# Gwithian, Cornwall

## Report on Palaeoenvironmental sampling fieldwork June 2005


**Historic Environment Service (Projects)**

**Cornwall County Council**

A Report for English Heritage

# Gwithian, Cornwall
# REPORT ON PALAEOENVIRONMENTAL SAMPLING FIELDWORK SCHEDULED MONUMENT CORNWALL 771


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Palaeoenvironmental samples were excavated in the field by specialists working on the Gwithian Archive Project team. Dr Helen Roberts (University of Aberystwyth) sampled for an OSL dating study, Dr Erika Guttmann (University of Reading) took soil samples, Vanessa Straker (English Heritage) took bulk samples for macro-plant remains, vertebrae and land snails (on behalf of Dr Paul Davies, University of Bath), and tephra samples, Dr David Earle Robinson (English Heritage) took samples for pollen assessment. Henrietta Quinnell and Carl Thorpe assessed the pottery and stonework, Dr Janice Light, the marine shell assemblage and Dr Andy Hammon assessed the animal bone.

Within the Historic Environment Service, the Project was managed by Jacky Nowakowski and the fieldwork was jointly directed with Professor Charles Thomas. The project team are grateful to Ian Morrison and Fachtna McAvoy of English Heritage and Andrew McDouall from English Nature for their support.


*Please note:* The report on the results of the OSL dating programme has been presented here as an interim statement (in the appendix). A fuller public statement of these results will be presented as part of a supplement on the current scientific dating programme which will be form a section of a summary publication on the Gwithian archive which will be published in a future volume of *Cornish Archaeology*. For any reference to the OSL dates please contact the author.

The views and recommendations expressed in this report are those of the Historic Environment Service projects team and are presented in good faith on the basis of professional judgement and on information currently available.

### Cover illustration

Photograph of Charles Thomas in Trench GMXVII during excavation 23-26/6/05

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## Abbreviations

| | |
|---|---|
| AMS | Accelerator Mass Spectrometry measurement |
| ALSF | Aggregates Levy Sustainability Fund |
| CRO | Cornwall County Record Office |
| EH | English Heritage |
| HER | Cornwall and the Isles of Scilly Historic Environment Record |
| HES | Historic Environment Service, Cornwall County Council |
| NGR | National Grid Reference |
| OS | Ordnance Survey |
| OSL | Optically Stimulated Luminescence |
| PRN | Primary Record Number in Cornwall HER |
| RIC | Royal Institution of Cornwall |
| SSSI | Site of Special Scientific Interest |

# 1 Summary

*In June 2005 a small-scale field investigation took place at the Bronze Age site at Gwithian in West Cornwall. The principal aim of the exercise was to revisit the main stratigraphic sequence and to recover palaeoenvironmental samples and samples for OSL dating (Optically Stimulated Luminescence Dating). Assessment and analysis of these samples will enhance the existing archive for the story of Gwithian during the 2nd Millennium BC. This report presents the results of this fieldwork and sets out recommendations for further analysis of main data-sets.*

# 2 Introduction

## 2.1 Project background

During the 1950s and 1960s a major archaeological project took place at Gwithian in West Cornwall. This was a significant landscape study which was directed by Professor Charles Thomas. For over 20 years an area some 4 sq miles in extent was the focus for extensive field survey and numerous excavations which charted the evolution and history of land use from the Mesolithic through to the Post-Medieval periods. The setting for this was a sand-duned environment (the towans) which provided special alkaline conditions for the excellent preservation of archaeological horizons and many classes of artefact. In addition frequent sand blows throughout the millennia ensured the unique survival of former land surfaces. Their study provides remarkable detailed insights into the varied character and history of land use within the project area (Fig. 1).

Two major excavations took place during this time – one centred on a post Roman settlement (GM/I etc) and the other, a major settlement of Bronze Age date (GM/IX, GM/X and GM/XV). Both excavations produced a wealth of data. The full results of these two major excavations have not been widely disseminated through publication despite continuing to have both national and regional significance.

Since 2003, a team from the Historic Environment Service has been working on a project which has assessed the archaeological significance of the results of this campaign of work and appraised the quality and integrity of the archaeological archives with the view to comprehensively publishing the results of the project. In the early stages of this project it was demonstrated that there were a number of key datasets which warranted further analysis leading towards full publication (Nowakowski *et al* 2004). The project is presently in its 3rd stage where the focus is on an assessment of the key datasets which will result in a series of recommendations towards a programme of targeted analyses (Nowakowski *et al* 2005 and Nowakowski forthcoming).

This report presents the results of one of the main tasks at this stage: a short piece of fieldwork conducted solely to collect additional key data groups which will enhance the existing record. These data groups were palaeoenvironmental and scientific dating samples. Although a small quantity of soil samples were taken (principally in 1956), routine sampling for environmental data (macroplant remains, land snails, soils, pollen) was not standard practice of the day, and so one of the major gaps in the extant Gwithian archive is the absence of such supporting data. This absence means that fundamental questions about the local environment, economic and agricultural practices, site formation processes and issues affecting longevity of settlement can not be addressed solely on the material and ecofactual datasets already available. The fieldwork reported here took place over 3 days in mid. June 2005 and involved revisiting the heart of the Bronze Age site where the full stratigraphic sequence was considered to be intact and suitable for palaeoenvironmental sampling.

A further aim was to carry out a pilot dating study using the OSL (Optically Stimulated Luminescence) dating technique. This was designed to complement a recent series of AMS dates which have also been obtained during this project (see Bayliss, Hamilton and Marshall in Nowakowski forthcoming). A further benefit of testing this technique within a landscape such as Gwithian with its clearly rich archaeological resource and a history of commercial sand extraction, is to highlight the potential impact of such industrial interests on the long-term future management of the historic environment (see Nowakowski 2005).

## 2.2 Aims

The overall aim of the fieldwork was to reopen a trench section first recorded in 1961 and to recover palaeoenvironmental samples from the main stratigraphic horizons which were recorded at that time.

Bulk sampling took place for:

- Macroplant remains - including charred seeds, cereal chaff and charcoal
- Vertebrae remains - including otoliths

A series of targetted samples were taken for:

- Geoarchaeology: soil micro morphology, phosphate analysis and soil magnetism
- Pollen
- Land snails
- Volcanic tephra

A further objective was to test the technique of Optically Stimulated Luminescence Dating (OSL dating). Given the exceptionally well preserved stratigraphic relationship of apparently Aeolian sand layers and the archaeological occupation surfaces at Gwithian, it was felt that the site provided a good opportunity to obtain further dates through this technique particularly given that accelerator (AMS) dates have also been obtained during this project (from residues on ceramics from the major occupation horizons).

The results of the tephra samples proved negative (Vanessa Straker pers. com).

## 2.3 Methods

During work on the reconstruction of the structure and stratigraphic narratives at the main Bronze Age sites at Gwithian (sites GM/IX and GM/X) by Joanna Sturgess, Anna Lawson Jones and Neil Craze, the team identified the most suitable location within the excavated area which could be successfully revisited. A major trench section within which the full stratigraphic sequence Layers 1 to 9 (bedrock) (top to base) had been recorded in 1961 was thus identified and this was targeted for sampling in June 2005.

Nine principal archaeological contexts or banded phases of archaeological activity at Gwithian was documented in the 1950s and 1960s as a series of major layers – known in the archive as layers 1 to 9 inclusive (Nowakowski 2004). At the time, the use of the term “layer” represented singular chronological periods within the Bronze Age Gwithian narrative each dated by diagnostic artefacts. For us today however the use of the term layer is slightly problematic as recent work on the archive has shown that within each of the major cultural horizons (layers 7/8, 5 and 3) there were episodic phases of activities which are clearly associated with “minor” phases linked to specific structures and features. The “layers” as recorded by the Gwithian team in the 1950s - 60s are therefore cultural concepts and represent more an “activity horizon” dated to a particular span of time within the period known as the Bronze Age - the 2nd Millennium BC (see Sturgess and Lawson Jones 2006).

As the site is under current Ancient Monument Protection, Scheduled Monument Consent for the fieldwork to take place was applied for and granted in June 2005. The site is also an SSSI and consent required from English Nature was given in May 2005.

### 2.3.1 Fieldwork

Fieldwork took place over 3 days in June 2005 (23rd to 25th June inclusive). A team from HES supervised by Joanna Sturgess excavated the trench. During this exercise, specialists on the Gwithian project team visited the site and hand collected their own samples.

The trench - which measured 4.60 metres long and 2.0 metres wide - was hand dug. The upper turf layer was removed in cut pieces and placed in a pile for reinstatement on the completion of the fieldwork. All subsequent lower layers were excavated by hand and placed into separate piles. Plans were made at a scale of 1:20 and the main section was drawn at 1: 10 (Figs 3 and 4). A full photographic record (Black and white photographs and digital images) was made.

On the completion of the excavation, the site was backfilled and the excavated layers were reinstated from the bottom up.

# 3 Background

## 3.1 Location and setting

The trench lay within the heart of the Bronze Age site between sites GMX and GMIX (Fig. 2). The location for the trench was determined by the presence of a previously documented intact stratigaphic sequence (see above).

# 4 Results

## 4.1 Structure and Stratigraphy by Jacky Nowakowski with Joanna Sturgess and Anna Lawson Jones

Following the removal of a compact layer of turf and sand lens **(616)**, a mid to dark brown silty sand layer **(600)** containing frequent burnt quartz, killas fragments, shell, occasional animal bone, pot and worked stone was revealed in the western half of the trench. On excavation this measured 2.10 m (east – west) and extended for at least 0.70 m (north-south). It proved to be at least 0.18 m deep. Twenty litres of soil samples for macroplant fossil remains were recovered. Thin pockets of clean sand **(615)** and **(616)** were recorded in section, above and below **(600)** (Fig. 4). **(600)** represents an upper part of the Bronze Age horizon recorded as "**layer 3"**.

Immediately below the turf in the eastern part of the trench was a thin lens of clean blown sand **(603)**. This probably represents the remnants of the former Bronze Age horizon "**layer 2"** and did not contain any inclusions or finds. "Layer 2" was not laterally present across the entire area of the trench as was initially anticipated (see below).

Early on during the investigation it became apparent that the main face of the 1961 trench edge (which had been left exposed) had collapsed in the years after its excavation. This resulted in the wholesale disappearance of the wind blown sand **"layer 2"** which had been recorded as laterally present in this part of the site in 1961. **(603)** was a relict survival of this layer.

In the south-eastern zone of the trench, a much cleaner sand (again probable remnants of slumped **"layer 2"**) was found to infill a small cutting which had been made during the 1961 excavation, and, which measured 2.90 m by 0.90 m. This 1961 cutting was located at the northern end of GMIX cuttings 5 & 6 (see Sturgess, Lawson Jones and Nowakowski 2006). The slumped infill into this cutting was removed first. The edges of the cutting within the new trench were planned and photographs were taken (Fig. 3a).

Beneath **(603)** a thin layer of **old turf (604)** was found in the extreme eastern corner of the trench. This was a sandy loam mid brown layer which contained a single sherd of pottery. This deposit was recorded during the 1961 exercise and is shown on original photographs taken at the time.

Beneath **(604)**, **(614)** and **(615)** was **layer (601)** which was found across the entire surface area of the trench. This light brown creamy sandy loam (10 YR 4/3) contained moderate bone, shell and occasional quartz fragments. It also contained a notable quantity of worked stone. A denser concentration of shell and charcoal was noted in the western section of the trench at the base of **layer (601)** (see Fig. 4). A **plough mark (613)** was noted in the section at the base of **(601)** (see Fig. 4). This was 10 cm wide and 10 cm deep. **(601)** was extensively sampled for geoarchaeological analyses, sampled for land snails and volcanic tephra and a pollen sample (4) was also taken (see Fig. 4). Forty litres of soil samples for macroplant fossil remains were also recovered. **Layer (601)** forms the bulk of the Bronze Age horizon known as **"Layer 3"**.

As time was tight it was clear that there was not enough time to excavate the whole trench in phase down to bedrock. So a decision was taken to excavate the eastern sector of the trench in order to expose the entire stratigraphic sequence. A section 2.40 metres in length was created. This was the main exposure from which the palaeoenvironmental samples were taken. A baulk (0.45 m wide) projecting out from the main section was maintained for health & safety reasons as well as to aid easy access and egress from the excavated trench as it deepened. Later a slot trench 1.10 m by 0.60m was excavated in the western half of the trench and this was taken down to layer 5 to reveal the plough marks **(607)** zone at the base of layer 5. This was principally done to show to the many site visitors the famous plough marks in the sand (see (605) below and Fig. 3b).

## 4.2 The sampled section

The next part of this account discusses the sequence recorded in the eastern sector of the trench. Some of the layers were partly exposed in the western part of the trench beyond the baulk (see section 4.1).

Following the removal of redeposited soils in the 1961 cutting (see above), the face of the 1961 trench was exposed (Fig. 3a). Beyond, the layers were undisturbed and so these were then excavated horizontally down to bedrock. A new section face had been created 0.70 m to the north of the original 1961 section line and this was the section which was sampled (Fig. 4).

Below layer **(601)** was **layer (602)a** which was a substantial horizontal band of very pale grey sand of uniform appearance. Below which was **(602)b** which was a very pale (straw) yellow sandy layer (10 YR 6/3). Both sand layers were friable and compact and contained occasional small stone and tiny shell fragments. In the eastern part of the trench their combined depth was up to 26 cm, although they were deeper in the west at 35 cm. In the NW part of the trench a very mixed up spread of soil and sand containing large stones, apparent burnt clay fragments intermixed with charcoal and shell was recorded: **(612)**. This amorphous spread **(612)** was 0.75 m long, 0.60 m wide and 0.30 m deep and lay within the horizon **(602) a** and **b**. It was not a well-defined or distinct feature.

Within **(602) a** and **b** occasional animal and root activity was noted. **(602) a** and **b** was extensively sampled for geoarchaeological analyses, land snails and volcanic tephra. One sample (Aber-101/GWT - 4) for OSL dating was also recovered from this layer (see Fig. 4). Forty litres of soil samples for macroplant fossil remains were also recovered. **Layer (602) a** and **b** is the equivalent of the horizon known as "**Layer 4"**. *Note*: The base of **(602)b** was mixed with the underlying layer **(605)**: this interface has been called **(605)a**. A control sample taken for geoarchaeological assessment is shown as "top of (605)" (see Fig. 4; that is **(605)a**).

Beneath **(605)a** was **layer (605)b**. **Layer (605)b** was a mid brown (10YR 5/3) sandy loam horizon. This contained bone, pot, stone and tiny shell fragments with occasional large stones (> 5-10 cm) and charcoal (flecks). At the base of layer **(605)b plough**

**marks (607)** etched into the underlying sand were recorded (see Figs 3b and 4). These were orientated N-S and E-W (see Fig. 3b). Across the entire trench **layers (605)a** and **b** were, on average, 20 cm deep. Very limited root activity and some rabbit burrowing was noted. **(605) a** and **b** was extensively sampled for geoarchaeological analyses, land snails and volcanic tephra One sample for pollen (3) was also recovered from this layer. Forty litres of soil samples for macroplant fossil remains were recovered. **Layers (605) a** and **b** form the bulk of the Bronze Age horizon known as **"Layer 5"**.

A clean thick band of sand **layer (606)** lay beneath **(605)b**. This was pale yellow (10YR 6/4) and contained occasional small stones. Very little root activity was noted. **Layer (606)** was 20 cm deep. **(606)** was extensively sampled for geoarchaeological analyses, land snails and volcanic tephra One sample (Aber-101/GWT-6) for OSL dating was recovered (see Fig. 4). Forty litres of soil samples for macroplant fossil remains were also recovered. **Layer (606)** is the equivalent to the Bronze Age horizon known as "**Layer 6"**.

Beneath the sandy horizon **(606)** was **layer (608)**. This loam sand horizon was mid to pale brown (10YR 5/4) in colour and contained some small stone and charcoal flecking. It was a paler yellow than underlying darker layer **(609)**. **(608)** was at least 13 cm deep. It was sampled for geoarchaeological analysis, land snails and volcanic tephra. A pollen sample (2A) and 40 litres of samples for macroplant remains were also recovered. **Layer (608)** forms the upper half of the Bronze Age horizon known as "**Layer 7"**.

**Layer (609)** - the penultimate layer to be excavated - was a thin friable darker layer than that which sealed it (that is **(608)**). **(609)** was a sandy loam, dark reddish brown in colour (10YR 4/4), and contained charcoal flecks, small stone and shell fragments. **(609)** was only excavated within the eastern area of the trench. It was sampled for geoarchaeological samples, pollen (2B), land snails and volcanic tephra. Forty litres of samples for macroplant remains were recovered from this horizon. **Layer (609)** forms the lower half of the Bronze Age horizon known as "**Layer 7"**.

