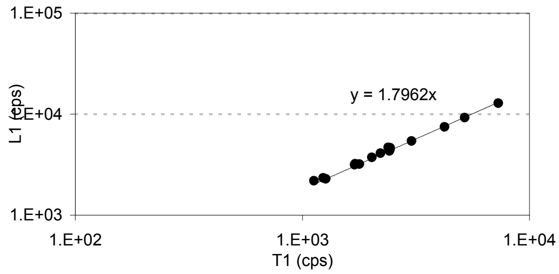


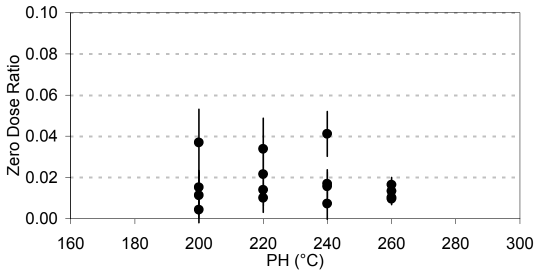


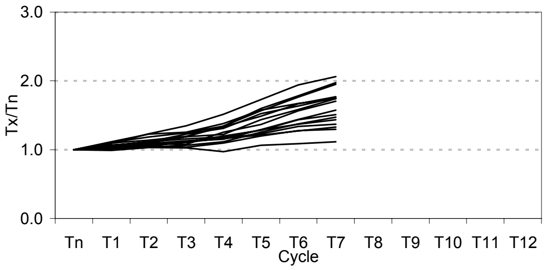












Sample SUTL 2165
Date 121107 to 151107
Reader Riso 1
Source Calibration 0.1007 ± 0.0017 Gy/s
Regenerative Dose Sequence (Gy)

Dn	D1	D2	D3	D4	D5	D6	D7	D8	D9
0.00	4.02	0.00	1.00	7.04	10.06	4.02	4.02	0.00	0.00

Test Dose (Gy) 2.00

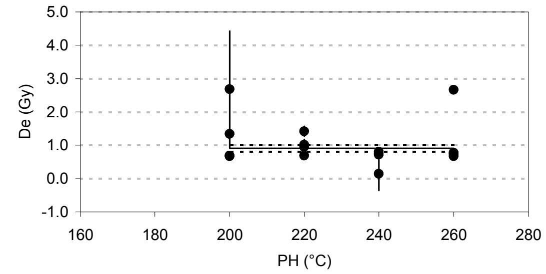
Measurement	Signal	Background
OSL 60s@125°C, 240Cl	11-30	191-230
IRSL 120s@50°C, 240C	11-30	191-230

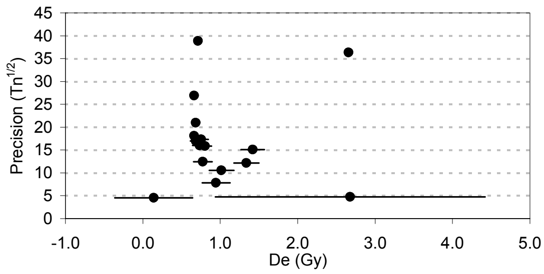
Aliquot	Preheat (°C/30s)	Aliquot Mass (g)	Sensitivity (cps/ mg/Gy)	Change (frn.)	Dose Response D0 (Gy)	Err	Recycling Point 4.02 Gy ratio	error	Post IRSL 4.02 Gy ratio	error	Zero Dose 0.00 Gy ratio	error	Equivalent Dose (Gy)	error
1	200	0.0	#DIV/0!	1.0	13	3.0	1.06	0.14	0.98	0.13	-0.013	-0.025	0.665	0.050
2	200	0.0	#DIV/0!	1.3	4887	######	1.00	0.20	1.09	0.22	0.068	0.051	1.339	0.161
3	200	0.0	#DIV/0!	2.9	5	3.7	0.72	0.53	0.54	0.39	0.123	0.180	*2.679*	*1.742*
4	200	0.0	#DIV/0!	1.0	20	6.3	0.96	0.11	0.93	0.11	-0.018	-0.020	0.685	0.040
5	220	0.0	#DIV/0!	1.5	63	101.5	1.01	0.17	0.93	0.16	0.020	0.046	1.420	0.151
6	220	0.0	#DIV/0!	1.1	2	0.8	0.71	0.58	0.50	0.38	-0.143	-0.132	0.947	0.181
7	220	0.0	#DIV/0!	1.8	158	360.6	1.15	0.14	1.17	0.14	-0.007	-0.029	0.685	0.070
8	220	0.0	#DIV/0!	1.6	15	8.1	0.98	0.26	0.94	0.24	0.004	0.055	1.017	0.161
9	240	0.0	#DIV/0!	1.7	27	3.8	1.02	0.04	1.03	0.04	0.008	0.006	0.715	0.020
10	240	0.0	#DIV/0!	1.7	3	3.7	0.75	1.66	1.23	1.66	-0.188	-0.358	*0.141*	*0.504*
11	240	0.0	#DIV/0!	1.5	58	60.8	0.99	0.14	0.97	0.13	0.024	0.034	0.755	0.091
12	240	0.0	#DIV/0!	1.9	15	3.6	1.07	0.14	1.01	0.13	0.002	0.026	0.806	0.081
13	260	0.0	#DIV/0!	2.4	3817	######	1.00	0.11	1.02	0.11	0.037	0.024	0.735	0.091
14	260	0.0	#DIV/0!	2.3	28	5.1	1.07	0.06	1.05	0.06	0.016	0.009	0.665	0.030
15	260	0.0	#DIV/0!	1.6	23	2.9	1.01	0.05	0.99	0.05	-0.001	-0.006	2.659	0.050
16	260	0.0	#DIV/0!	2.1	16	5.8	0.97	0.18	0.95	0.17	0.041	0.038	0.775	0.121
												n =	16	
Mean		0.0	#DIV/0!	1.7	571.8		0.97		0.96		-0.002	Mean	1.043	Internal
SD		0.0	#DIV/0!	0.5	1489.1		0.13		0.19		0.073	SD	0.697	Error
SD/rtN		0.0	#DIV/0!	0.1	372.3		0.03		0.05		0.018	SD/rtN	0.174	0.116
%err		#DIV/0!	#DIV/0!	8	65		3		5		-1029	%err	17	

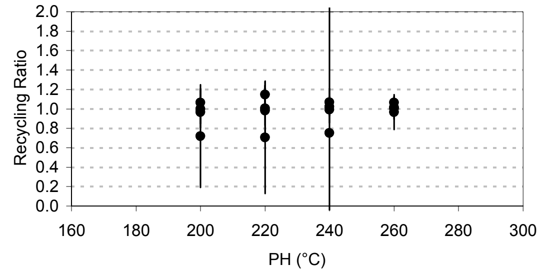
AMC Robust Statistics V1.(

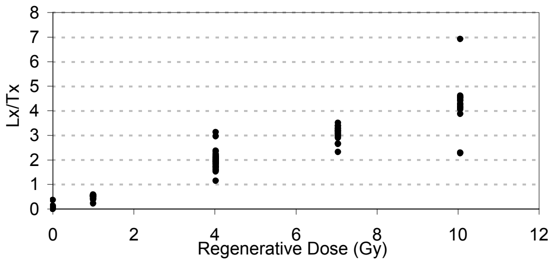
ROBUST STATISTICS SU	
Estimate	*Estimate value*
Median	0.76536
A15 mea	0.8075
H15 mea	0.90518
MAD	0.10071
MADe	0.14931
sMAD	0.14931
H15 Std	0.38515

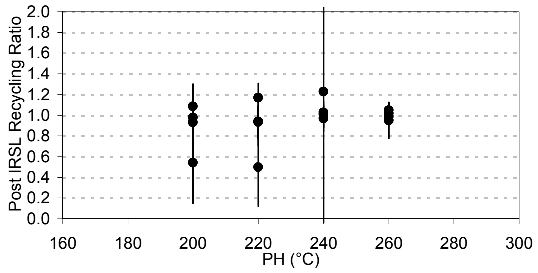
n =	16
H15 mean	0.905
H15 Std Dev	0.385
SD/rtN	0.096
%err	11