The final horizon exposed in section was **layer (610)**. **Layer (610)** was a hard and very compact dark brown (10YR 4/5) clay layer which, by contrast to all the overlying horizons, was extremely tough to dig. In texture, **(610)** was plastic and moist with a slightly gritty texture (revealing some sandy inclusions). Traces of **plough marks (611)**, aligned E-W, scoured the surface of this layer (see Fig. 9). The plough marks were V-shaped in profile, 4-8 cm wide and up to 6 cm deep. **Layer (610)** contained occasional small stones, shell fragments, pottery, flint and frequent charcoal flecks. It was only excavated in the eastern part of the trench where it was sampled for geoarchaeological samples, land snails, pollen (1), and volcanic tephra. Sixty litres of soils were taken for macroplant fossil remains. Given its clear clay make-up a sample of this layer was taken for petrographic and geological assessment. **Layer (610)** is the equivalent of the Bronze Age horizon known as "**Layer 8"**.

## 4.3 Artefacts

In total, 595 artefacts were recovered from the archaeological horizons excavated in June 2005. The largest number of finds were marine and land snails: 454. These were hand collected and not systematically recovered through sieving. The greatest quantity and variety of material came from layers: (600), (601) and (612) – (600) and (601) are equivalent to the Bronze Age horizon known as "Layer 3". Smaller quantities came from (602)a and b ("Layer 4"), (605)a and b ("layer 5"), (608) (top of "layer 7") and, of interest, (610) ("layer 8").

## 4.4 Gwithian 2005: Soil Assessment by Dr Erika Guttmann

### 4.4.1 Introduction

The well-preserved Bronze Age soils at Gwithian are likely to hold cultural material and geochemical signatures which will provide a good indication of the intensity of past agricultural land use. These soils are important not only because of the excellent preservational conditions provided by the blown sand deposits which overlie them, but also because of the distinctive agricultural traditions of the region, which can be traced back to the Middle Ages. Arable soils in Cornwall have traditionally been improved by the addition of shell sand, seaweed and animal manures, and one of the aims of this project is to establish whether such practices may have originated in prehistory.

The site at Gwithian is of great importance because it is one of the few sites in the UK to retain evidence for the possible use of seaweed fertiliser in prehistory (Fowler 1983, 157). There is also evidence for ard and spade marks (ibid., 150 & 152), as well as buried soils containing domestic waste. The thin section, phosphate and magnetic analysis of the soils on this site will aim to identify the use of domestic waste and animal manures as potential fertilisers in the Bronze Age agricultural regimes.

The distinction between fertilisation with domestic waste and fertilisation with animal manures is an important one, because animal manures provide vastly more nutrients than hearth ash and kitchen waste (Guttmann 2005a). In Britain most of the evidence points to fertilisation with domestic waste in early prehistory, with the extensive use of animal manures only occurring in the Iron Age and after (Guttmann et al. 2005b). The actual type of fertiliser used at Gwithian is therefore an important research theme for this project, the key issues being:

- What fertilising materials, if any, do the soils contain? The type of material will be an indication of the intensity of arable production.
- How did this change over time?

### 4.4.2 Site visit

The site was visited and sampled during fieldwork on 23-25 June, 2005, and the samples are listed in Table 1. Thin section samples were taken in Kubiena tins, mostly across horizon boundaries. Geochemical samples (for both geochemistry and soil magnetism) were taken from the top, middle and base of each of the thicker layers, from the top and bottom of the thinner ones and from the middle of each of the two very thin basal layers.

The original plan for the geoarchaeological analysis was to sample and compare the individual layers that were exposed in the section face, but on-site discussions and observation of the section face made it clear that there were distinct layers within several of the horizons that were originally thought to be single contexts. Five samples were therefore taken from each of these subdivisions (top, middle and base of each layer) so that statistical comparisons can be made between different parts of each individual layer, as well as between the different layers.

The control samples were taken in two clusters. Five samples were taken from the nearest modern analogue to the soils found on site, which was the turf formed on wind-blown sands on the hill immediately to the north of the site. A key difference between this modern analogue and the prehistoric soils is that today this area is heavily frequented by rabbits, which would have been absent in the Bronze Age; the rabbits serve to destabilise the soil with their burrowing, and also add phosphorus with their dung. It is worth noting that control samples of pure blown sand in other regions indicate that it is extremely low in phosphorus, and therefore the soil that develops upon it can also be expected to be relatively low in phosphorus unless it is affected by humans and/or their domestic animals.

The second control sample was taken from a Mesolithic soil (a coastal exposure at site RR, Nowakowski 2004) dated by the presence of artefacts scattered on the surface. This analogue has the advantage of predating all farming activity, having been sealed by blown sand which in this region is generally dated to the Neolithic and later (Roberts 1987). The layer has therefore probably not been affected by agricultural use - however, if it was an activity site it may have been enhanced by phosphates from other sources such as food waste. A further caveat is that this soil developed on Head, so is comparable to Layer 610 [=8] but not strictly comparable to the soils developed on blown sand.

#### 4.4.3 Table 1: Geoarchaeological assessment, description and sampling of deposits

| Context [= layer no in earlier archive] | Description | Samples |
|---|---|---|
| 601 [=3] | Buried Bronze Age ploughsoil with ard marks at the base. | Thin section: tins 1 & 2<br>Geochemical:<br>5 from top, 5 from middle, 5 from base |
| 602 [=4] | Pale brown sand; this appears to be 3 distinct layers. Sand-filled ard marks at the base cut into layer 605, below. | Thin section: tins 3, 4, 9<br>Geochemical:<br>5 from top, 5 from middle, 5 from base |
| 605 [=5] | Buried Bronze Age ploughsoil with ard marks at the base and the surface. This context probably represents 2 layers. | Thin section: 4, 5, 6<br>Geochemical:<br>5 from top, 5 from middle, 5 from base |
| 606 [=6] | Light yellowish brown sand. | Thin section: 6 and 7<br>Geochemical:<br>5 from top, 5 from middle, 5 from base |
| 608 [=7a] | Yellowish brown sand. | Thin section: 7 and 10<br>Geochemical:<br>5 from top, 5 from base |
| 609 [=7b] | Dark yellowish brown sand | Thin section: 8 and 10<br>Geochemical: 5 samples |
| 610 [=8] | Stony brown clay; v. compact. | Thin section: 8<br>Geochemical: 5 samples |
| Control | Thin turf over blown sand. Acid heathland vegetation. | 5 geochemistry samples taken from the hill above the excavation. |
| Control | Dark yellowish brown sandy clay over Head deposits. Soil contains Mesolithic artefacts. | 5 geochemistry samples taken from soils exposed on the coast at around 5825/4270 |

The methods which will be used to investigate the soils will include thin section micromorphology, soil magnetism and phosphate analysis. The pH and organic content of the soils will be ascertained and compared with that of the uncultivated analogues using a pH meter and loss on ignition. Soil magnetism will be analysed using a Bartington susceptibility meter in order to roughly estimate the quantities of fuel ash which may have been added to the soil. While thin section analysis will be used to identify burnt material, tests for magnetism give better estimates of the amount of burnt material in the soil, so that variations between areas can be compared statistically. The soil phosphate will be assessed in order to ascertain whether organic material and/or kitchen waste including animal bone have been added to the soil; the materials will be distinguished in thin section. Analysis of shells within the buried arable soils, undertaken by Paul Davies, will be used to identify species that are associated with seaweed (c.f. Fowler 1983, 157; Milles 1994; Donaldson et al. 1981; Bell 1981).

The thin sections will be prepared as described by Murphy (1986) and soil magnetism will be assessed by mass susceptibility and frequency dependent susceptibility using a Bartington susceptibility meter; saturation anhysteretic remanent magnetisation may also be employed. The phosphates will be processed by acid extraction and the content will be assessed using ammonium molybdate colourimetry.

#### 4.4.4 Soils: Updated research aims

The soil sequence at Gwithian is very similar to the sequences of buried soils and blown sands recorded on a number of prehistoric sites in the Northern and Western Isles of Scotland. Soils interleaved with blown sands were formerly thought to represent periods of decreased storminess, but detailed analysis of the soils and sediments on sites in the Western Isles has since demonstrated that many of the apparently natural soil horizons were in fact man-made, created by dumping midden material onto the shifting sands (Gilbertson et al. 1999). A similar attempt to stabilise blown sand with midden material is known from Orkney (Guttmann et al. accepted). The number of prehistoric ard mark horizons at Gwithian is striking, and indicates a long-term investment in this particular site, despite the difficulty of coping with the unstable environment. The key hypothesis for this analysis is:

- The sand horizon 602 [=4] is a blown sand deposit that has been stabilised through the addition of midden material. This is a departure from the interpretation suggested by Fowler (1983, 152), which assumed that the sand-filled ard marks represented not the continued cultivation of a soil after a sand blow but rather the abandonment of the land following a storm in which the newly ploughed ard grooves were filled with sand.

Gwithian is a site of outstanding importance, and it is suggested that the land management system of this Bronze Age settlement may have more in common with coastal sites as far north as Orkney than with contemporary sites in the south of Britain.

## 4.5 Gwithian 2005: Land snail assessment by Dr Paul Davies

*Dated: September 2005*

### 4.5.1 Introduction and Method

A molluscan column (comprising 17 continuous samples) was obtained form the south facing section of GMXVII by Vanessa Straker (English Heritage), and subsequently provided to the author.

Each sample was air-dried and 0.5kg of each processed by dry-sieving through a nest of sieves consisting 2mm, 1mm and 0.5mm mesh sizes (following Evans 1972). Sieved fractions were assessed using a low-power zoom binocular microscope (x6-x40). Identifications were made to at least Family level (most to species), using Evans (1972), Kerney and Cameron (1979), and Kerney (1999) as aids to identification when required. Abundance was estimated using the following scale:

**A** (abundant) – 50+ individuals

**C** (common) – 10-50 individuals

**R** (rare) – less than 10 individuals

### 4.5.2 Results

Preservation was good to excellent throughout. However, the abundance of Mollusca was variable, the lowermost samples generally providing few shells. Relative abundance estimates are given as Table 2.

There are major changes in the fauna through the sequence, particularly concentrated on context 602a and context 601. Broadly, 4 molluscan zones (MZ) can be recognised at this stage:

***116-44cm*** MZ1: low-diversity open-country type assemblages mainly comprising of *Pupilla muscorum*, *Cochlicella acuta*, ‘other Helicidae’ (at least 2 species), and *Vallonia* sp. Possibly a hint of increasing shade from 61-51cm.

***44-39cm*** MZ2: A higher diversity assemblage with a strong catholic and shade-requiring component, principally *Carychium*, *Cochlicopa*, ‘Other Zonitidae’ (at least 3 species including *Aegopinella nitidula* and *A. pura*), *Vallonia*, *Punctum* and *Lauria*. Although in low numbers, the presence of *Acanthinula*, in particular, and also *Clausilia* are noteworthy here too. Open-country species generally are rare or absent. A well-shaded, stable environment is indicated, possibly woodland or scrub.

***39-34cm*** MZ3: A very low diversity assemblage with low numbers of shells. Only open-country species represented plus a freshwater *Pisidium* spp. Also lots of plant fragments and stony material with some marine shell fragments. Possibly derived (?dump deposit).

***34-9cm*** MZ4: Initially a return to a higher-diversity assemblage with some shade-requiring species (as for 44-39cm). However, open-country species (as for 116-44cm) expanding, and becoming predominant in the upper two samples (29-9cm).

### 4.5.3 Discussion

At this stage, the sequence apparently shows open-country environment(s) (116-44cm) giving way to scrub or woodland (44-34cm) onto which material was also

| species/depth (cm) | 111-116 | 106-111 | 103-106 | 98-103 | 93-98 | 83-93 | 73-83 | 66-73 | 61-66 | 56-61 | 51-56 | 44-51 | 39-44 | 34-39 | 29-34 | 19-29 | 9-19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Context | 610 | 609 | 609 | 608 | 608 | 606 | 606 | 605b | 605b | 605b | 605a | 602b | 602a | 602a | 601 | 601 | 601 |
| Layer | 8 | 8 | 7b | 7a | 7a | 6 | 6 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 3 | 3 | 3 |
| ***Carychium* sp.** | | | | | | | | | | | | | A | | A | R | R |
| ***Cochlicopa lubrica*** | R | | | | C | | | | C | C | C | C | C | R | C | C | |
| ***Pupilla muscorum*** | | | | | C | C | | C | A | A | A | C | | R | C | R | C |
| ***Vallonia* sp.** | R | R | | R | C | C | | C | C | C | C | C | C | | C | C | C |
| ***Vitrea* sp.** | | | | | | | | | | | | C | | | C | | R |
| ***Vitrina pellucida*** | | | | R | | | | | | | R | R | | | | | |
| **Other Zonitidae** | | | | | | | | | | R | | | C | | C | R | |
| ***Discus rotundatus*** | | | | | | | | | | | | | R | | C | C | R |
| ***Acanthinula aculeata*** | | | | | | | | | | | | | R | | R | | |
| ***Lauria cylindracea*** | | | | | | | | | | | | | C | | | | |
| ***Clausilia sp.*** | | | R | | | | | | | | | | R | | | | |
| ***Punctum pygmaeum*** | | | | | | R | | | | | R | | C | | | | |
| ***Cochlicella acuta*** | R | | | | | | | C | A | A | A | A | R | R | C | C | A |
| ***Ashfordia granulata*** | | | | | | | | | | R | R | R | R | | C | C | C |
| **Other Helicidae** | | | | R | A | C | R | C | C | C | C | R | | | | C | |
| ***Pisidium* sp.** | | | | | | | | | | | | | | R | | | |
| **Marine sp (frag Y/N)** | Y | Y | | Y | N | N | N | N | N | N | N | N | N | Y | N | N | N |
| **Total (estimate)** | **>10** | **>10** | **>10** | **>10** | ***c*.50** | ***c*.30** | **>10** | ***c*.100** | ***c*.150** | **150+** | **150+** | ***c*.100** | ***c*.100** | **>10** | ***c*.100** | ***c*.100** | ***c*.100** |

**Table 2: Mollusca recovered from Gwithian 2005 (south facing section of GMXVII)**

deliberately dumped (39-34cm). Subsequently, the environment reverts to open-country (34-9cm). If this is subsequently confirmed, it would indicate that following occupation (contexts 605b and a) the land reverted to woodland/scrub (ie. a relatively stable environment), onto which some material was deliberately dumped before a further occupation phase (context 601). This, however, remains a provisional assessment until further analysis of the assemblages and integration with other environmental data (soil micromorphology in particular) and recovered archaeology.

The sequence has similarities with respect to other land snail analysis previously undertaken at Gwithian by Penny Spencer (Spencer 1975), though the woodland component here is much stronger than in that found by her. More widely, the sequence is unusual in comparison to other snail sequences from western England and Scotland in seemingly having a strong woodland/scrub episode *within* a blown sand sequence. More usually, woodland environments are recorded before sand inundation and accumulation.

#### 4.5.4 Recommendation

Thirteen samples have excellent potential for full analyses, including all those samples pertinent to the open-shaded-open sequence covering Contexts 605b, 605a, 602b, 602a and 601 (and covering all four provisional molluscan zones). Further analysis of the lowermost open-country assemblages will allow an assessment to be made of the relative stability of the environment (mobile sand against relatively consolidated or stable surfaces). Additionally, further analyses of samples from 61-9cm will provide greater detail on the apparent open-shaded-open sequence.

### 4.6 Gwithian 2005: Assessment of soil samples from GM X and GM XVII

by Vanessa Straker

#### 4.6.1 Introduction

Soil samples from sites GM X and GM XVII were flotation sieved by Imogen Wood at HES, Truro. Floats were recovered on a 250 micron mesh and residues on a 500 micron mesh. The GM X samples were taken during the excavations in 1956 and stored in milk bottles. The GM XVII were taken during the excavation of a trench to examine the Bronze Age sequence in 2005.

#### 4.6.2 Results

The summary results are presented in Tables 3 and 4. Most of the samples included varying concentrations of fragments of marine bivalves, mainly mussels, land snails and charcoal. The small amounts in GM X would not be worth taking to full analysis, but the samples from GM XVII have been assessed for their marine shell content and charcoal in separate studies. A series of duplicate samples was taken for land snail assessment.

Charred plant macrofossils, other than charcoal, were absent from GM X and very infrequent in GM XVII. The only identifiable remains were occasional grains of wheat, which were probably emmer, to judge from the humped dorsal surface, but no chaff, which would be more conclusive evidence of emmer, was present. One of the occasional barley grains was of the naked (free-threshing) variety. Both emmer and naked barley are common Bronze Age crops and naked barley particularly characteristic of cereal assemblages in Cornwall, most notably at Trethellan Farm and on Scilly at East Porth on Samson (Campbell and Straker, 2003).

**Table 3 Gwithian 2005 GMXVII charred plant remains. Sieved samples, assessment of floats and residues**

| Context | sample | Soil sample vol (litres) | Float vol (ml) | Shell, bivalve | Shell, land snail | charcoal | Other | Charred plant |
|---|---|---|---|---|---|---|---|---|
| 600 | 1 equivalent layer 3 | | 625 | freq. frags | freq. | freq. | - | - |
| 601 | 2 equivalent layer 3 | | 3000 | occ | freq. | freq. | | 1 *Triticum* cf. *dicoccum* (cf emmer wheat): 1 cereal sp.;2 plant fragments, unidentified |
| 602 | 5 equivalent layer 4 | | 37 | | mod | | | 1 *Triticum* cf. *dicoccum* (cf emmer wheat) |
| 605 | 6 equivalent layer 5 | | 200 | | freq. | | | 2 seed frags, unidentified: 1 *Triticum* cf. *dicoccum* (cf emmer wheat); 1 *Sherardia arvensis* (field madder) |
| 606 | 7 equivalent layer 6 | | 30 | | freq. | occ | | 1 unidentified fragment |
| 608 | 8 equivalent layer 7 | | 60 | | | occ | | 1 *Hordeum* sp. (barley); 1 cereal indeterminate; 1 stem fragment, unidentified |
| 609 | 3 equivalent layer 7 | | 75 | | | freq. | 1 bone frag | 1 *Hordeum* sp. (barley, naked grain; 2 cereal fragments; 1 fragment unidentified |
| 610 | 4 equivalent layer 8 | | 115 | | Freq. | occ | | 1 ?tuber frag. Unidentified. |

Key: occ: occasional, 0-15 items; mod; moderate, 15-30 items; freq, frequent >30 items

**Table 4 Gwithian GMX Cutting 3 charred plant remains. Sieved samples, assessment of floats and residues**

| layers | Context details | Soil sample vol *(litres)* | Float vol *(ml)* | Residue vol (*ml*) | Shell, bivalve | Shell, land snail | charcoal | Other | Charred plant |
|---|---|---|---|---|---|---|---|---|---|
| 0 | V section 3 | | c. 7 | < 5 | occ | mod | Freq small | 4 frags fired clay | 1 frag, unidentified |
| 2 | V section 3 | | c. 10 | < 5 | occ | occ | | | |
| 3 | N Face | | < 5 | c. 10 | occ | occ | occ | | |
| 4 | N face | | < 5 | < 5 | occ | 1 | occ | Occ frags ?crab claw | |
| 5 | N face | | c. 1 | < 5 | - | - | - | | |
| 5a | N face | | < 5 | 10 | occ | 1 | occ | 1 bone frag | |
| 6a | N face | | < 5 | < 10 | occ | occ | occ small | 1 bone frag | |
| 7 | N face | | c. 5 | c. 5 | occ | occ | occ | | |
| 8 | N face | | < 5 | c. 10 | Frags 1 valve | mod | occ | | |
| 9 | N face | | < 5 | < 5 | occ | Occ | | | |

Key: occ: occasional, 0-15 items; mod; moderate, 15-30 items; freq, frequent >30 items

#### 4.6.3 Recommendations

Owing to the limited size of the assemblage, all the identifiable plant macrofossils were identified as far as is possible. No further analysis is recommended.

### 4.7 Gwithian 2005: Pollen assessment by Dr David Earle Robinson

*Dated: April 2006*

#### 4.7.1 Material

*Settlement layers:* Five samples (ca. 50 g) were collected for pollen analysis from the section exposed during fieldwork in late June 2005 (fig. 4). Samples 1, 2A and 2B came from the lower settlement/culture layer ("layers 8 and 7" respectively) which developed over the mineral soil. Sample 3 came from the middle settlement/culture layer ("layer 5") and sample 4 from an apparent upper settlement/culture layer ("layer 3"). The settlement layers were characterised by a darker colour and a slightly elevated content of silt and organic material. They were separated by layers of apparently sterile blown sand. The latter were not sampled as they were thought extremely unlikely to contain preserved pollen. It was hoped that pollen was preserved in the settlement layers which could give information about the environmental conditions (vegetation etc.) and human activities in the immediate vicinity of the settlement.

*Coprolites:* One sample was also taken from one of a number of coprolites recovered during the main excavations in 1949 – 1963 (GM/X Bag 501; Cutting 21 Layer 3). The form, consistency and conspicuous bone content of the coprolites suggested that they were from dog. It was hoped that preserved pollen could provide further information on the food consumed by the animal(s).

#### 4.7.2 Methods

Three samples were prepared for analysis – two from the lower settlement layer (layers 7A and 8) which appeared to have the highest content of organic material and therefore the greatest chance of containing preserved pollen – and one from a coprolite which had disintegrated releasing a number of bone fragments. The latter were passed on to Andy Hammon for possible identification and assessment (Nowakowski forthcoming).

The samples were prepared using standard methods involving treatment with hydrochloric acid, potassium hydroxide, cold hydrofluoric acid and acetolysis. The resulting pollen was stained with aqueous safranin and mounted in silicone oil. The slides were examined at  x400 using a Leitz Laborlux binocular microscope.

#### 4.7.3 Results

*Settlement layer:* Both samples were found to contain pollen but this was very sparse and the grains recorded were almost all so degraded as to make identification impossible. Layer 8 contained the greatest concentration of pollen, but this was still very sparse. The few identifiable grains present were from open-habitat species (grass, dock and plantain). Two large grass pollen grains were encountered but these were probably from coastal grasses rather than cereals – further identification was impossible due to state of preservation. A full count could possibly be obtained from layer 8, but these data are unlikely to be either reliable or particularly useful, given the state of the pollen preservation.

*Coprolite:* No pollen whatsoever was detected in the sample.

#### 4.7.4 Recommendations

No further work is recommended on either the settlement layers or the coprolites.

### 4.8 Gwithian 2005: Charcoal assessment from GMXVII 2005 and GMX by Rowena Gale

*Dated: September 2005*

#### 4.8.1 Introduction

The current assessment includes eight samples (Layers 1-8) from the 2005 excavation of GM XVII and 10 samples from GM X (Layers 0 and 2-9, Cutting 3, North face). The latter were held in the Gwithian Archive but since they had been packed in bottles (with other material) and needed sorting, they were not included in the previous assessment.

Although not scheduled for C14 dating, suitable material is indicated in Table 5, should it be required.

#### 4.8.2 Methods

Bulk soils samples collected during 2005 were processed by flotation and sieving. The resulting flots and residues were sorted by Vanessa Straker 9see section 4.6). Charcoal was generally very sparse (<10 fragments per sample) although samples 1, 2, 3 and 6 were more abundant. Archive samples from GMX were also sorted by Vanessa Straker but these rarely contained charcoal and, when present, it was exceedingly sparse (see table 5).

The charcoal in all samples was friable and poorly preserved. When possible three fragments were examined from each sample in order to provide a baseline range of taxa present. These were prepared using similar methods to those described in the previous assessment.

#### 4.8.3 Results

The results are presented in Table 5. Samples with suitable material for C14 dating are indicated in bold type. The taxa identified included:

- birch (*Betula* sp.)
- hazel (*Corylus avellana*)
- hawthorn/ *Sorbus* group (Pomoideae)
- gorse (*Ulex* sp.) or broom (*Cytisus scoparius*)
- oak (*Quercus* sp.)
- bramble (*Rubus* sp.) or briar (*Rosa* sp.)

***Site GM XVII 2005***

The 2005 excavation opened a trench in the central area of Bronze Age occupation, just south of midden GMX. Environmental samples were collected from Layers 1-8 and the charcoal fraction extracted from each. In most instances very little charcoal was present, especially in the lower layers. The origin of the charcoal is unknown; domestic fuel debris seems the likeliest source. Although less diverse, the range of taxa indentified (see above) corresponds to that named from contemporary archive material from GMX (see Nowakowski 2004).

***GMX Gwithian Archive, Middle Bronze Age – Late Bronze Age***

Of the ten samples examined from Cutting 3, North face, only four of the Layers included viable charcoal and even this was extremely sparse. Oak was recorded in Layers 0, 4 and 5; and the hawthorn group in Layer 8.

#### 4.8.4 Recommendations

***GMXVII 2005***

It is recommended that samples 1, 2, 3 and 6 are examined in full and the results incorporated with the main report (see previous Charcoal Assessment).

***GMX Gwithian Archive***

No further identification work is possible on these samples. The results obtained should be included in the main report (see Gale in Nowakowski 2004).

**Table 5 Assessment of charcoal from GM XVII 2005 and GM X. Gwithian Archive**

Key. Number of fragments: x = <10; xx = 10 – 19; xxx = 20 – 50; h/w = heartwood; s/w = sapwood (diameter unknown)

**C14**. Charcoal suitable for dating is indicated in bold type.

| Sample | Context | Context description | No of fragments | Species identified | Further work | Comments |
|---|---|---|---|---|---|---|
| GM XVII 2005 | | | | | | |
| 1 | 600<br>equivalent layer 3 | - | xxx | **2 x hawthorn/ *Sorbus* group (Pomoideae);**<br>**1 x gorse (*Ulex* sp.) and broom (*Cytisus scoparius*)** | Yes | Smallish fragments |
| 2 | 601<br>equivalent layer 3 | Pale brown sand | xxx | **1 x hawthorn/ *Sorbus* group (Pomoideae);**<br>**1 x hazel (*Corylus avellana*);**<br>**1 x birch (*Betula* sp.)** | Yes | Small fragments in poor condition, but worth examining |
| 3 | 609<br>equivalent layer 7 | Dark yellowish brown sand | Xx | 2 x oak (*Quercus* sp.);<br>**1 x hazel (*Corylus avellana*)** | Yes | Small fragments |
| 4 | 610<br>equivalent layer 8 | Stoney brown clay | X | 2 x oak (*Quercus* sp.) h/w;<br>**1 x hawthorn/ *Sorbus* group (Pomoideae)** | No | Insufficient for further work |
| 5 | 602<br>equivalent layer 4 | Pale brown sand | X | **3 x hawthorn/ *Sorbus* group (Pomoideae)** | No | Insufficient for further work |
| 6 | 605<br>equivalent layer 5 | Buried B/A plough soil | Xx | 1 x oak (*Quercus* sp.) h/w;<br>1 x oak (*Quercus* sp.) s/w;<br>**1 x gorse (*Ulex* sp.) or broom (*Cytisus scoparius*)** | Yes | - |
| 7 | 606 | Light yellowish | x | **1 x *cf.* bramble (*Rubus* sp.) or** | No | Stem diameter |

| | | | | | | |
|---|---|---|---|---|---|---|
| | equivalent layer 6 | brown sand | | **briar (*Rosa* sp.)** | | 3mm |
| 8 | 608<br>equivalent layer 7 | Yellowish brown sand | x | 2 x oak (*Quercus* sp.) s/w;<br>**1 x gorse (*Ulex* sp.) or broom (*Cytisus scoparius*)** | No | Small fragments |
| **GM X – Gwithian Archive** | | | | | | |
| Layer 0 | | Cutting 3 North face | Xx | **2 x oak (*Quercus* sp.) s/w** | No | Tiny and sparse |
| Layer 2 | | Cutting 3 North face | - | - | No | No charcoal |
| Layer 3 | | Cutting 3 North face | - | - | No | No charcoal |
| Layer 4 | | Cutting 3 North face | X | 1 x *cf.* oak (*Quercus* sp.) | No | Very small frags. |
| Layer 5 | | Cutting 3 North face | X | - | No | No charcoal |
| Layer 5a | | Cutting 3 North face | X | 2 x oak (*Quercus* sp.) h/w | No | No further charcoal |
| Layer 6a | | Cutting 3 North face | x | - | No | Insufficient for id |
| Layer 7 | | Cutting 3 North face | - | - | No | No charcoal |
| Layer 8 | | Cutting 3 North face | X | **2 x hawthorn/ *Sorbus* group (Pomoideae)** | No | Sparse; tiny fragments |
| Layer 9 | | Cutting 3 North face | - | - | No | No charcoal |

## 4.9 GWITHIAN, CORNWALL 2005 FIELDWORK (GMXVII) Assessment of the vertebrate assemblage by Dr Andy Hammon

*Dated: Thursday 29th September 2005*

### 4.9.1 Background

Fieldwork at Gwithian in June 2005 produced a small animal bone assemblage, consisting of 301 fragments (Table 6). The assemblage derived from both hand-collection and sample heavy residues (washed over a 500µm mesh – Vanessa Straker pers. comm.).

The material was scanned using the methodology outlined in Hammon (2004: 4-5). Table 6 outlines the quantity of countable, ageable and measurable specimens the assemblage would produce: 28 countable and 9 ageable fragments, plus one measurable fragment.

In isolation, the assemblage has very little information potential regarding reconstruction of the site economy and husbandry practices. It would add very little to that from the assemblages previously considered (see Hammon in Nowakowski 2004).

If the 2005 samples are representative they demonstrate that the hand-collected assemblages from the earlier excavations do not suffer from a significant degree of recovery bias. Although, the scarcity of bird remains and virtual absence of fish remains for the 2005 samples is curious.

#### 4.9.2 Recommendation

It is recommended that the 2005 material be considered in conjunction with the other Gwithian assemblages. Doing so will have no additional cost implications; the 'task list' previously provided (see Hammon in Nowakowski 2004: 11) remains current.

**Table 6 Summary of vertebrae remains from Gwithian 2005 fieldwork (GMXVII)**

| **Context and equivalent layer (in bold)** | **Bag comments** | **Collection** | **No. frags** | **Bone comments**<br>**(Countable, ageable, measurable frags etc).** |
|---|---|---|---|---|
| 600 **3** | Cleaning below turf | Hand | 9 | inc. cattle maxillary molar (x2); cattle humerus |
| 600 **3** | Act(ual?) trench fill | Hand | 11 | - |
| 600 **3** | | Hand | 2 | inc. sheep/goat metacarpal |
| 601 **3** | | Hand | 3 | inc. cattle 1st phalange (ageable); pig mandible |
| 601 **3** | | Hand | 42 | inc. cattle incisor & humerus (neonate): sheep/goat maxillary premolar, maxillary molar, mandible (ageable; measurable), humerus, radius, femur & metatarsal |
| 602 **4** | | Hand | 3 | inc. sheep/goat tibia |
| 605 **5** | | Hand | 5 | inc. sheep/goat pelvis (ageable; measurable; female) |
| Deturfing **3** | | Hand | 2 | - |
| U/S **3** | | Hand | 2 | inc. cattle scapula; sheep/goat/roe deer femur (ageable) |
| 600 **3** | | Sample 1 | 31 | inc. small rodent maxillary/mandibular incisor & tibia (ageable) |
| 601 **3** | | Sample 2 | 106 | inc. pig maxillary incisior; small rodent tibia |
| 602 **4** | | Sample 5 | 28 | inc. rat/water vole tibia (ageable) & 1st phalange; small passerine (songbird) carpometacarpus (ageable) |
| 605 **5** | | Sample 6 | 53 | inc. mouse maxilla; small rodent humerus (ageable); 1 fish bone (identifiable?) |
| 608 **7A** | | Sample 8 | 4 | - |

## 4.10 Gwithian 2005: Marine shells assessment by Dr Janice Light

*Dated: 29th March 2006*

#### 4.10.1 Background and principal objectives

In June 2005 a small-scale field investigation took place at the Bronze Age site at Gwithian. The principal aim of the exercise was to revisit the main stratigraphic sequence and to recover palaeoenvironmental samples. Bulk sampling took place for remains of macroplants, vertebrates and land snails, and samples for geoarchaeological, pollen and volcanic tephra analyses were taken. Sampling was also carried out in order that OSL dating could be attempted. A trench was hand dug and layers were excavated by hand. The trench lay within the heart of the Bronze Age site between sites GMX and GMIX, the location being determined by the presence of a previously documented intact stratigraphic sequence. Hand-collected marine shells were recovered during excavation and form the basis of this assessment. As most of the shells came from archaeologically sound layers the results of this assessment can be integrated into the existing marine shell assessment in order to enhance understanding of that pre-existing marine shell dataset (see Light in Nowakowski 2004).

#### 4.10.2 Material available for assessment and analytical methodology

Eleven sample bags of shell were received (Table 7). During preliminary sorting for this assessment nonmarine shells were extracted from samples 1, 2 and 6 and sent to Dr Paul Davies. Marine shells were identified, quantified and examined for taphonomic and artefactual evidence. The results were then assessed in the light of the assessment carried out for the main marine shell archive (Light ibid). For comparison purposes, the marine shell from the original excavation was subjected to a rapid re-examination.

#### 4.10.3 Results

Some 580 shells and fragments were identified. Of these, 237 were valves or umbonal units of mussel (119 MNI) and 263 items were mussel fragments other than umbones. (Bivalve umbones (hinge fragments) are used to obtain counts of numbers of shell valves. The total is then divided by 2 to obtain MNI). Of the remaining 80 items, 59 were limpet shell of which 51 were complete shells or apical fragments, 9 were dog whelk shells and there were 11 shells spread across 8 other species.

***Patella spp. (Limpets)***

The limpet shells were in an excellent state of preservation as has been noted in other Cornish coastal midden assemblages where the calcareous soils impede decalcification processes. The shells are mainly of medium size (2.5-3.5cm shell length) which accords with the size profile of limpets present in the shell middens at Atlantic Road, Fistral Bay (Light 2001). Small limpets are not worth harvesting and large ones are considered tough. Both *Patella vulgata* and *P. ulyssiponensis* are present in the Gwithian assemblage, the latter being a lower shore species and considered by experts to be more palatable. (Modern day residents on Colonsay, who eat limpets occasionally, state that high shore limpets are much tougher and less tasty than low shore ones (Jones, 1985). This opinion is reinforced by S.J. Hawkins (pers. comm.) who advises that, in modern times, *Patella ulyssiponensis* is widely eaten in the Canaries, Azores, Madeira and Portugal.