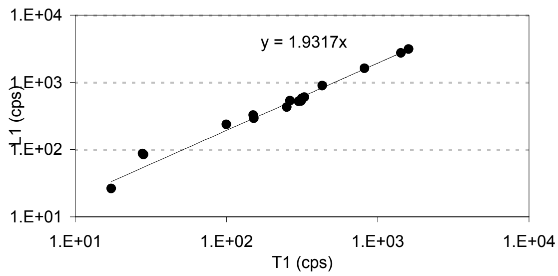


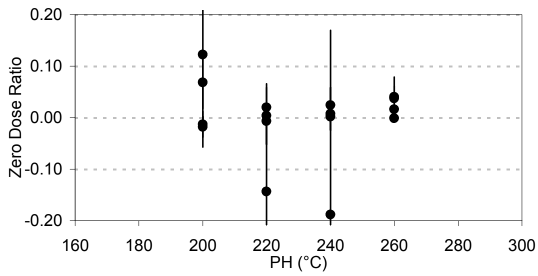


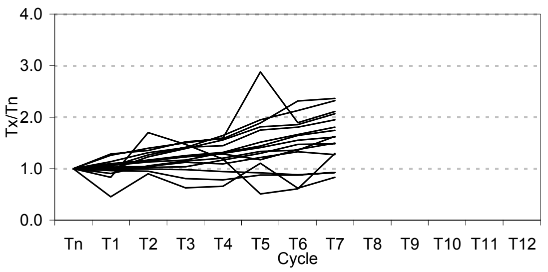












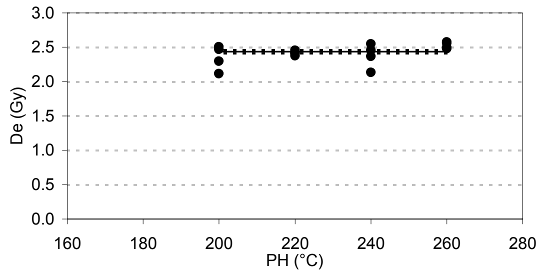
Sample SUTL 2166
Date 121107 to 151107
Reader Riso 1
Source Calibration 0.1007 ± 0.0017 Gy/s
Regenerative Dose Sequence (Gy)

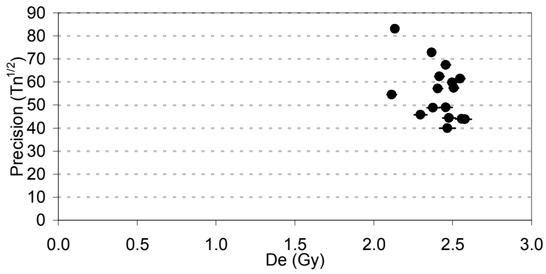
Dn	D1	D2	D3	D4	D5	D6	D7	D8	D9
0.00	4.02	0.00	1.00	7.04	10.06	4.02	4.02	0.00	0.00

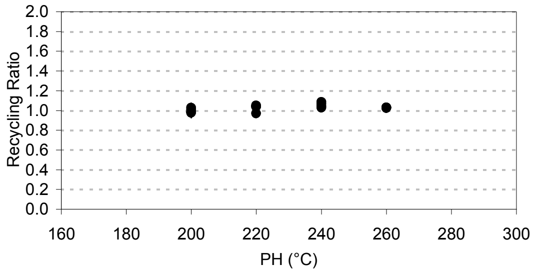
Test Dose (Gy) 2.00

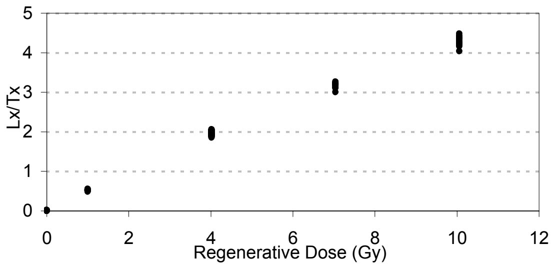
Measurement	Signal	Background
OSL 60s@125°C, 240Cl	11-30	191-230
IRSL 120s@50°C, 240C	11-30	191-230

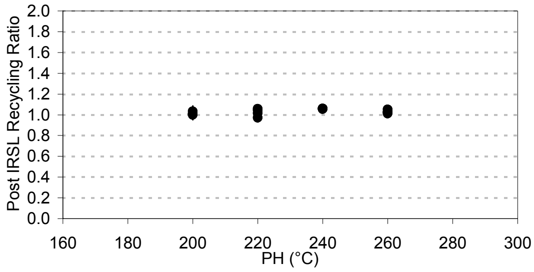
Aliquot	Preheat	Aliquot	Sensitivity		Dose Response		Recycling Point		Post IRSL		Zero Dose		Equivalent Dose		AMC Robust Statistics V1.(		
		Mass	(cps/	Change			4.02	Gy	4.02	Gy	0.00	Gy					
	(°C/30s)	(g)	mg/Gy)	(frn.)	D0 (Gy)	Err	ratio	error	ratio	error	ratio	error	(Gy)	error	ROBUST STATISTICS SU		
17	200	3.2	513	1.1	26	2.9	0.98	0.03	1.01	0.03	0.003	0.004	2.508	0.030	*Estimate*	*Estimate*	*Paramet*
18	200	4.0	261	1.2	28	4.4	1.03	0.05	1.00	0.04	0.014	0.007	2.296	0.040	*Median*	2.45721	
19	200	3.9	380	1.2	25	3.1	1.00	0.04	1.01	0.04	0.000	0.006	2.115	0.030	*A15 mea*	2.43714	c=1.5: C
20	200	2.9	274	1.3	20	2.8	0.98	0.05	1.03	0.05	0.014	0.008	2.467	0.050	*H15 mea*	2.43519	c=1.5: C
21	220	4.0	485	1.1	36	4.8	1.05	0.03	1.06	0.03	0.003	0.004	2.417	0.030	*MAD*	0.06546	
22	220	4.8	249	1.3	38	7.7	1.04	0.04	1.02	0.04	0.002	0.006	2.457	0.040	*MADe*	0.09705	
23	220	4.0	408	1.5	23	2.0	1.04	0.03	1.04	0.03	0.005	0.004	2.407	0.030	*sMAD*	0.09705	
24	220	3.8	313	1.2	20	2.0	0.97	0.04	0.97	0.04	0.007	0.006	2.377	0.040	*H15 Std*	0.10963	c=1.5: C
25	240	3.4	779	1.4	6	3.8	1.03	0.02	1.06	0.02	0.003	0.002	2.367	0.020			
26	240	5.2	663	1.8	29	1.8	1.04	0.02	1.06	0.02	0.004	0.002	2.135	0.020			
27	240	4.4	428	1.8	22	1.5	1.09	0.03	1.06	0.03	0.003	0.003	2.548	0.030			
28	240	5.9	384	1.6	23	1.6	1.07	0.03	1.05	0.03	0.004	0.003	2.457	0.030			
29	260	3.0	319	2.0	22	2.1	1.03	0.04	1.03	0.04	0.008	0.005	2.578	0.040			
30	260	3.1	311	2.1	15	0.9	1.03	0.04	1.01	0.04	0.002	0.004	2.558	0.040			
31	260	4.7	379	1.9	24	1.7	1.03	0.03	1.02	0.03	0.008	0.003	2.497	0.030			
32	260	4.2	235	2.2	23	2.1	1.02	0.04	1.05	0.04	0.007	0.004	2.477	0.040			
													n =	16		n =	16
Mean		4.0	399	1.5	23.8		1.03		1.03		0.005	Mean	2.416	Internal		H15 mean	2.435
SD		0.8	151	0.4	7.4		0.03		0.03		0.004	SD	0.136	Error		H15 Std Dev	0.110
SD/rtN		0.2	38	0.1	1.9		0.01		0.01		0.001	SD/rtN	0.034	0.009		SD/rtN	0.027
%err		5	9	6	8		1		1		18	%err	1			%err	1