***Mytilus* spp. (Mussels)**

Based on the small sample examined, the relative proportion of mussel shells retrieved at Gwithian as whole valves was considerably higher than those retrieved at Atlantic Road. Many of the shells were evidently large individuals when harvested and at least

50% of the shells were *Mytilus galloprovincialis,* currently known as the Padstow mussel. It is considered to be a southern species, the shells being larger and flatter than the native *M. edulis.* It is principally known from the southwestern coasts of the UK. Some shells showed the abrasion features noted on the Atlantic Road mussels (Light 2001) and mussels in the Trevelgue Head samples (Light 2005a), where the blue outer surface layers of the mussels have been eroded to reveal facetted, nacreous areas on the shell exteriors. These repetitive patterns of wear were initially attributed to hand-working, either as a result of their use for some utilitarian purpose, or from deliberate modification in order to create a useful artefact or implement (Light 2005b). However the abrasion is attributed to progressive shell removal where densely packed mussels are jostled against each other in the high energy conditions of the north Cornish coastal environment.

***Nucella lapillus* (Dog whelks)**

Dog whelks complete the trio of species which are consistent and important features of Cornish coastal midden assemblages. They are always considerably fewer in number than limpets and mussels and the purpose for their harvesting, whether for food or bait, has never been fully resolved. There were only 9 shells in the Gwithian 2005 assemblage. Of these, one was an apertural fragment, a second had been broken by removal of the shell apex, in a characteristic style noted and discussed elsewhere. Shells broken in this manner might have been damaged to remove the animal without breaking the soft tissue but for what purpose is unclear, whether for use as food, bait or dye production (Light 1995 re Duckpool). Such broken *Nucella* shells have also been retrieved from Atlantic Road and Trevelgue Head excavations (Light 2001, 2005a) and large mounds have been found at sites in Ireland (Murray 1999). A third *Nucella* shell has two small neat opposing perforations high on the body whorl. The holes are not the result of predation by gastropods which bore their prey (muricid and naticid snails) and are oriented such that they are capable of being threaded by a flexible thread (e.g. nylon fishing line) but, with one example, an interpretation of deliberate modification is speculative.

***Buccinum undatum* (Common whelk)**

The single specimen of this species is of interest. During assessment of the main Gwithian dataset it was noted that this species recurred as a partial shell fragment. These consisted of the body whorls with the apical region removed. These shells were a feature of the Bronze Age sites GM/X (5n) and GM/XV (5n). The style of fracture is consistent, with the same region of shell removed. One additional example occurs in a GM/I sample, as well as a basal columellar fragment which does not appear to be 'natural'. There are no shells of *Buccinum undatum* in the Gwithian archive which appear to represent food debris.

**Other species**

The remaining 10 shells in the current assessment represent 7 of the 12 large bivalve species present in the main Gwithian assemblage, some of which are present in considerable numbers. All 10 bivalves retrieved in 2005 were evidently brought to the site as dead-collected shells and none is perforated or shows evidence of modification by the human hand.

**Table 7 Gwithian GMXVII Assessment of marine shells**

| Sample number | context | Equivalent layer in BA sequence | *Patella* spp. | *Nucella lapillus* | *Buccinum undatum* |
|---|---|---|---|---|---|
| 1 | (608) | Layer 7 | - | - | - |
| 2 | u/s | Probably layer 3 | 2 frags (1 apex) | - | - |
| 3 | (602) | Layer 4 | 2 shells | - | - |
| 4 | (609) | Lower half layer 7 | 1 shell | 1 clipped. 1 apertural frag | - |
| 5 | ACT turf trench infill (600) | Upper part of layer 3 | - | nil | - |
| 6 | (605) | Layer 5 | 6 shells plus 1 frag | Nil | - |
| 7 | (610) | Layer 8 | 2 shells | 1 shell very fresh | - |
| 8 | (601) | Layer 3 | 29 items of which 25 shells or nearly so | 2 shells | Body whorl and aperture frag |
| 9 | Cleaning below turf layer shell (600) | Layer 3 | 1 shell 2 frags (1 apex) | 1 whole shell | - |
| 10 | (612) | Layer 3 | 7 shells, one large collar frag | 1 fat shell | - |
| 11 | Cleaning below turf layer shell (600) | Layer 3 | 4 shells | 2 whole shells ( 1 perf) | |

#### 4.10.4 Comparison with main Gwithian marine shell dataset

In all, 29 species were identified in the principal Gwithian assemblage assessed in February 2004. (This includes 3 species of limpet and 2 species of mussel). There are 13 species in the 2005 assemblage. Several of the taxa absent from the current assessment are occasional occurrences of species that might be regarded as adventitious rather than the result of deliberate collection, for example top shells and winkles and other taxa marked as Sporadic in Table 1 of Light (2004). However, notable is the absence of *Ostrea edulis* the native oyster which was present in assemblages from all Gwithian sites in the original excavation. Oysters are not common at Cornish archaeological sites and wild populations have suffered a severe decline in recent years. It is not at all clear to what extent oysters may have been a resource available for exploitation to earlier inhabitants of north Cornish coasts.

In the main Gwithian marine shell dataset there was a paucity of mollusc shell whose presence would be suggestive of food remains. The species profile of the Gwithian 2005 assemblage differs from the main archive in the dominance of mussel shells (500 of 580 shells and fragments). Limpets are the second dominant species. These presences go some way to mitigating (in a ‘snapshot’) the bias noted in the principal assemblage. There the paucity of mussel shell did not reflect the documented assumptions that the inhabitants “lived on shellfish, in enormous quantities, which they gathered from the creek or the shore, and the shells were buried, together with other rubbish, in pits in the sand all round", (Thomas 1958). The mussel shells are principally in samples 8 and 10 (Layer 3) (601) and (612). Layer (601) forms the bulk of the Bronze Age horizon known as 'Layer 3' and in addition to bone and stone including worked stone, a dense concentration of shell and charcoal was noted in the western section of the trench. This stratigraphic horizon represents the final major episode of Bronze Age settlement at Gwithian where houses, middens and fields are the main landscape features.

The shell from (612) was taken from the northwest part of the trench where a mixed spread of soil and sand contained large stones, apparently burnt clay fragments intermixed with charcoal and shell and was not considered a well-defined or distinct feature (Lawson-Jones in Nowakowski *et al*. 2005).

The shell retrieved from the 2005 excavation has provided a useful window into the extensively worked site at Gwithian. The retrieval of the mussel shells has provided a small sample of the substantial deposits described by Charles Thomas (1958). The substantial and diverse assemblage of shells that do not evidently represent food debris which are present in the main archive, is represented by a small subset of some of those species excavated in 2005. That main assemblage offers a unique opportunity to consider how the inhabitants of the settlements exploited shells beyond the prime purpose of food, and to speculate about the meaning that the shells, many of them bearing perforations of evidence of deliberate modification, may have had for the settlement inhabitants.

#### 4.10.5 Recommendation

No further analysis of the Gwithian 2005 assemblage is recommended. The material considered herein results from a structured and exhaustive retrieval of all marine shell uncovered in the GM XVII trench. The foregoing results and observations can be used to augment and elucidate any future work on the main marine shell assemblage.

**Table 8 Gwithian GMXVII Mollusc assessment**

| ***Mytilius* spp.** | ***Atrina fragilis*** | ***Pecten maximus*** | ***Venus verrucosa*** | ***Acanthocardia* sp.** | ***Laevicardium crassum*** | ***Tapes rhomboides*** | ***Glycymeris glycymeris*** | ***Land snails*** |
|---|---|---|---|---|---|---|---|---|
| 36 frags (13 umbos) | | | | | | | | Extracted and sent to Paul Davies |
| 18 frags ( 5 umbos), flakes | | | | | | | | Extracted and sent to Paul Davies |
| 2 umbos plus 2 frags | | | | | | 1 valve, dead-coll? | | |
| 3 umbos, plus 6 frags, flakes | | | | | | | | |
| 1 umbo, 1 valve with abrasion | | 1 frag | | | | | | |
| 13 umbos plus 11 frags | | | | 1 marginal frag | 1 valve almost complete | | | Extracted and sent to Paul Davies |
| 7 frags (2 umbos) | | | 1 umbonal frag | | | | | |
| 88 valves/umbos and - 100 frags | | | 1 valvae, 1 frag | | | | 2 valves unperf | |
| 105 umbos plus – 100 frags | 1 frag? | | | | | | | |
| 7 frags (4 umbos) | | | | | | | | Nil |

**Table 9 Gwithian 2005 GMXVII marine shell assessment**

| **Ttl marine shells** | **Comments** |
|---|---|
| 38 | Some umbones large |
| 20 | 1 *Patella* with external calcification and serpulid inside, not food. |
| 8 | |
| 10 | |
| 3 | |
| 33 | *Patella* mostly *ulyssiponensis* |
| 11 | |
| 225 | *Buccium* frag like others (11n) seen in main assemblage |
| 4 | |
| 215 | |
| 13 | Includes *ulyssiponensis* and *vulgata*. One *Patella* juv. |
| **580** | |

## 4.11 Gwithian 2005 The lithics by Anna Lawson Jones

A total of 11 pieces of worked flint were collected during the 2005 field work at Gwithian, the majority coming from the basal layer. They are described below in order of stratigraphic recovery from top to bottom. All are of pebble flint origin and are likely to have been collected from local beaches. The colour and quality of the flint is variable, much of it mottled, some of it faulted and poor quality. All of the pieces have begun to repatinate, and two have been burnt with resultant crazing and blistering. There are at least two and possibly three cores, which represent the largest pieces (measuring 3.8cm max. across) in the assemblage.

A single, faulted multiplatform flake core was found in **(600) ("layer 3")**. It shows crushing or bruising on one edge indicative of secondary reuse as a hammer, and has been worked on a previously worked, re-patinated probable core. The reworking of flint is a frequently cited trait with middle and later Bronze Age flint, and would fit in well with known layer 3 Bronze Age associated activity. A second multiplatform, patinated, flake core with crushed bruising on one edge was found in **(608) ("layer 7A"),** again indicative of secondary hammer use. Context **(609) ("layer 7B")** produced a badly faulted primary waste flake **<3>.** Context **(610) ("layer 8")** produced eight pieces; a burnt and thoroughly blistered probable core; a burnt flakelette; two waste flakelettes (one primary, one secondary); a larger, faulted, secondary flake with remnant partial retouch along one straight corticated edge forming a cutting flake; and a probable core rejuvenation, tertiary piece from a flake core. The two remaining small find number **<4>** pieces consist of a minute flakelette and the bulbar end of heavily patinated blade with fine lateral retouch along one surviving length and opposing use or post-depositional damage.

The retouched knife blade represents the earliest identifiable piece in the collection and is potentially of later Mesolithic (possibly early Neolithic) date. The remainder of the pieces are not diagnostic forms. The cores/core tools with their apparently haphazard removals are more typically Bronze Age although the fact that they have seen subsequent crushing/ hammering use may imply some deliberation. The stratigraphically latest context to produce flint (context **(600)**), produced the only evidence for flint re-use. Re-use of flint is a frequently seen trait found in many Middle Bronze Age and later assemblages (see Edmonds 1995, Butler 2005, etc.). The identification of flint re-use implies the presence of a near-by (on-site?) source of residual flint. The ever present but varying levels of patination maybe related to soil alkalinity.

## 4.12 Bronze Age pottery and fired clay assessment by Henrietta Quinnell and Carl Thorpe

*Dated May 2006*

### 4.12.1 Pottery

Twenty eight sherds totalling 242g were found, average weight 8.6g. All except that from 610 were of gabbroic admixture fabric, soft with variations in reduction/oxidisation, and generally comparable to the fabric used in the assemblage in GMX/XI; burnt reduced inner surfaces are common. That from 610 is a fine gabbroic fabric without admixture.

**Table 10 Details of pottery from 2005 excavation, presented in ascending stratigraphic order.** *B/s = bodysherd*

| Context | Description of context | Pottery | Abrasion |
|---|---|---|---|
| **610** | Brown clay, equivalent Layer 8 | 1b/s beaker, fine incised decoration | 2 |
| **612** | Spread with stones and charcoal within 602 | 1 plain b/s | 1, 2 |
| **602** | Pale grey sand, equivalent Layer 4 | I plain b/s | 1/2 |
| **601 <2>** | Creamy sandy loam, equivalent main part of Layer 3 | 8 plain b/s. One has scrap of internal residue | 1/2 |
| **600** | Dark brown silty sand, equivalent upper part Layer 3 | 1 base angle, 1 b/s split along coil join, 4 b/s, all plain | 1/2 |
| **600 <1>** | " " | 4 plain b/s | 1/2 |
| **604** | Sandy loam layer representing old turf line, beneath 603 and over 601, not distinguished in 1961 | 1 rim sherd, plain and flat-topped, scar for small circular lug on girth set within design of horizontal incised lines | 1/2 |
| **u/s** | Probably Layer 3 | 1plain b/s | 1/2 |
| **-----** | Cleaning below turf | 3 plain b/s | 1/2 |
| **-----** | Deturfing topsoil | I plain b/s | 1/2 |
| **-----** | Backfill of ACT' trench | 1 plain neck sherd | 1/2 |

The beaker sherd from 610 has good similarities to those found previously in Layer 8, both with regard to decoration and to the comparatively high degree of abrasion. The decorated rim sherd from 604 has many parallels in the assemblage from GM X/XI Layer 3, typical of this poorly made and poorly fired material with untidy incised decoration. The plain neck sherd from trench backfill is a shape common within Trevisker assemblages. All the material except the beaker sherd can be assigned with confidence to the distinctive Trevisker assemblage from GM X/XI Layer 3.

#### 4.12.2 Recommendation

This small collection can be included in analysis of the main GMX/XI assemblage without additional cost. Possible conjoins for the sherd from 604 should be sought, which merits illustration if none are found.

#### 4.12.3 Fired clay assessment

One lump weighing 36g came from 600; this had the remains of a distinct smoothed surface. A second lump weighing 7g came from 601 and lacked any original surface. The fabric appears to be non-gabbroic and local, similar to that of the possible pieces from 'loomweights' from the main GMX/XI assemblage. It should be noted that only Layer 3 from this and other sites in GM produced pieces of fired clay likely to be artefacts as opposed to structural daub.

## 4.13 **Stonework** by Henrietta Quinnell and Carl Thorpe

There are 16 artefacts (Table 11), all but four small fragments, and 31 pieces which show no signs of use. The latter have been retained, with an annotated archive list.

**Table 11 Details of stonework from GMXVII presented in ascending stratigraphic order**

| Context | Description of context | Stonework |
|---|---|---|
| **612** | Spread with stones and charcoal within 602 (equivalent Layer 4) | 1 fragment of cobble muller with heavily worn surface |
| **601** | Creamy sandy loam, equivalent main part of Layer 3 | 1 fragment of cobble muller with heavily worn surface<br>1 fragment of cobble muller<br>1 fragment from saddle quern working surface<br>1 fragment from saddle quern working surface; one edge has slight reworking ? for cutting<br>1 rubbing stone, re-used as hammerstone |
| **600** | Dark brown silty sand, equivalent upper part Layer 3 | 1 fragment of cobble muller with heavily worn surface<br>1 fragment of cobble muller working surface<br>2 fragments from working surfaces of different saddle querns<br>1 fragment granite saddle quern working surface<br>1 elongated cobble with slight use as flensing tool<br>1 fragment rubbing stone<br>1 flat cobble utilised as anvil<br>1 killas slab, edge use as whetstone |
| **u/s** | Probably Layer 3 | I killas fragment, edge trimmed for cutting |

The types of artefacts are all well represented in the assemblage from GMX/XI. The rubbing stone re-used as a hammerstone from 601 demonstrates the frequent re-use of stone artefacts for different purposes which is a distinctive feature of that assemblage. A large number of the items, mullers and saddle querns, were used for cereal processing. The types of rock selected are generally hard, granites, elvans, greenstones, and most appear to have been waterworn and therefore to have come from beach or stream bed. The two pieces with secondary working to provide ad hoc cutting edges do not have comparanda in the assemblage from previous excavations. However all the material from previous collections represents either complete, or very substantial parts of, artefacts, with few small fragments with suitable edges for trimming. Overall the fragmentary nature of the 2005 assemblage is marked, with most artefacts represented by pieces which are fist-size or smaller. Such small pieces do not appear to have been retained from the previous excavations and their presence suggests that the overall number of stone artefacts present on the site is larger than supposed. The process by which large artefacts such as querns became reduced to small fragments is unclear as no impact fractures are identifiable.

#### 4.13.1 Recommendation

This material can be included for analysis with that from the previous excavations without additional cost. All items would need rapid expert petrological scanning to provide details of lithology but this can be carried out within the time allowed. No additional drawings would be required but one or more of the 2005 items might be selected for illustration in place of those from the main assemblage.

# 5 **Overall Summary** by Jacky Nowakowski with Joanna Sturgess and Anna Lawson Jones

The main objective of the field exercise carried out in June 2005 at Gwithian was to revisit a location on the major Bronze Age sites where it was known that the principal stratigraphic sequence was extant so that a section could be re-exposed and samples for palaeoenvironmental assessment and analyses could be recovered for analysis. This was achieved. All the major archaeological horizons, with the exception of wind blown sand horizon known as “Layer 2” were extant and sampled. The general absence of “Layer 2” was the result of erosion and exposure as the original 1961 excavation had not been backfilled on the completion of the work. As a consequence “Layer 2” at this location was exposed, collapsed inwards into the open trench and the once intact horizon disappeared (see above).

Six of the principal horizons excavated and recorded in 1961 were revealed during this exercise. Each horizon corresponds to a major phase of settlement activity at Gwithian and the sequence spans approximately 1,000 years during the 2$^{nd}$ Millennium BC. This has been confirmed by the results of a recent pilot scientific dating study (obtaining AMS dates from residues on featured sherds, Nowakowski et al forthcoming) and to some degree by the OSL dates obtained during this field exercise (see appendix 8).

Recent work on producing an updated phased narrative to the Gwithian Bronze Age story has enabled the structural data for each major phase to be more clearly defined. The phases have been dated by diagnostic ceramics which have been broadly confirmed by a recent programme of scientific dating (Hamilton and Marshall in Nowakowski forthcoming). This has resulted in an overall sequence made up of specific phases as set out below (and see Sturgess and Lawson Jones 2006):

- Phase 1 - Early Bronze Age occupation - equivalent “layers 8 and 7”
- Phase 2 - Sand Horizon event/s - equivalent “layer 6”
- Phase 3 - Middle Bronze Age occupation - equivalent “layer 5”
- Phase 4 - Middle Bronze Age fields - equivalent “layer 4”
- Phase 5 - Middle/late Bronze Age settlement and fields - equivalent “layer 3”
- Phase 6 - Post Bronze Age “sand blow” - equivalent “layer 2”
- Phase 7 - Post Bronze Age Turf and topsoil – equivalent “layer 1”

No structural or major archaeological features were found during this field exercise apart from the imprints and profiles of plough marks identified in horizon layers 8, 5 and 3. Only spread (600) with a notable density of animal bone, pot, stone, shell and may be interpreted as related to midden deposits which were excavated adjacent to this area in 1960 (see cuttings GMIX5 and GMIX6 in Sturgess and Lawson Jones 2006).

All the horizons recorded and sampled have produced both palaeoenvironmental and artefact data whose full analyses will significantly contribute to the analysis of the structural and stratigraphic narrative which has recently been completed (Sturgess, and Lawson Jones 2006).

The following summary presents the results of this field study linked to the work which has been carried out on the reconstruction of structural data for the Bronze Age story at Gwithian. It concludes by setting out specific recommendations for analysis which is linked into a broader proposed programme of future work on the archive (Nowakowski et al, forthcoming).

## 5.1 Early Bronze Age Phase 1 Occupation and settlement – "Layers 8 and 7"

The earliest excavated evidence for settlement at Gwithian dates to the Early Bronze Age period and is represented by the major layers coded in the archive as 7 and 8. This occupation horizon has now been called phase 1. The major features of this early period are at least one circular wooden building set in an enclosure on a terrace which overlooked (probable) enclosures and fields (Sturgess and Lawson Jones 2006).

Both of these major horizons were not comprehensively uncovered during the main excavation campaign in the 1950s and 60s. Layer 8 was only fully excavated at site GM/XV and only in part at site GM/X. Layer 7 was notably absent from GM/XV, but was present at site GM/X and revealed during recent work at site GMXVII. It is clear that we have an incomplete picture of the presence and or absence of these layers across the entire investigated area of the Bronze Age settlement and that the material they provide for analysis represents a sample of the potential still extant on the site.

Nevertheless they are key horizons and the data collected during work at site GMXVII adds significant new knowledge to the early Bronze Age story. In June 2005 plough marks were recorded for the first time in layer (610) (equivalent Layer 8). A sherd of Beaker pottery and a handful of flint diagnostic of the early Bronze Age period were also found at this horizon. All of this suggests that Early Bronze Age activity was much more extensive within the general area than previously recognised (that is, focussed on the single building found at site GMXV). The new discovery of plough marks (detected by photograph) around the wooden structure at site GMXV fleshes out our picture on the exact character of settlement at this early period (Sturgess and Lawson Jones 2006).

"Layer 7" was detected as a cultivation horizon during work in 2005. Here a few seeds of barley and other unidentified cereal remains have been identified and these represent the first direct macrofossil evidence for arable cultivation at Gwithian. The recent assessment of the land snail samples from (610), (609) and (608) suggests that the broader environment was generally one of open country and although assessment has shown that pollen survival as whole, is poor, with remains sparse and degraded, identifiable grains from open habitat species (grass, dock and plantain) have survived and this adds support to the general picture painted by the land snail data. Small fragments of wood charcoal – oak, hazel, hawthorn, gorse and broom have been identified from samples recovered from these two horizons and indicate the potentially wide range of habitats that were being used and perhaps managed during this early period. Bracken (fern) spores found in the layer 8 structure (site GMXV) (identified by palynologist Geoffrey Dimbleby in the 1960s, see Sturgess and Lawson Jones 2006) and the imprint of bracken leaves have been noted on some of the ceramics from this early phase. This data gives further indication of the resources, local and perhaps at some distance away, that these early settlers were exploiting. There is minimal presence of marine molluscan species within this major phase of settlement, which provides a contrast with our picture of later subsequent phases of settlement. It is impossible, given the small character of the sample, to know exactly how representative this "snapshot" is. It will be important to carry out full analysis of the soils to gain a more detailed picture of their character and composition and to determine to what degree they have been built up with the addition of cultural debris.

## 5.2 Phase 2 "Layer 6" Sand Horizon

"Layer 6", made up of context (606), sealed the earlier horizon "layer 7a" that is (608). When exposed at site GMXVII, this was a very clean thick band of sand. A couple of plough marks were recorded scored into the top of this layer but none were recorded at the base. Where exposed elsewhere on the earlier excavations it was always found to be a clean layer although, work on the stratigraphic reconstruction has shown that it was never fully excavated in many cuttings and frequently, when found, excavations halted with the discovery of the top of this layer (Sturgess and Lawson Jones 2006). Sparse wood charcoal was found in samples assessed from site GMXVII and these have been identified as bramble or/briar. One unidentified charred plant fragment was found in (606). The land snail assessment shows that there was a low density of open country species within this horizon with *Pupilla muscorum* noted at its base and at the interface with underlying context ((608) (that is "layer 7"). No animal bone, marine shell or other artefacts were found in this context which generally confirms its predominantly clean and sterile make-up.

A sample for an OSL date (Aber-101/GWT-6) was taken from this horizon and a reading 3360 $\pm$ 160 yr was obtained (2150 - 1250 cal BC). Whilst this fits into the $2^{nd}$ millennium BC time frame, this result is too wide ranging to be of use to fine tune the deposition and formation of this major horizon.

Further work on a more precise interpretation for layer 6, which is now coded as phase 2, is required. Full analysis of the soil samples will be very significant here so that this earlier horizon maybe usefully compared with later horizon "layer 4" (see below).

## 5.3 Phase 3 "Layer 5" Occupation, settlement, farming and human cremation burials

Phase 3 represented by "layer 5" represents a complex story within the Bronze Age narrative at Gwithian and is principally characterised by fields (enclosed spaces), settlement and human (cremation) burial. The remains of criss-cross plough marks were found at the base and throughout the thick horizon known as "layer 5" which, at site GMXVII, is represented by contexts (605)b and (605)a (the interface between layers 4 and 5). This suggests prolonged and continuous episodes of arable cultivation in this part of the larger site. A view now supported by the reconstruction work on adjacent and other cuttings on the western and eastern parts of the main areas of excavation (see Sturgess and Lawson Jones 2006). A sample of the dense lattice pattern of plough marks (606) and (607) so dominant throughout this horizon, was uncovered and planned at the base of layer 5 in 2005 (see Figs 3 b and 4). On site GMXVII, this was seen in the broadest way in the section where two main layers of ploughing were detected, although, elsewhere on the wider site, it is clear that there were many overlapping ploughing events during this phase. A major feature of this phase is the appearance of a number of parallel field boundaries which, initially, were banks which were later built upon to form stone walls/hedges and these formed part of a terraced field system. The remains of a probable stone building (found in a ruinous abandoned state) associated with this phase was found at site GMXV (see Sturgess, and Lawson Jones 2006).

Macroplant charred remains of emmer wheat and field madder have been identified in samples taken in 2005. Charcoal (wood) fragments of species Oak, gorse and broom have also been identified. The largest quantity of land snails have been collected from this horizon and these indicate open fieldscapes. The species *Pupilla muscorum* and *Cochlicella acuta* appear in some abundance (partly in the upper half) and denote some major change in the locality. A change *perhaps* brought about by a major phase of arable cultivation and which left its imprint deep within the land surface as this is the major phase where the greatest extent of criss-cross plough marks have been identified (see Fig. 8 in Sturgess and Lawson Jones 2006). A sizeable quantity of animal bone including the remains of sheep/goat, mouse, rodent and 1 fish bone have been identified in the 2005 samples.

No pottery, worked stone, flint or marine mollusca were found in (605) at site GMXVII. Pollen did not survive.

## 5.4 Phase 4 Middle Bronze Age Fields - "layer 4"

The horizon known as "layer 4" has previously been interpreted as sand inundation across the entire area which sealed all traces of underlying settlement remains. There is no clearly identifiable structural data identified with this major horizon. At site GMXVII this was (602) a and b. Cultural material recovered from (602) a and b suggests that this interpretation should be closely scrutinised as this puts an entirely new light on the formation processes associated with this major horizon which is likely to comprise at least two major land surfaces or phases. Preliminary assessment of soils taken from this horizon suggests that midden material had been added to sand to stabilise and create a cultivable series of soil horizons (see section 4.4.3 and Table 1).

A single plain abraded body sherd of Bronze Age date was found in this horizon at GMXVII. No flint or worked bone were found.

Assessment of the land snail samples indicates a change from a preceding open fieldscape to a woody scrub (local) environment. This later reverts to open fieldscapes (see 5.5 below). This horizon contained the greatest diversity of land snail species. That this represents some neglect in land use rather than wholesale abandonment of the area is suggested particularly in the areas immediately west of the main stone-walled field boundary. This is not a sterile horizon however as 31 fragments of animal bone were recovered from hand collected and processed bulk samples. Identified species include a rather mixed assemblage with sheep/goat, rat/water vole and passerine (songbird). Pollen did not survive in sufficient quantities to be useful.

A single seed of *Triticum* cf *dicoccum* (cf emmer wheat) has been identified from (602). Preliminary assessment of character of the soils within "layer 4" has shown that this was not, as previously suggested, a purely sterile horizon. The presence of midden debris within the layer could indicate attempts at stabilising the land surface with the systematic addition of organic-rich material. Sand-filled ard marks were recorded at the base of this layer at site GMXVII in 2005. In addition the land snail data, with it's wide variety of species, could indicate "dumping" and possibly deliberate attempts to introduce re-deposited (cultural) material to the soil. In this light, a previous interpretation of "layer 4" as being a sand blown horizon wholly unaffected by anthropogenic processes, requires to be reviewed.

A sample for an OSL date (Aber-101/GWT-4) was recovered from this horizon (602a). A reading 3650 $\pm$ 160 yr was obtained (2500 - 1600 cal. BC). The result is earlier than anticipated and the result is too wide-ranging to be of value in fine tuning the deposition/formation episode.

## 5.5 Phase 5 Middle/Late Bronze Age settlement and fields - “layer 3”

The horizon known as “layer 3” presents the most complex story at Gwithian during the 2nd Millennium BC. It is characterised by a number of freestanding structures, fields, middens and the burial of whole and selective parts of human remains within the buildings (Sturgess and Lawson Jones 2006). During this major phase, that is phase 5, a physical shift for settlement appears to take place where a small “hamlet” of several buildings were built in the area which previously had been fields during phases 3 and 4 (see Fig. 6 in Sturgess and Lawson Jones 2006). Site GMXVII is located on the edge of a complex sequence of events which belong to this phase.

At site GMXVII, the “layer 3” horizon was a thick band which measured up to 0.30m deep. It contained the largest quantity of artefacts found during the excavation. The ceramics form a coherent Trevisker style group which can be compared with other assemblages in the main archive for this phase. There is a distinctive collection of worked stone artefacts from the deposits associated with this main layer; some with signs of having been reworked. The fragmentary character of the material is in contrast with other material in the archive. These finds have been located on the edge of a working hollow in this general area of the site and it is likely that they were used and discarded during small-scale craft activities (bone working and leather-working) (Sturgess and Lawson Jones 2006). Overlying the main layer (601) where a number of smaller deposits. (615) and (616) were small clean sandy lenses located in the western end of the trench. (600), which produced the largest quantity of finds was also located here and this distinctively dirty layer is likely to be the remnants of a general spread “layer 3” that is (126) which was identified in adjacent cutting GMX/18.

Episodes of arable cultivation have been identified for this phase (Sturgess and Lawson Jones 2006). There are ard marks and spade marks associated with this phase. Ard marks (613) were found at the base of (601) during work at site GMXVII. The geoarcheaological assessment has interpreted this horizon as a ploughsoil. The spade marks may be related to episodes of ground preparation and perhaps the removal of scrubby vegetation during the latter periods of phase 4. Additionally they could represent traces of boundary and hedge maintenance. Clear areas of actual ploughing are less clearly defined than that seen in the earlier “layer 5” horizon. It does however seem as though arable cultivation (by ard) was taking place right throughout this major phase of settlement. Throughout this period the N-S boundaries are permanent landscape features.

The largest number of wood charcoal fragments have been identified from samples recovered from site GMXVII for this major horizon ((600) and (601)). A diverse range of species have been identified and these include hawthorn, gorse and broom, hazel and birch these are all small fragments but indicate exploitation of a wide range of habitats. Pollen had not survived in sufficient quantities in this horizon.

Charred plant remains of *Triticum* cf *dicoccum* (cf emmer wheat), cereal sp. and other unidentified plants have been identified from samples ((600) and (601).

208 animal bone fragments were found in samples (600) and (601) recovered during fieldwork in June 2005 from site GMXVII. This includes cattle and roe deer and pig, alongside sheep/goat. A coprolite (probably from a dog) was found from a midden deposit associated with this phase and this contained many bone fragments: fragments of skull, teeth, jaw and leg bones of a foetal/neonatal sheep/goat and the feet remains of an adult sheep/goat.

Recent land snail evidence for “layer 3” indicates a high diversity range of species including some shade-loving species but with a dominance of the open-country species in the upper layers of this horizon (601).

## 5.6 Post Bronze Age settlement Phase 6 “Layer 2”.

“Layer 2” has been interpreted as a sand blown episode. Contrary to expectations this was not present at site GMXVII. The most likely explanation for its absence is that it was not a wholesale or indeed an even deposit across the entire area and as the trenches from the past excavations were never backfilled, any survival of this layer at this location would have eroded and collapsed through exposure.

## 5.7 Phase 7 “Layer 1” Turf and topsoil

Turf and topsoil (616) covered the entire area sealing all that was below. This would have following the demise of Bronze Age settlement in the area and more likely to have formed during the 1st Millennium BC.

## 5.8 Recommendations for further work – summary

Further work is required on the full analysis of some of the data sets from this field exercise so that their results can then be presented in an integrated future account of the changing character of land-use and settlement at Gwithian during the 2nd Millennium BC.

### 5.8.1 Stratigraphic summary

Site GMXVII has provided further detail which can be linked and integrated into the overall stratigraphic narrative for the Bronze Age sites as a whole (Sturgess and Lawson Jones 2006).

### 5.8.2 Geoarchaeological analysis

Work at GMXVII has produced the first comprehensive series of soil samples from each of the major phases in the overall stratigraphic sequence. Their full analysis will be crucial to gaining an understanding of the character of land use across a time frame of some 1,000 years. This is new data which will greatly enhance current understanding of ancient farming practices at Gwithian.

### 5.8.3 Land snail analysis

Land snail preservation at site GMXVII was found to be exceptional and the full series of samples taken through the main stratigraphic sequence has the potential to add further to our present understanding of the local environment and changing land use through time. Their full analysis is recommended and their results presented and compared with past land snail research work at Gwithian (cf Spencer 1975).

### 5.8.4 Charcoal analysis

Full analysis for a selected number of charcoal samples from site GMXVII has been recommended. These results will further contribute to a detailed picture of the local landscape as well as add to current understanding of the exploitation of management of woodland resources both near and far through the Bronze Age story. A number of wood charcoal samples are suitable for scientific (radiocarbon) dating.

### 5.8.5 Animal bone analysis

Analysis of the small assemblage of animal bone from site GMXVII can take place during a future programme of analysis on material from the main archive.

### 5.8.6 Marine shell analysis

The results of an assessment of the marine shell assemblage from site GMXVII can be integrated into an account of material from the main archive during a future programme of analysis.