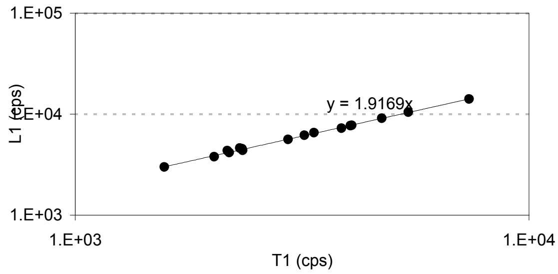


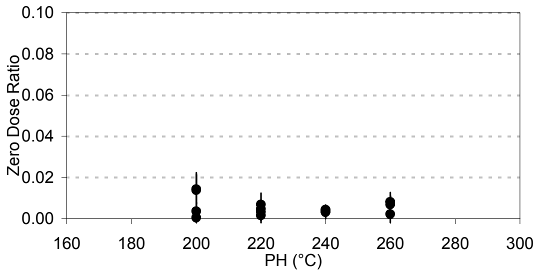


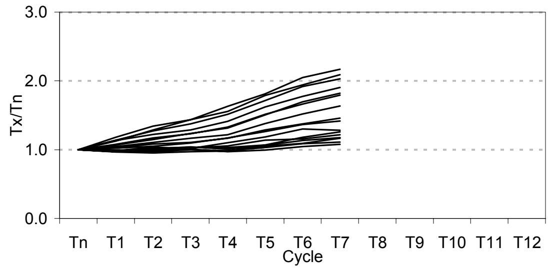












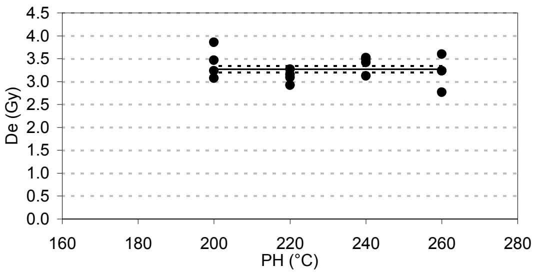
Sample SUTL 2167
Date 121107 to 151107
Reader Riso 1
Source Calibration 0.1007 ± 0.0017 Gy/s
Regenerative Dose Sequence (Gy)

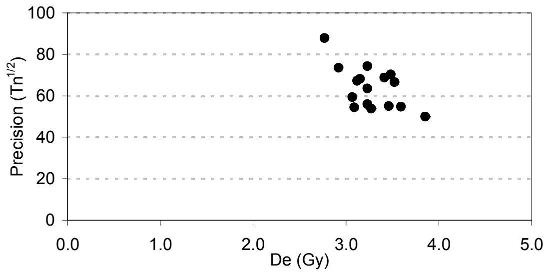
Dn	D1	D2	D3	D4	D5	D6	D7	D8	D9
0.00	4.02	0.00	1.00	7.04	10.06	4.02	4.02	0.00	0.00

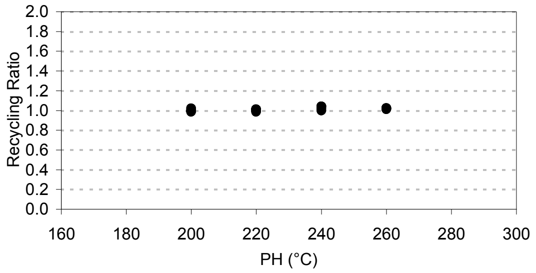
Test Dose (Gy) 2.00

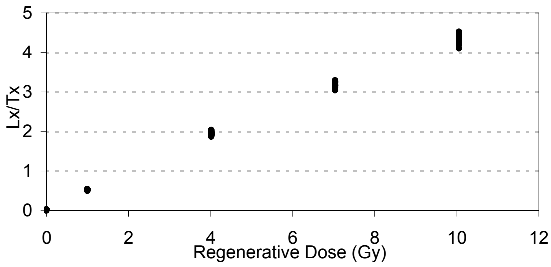
Measurement	Signal	Background
OSL 60s@125°C, 240Cl	11-30	191-230
IRSL 120s@50°C, 240C	11-30	191-230

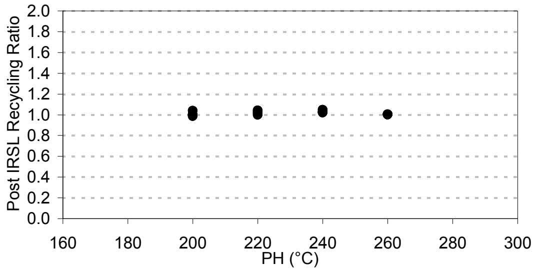
Aliquot	Preheat	Aliquot	Sensitivity		Dose Response		Recycling Point		Post IRSL		Zero Dose		Equivalent Dose		AMC Robust Statistics V1.(		
		Mass	(cps/	Change			4.02	Gy	4.02	Gy	0.00	Gy					
	(°C/30s)	(g)	mg/Gy)	(frn.)	D0 (Gy)	Err	ratio	error	ratio	error	ratio	error	(Gy)	error	ROBUST STATISTICS SU		
33	200	4.2	297	1.1	36	7.4	1.00	0.04	1.00	0.04	0.014	0.007	3.857	0.050	*Estimate*	*Estimate*	*Paramei*
34	200	4.8	420	1.1	22	2.1	0.99	0.03	1.00	0.03	0.002	0.005	3.233	0.040	*Median*	3.23264	
35	200	5.3	285	1.1	44	9.8	1.02	0.04	1.04	0.04	0.009	0.007	3.464	0.040	*A15 mea*	3.26726	c=1.5: C
36	200	5.6	314	1.2	29	3.8	0.99	0.03	0.99	0.03	0.003	0.005	3.072	0.040	*H15 mea*	3.27221	c=1.5: C
37	220	4.7	493	1.2	27	2.5	1.00	0.03	1.01	0.03	0.007	0.004	3.152	0.030	*MAD*	0.1712	
38	220	6.1	442	1.3	23	1.7	0.99	0.03	1.00	0.03	0.005	0.003	2.920	0.030	*MADe*	0.25382	
39	220	5.0	295	1.6	19	1.6	1.01	0.03	1.04	0.04	0.008	0.005	3.092	0.040	*sMAD*	0.25382	
40	220	5.8	249	1.3	24	3.0	1.01	0.04	1.03	0.04	0.008	0.006	3.273	0.050	*H15 Std*	0.2611	c=1.5: C
41	240	5.3	417	1.4	35	4.0	1.04	0.03	1.02	0.03	0.012	0.004	3.525	0.040			
42	240	6.2	398	1.6	36	3.8	1.00	0.02	1.05	0.03	0.015	0.003	3.484	0.030			
43	240	5.3	426	1.5	28	2.5	1.02	0.03	1.02	0.03	0.013	0.004	3.122	0.030			
44	240	4.8	492	1.7	32	2.8	1.04	0.03	1.03	0.02	0.011	0.003	3.414	0.030			
45	260	3.8	411	1.8	21	1.4	1.02	0.03	1.00	0.03	0.009	0.003	3.233	0.040			
46	260	6.1	452	1.8	21	1.2	1.01	0.02	1.01	0.02	0.007	0.002	3.233	0.030			
47	260	3.4	439	2.2	25	1.9	1.01	0.03	1.00	0.03	0.009	0.003	3.595	0.040			
48	260	4.6	837	1.4	29	1.8	1.02	0.02	1.00	0.02	0.008	0.002	2.769	0.020			
													n =	16		n =	16
Mean		5.1	417	1.5	28.2		1.01		1.01		0.009	Mean	3.277	Internal		H15 mean	3.272
SD		0.8	136	0.3	6.8		0.02		0.02		0.004	SD	0.271	Error		H15 Std Dev	0.261
SD/rtN		0.2	34	0.1	1.7		0.00		0.00		0.001	SD/rtN	0.068	0.009		SD/rtN	0.065
%err		4	8	5	6		0		0		11	%err	2			%err	2