### 5.8.7 OSL dating results

The aim of the OSL dating exercise at site GMXVII was to test the technique at a site where there was a well-preserved and relatively well understood stratigraphic sequence. The two readings broadly fall across the 3rd and 2nd Millennia BC and are useful only as background to the deposition events which lead to the formation of major layers 6 and 4. The wide scatter in the data suggests that sand grains were incorporated into both major surface horizons as material in addition to soil. The OSL dating programme is presented in this report as an interim statement in appendix 8. The results will be considered during a review of the scientific dating programme and contribute to a review of the results of the AMS scientific dating programme.

### 5.8.8 Ceramics, fired clay and stonework

Analyses of additional small quantities of ceramics, fired clay and stonework from site GMXVII can take place during a future programme of analysis on the larger collections of material from the main archive.

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# 7 Project archive

The HES project number is **20054090**

The project's documentary, photographic and drawn archive is housed at the offices of the Historic Environment Service, Cornwall County Council, Kennall Building, Old County Hall, Station Road, Truro, TR1 3AY. The contents of this archive are as listed below:

1. A project file containing site records and notes, project correspondence and administration.
2. Electronic drawings stored in the directory Drawings\CAD ARCHIVE\Sites G\Gwithian 2005
3. Black and white photographs archived under the following index numbers: GBP1845 and 1846.
4. Digital photographs stored in the directory CAU \HES Images\Sites G\Gwithian
5. This report held in digital form as: CAU\HE Projects\Sites G\Gwithian Design for Assessment\Palaeoenvironmental report

Artefacts and environmental material retrieved during the project are currently stored at the offices of the Historic Environment Service in Truro. On the completion of the project they will be stored with the rest of the Gwithian archive at the Royal Cornwall Museum, Truro, Cornwall.


*Figure 6: Photograph of south facing section of GMXVII*

*Figure 7: Working shot during sampling*


*Figure 8: Photograph showing ploughmarks at the base of (605) (Layer 5)*

*Figure 9: Photograph showing ploughmarks at the top of (610) (Layer 8)*

# 8 Appendix: Optically stimulated luminescence (OSL) dating of sands from GMXVII



## Optically stimulated luminescence (OSL) dating of sands from a Bronze Age archaeological site at Gwithian, West Cornwall, U.K.

H.M. Roberts

## 8.1 Summary

Two wind-blown sand units found at the Bronze Age site at Gwithian, near Hayle, West Cornwall, were dated using optically stimulated luminescence (OSL) applied to coarse (sand sized) quartz grains. The quartz proved sufficiently sensitive to enable well-resolved dating using the Single Aliquot Regenerative dose (SAR) measurement protocol.

The OSL ages are indistinguishable within errors, showing that the two sand units were deposited in relatively rapid succession approximately 3500 years ago, with only a brief period of stabilisation due to cultivation in between. The OSL ages are in agreement with independent evidence from radiocarbon dating of intervening and overlying stratigraphic units.

**Keywords**

Optically stimulated luminescence, OSL, dating, coarse grained quartz, SAR, Bronze Age, aeolian sand

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## 8.2 Introduction

This report describes the measurements and findings of an optically stimulated luminescence (OSL) dating study undertaken as part of a project undertaken by the Historic Environment Service of Cornwall County Council in collaboration with English Heritage, studying the Bronze Age archaeological site at Gwithian, near Hayle, West Cornwall (Fig 1). The site at Godrevy Towans was originally excavated during the 1950's and 1960's under the direction of Professor Charles Thomas. The present study forms part of a project re-examining the Bronze Age sequence at Gwithian, in which further samples were taken to enhance the original data sets, and reflecting more recent developments in archaeological practice. In June 2005, samples were taken for palaeoenvironmental reconstruction, and also for dating using optically stimulated luminescence (OSL). This report discusses the findings of the OSL work.

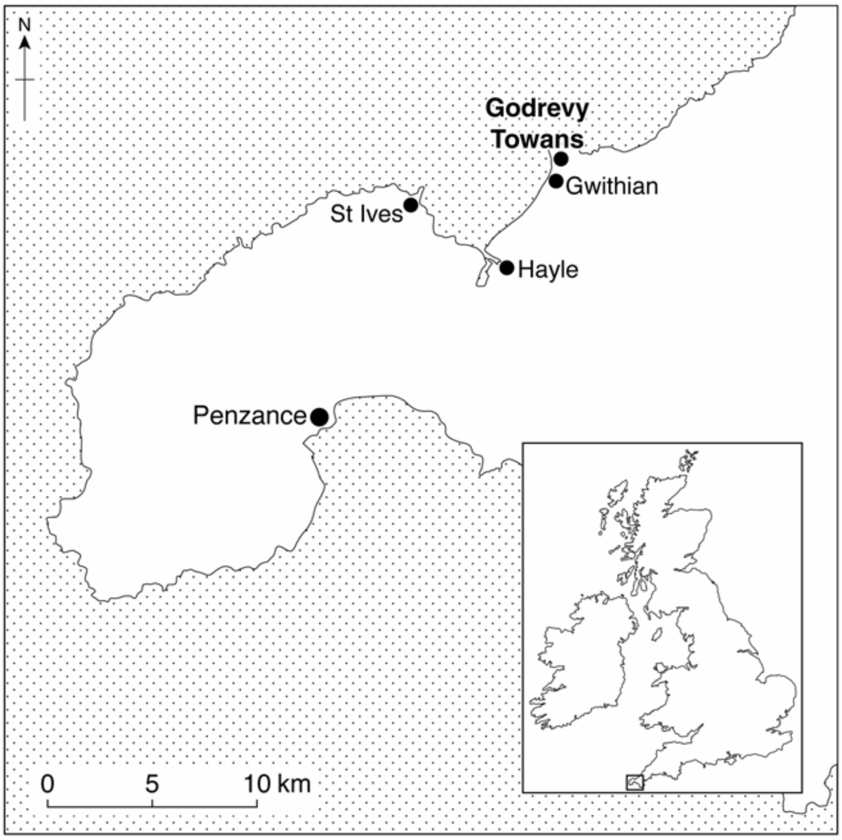



Figure 1: Location of study site at Godrevy Towans, Gwithian, near Hayle, West Cornwall, UK.

## 8.3 The principles of optically stimulated luminescence dating

Optically stimulated luminescence (OSL) dating examines the time-dependent signal that arises from the exposure of naturally occurring minerals, typically quartz and feldspar, to ionizing radiation in the natural environment. This dating technique can be applied directly to the mineral grains that make up sediment deposits, and here the event being dated is the last time the mineral grains were exposed to sunlight ie the time the sediments were deposited and buried by further sediments. The technique relies upon the principle that any pre-existing luminescence signal contained in the sediment grains is lost on exposure to sunlight during transport, prior to deposition. Once the sediments are deposited and shielded from light exposure by the deposition of further sedimentary material, the luminescence signal re-accumulates over time through exposure to cosmic radiation, and to radiation from the decay of naturally occurring radioisotopes of uranium, thorium and potassium located within the surrounding sediment. The luminescence signal is measured in the laboratory by stimulating small sub-samples, or aliquots, of prepared mineral grains with light – hence the term 'optically stimulated luminescence' or OSL. The size or intensity of the OSL signal observed in the laboratory is related to the time elapsed since the mineral grains were last exposed to sunlight. The OSL age is determined by calibrating the intensity of the OSL signal against known laboratory-administered radiation doses in order to determine how much radiation the sample was exposed to during burial (termed the equivalent dose, $D_e$, or the 'burial dose'). This value is divided by the radiation dose to which the sample was exposed each year since deposition and burial (termed the 'annual dose rate'), to give the OSL age (see Equation 1). Further details on OSL methods are given in Aitken (1998), and in recent reviews by Stokes (1999) and Duller (2004).

Equation 1

$$\text{OSL age (years)} = \frac{\text{Burial dose (Grays)}}{\text{Annual dose rate (Grays per year)}}$$

(1 Gray = 1 Joule/kg)

In this study, the $D_e$ was obtained using the Single Aliquot Regenerative dose (SAR) measurement protocol (Murray and Wintle 2000), applied to coarse-grained quartz (ie grains > 90μm diameter). Working with quartz offers the advantage that it is not subject to anomalous fading, unlike some feldspars (eg Spooner 1994; Huntley and Lamothe 2001). The SAR protocol uses the response to a fixed test dose to correct for any change in luminescence sensitivity occurring in the sample during laboratory measurements (eg as a result of thermal pretreatments), with all of the measurements necessary for the determination of $D_e$ being made on a single aliquot. By measuring several aliquots, many independent determinations of $D_e$ can therefore be obtained. Figure 2 illustrates how $D_e$ is obtained from the SAR measurements made. Following measurement of the natural luminescence intensity (denoted by the square symbol on the y-axis of Fig 2), the response ($L_x$) to a series of artificial radiation doses is measured, and normalised to the response ($T_x$) to a fixed test dose. A normalised dose-response or 'growth' curve can then be constructed by plotting the ratio $L_x/T_x$ as a function of radiation dose. This enables the natural luminescence intensity to be calibrated to these responses to a given laboratory radiation dose, thereby determining the laboratory equivalent dose, $D_e$.

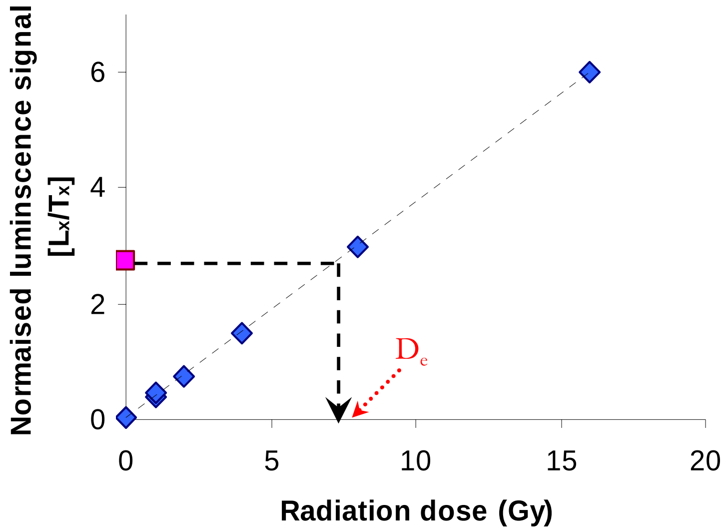



**Figure 2:** Dose-response or 'growth' curve (diamond symbols) generated from measurements made using the Single Aliquot Regenerative dose (SAR) measurement protocol, used in this study. The natural luminescence intensity (square symbol) of the aliquot is calibrated against the response to these known artificial irradiation doses to determine the laboratory equivalent dose, $D_e$.

## 8.4 Sample site and OSL sample collection

In this project, OSL dating was to be used to date the wind-blown ('aeolian') sands lying between the archaeological units (including ploughed units) at one exposed section of the Gwithian site. For this pilot study, samples were selected from homogeneous sand units and taken as far away as possible from any change in stratigraphic unit, to minimise potential complications from any differences in dosimetry. Field gamma spectrometry measurements were also made at the point from which the OSL sample was taken to record the *in situ* dose rate to the sample.

One sample was taken from each of two sand units in the south facing section GMXVII using a 25cm length of 5cm diameter opaque plastic pipe driven horizontally into the sand units. The samples were taken from context 602a and 606, and given the laboratory codes *Aber*-101/GWT-4 and *Aber*-101/GWT-6, for the upper and lower units, respectively (Fig 3).

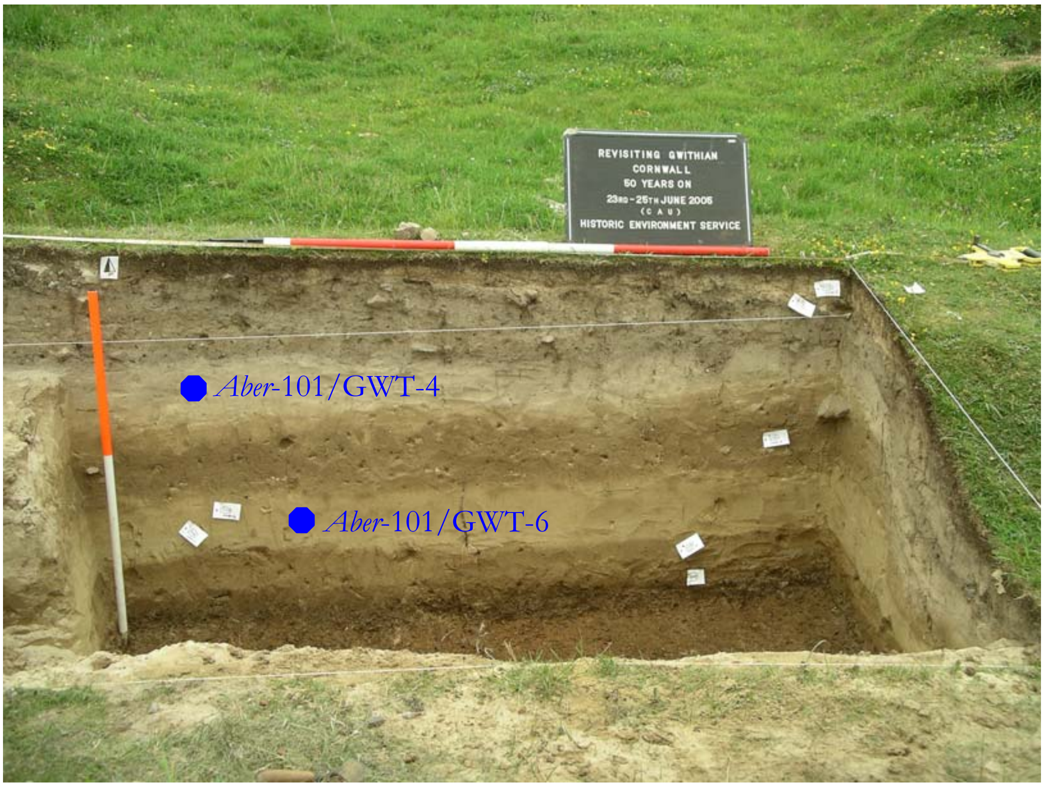



**Figure 3:** Section GMXVII at Gwithian, sampled 23rd-25th June 2005. The OSL sample locations are shown along with Aberystwyth Luminescence Research Laboratory codes; sample *Aber*-101/GWT-4 was taken from context 602a (part of "Layer 4" in the original excavation), whilst sample *Aber*-101/GWT-6 was taken from context 606 (formerly termed "Layer 6").

## 8.5 Methodology

### 8.5.1 Laboratory preparation

Samples were taken for preparation for OSL measurements by excavating material from the leading edge of the plastic sample tube (ie. the material from deepest into the section) under subdued red lighting conditions in the luminescence laboratory. The first 1cm of the sample that had been exposed to daylight during sampling and retrieval was removed prior to the excavation of sample material for luminescence dating. Coarse-grained quartz was prepared using standard methods, outlined below.

Samples were pre-treated with a 10% v.v. dilution of concentrated (37%) hydrochloric acid (HCl) to remove carbonates and surficial coatings, then washed three times in distilled water. Samples were then treated with 20 vols. hydrogen peroxide ($H_2O_2$) to remove organic material, and then washed as previously. Samples were dried and then sieved using the following mesh sizes: 355, 300, 250, 212, 180, 150, 125, 90 micron diameter mesh.

Grains of 180-212 μm diameter were selected for OSL dating, and refined using a solution of sodium polytungstate ('heavy liquid') to separate out the quartz material from the feldspar and heavy mineral fractions of the sediments, on the basis of differences in density. The quartz-rich fraction of the sediments (density between 2.62 – 2.70 $gcm^{-3}$), was treated with 40% hydrofluoric acid (HF) for 45 minutes, to remove the alpha-irradiated surface of the quartz grains and to dissolve any remaining feldspar material, followed by a further 45 minutes in concentrated (37%) HCl, to dissolve any fluorides formed during the etch procedure. The samples were rinsed a minimum of 3 times in distilled water, centrifuging between washings, and then dried at 50ºC, prior to re-sieving. This final sieving acts as a further quartz purification step, as it removes feldspar grains which have not been totally dissolved with HF, but which have been significantly etched and therefore reduced in diameter. The final quartz is then ready for OSL measurements to determine the 'burial dose' or equivalent dose, $D_e$.

The light-exposed material removed from the end of each OSL sample tube was suitable for laboratory-based measurements of water content and dosimetry as these measurements do not require un-exposed sample material. The light-exposed portion of each OSL sample was weighed prior to drying at 50ºC. Drying continued until a constant mass was recorded, to establish the field water content at the time of sampling. These measurements of conditions at the time of sampling provide a benchmark for the water content values employed in the final age calculations (shown in Table 3). After drying, the light-exposed material was then crushed to a fine powder using a ball mill, prior to beta counting (discussed further below, section 4.2).

### 8.5.2 Equipment and Methods

All OSL measurements were conducted using an automated *Risø* TL/OSL reader, equipped with a combined high-power blue LED/ infra-red laser diode OSL unit, and a beta source for irradiations. The combined OSL unit was employed at 80% of full diode current, providing approximately 17mW/cm$^2$ power from the blue LED unit (470nm), and 370mW/cm$^2$ from the IR laser diode (830nm). All measurements were made whilst holding the sample at 125°C, and OSL was detected using 7.5 mm Hoya U-340 filters.

Measurements of OSL were made on coarse-grained quartz, using the Single-Aliquot Regenerative-dose (SAR) protocol of Murray and Wintle (2000). The advantage of SAR over previous measurement protocols is that it uses a measurement of the luminescence production per unit dose to monitor and correct for changes in luminescence sensitivity that have occurred as a function of time, temperature, and past-radiation exposure

(Wintle and Murray 2000). The SAR procedure permits the determination of an equivalent dose ($D_e$), and hence potentially an OSL age, for each aliquot examined.

As part of the sequence of OSL measurements made, outlined in Table 1, a minimum of four regenerative beta doses were applied to each aliquot, bracketing the expected natural dose. Two zero beta doses were also included towards the beginning and end of the measurement cycle to monitor recuperation, and the first regenerative dose (applied at the end of the measurement protocol) was repeated to monitor the sensitivity correction applied (this is sometimes referred to as monitoring of the 'recycling'). Following measurement of each natural or regenerative-dose signal, a fixed test dose was applied, with a cut-heat of 160°C, to monitor and correct for sensitivity change during the measurement procedure. Measurements were made for a range of pre-heat temperatures (held for 10s) to enable $D_e$ to be obtained as a function of pre-heat temperature: 24 aliquots were examined at preheat temperatures ranging between 160-300°C in 20°C step intervals, with 3 aliquots at each temperature.

Dose-rates were determined using a *Risø GM-25-5* beta counter for laboratory-based beta counting, applied to finely ground bulk sample material, and a portable MicroNomad gamma detector fitted with a 2" crystal was used in the field (section 3). The cosmic ray dose was estimated from the burial depth (Prescott and Hutton 1994). Water contents were determined in the laboratory from sealed field samples (section 3), and the values employed in the calculation of ages are presented in Table 3. Moisture and beta attenuation factors are given in Aitken (1985). The beta and gamma counting results, cosmic dose rates, water content values, and the dose rates calculated using the conversion factors of Adamiec and Aitken (1998), are given for each sample in the final age table (Table 3).

**Table 1:** Outline of the SAR measurement protocol applied to each aliquot in this study. A minimum of four regenerative doses were employed in this study, designed to characterise the dose-response curve and bracket the natural signal.

| Step Number | SAR sequence description |
|---|---|
| 1 | Preheat: (160-300°C), heating rate 5°C/s, hold at temperature for 10s |
| 2 | Measure natural or regenerative dose signal ('$L_x$'): 100s OSL @125°C |
| 3 | Apply Test Dose |
| 4 | Cut heat: 160°C, heating rate 5°C/s |
| 5 | Measure test dose signal ('$T_x$'):100s OSL @125°C |
| 6 | Apply 0Gy dose ('recuperation' check) |
| 7-11 | *Repeat steps 1-5* |
| 12 | Apply regenerative dose 1 |
| 13-17 | *Repeat steps 1-5* |
| 18 | Apply regenerative dose 2 (larger than dose 1) |
| 19-23 | *Repeat steps 1-5* |
| 24 | Apply regenerative dose 3 (larger than dose 2) |
| 25-29 | *Repeat steps 1-5* |
| 30 | Apply regenerative dose 4 (larger than dose 3) |
| 31-35 | *Repeat steps 1-5* |
| 36 | Apply 0Gy dose ('recuperation' check) |
| 37-41 | *Repeat steps 1-5* |
| 42 | Apply regenerative dose 1 ('recycling' test) |
| 43-47 | *Repeat steps 1-5* |

## 8.6 Results of experimental tests

As part of the OSL measurements made in this project, a series of tests were undertaken to monitor the OSL measurement procedure, the response and behaviour of the samples, plus the choice of grain size and aliquot size. These experimental checks are discussed below.

### 8.6.1 Aliquot size

Prepared quartz grains for each sample were presented for OSL measurements by mounting the grains in a monolayer onto 1cm diameter aluminium discs, sprayed lightly with Silkospray™ silicone oil to hold the grains in place during measurement. The discs, or aliquots, may be prepared using various amounts of sample. In this study, initial tests showed that signal levels were low due to the material being relatively insensitive and/or due to the relatively young age of the material. Large aliquots (8mm diameter, giving >1000 grains per aliquot) were therefore examined throughout this study, to maximise the luminescence signal observed from each aliquot.

### 8.6.2 OSL signal checks

The OSL signal of each aliquot measured was examined visually, to check the initial signal intensity and the form of the decay curve. A typical decay curve is shown in Figure 4, and shows a rapid decrease in signal which is characteristic of the decay of a signal from quartz. Routinely, the $D_e$ values were calculated using the first two data channels (0.8 s stimulation) and the background was taken from the end of the decay curve (channels 230-250, the final 8.4 s stimulation). This maximised the contribution of the fast component of the OSL signal (Bailey *et al* 1997; Murray and Wintle 2003), and typically represented ~15-35 % of the total OSL signal.

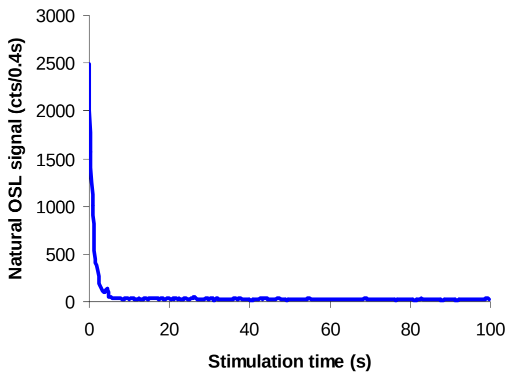



**Figure 4:** Typical OSL signal for aliquots in this study. The example shown is from an aliquot of sample *Aber*-101/GWT-6 which was preheated to 220°C/10s. The very rapid decrease in signal, quickly reaching a steady low background is a form which is frequently observed in the study of quartz aliquots. The signal integrated to derive the value of $D_e$ is that from the first 0.8s of optical stimulation.

The form of the dose-response or 'growth' curve was also examined, and a minimum of four artificial irradiation doses were used to define the growth curve for each aliquot, designed to bracket the 'natural' signal and hence determine the value of $D_e$. Figure 5 shows a typical growth curve; error bars are shown, calculated following Banerjee *et al* (2000) and Galbraith (2002), and generated by *Analyst* (written by Dr. Geoff Duller, University of Wales, Aberystwyth).

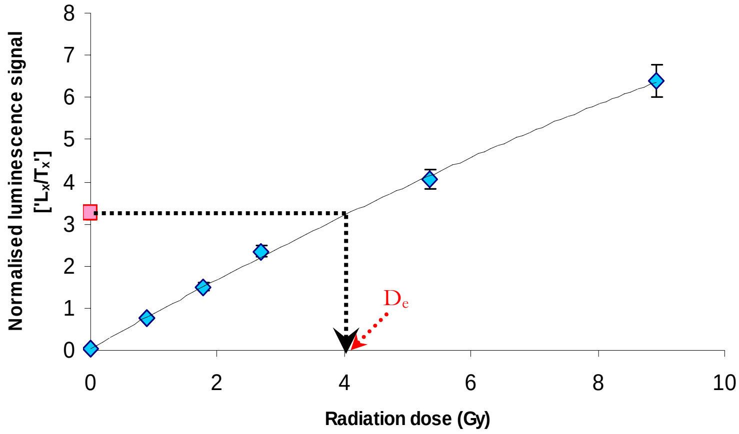



**Figure 5:** Typical growth curve constructed for aliquots in this OSL dating study. The example shown is from an aliquot of sample *Aber*-101/GWT-6 which was preheated to 220ºC/10s.

Once the sequence of dating measurements was completed, each aliquot was irradiated and then stimulated using infra-red (IR) laser-diodes at a temperature of 125ºC to check the purity of each aliquot. Stimulation with IR was proposed as a check on the purity of prepared quartz material by Stokes (1992). Feldspathic minerals respond to simulation with IR, giving a rapidly decaying signal, however, quartz does not appear to respond to stimulation with IR (Spooner and Questiaux 1989). There was little evidence of any response above background signal levels to stimulation with IR for any aliquot in this study (a typical IR stimulated luminescence signal response is shown in Fig 6). No feldspar contamination was therefore considered to be present in any quartz separates prepared for this OSL dating study.

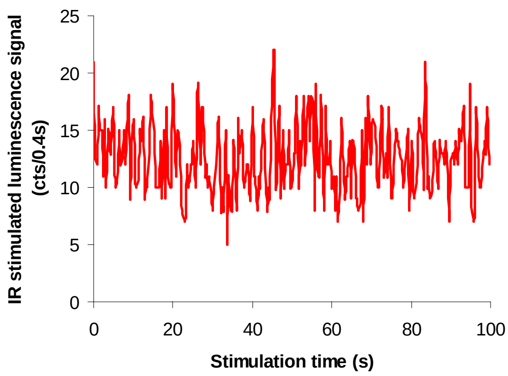



**Figure 6:** Typical response to stimulation with IR. The signal level is very low, being approximately at background levels, thereby suggesting that no feldspar is present in the quartz material prepared for OSL dating. The example shown is from an aliquot of sample *Aber*-101/GWT-6 which was preheated to 220ºC/10s.

### 8.6.3 Recovery of a known laboratory irradiation dose

An important test of any luminescence dating protocol employed is whether the value of a previously delivered laboratory irradiation dose can be accurately and precisely determined. This is sometimes referred to as a 'dose-recovery' test and should be conducted on material which has not previously received any thermal pre-treatments. This fundamental test was conducted for both samples in this dating study using three aliquots of unheated material to study the dose recovery across a range of preheat temperatures (160-240ºC for sample *Aber*-101/GWT-4, and 160-300ºC for sample *Aber*-101/GWT-6).

The laboratory beta dose chosen for the dose-recovery experiment was 2.7Gy. Between 15 and 24 aliquots of each sample were prepared in the same way as the aliquots used for dating. The natural signal was removed from each aliquot by 2 x 1000s stimulation with blue diodes at room temperature, with a 10,000s pause between each stimulation; a beta dose was then applied to each of the aliquots in the dose recovery experiment. The SAR protocol was then applied using regeneration and test dose values of the same size as used in the dating measurement sequences, and applying a preheat of between 160-300ºC for 10s, and a cut heat of 160°C.

The beta dose recovered for each set of sample aliquots is shown in Figure 7 relative to the beta dose applied, and is also shown numerically in Table 2 as mean dose recovery values for each preheat temperature. With the exception of one aliquot of sample *Aber*-101/GWT-6 which is clearly anomalous (Fig 7b), the ratio of the beta dose applied to the dose recovered is within ± 10% of unity for both samples using a range of preheat temperatures. The SAR measurement protocol therefore seems to be appropriate and working well for the sample material used for dating in this study, even at high and low preheat temperatures.

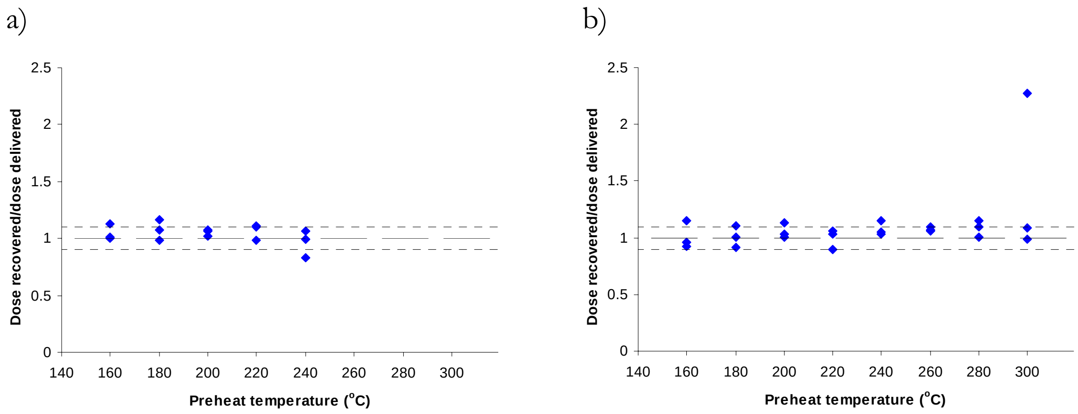



**Figure 7:** Dose recovery test results for sample a) *Aber*-101/GWT-4 and b) *Aber*-101/GWT-6, showing the dose recovered relative to the dose applied for each of the three aliquots measured using a range of different preheat temperatures. Unity and the error limits at ± 10% are indicated as dashed lines.

**Table 2:** Recovery of a known beta dose for three aliquots prepared from each sample dated in this OSL study. The dose applied to sample *Aber*-101/GWT-4 for recovery was 74% of the natural $D_e$, and for *Aber*-101/GWT-6 the dose to recover was 71% of the natural $D_e$.

| **Sample** | Dose applied (Gy) | Dose recovered / Dose applied (mean and s.d. of 3 aliquots) |
|---|---|---|
| **101/GWT-4 160°C** | 2.68 | 1.05 ± 0.07 |
| **101/GWT-4 180°C** | 2.68 | 1.07 ± 0.09 |
| **101/GWT-4 200°C** | 2.68 | 1.05 ± 0.03 |
| **101/GWT-4 220°C** | 2.68 | 1.06 ± 0.07 |
| **101/GWT-4 240°C** | 2.68 | 0.96 ± 0.12 |
| **101/GWT-6 160°C** | 2.68 | 1.01 ± 0.12 |
| **101/GWT-6 180°C** | 2.68 | 1.01 ± 0.09 |
| **101/GWT-6 200°C** | 2.68 | 1.06 ± 0.07 |
| **101/GWT-6 220°C** | 2.68 | 0.99 ± 0.09 |
| **101/GWT-6 240°C** | 2.68 | 1.08 ± 0.06 |
| **101/GWT-6 260°C** | 2.68 | 1.07 ± 0.02 |
| **101/GWT-6 280°C** | 2.68 | 1.08 ± 0.07 |
| **101/GWT-6 300°C** | 2.68 | 1.04 ± 0.07* |

* The anomalous dose recovery point shown in Fig 7b and discussed above is omitted here; the mean shown is therefore that of two aliquots for this preheat temperature.

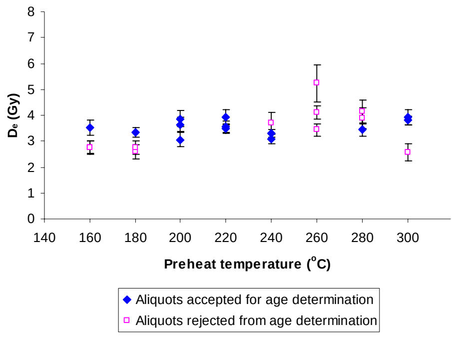
### 8.6.4 OSL dating measurements and checks

The SAR measurement sequence employed in this study has several checks built into it to monitor the behaviour of the sample and the efficacy of the sensitivity correction. For each sample, 24 aliquots were examined to establish $D_e$ values for use in determining an OSL age. The advantage of working with single-aliquot, rather than multiple-aliquot methods, is that each of the 24 aliquots measured gives rise to an independent assessment of $D_e$, and hence, potentially to an OSL age.

Working with a number of aliquots offers the advantage of making measurements using a range of thermal pre-treatments, to compare the $D_e$ values determined for aliquots using different preheat temperatures. Thermal pre-treatments are employed in order to remove any unstable trapped charge prior to measurement of either the natural or an artificially irradiated OSL signal. However, high preheat temperatures are sometimes problematic for young samples, and can lead to erroneously high $D_e$ values being determined due to thermal transfer of trapped charge from relatively stable yet optically-insensitive traps into OSL traps during preheating (eg Bailey *et al* 2001). Given the likely young age of the samples in this study, it was therefore of particular importance to make OSL measurements using a range of preheat temperatures to try to establish a preheat plateau where common values of $D_e$ could be identified and any erroneously high $D_e$ values could be discounted. A range of preheat temperatures was therefore investigated during OSL dating measurements of each sample, increasing to the given temperature at a rate of 5ºC/s and held for 10s on reaching the required temperature; a minimum of three aliquots were examined at each of 8 preheat temperatures (160 – 300 ºC).

The preheat plots generated for the samples in this study are given in Figure 8, showing $D_e$ values for each of three aliquots measured using one of eight preheat temperatures. All aliquots measured are shown in Figure 8, including those rejected from the final age determination (Table 3). Aliquots were rejected on the basis of several criteria: where recycling ratios exceeded ± 10%, where the maximum error on the test dose or the $D_e$ exceeded 10%, and where signal intensities were <1000 counts/0.8s stimulation. The plateau test, suggests that a wide range of preheat temperatures are suitable for dating these samples; furthermore, thermal transfer of trapped charge does not seem to be a problem here.

a)




b)

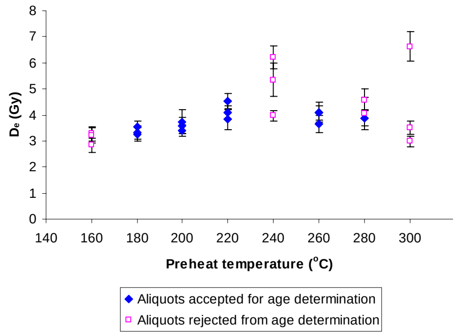



**Figure 8:** Preheat plots for a) sample *Aber*-101/GWT-4, and b) sample *Aber*-101/GWT-6, showing the $D_e$ value determined for each of the three aliquots measured using a range of different preheat temperatures. The associated error in $D_e$ is from the error on 'n' as defined by Galbraith (2002) from counting statistics and the error associated with curve fitting as used in *Analyst* (written by Dr. Geoff Duller, University of Wales, Aberystwyth).