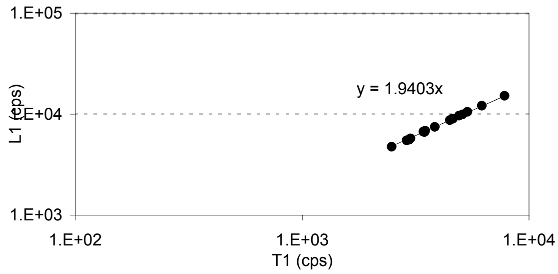


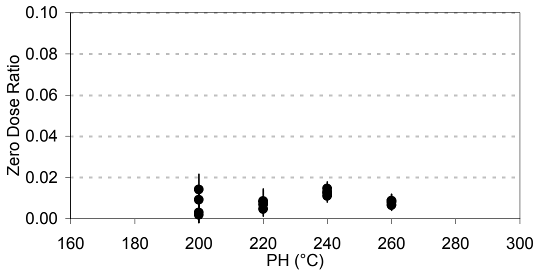


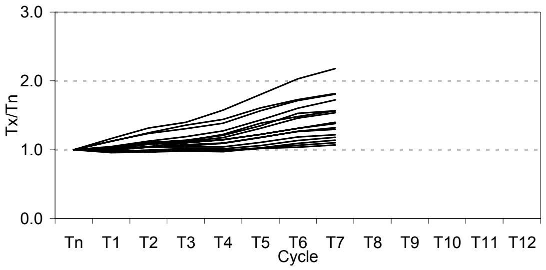












Sample SUTL 2168
Date 151107 to 181107
Reader Riso 2
Source Calibration 0.0936 ± 0.001 Gy/s
Regenerative Dose Sequence (Gy)

Dn	D1	D2	D3	D4	D5	D6	D7	D8	D9
0.00	3.77	0.02	0.96	6.57	9.38	3.77	3.77	0.02	0.02

Test Dose (Gy) 1.89

Measurement	Signal	Background
OSL 60s@125°C, 240Cl	11-30	191-230
IRSL 120s@50°C, 240C	11-30	191-230

Note:
1. Final test dose irradiation appeared incomplete (possibly due to reduced gas pressure: see plot of Tx/Tn vs cycle). Previous test dose response used t normalise OSL signal measured following IRSL was This did not affect measurements for De determinati

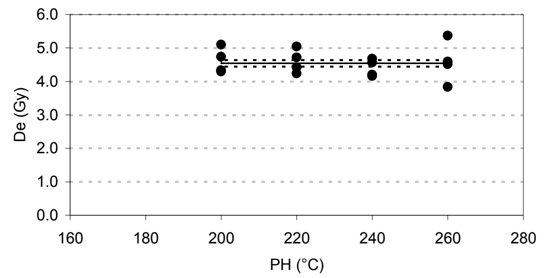
Aliquot	Preheat	Aliquot Mass	Sensitivity	Change	Dose Response		Recycling Point 3.77 Gy		Post IRSL[1] 3.77 Gy		Zero Dose 0.00 Gy		Equivalent Dose	
	(°C/30s)	(g)	(cps/ mg/Gy)	(frn.)	D0 (Gy)	Err	ratio	error	ratio	error	ratio	error	(Gy)	error
1	200	4.2	451	1.3	22	2.5	1.04	0.04	1.06	0.04	0.011	0.007	4.332	0.056
2	200	5.7	322	1.5	25	3.2	0.98	0.03	1.04	0.04	0.020	0.007	5.100	0.066
3	200	4.7	121	1.2	40	21.9	1.04	0.09	1.10	0.09	0.031	0.022	4.735	0.140
4	200	3.8	568	1.3	28	3.2	1.03	0.03	1.06	0.03	0.011	0.005	4.295	0.047
5	220	5.9	784	1.6	21	1.1	1.03	0.02	1.09	0.02	0.011	0.003	5.044	0.037
6	220	5.1	416	1.4	18	1.4	1.03	0.03	1.08	0.03	0.017	0.005	4.417	0.056
7	220	4.9	233	1.6	19	2.3	1.00	0.04	1.03	0.05	0.029	0.009	4.716	0.094
8	220	5.1	245	1.5	22	2.8	1.01	0.04	1.04	0.04	0.030	0.008	4.239	0.075
9	240	5.6	572	1.8	20	1.1	1.01	0.02	1.06	0.02	0.013	0.003	4.164	0.037
10	240	5.1	316	1.9	24	2.5	1.04	0.03	1.08	0.03	0.027	0.006	4.679	0.075
11	240	4.7	815	1.7	27	1.8	1.05	0.02	1.09	0.02	0.011	0.003	4.201	0.037
12	240	5.1	256	2.0	26	3.1	1.01	0.04	1.10	0.04	0.036	0.007	4.566	0.075
13	260	5.6	369	1.9	18	1.1	0.98	0.03	1.00	0.03	0.023	0.004	4.594	0.056
14	260	6.4	694	1.6	29	1.9	1.03	0.02	1.05	0.02	0.011	0.002	3.836	0.028
15	260	6.8	627	1.9	24	1.2	0.99	0.02	1.01	0.02	0.017	0.002	5.371	0.037
16	260	5.2	665	2.1	21	1.0	0.99	0.02	1.03	0.02	0.015	0.002	4.510	0.037
													n =	16
Mean		5.2	466	1.7	24.0		1.02		1.06		0.019	Mean	4.550	Internal
SD		0.8	213	0.3	5.5		0.02		0.03		0.009	SD	0.392	Error
SD/rtN		0.2	53	0.1	1.4		0.01		0.01		0.002	SD/rtN	0.098	0.016
%err		4	11	4	6		1		1		11	%err	2	

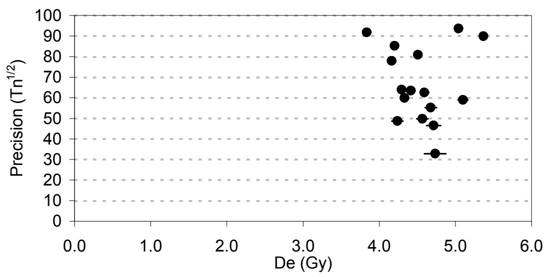
AMC Robust Statistics V1.(

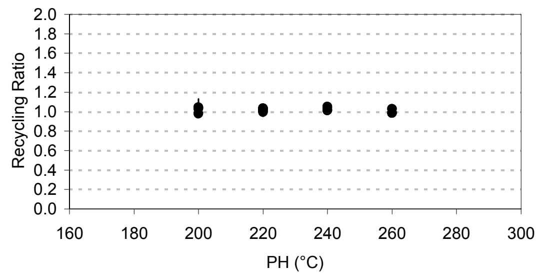
ROBUST STATISTICS SU

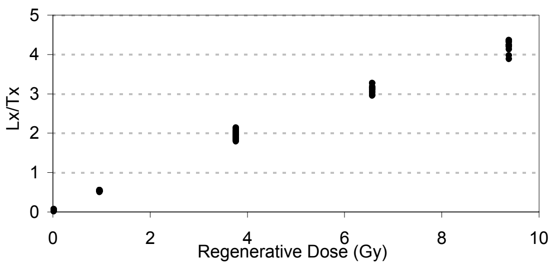
Estimate	*Estimate value*
Median	4.53829
A15 mea	4.53733
H15 mea	4.54229
MAD	0.22458
MADe	0.33296
sMAD	0.33296
H15 Std	0.38779

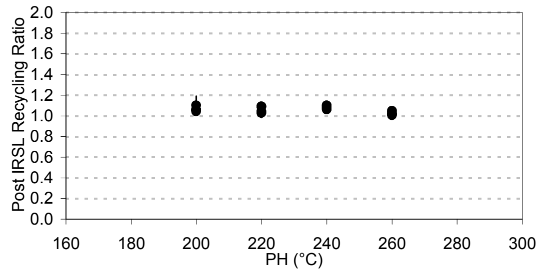
n =	16
H15 mean	4.542
H15 Std Dev	0.388
SD/rtN	0.097
%err	2

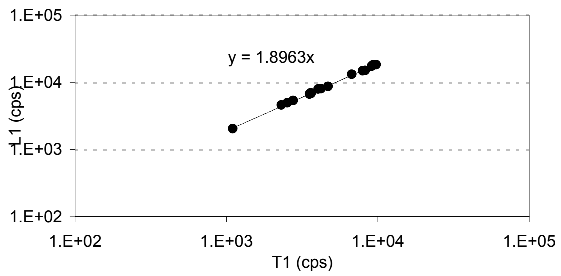


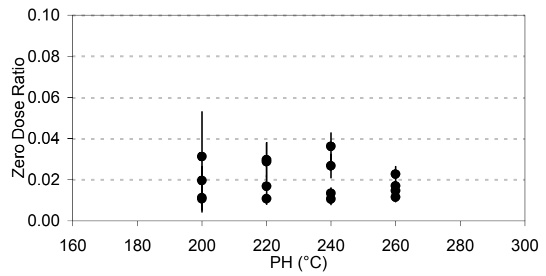


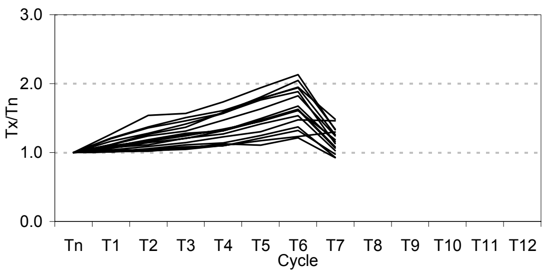












Sample SUTL 2169
Date 151107 to 181107
Reader Riso 2
Source Calibration 0.0936 ± 0.001 Gy/s
Regenerative Dose Sequence (Gy)

Dn	D1	D2	D3	D4	D5	D6	D7	D8	D9
0.00	3.77	0.02	0.96	6.57	9.38	3.77	3.77	0.02	0.02

Test Dose (Gy) 1.89

Measurement	Signal	Background
OSL 60s@125°C, 240Cl	11-30	191-230
IRSL 120s@50°C, 240C	11-30	191-230

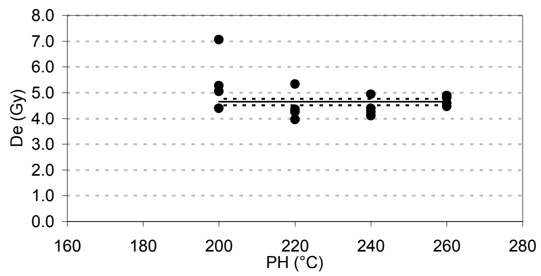
Note:
1. Final test dose irradiation appeared incomplete (possibly due to reduced gas pressure: see plot of Tx/Tn vs cycle). Previous test dose response used t normalise OSL signal measured following IRSL was This did not affect measurements for De determinati

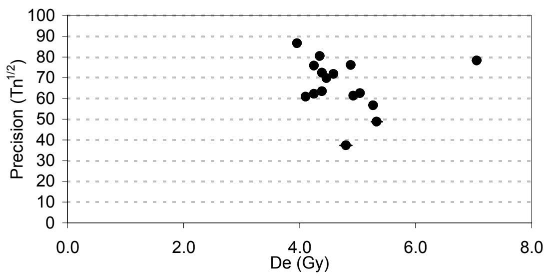
Aliquot	Preheat	Aliquot Mass	Sensitivity (cps/	Change	Dose Response		Recycling Point		Post IRSL[1]		Zero Dose		Equivalent Dose	
							3.77	Gy	3.77	Gy	0.00	Gy		
	(°C/30s)	(g)	mg/Gy)	(frn.)	D0 (Gy)	Err	ratio	error	ratio	error	ratio	error	(Gy)	error
17	200	5.1	332	1.3	25	3.4	0.98	0.04	1.05	0.04	0.012	0.007	5.268	0.075
18	200	4.1	503	1.1	18	1.6	1.05	0.04	1.08	0.04	0.015	0.006	5.044	0.066
19	200	3.8	727	1.1	20	1.7	0.99	0.03	1.03	0.03	0.008	0.005	4.389	0.047
20	200	4.4	736	1.2	29	3.2	1.04	0.03	1.08	0.03	0.014	0.005	7.055	0.075
21	220	4.1	306	1.6	27	4.2	0.99	0.04	1.04	0.04	0.030	0.008	5.334	0.094
22	220	4.3	705	1.6	21	1.3	1.01	0.02	1.06	0.03	0.010	0.003	4.248	0.037
23	220	5.4	734	1.3	30	2.8	1.03	0.02	1.06	0.02	0.012	0.004	3.958	0.037
24	220	5.0	682	1.3	26	2.0	1.02	0.02	1.06	0.02	0.008	0.003	4.351	0.037
25	240	4.0	510	1.7	22	1.7	1.04	0.03	1.08	0.03	0.015	0.004	4.248	0.056
26	240	4.4	483	1.6	21	1.6	1.00	0.03	1.04	0.03	0.017	0.004	4.389	0.056
27	240	4.3	453	1.6	26	2.7	1.01	0.03	1.04	0.03	0.018	0.005	4.108	0.056
28	240	3.6	551	2.0	21	1.5	1.02	0.03	1.06	0.03	0.009	0.004	4.931	0.056
29	260	3.6	756	1.8	18	0.9	1.00	0.02	1.00	0.02	0.016	0.003	4.585	0.047
30	260	3.0	857	2.0	18	0.9	1.00	0.02	1.01	0.02	0.007	0.002	4.463	0.047
31	260	1.6	462	1.8	21	2.8	0.99	0.05	0.99	0.05	0.020	0.007	4.800	0.103
32	260	4.0	763	1.9	21	1.2	0.98	0.02	1.01	0.02	0.015	0.002	4.885	0.047
													n =	16
Mean		4.0	597	1.6	22.9		1.01		1.04		0.014	Mean	4.754	Internal
SD		0.9	167	0.3	3.9		0.02		0.03		0.006	SD	0.736	Error
SD/rtN		0.2	42	0.1	1.0		0.01		0.01		0.001	SD/rtN	0.184	0.015
%err		5	7	5	4		1		1		10	%err	4	

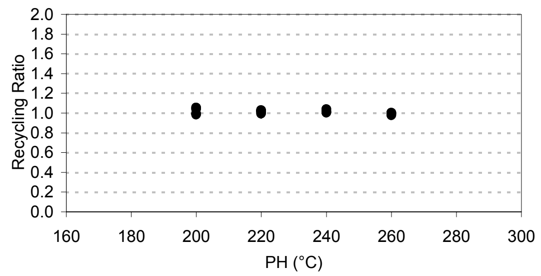
AMC Robust Statistics V1.(

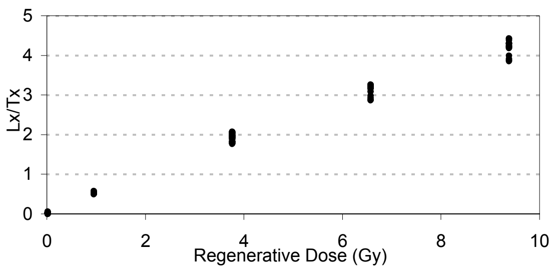
ROBUST STATISTICS SU		
Estimate	*Estimate*	*Parame*
Median	4.52426	
A15 mea	4.63089	c=1.5: C
H15 mea	4.64974	c=1.5: C
MAD	0.31815	
MADe	0.47169	
sMAD	0.47169	
H15 Std	0.51332	c=1.5: C

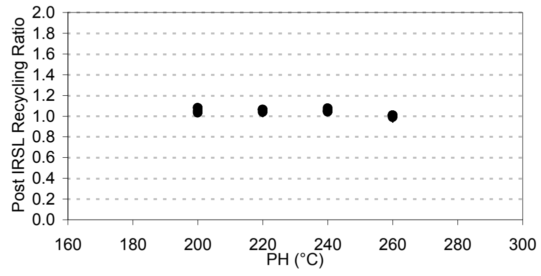
n =	16
H15 mean	4.650
H15 Std Dev	0.513
SD/rtN	0.128
%err	3

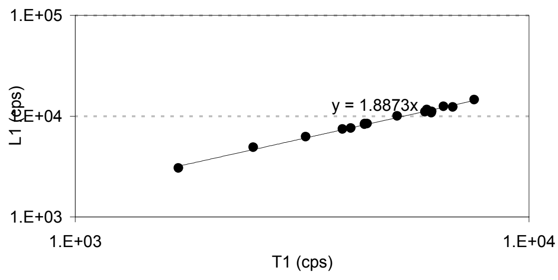


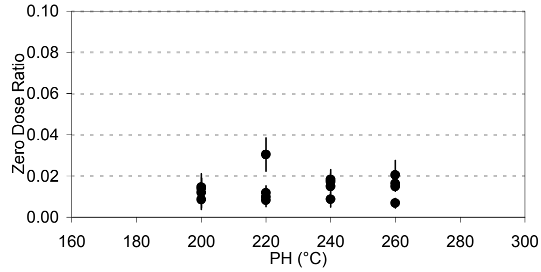


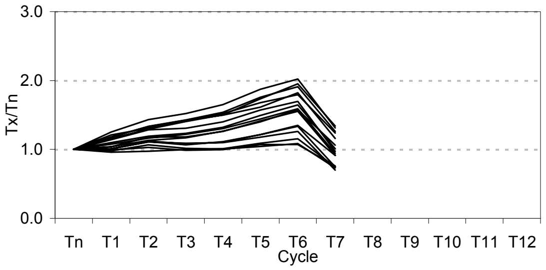












Sample SUTL 2170
Date 151107 to 181107
Reader Riso 2
Source Calibration 0.0936 ± 0.001 Gy/s
Regenerative Dose Sequence (Gy)

Dn	D1	D2	D3	D4	D5	D6	D7	D8	D9
0.00	3.77	0.02	0.96	6.57	9.38	3.77	3.77	0.02	0.02

Test Dose (Gy) 1.89

Measurement	Signal	Background
OSL 60s@125°C, 240Cl	11-30	191-230
IRSL 120s@50°C, 240C	11-30	191-230

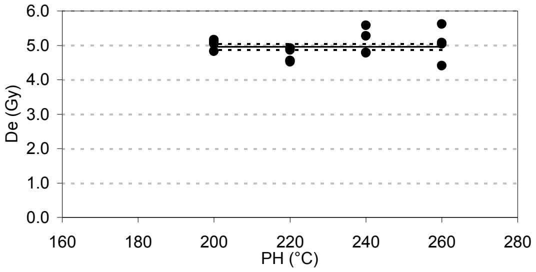
Note:
1. Final test dose irradiation appeared incomplete (possibly due to reduced gas pressure: see plot of Tx/Tn vs cycle). Previous test dose response used t normalise OSL signal measured following IRSL was This did not affect measurements for De determinati

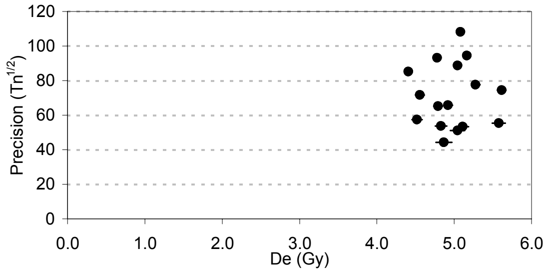
Aliquot	Preheat (°C/30s)	Aliquot Mass (g)	Sensitivity (cps/ mg/Gy)	Sensitivity Change (frn.)	Dose Response D0 (Gy)	Dose Response Err	Recycling Point 3.77 Gy ratio	Recycling Point 3.77 Gy error	Post IRSL[1] 3.77 Gy ratio	Post IRSL[1] 3.77 Gy error	Zero Dose 0.00 Gy ratio	Zero Dose 0.00 Gy error	Equivalent Dose (Gy)	Equivalent Dose error
33	200	5.5	855	1.0	18	1.1	1.01	0.02	1.00	0.02	0.007	0.003	5.165	0.037
34	200	3.3	455	1.3	21	2.6	1.01	0.04	1.05	0.04	0.003	0.008	5.109	0.075
35	200	3.4	407	1.2	24	4.1	1.00	0.05	1.01	0.05	0.012	0.010	5.044	0.094
36	200	4.0	380	1.4	22	2.6	1.05	0.04	1.08	0.04	0.022	0.008	4.828	0.075
37	220	6.1	445	1.4	20	1.5	1.05	0.03	1.09	0.03	0.016	0.005	4.557	0.056
38	220	3.4	511	1.7	20	1.9	1.06	0.04	1.13	0.04	0.007	0.006	4.520	0.066
39	220	3.0	761	1.6	24	2.0	1.08	0.03	1.11	0.03	0.013	0.004	4.922	0.056
40	220	3.7	279	1.4	16	1.9	1.01	0.05	1.06	0.05	0.013	0.010	4.866	0.103
41	240	4.9	935	1.6	29	1.8	1.01	0.02	1.04	0.02	0.013	0.002	4.782	0.037
42	240	4.3	377	2.1	20	1.6	1.02	0.03	1.09	0.03	0.035	0.006	5.577	0.084
43	240	5.9	379	2.1	16	0.9	1.01	0.03	1.07	0.03	0.016	0.004	4.791	0.056
44	240	6.3	504	1.8	22	1.3	1.03	0.02	1.07	0.02	0.015	0.003	5.278	0.056
45	260	6.5	640	2.7	23	1.1	0.97	0.02	1.01	0.02	0.015	0.002	5.044	0.037
46	260	5.6	523	2.7	16	0.6	0.98	0.02	1.02	0.02	0.015	0.003	5.614	0.056
47	260	7.3	846	1.9	20	0.7	1.00	0.01	1.01	0.01	0.016	0.002	5.081	0.037
48	260	5.6	684	2.0	24	1.3	1.03	0.02	1.05	0.02	0.016	0.002	4.407	0.037
												n =	16	
Mean		4.9	561	1.7	21.0		1.02		1.06		0.015	Mean	4.974	Internal
SD		1.3	201	0.5	3.4		0.03		0.04		0.007	SD	0.342	Error
SD/rtN		0.3	50	0.1	0.9		0.01		0.01		0.002	SD/rtN	0.085	0.016
%err		7	9	7	4		1		1		12	%err	2	

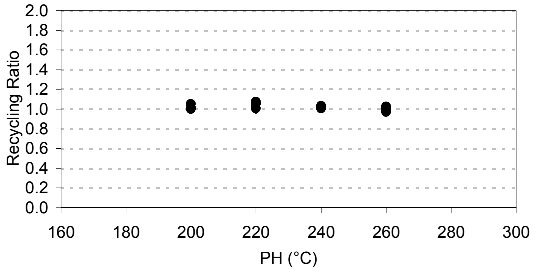
AMC Robust Statistics V1.(

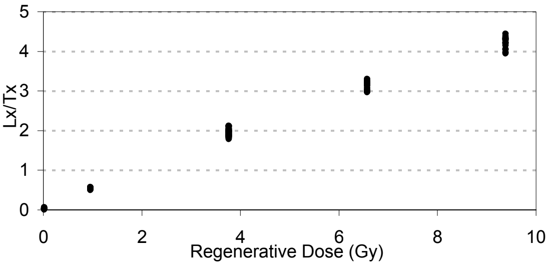
ROBUST STATISTICS SU		
Estimate	*Estimate*	*Parame*
Median	4.98276	
A15 mea	4.95548	c=1.5: C
H15 mea	4.96046	c=1.5: C
MAD	0.18715	
MADe	0.27746	
sMAD	0.27746	
H15 Std	0.34518	c=1.5: C

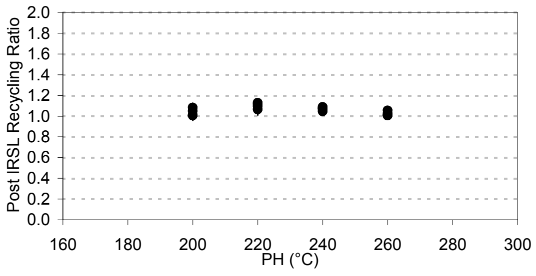
n =	16
H15 mean	4.960
H15 Std Dev	0.345
SD/rtN	0.086
%err	2

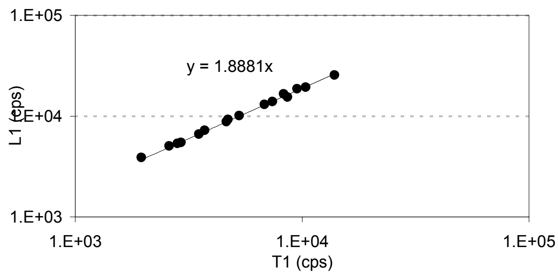


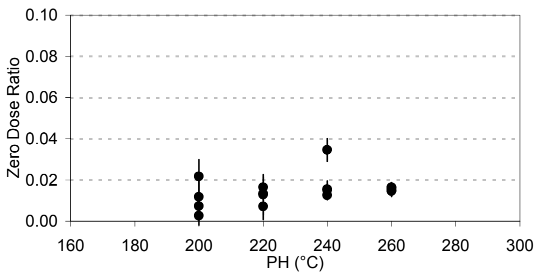


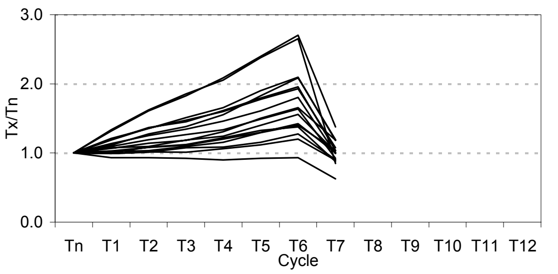












Appendix E: Luminescence Profiling

Site	Newry Ring Fort Section 1									
Seq File	pmc32.seq	hfc32.seq								
Bin File	new1pmc.bin	new1hfc.bin				new1pmc.bin		new1hfc.bin		
Date	12/18/07	12/18/07		Dose	DN	D1	Dt (HFC)	DN	D1	Dt (HFC)
Reader	Riso 2	Riso 1		(sB)	0	100	-	0	100	20
Calib	0.0934	0.1005	(Gy/s)	(Gy)	0	9.34	-	0	10.05	2.01
Err	0.0010	0.0017	(Gy/s)	(Err)	-	0.10	-	-	0.17	0.03

Sample				**Sensitivity**				**Equivalent Dose**			
				Polymineral Coarse			HFE Coarse	Polymineral Coarse			HFE Coarse
	DfS			IRSL	Post IR OSL	Post IR & OSL TL	OSL	IRSL	Post IR OSL	PostIR&OSLTL	OSL
SUTL	(cm)	Layer	Ali	(cps/Gy)	(cps/Gy)	(cp°C/Gy)	(cps/Gy)	(Gy)	(Gy)	(Gy)	(Gy)
2156 # 1	5	1	1	250 ± 4	1289 ± 16	60.7 ± 0.7	392 ± 7	2.28 ± 0.06	0.23 ± 0.02	73.6 ± 0.9	0.06 ± 0.02
			2	218 ± 3	1319 ± 16	56.2 ± 0.7	564 ± 10	1.73 ± 0.06	0.56 ± 0.02	56.6 ± 0.7	0.39 ± 0.02
2156 # 2	11	1	1	73 ± 2	391 ± 6	32.5 ± 0.4	2417 ± 41	4.63 ± 0.18	1.02 ± 0.08	78.4 ± 1.1	0.43 ± 0.01
			2	147 ± 3	698 ± 9	41.2 ± 0.5	1853 ± 32	3.64 ± 0.11	0.78 ± 0.05	60.5 ± 0.8	0.49 ± 0.01
2156 # 3	19	2	1	114 ± 2	571 ± 8	34.8 ± 0.5	1962 ± 34	7.20 ± 0.19	1.37 ± 0.06	65.1 ± 0.9	0.55 ± 0.01
			2	119 ± 2	581 ± 8	36.1 ± 0.5	2773 ± 47	4.81 ± 0.14	0.92 ± 0.05	61.5 ± 0.8	0.68 ± 0.02
2156 # 4	39	2	1	92 ± 2	553 ± 8	30.2 ± 0.4	880 ± 15	16.9 ± 0.41	1.97 ± 0.08	110 ± 1.6	0.93 ± 0.03
			2	168 ± 3	738 ± 10	50.8 ± 0.6	358 ± 7	15.2 ± 0.29	1.98 ± 0.07	66.4 ± 0.9	0.87 ± 0.04
2156 # 5	56	2	1	83 ± 2	376 ± 6	21.7 ± 0.3	684 ± 12	4.83 ± 0.17	4.10 ± 0.11	57.3 ± 0.9	1.97 ± 0.06
			2	99 ± 2	863 ± 11	26.7 ± 0.4	778 ± 14	16.7 ± 0.39	3.58 ± 0.07	70.8 ± 1.0	2.13 ± 0.06
2156 # 6	79	2	1	119 ± 2	908 ± 12	35.6 ± 0.5	1076 ± 19	8.18 ± 0.20	3.33 ± 0.06	54.2 ± 0.8	23.2 ± 0.52
			2	175 ± 3	565 ± 8	50.2 ± 0.6	793 ± 14	13.2 ± 0.25	3.72 ± 0.09	66.4 ± 0.9	2.71 ± 0.07
2156 # 7	93	2	1	156 ± 3	660 ± 9	51.8 ± 0.7	2927 ± 50	10.9 ± 0.23	4.61 ± 0.10	90.5 ± 1.2	3.75 ± 0.07
			2	173 ± 3	620 ± 9	36.9 ± 0.5	911 ± 16	7.93 ± 0.17	3.59 ± 0.08	62.1 ± 0.9	2.97 ± 0.07
2156 # 8	99	3	1	169 ± 3	558 ± 8	42.5 ± 0.6	2052 ± 35	6.92 ± 0.15	4.92 ± 0.10	53.9 ± 0.7	2.66 ± 0.06
			2	98 ± 2	666 ± 9	33.3 ± 0.5	1114 ± 19	23.8 ± 0.54	5.49 ± 0.11	98.8 ± 1.4	2.69 ± 0.06
2156 # 9	105	4	1	184 ± 3	784 ± 10	50.7 ± 0.6	1457 ± 25	94.6 ± 1.55	12.4 ± 0.22	192 ± 2.4	3.27 ± 0.07
			2	114 ± 2	365 ± 6	40.4 ± 0.5	837 ± 15	50.4 ± 1.00	7.03 ± 0.18	112 ± 1.5	3.94 ± 0.10
2156 # 10	112	5	1	174 ± 3	1130 ± 14	39.2 ± 0.5	2269 ± 39	204 ± 3.33	12.3 ± 0.18	193 ± 2.6	5.75 ± 0.12
			2	282 ± 4	578 ± 8	42.9 ± 0.6	1558 ± 27	155 ± 2.22	20.9 ± 0.35	206 ± 2.7	4.67 ± 0.10
2156 # 11	124	6	1	202 ± 3	248 ± 5	47.1 ± 0.6	1180 ± 21	10.9 ± 0.20	5.82 ± 0.21	96.2 ± 1.2	5.46 ± 0.14
			2	178 ± 3	999 ± 13	41.2 ± 0.5	784 ± 14	15.3 ± 0.28	3.03 ± 0.07	101 ± 1.3	3.58 ± 0.10
2156 # 12	134	7	1	182 ± 3	998 ± 13	26.6 ± 0.4	1691 ± 29	15.1 ± 0.28	3.34 ± 0.06	95.0 ± 1.4	3.81 ± 0.09
			2	137 ± 2	265 ± 5	32.3 ± 0.4	762 ± 13	19.1 ± 0.38	6.45 ± 0.24	126 ± 1.8	3.92 ± 0.10
2156 # 13	145	7	1	200 ± 3	1010 ± 13	42.9 ± 0.6	885 ± 16	17.2 ± 0.30	7.23 ± 0.11	102 ± 1.3	4.54 ± 0.11
			2	253 ± 4	559 ± 8	47.1 ± 0.6	407 ± 8	495 ± 7.23	44.6 ± 0.71	286 ± 3.7	5.79 ± 0.19
2156 # 14	154	8	1	182 ± 3	785 ± 10	38.1 ± 0.5	755 ± 13	22.1 ± 0.39	5.43 ± 0.11	93.5 ± 1.3	4.72 ± 0.12
			2	114 ± 2	466 ± 7	26.3 ± 0.4	1473 ± 26	15.3 ± 0.34	5.60 ± 0.12	91.4 ± 1.3	4.19 ± 0.09
2156 # 15	164	9	1	49 ± 1	24 ± 2	10.9 ± 0.2	141 ± 3	340 ± 9.33	103 ± 7.21	398 ± 7.8	28.4 ± 1.82
			2	82 ± 2	94 ± 3	24.0 ± 0.4	260 ± 5	338 ± 7.21	47.7 ± 1.58	388 ± 5.8	18.5 ± 0.91
2156 # 16	105	3	1	232 ± 3	2081 ± 24	68.1 ± 0.8	1911 ± 33	6.45 ± 0.13	2.67 ± 0.04	49.2 ± 0.6	2.08 ± 0.04
			2	135 ± 2	1549 ± 19	42.8 ± 0.6	1262 ± 22	10.7 ± 0.23	4.35 ± 0.06	67.2 ± 0.9	2.44 ± 0.06

Site	Newry Ring Fort Section 2									
Seq File	pmc30.seq	hfc30.seq								
Bin File	new2pmc.bin	new2hfc.bin			new2pmc.bin			new2hfc.bin		
Date	12/20/07	12/20/07		Dose	DN	D1	Dt (HFC)	DN	D1	Dt (HFC)
Reader	Riso 2	Riso 1		(sB)	0	100	-	0	100	20
Calib	0.0934	0.1005	(Gy/s)	(Gy)	0	9.34	-	0	10.05	2.01
Err	0.0010	0.0017	(Gy/s)	(Err)	-	0.10	-	-	0.17	0.03

Sample				**Sensitivity**				**Equivalent Dose**			
				Polymineral Coarse			HFE Coarse	Polymineral Coarse			HFE Coarse
	DfS			IRSL	Post IR OSL	Post IR & OSL TL	OSL	IRSL	Post IR OSL	PostIR&OSLTL	OSL
SUTL	(cm)	Layer	Ali	(cps/Gy)	(cps/Gy)	(cp°C/Gy)	(cps/Gy)	(Gy)	(Gy)	(Gy)	(Gy)
2164 # 1	8	1	1	107 ± 2.05	474 ± 7	31.1 ± 0.43	3381 ± 58	1.14 ± 0.077	0.45 ± 0.04	48.5 ± 0.7	0.4 ± 0.01
			2	235 ± 3.52	316 ± 5.36	48.9 ± 0.62	1316 ± 23	1.46 ± 0.05	0.35 ± 0.06	54.6 ± 0.7	0.4 ± 0.01
2164 # 2	17	2	1	118 ± 2.21	385 ± 6.03	40.5 ± 0.53	928 ± 16	4.41 ± 0.132	0.65 ± 0.05	55.2 ± 0.7	1.44 ± 0.04
			2	160 ± 2.68	379 ± 6.01	48.7 ± 0.62	758 ± 13	7.75 ± 0.172	1.44 ± 0.09	83.7 ± 1.1	0.72 ± 0.03
2164 # 3	31	3	1	211 ± 3.28	699 ± 9.51	54.5 ± 0.68	2653 ± 45	37.6 ± 0.618	1.57 ± 0.06	88.5 ± 1.1	1.06 ± 0.02
			2	174 ± 2.84	745 ± 9.96	47.3 ± 0.61	1075 ± 19	10.8 ± 0.219	2.86 ± 0.09	140 ± 1.8	1.87 ± 0.05
2164 # 4	48	3	1	82.4 ± 1.76	331 ± 5.39	26.6 ± 0.38	825 ± 15	9.71 ± 0.279	1.51 ± 0.08	88.3 ± 1.3	1.45 ± 0.04
			2	114 ± 2.14	321 ± 5.32	30.3 ± 0.42	1075 ± 19	14.2 ± 0.318	1.34 ± 0.08	81.4 ± 1.2	2.12 ± 0.05
2164 # 5	67	3	1	120 ± 2.21	1462 ± 17.6	38.4 ± 0.51	1620 ± 28	4.11 ± 0.126	1.76 ± 0.03	47.8 ± 0.7	2.5 ± 0.06
			2	327 ± 4.52	1359 ± 16.6	53.4 ± 0.67	716 ± 13	10.4 ± 0.172	2.08 ± 0.05	95.3 ± 1.2	2.08 ± 0.06
2164 # 6	80	3	1	105 ± 2.05	974 ± 12.4	31.1 ± 0.43	1460 ± 25	25.1 ± 0.544	3.51 ± 0.06	46 ± 0.7	3.68 ± 0.08
			2	180 ± 2.93	1523 ± 18.3	42 ± 0.55	1728 ± 30	6.53 ± 0.143	2.28 ± 0.04	43.2 ± 0.6	3.04 ± 0.07
2164 # 7	98	3	1	87.2 ± 1.83	770 ± 10.2	24.3 ± 0.36	1545 ± 27	4.96 ± 0.169	3.35 ± 0.07	47.3 ± 0.7	2.95 ± 0.07
			2	97.1 ± 1.94	843 ± 11	27.8 ± 0.4	2017 ± 35	4.18 ± 0.142	2.65 ± 0.05	30 ± 0.5	3.13 ± 0.06
2164 # 8	107	4	1	164 ± 2.72	1221 ± 15.1	47.8 ± 0.61	2020 ± 35	15.7 ± 0.302	2.61 ± 0.05	42.7 ± 0.6	2.9 ± 0.06
			2	169 ± 2.8	1131 ± 14.1	43.1 ± 0.56	1172 ± 20	11 ± 0.223	3.34 ± 0.06	62.9 ± 0.8	3.37 ± 0.08
2164 # 9	116	4	1	63.2 ± 1.52	281 ± 4.83	20.4 ± 0.32	929 ± 16	4.54 ± 0.192	2.68 ± 0.09	40.9 ± 0.7	3.69 ± 0.09
			2	57.4 ± 1.44	483 ± 7.04	21.3 ± 0.32	801 ± 14	4.61 ± 0.207	3.94 ± 0.09	53.8 ± 0.9	3.65 ± 0.09
2164 # 10	126	5	1	163 ± 2.7	1189 ± 14.7	42.9 ± 0.56	1535 ± 27	5.65 ± 0.134	3.36 ± 0.06	55.3 ± 0.7	4.15 ± 0.09
			2	103 ± 2.02	582 ± 8.17	32.9 ± 0.45	1095 ± 19	26.9 ± 0.583	3.76 ± 0.09	84.5 ± 1.2	3.79 ± 0.09
2164 # 11	143	5/6	1	158 ± 2.65	1065 ± 13.4	42.4 ± 0.55	1683 ± 29	8.84 ± 0.19	3.1 ± 0.06	72.1 ± 1	4.75 ± 0.1
			2	69.5 ± 1.59	388 ± 6.01	21.6 ± 0.33	1415 ± 24	10.6 ± 0.316	3.9 ± 0.1	88.2 ± 1.4	4.98 ± 0.11
2164 # 12	155	6	1	154 ± 2.59	728 ± 9.76	30.7 ± 0.43	1655 ± 29	9.52 ± 0.202	4.23 ± 0.08	67.2 ± 1	4.99 ± 0.11
			2	96.9 ± 1.94	451 ± 6.72	24.5 ± 0.36	1034 ± 18	22.7 ± 0.518	5.87 ± 0.13	124 ± 1.8	4.66 ± 0.11
2164 # 13	161	7	1	119 ± 2.19	868 ± 11.3	27.2 ± 0.39	722 ± 13	47.2 ± 0.921	5.77 ± 0.1	138 ± 2	5.53 ± 0.15
			2	202 ± 3.15	894 ± 11.6	43.4 ± 0.56	1173 ± 20	31.4 ± 0.523	4.67 ± 0.09	116 ± 1.5	7.25 ± 0.17
2164 # 14	171	8	1	383 ± 5.13	992 ± 12.8	87.4 ± 1.04	2712 ± 46	26.6 ± 0.378	4.82 ± 0.08	48.7 ± 0.6	10 ± 0.2
			2	190 ± 3.02	851 ± 11.1	43.1 ± 0.56	2420 ± 41	35.3 ± 0.599	5.07 ± 0.1	106 ± 1.4	5 ± 0.1
2164 # 15	180	9	1	51.5 ± 1.38	46.4 ± 1.93	13.2 ± 0.24	397 ± 7.5	62.7 ± 1.763	15.7 ± 1	277 ± 5	10 ± 0.35
			2	71 ± 1.6	31.6 ± 1.83	18 ± 0.29	315 ± 6.1	74.4 ± 1.749	34.3 ± 2.31	286 ± 4.6	14.3 ± 0.54