Other criteria may also be used to evaluate the behaviour and reliability of the aliquots used for dating. One of the most powerful of these tests arises from the use of the SAR protocol for the OSL dating measurements. In this measurement procedure, the natural luminescence signal is measured, followed by the response to a series of artificial laboratory beta doses of increasing magnitude designed to bracket the intensity of the natural signal (Table 1). In the SAR measurements made in this study, a low irradiation dose was repeated, or recycled, and applied at the end of the measurement cycle for all aliquots to test how well the sensitivity correction procedure is working. If the sensitivity correction is adequate, then the ratio of the signal arising from this repeated regenerative dose at the end of the measurement sequence to that of its earlier regeneration dose (eg Table 1) should fall within the range of 1.0 ± 0.1 (Murray and Wintle 2000). Only 2 of the 48 aliquots examined for OSL dating failed this 'recycling test', indicating that the sensitivity correction in the SAR measurement procedure is working well for these samples in monitoring and correcting for changes in luminescence sensitivity that may have occurred as a function of time, temperature, and past-radiation exposure.

A further test of the reliability of the sensitivity corrected growth curve generated using the SAR measurement protocol is a check on the 'recuperation' of signal (Murray and Wintle 2000) following the application of a regeneration dose of 0 Gy at both the beginning (following measurement of the natural signal) and towards the end of the measurement cycle (following the largest regeneration dose and prior to the application of the recycling regeneration dose). No significant net OSL signal should be observed following this 0 Gy beta dose if the sensitivity correction is working correctly. For the two samples in this study, no recuperation in OSL signal was observed at low through to high preheat temperatures, and the dose-response or 'growth' curve generated passed through the origin (eg Fig 9a and b). This suggests again that thermal transfer of charge from optically insensitive traps into OSL traps is not a factor in this study.

(a) (b)

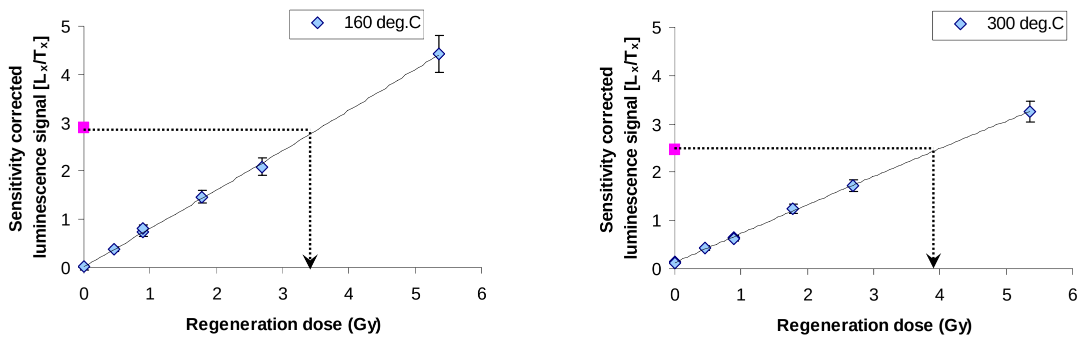



**Figure 9:** Sensitivity corrected dose-response or 'growth' curves measured following (a) low (160ºC) and (b) high (300ºC) preheat temperatures for the aliquots shown in the preheat plot of Figure 8a (sample *Aber*-101/GWT-4). In both cases, the dose-response curve passes through the origin, and no increase in recuperation of the OSL signal is observed between the beginning and the end of the measurement sequence. The aliquot also passes the recycling ratio test (repeating a regeneration dose at the end of the measurement sequence, here of ~0.9 Gy).

### 8.6.5 Determination of the equivalent dose for use in the final OSL age calculation

The aliquots on which OSL dating measurements were conducted were screened for their suitability for use in the final age equation using the series of tests described and discussed above. These checks included examination of signal intensity levels, decay curve shape, growth curve shape, recycling ratio, recuperation, preheat plots, and feldspar contamination checks using IR stimulation. The most common reason for rejection of aliquots (accounting for 91% of the aliquots rejected) was on the basis of low signal levels, causing errors on the test dose and $D_e$ to exceed 10%. In spite of this, the number of acceptable aliquots combined to determine a final OSL age for each sample was 13.

For each sample, the $D_e$ values of the aliquots accepted following screening were normally distributed (an example is shown in Fig 10). The simple arithmetic mean of these $D_e$ values was therefore taken for calculation of the final OSL age. The error on each determination of $D_e$ was calculated using the standard error (ie the standard deviation divided by the square root of the number of estimates of $D_e$). The $D_e$ and standard error are given for each sample in the final OSL age table (Table 3).

(a) (b)

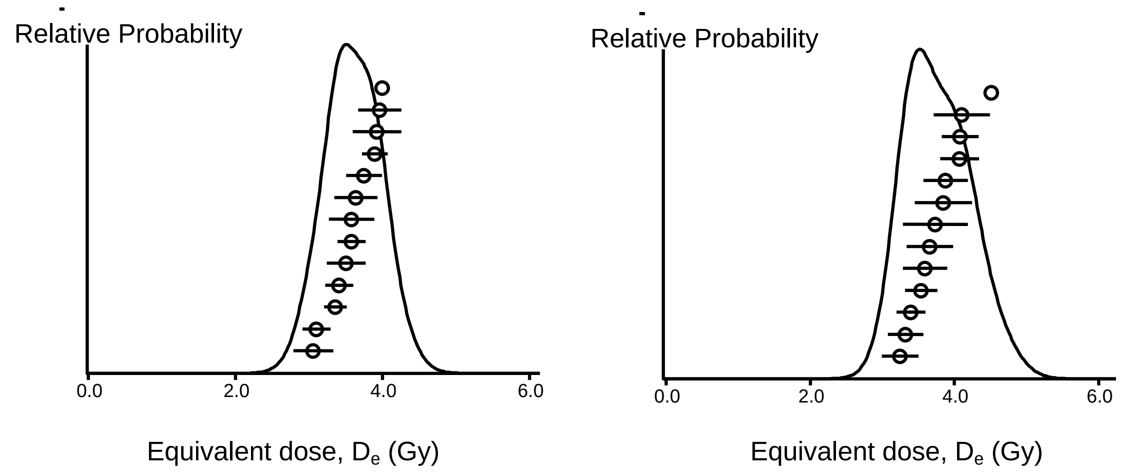
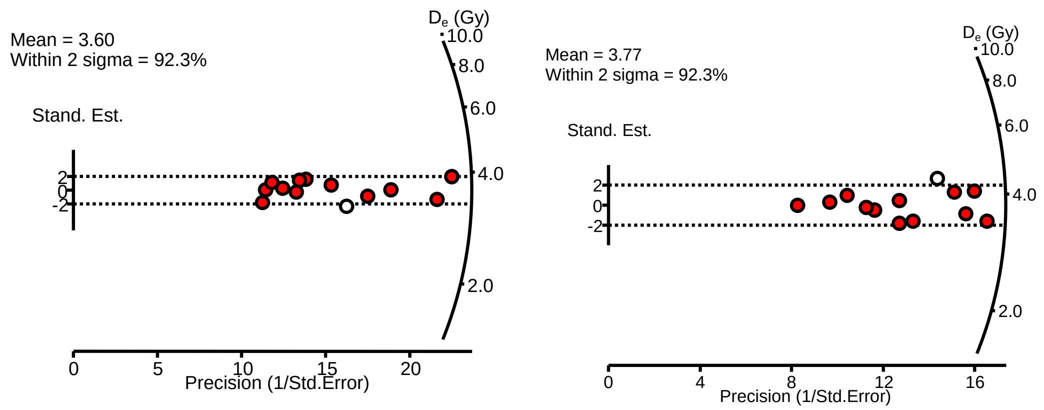



**Figure 10:** The distribution of $D_e$ values obtained for a) sample *Aber*-101/GWT-4, and b) sample *Aber*-101/GWT-6. Each of the 13 points shown is an individual aliquot, which is plotted with the associated error. The probability density plots demonstrate that the $D_e$ values of both samples are normally distributed.

The aliquots which were accepted following all the screening tests (Fig 10) are also shown replotted for both samples in this study in Figure 11. Here, the distribution of $D_e$ values are presented as radial plots (Galbraith 1990), with the $D_e$ of each aliquot being shown as a single point on the plot. These plots are presented as a visual aid to the data only, and displaying the data on such plots offers the advantage of showing the precision to which each data point is known. The precision is displayed on the x-axis, with data of high precision being plotted towards the right hand side of the plot. The y-axis shows the number of standard deviations away from a central value for each $D_e$ value, whilst the radial scale displays the $D_e$ value. The horizontal dotted line extending from 0 on the y-axis is the mean $D_e$ calculated for the sample. The dotted lines extending from the y-axis to the radial scale in Figure 11 are placed at two standard deviations, and any points falling within these limits (indicated by infilled circles) therefore lie within two standard deviations of the mean $D_e$ value. Ideally, the data for all aliquots will fall within this band indicated on the diagrams, indicating one population of $D_e$ values. The data for both samples in this study show very little scatter in the distribution of $D_e$ values obtained following screening (Fig 11), suggesting only one population of $D_e$ values for each sample.

**Figure 11:** Distribution of equivalent dose ($D_e$) values used for the determination of OSL ages for a) sample *Aber*-101/GWT-4, and b) sample *Aber*-101/GWT-6.

**a)** **b)**



## 8.7 OSL age determinations

The equivalent dose ($D_e$) data (discussed in section 5) and the results of laboratory dosimetry measurements were combined for each sample, with corrections being made for attenuation by water and for grain size, to give an OSL age for both samples in this study. These data, including the final age determinations, are presented in detail for each sample in Table 3. The error shown for the $D_e$ determination of both samples (Table 3) is the standard error (see section 7.6) (ie the standard deviation divided by the square root of the number of independent estimates of $D_e$). The average percentage error on the OSL ages is small, being < 5.0 %.

The finalised OSL ages are also shown in Figure 13, superimposed on a photograph of the Gwithian section. Although the ages central are not in stratigraphic order, they are consistent with each other within 1σ errors. The fact that the ages cannot be resolved, in spite of their high precision, suggests that the sand deposition was rapid, with only a brief period of stabilisation due to cultivation occurring in between as indicated by the intervening Bronze Age plough-soil (context 605, formerly 'layer 5'). These OSL ages are in agreement with radiocarbon dates obtained from the intervening layer 5 (c. 1400-1300 cal BC) and from layer 3 (located above layer 4, giving c. 1000 cal BC) (Nowakowski, pers. comm.).

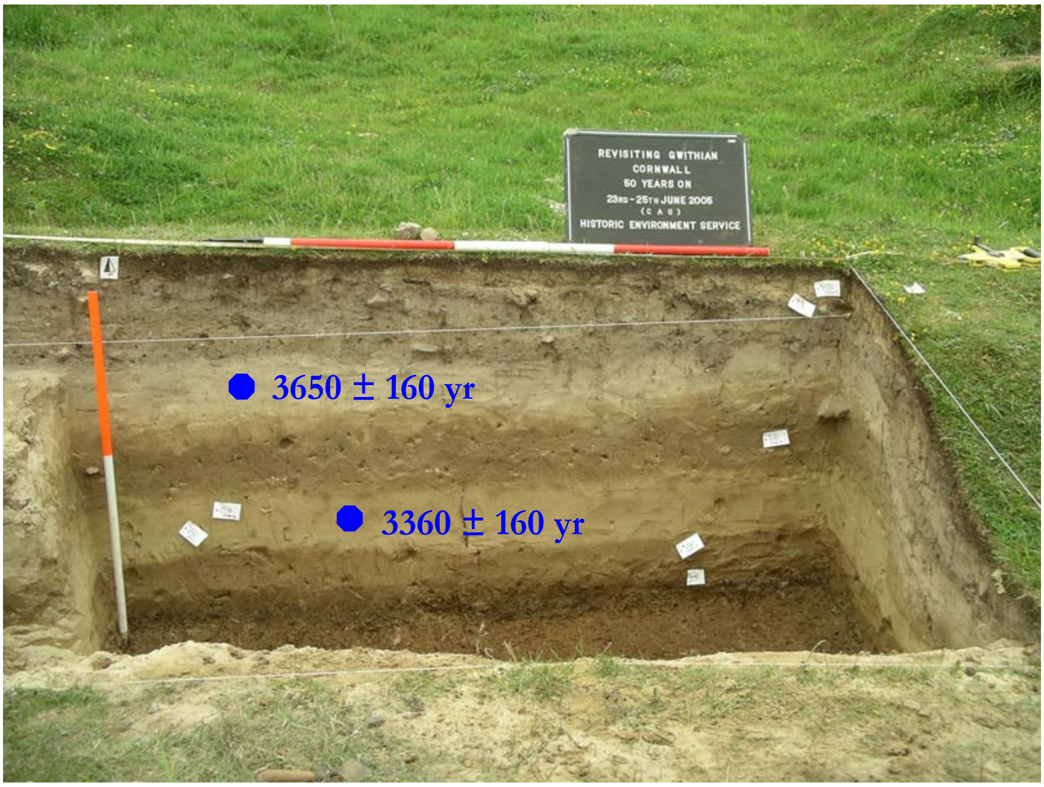



**Figure 12:** The OSL ages of the two sand units dated for Gwithian (see Table 3 for full details of the OSL age determinations). The uppermost sample, *Aber*-101/GWT-4, was taken from context 602a (part of "Layer 4" in the original excavation), whilst the lower sample, *Aber*-101/GWT-6, was taken from context 606 (formerly termed "Layer 6").

**Table 3:** OSL sample details, equivalent dose and dose rate data, and OSL ages.

| Gwithian OSL samples | | |
|---|---|---|
| **Aberystwyth Lab. number** | **101 GWT 4** | **101 GWT 6** |
| **Sample description** | **Context 602a** | **Context 606** |
| *Depth down-section (m)* | 0.45 ± 0.02 | 0.85 ± 0.02 |
| *Material used for dating* | Quartz | |
| *Grain size (μm)* | 180-212 | 180-212 |
| *Preparation method* | Heavy liquid separation (sodium polytungstate); 40% HF etch 45 mins | |
| *Measurement protocol* | SAR; OSL 470nm; detection filter 7.5mm Hoya U-340 | |
| *No. aliquots measured* | 24 | 24 |
| *No. aliquots used for $D_e$* | 13 | 13 |
| ***Equivalent Dose, $D_e$ (Gy)**** | **3.60 ± 0.09** | **3.77 ± 0.10** |
| *Water content (% dry mass)* | 7 ± 5 | 7 ± 5 |
| *U (ppm)* | 0.62 ± 0.04 | 0.63 ± 0.04 |
| *Th (ppm)* | 1.71 ± 0.11 | 2.49 ± 0.14 |
| *K (%)* | 0.65 ± 0.05 | 0.73 ± 0.05 |
| *Layer removed by etching (μm)* | 10 ± 2 | 10 ± 2 |
| *Infinite β dose rate (Gy/ka)* | 0.599 ± 0.008 | 0.734 ± 0.015 |
| *External β dose rate 'wet' (Gy/ka)* | 0.484 ± 0.029 | 0.593 ± 0.036 |
| *External γ dose rate 'wet' (Gy/ka)* | 0.287 ± 0.020 | 0.340 ± 0.022 |
| *Cosmic (Gy/ka)* | 0.214 ± 0.002 | 0.189 ± 0.002 |
| ***Total dose rate (Gy/ka)*** | **0.99 ± 0.04** | **1.12 ± 0.04** |
| ***OSL Age# (a)*** | **3650 ± 160** | **3360 ± 160** |

# Ages are expressed as years before 2005 AD, rounded to the nearest 10 years. All calculations were performed before rounding.

* The error shown is the standard error on the mean.

*Dr. Helen M. Roberts, Luminescence Laboratory, University of Wales, Aberystwyth*

## 8.8 Summary and Conclusions

Two sand units, interpreted to be aeolian in origin, found at the Bronze Age site at Gwithian were dated using OSL applied to coarse-grained quartz. The OSL measurement procedure employed was the Single Aliquot Regenerative dose (SAR) protocol which corrects for sensitivity change. Several checks and screening criteria were applied to the OSL dating aliquots and also to additional aliquots prepared from the samples to ensure that the data included in the final age calculation were of the highest quality. The SAR measurement protocol was appropriate for these samples and the sensitivity correction worked well. Using large aliquots, the samples studied proved sufficiently sensitive and responsive to facilitate well-resolved dating using OSL.

The final OSL ages generated were both accurate and of high precision, being supported by other independent dating evidence from radiocarbon. The OSL ages of the two units dated were indistinguishable, in spite of the high precision obtained. This implies that the deposition of the two wind-blown sand units was rapid, and took place at approximately 3500 years ago, with only a brief period of stabilisation due to cultivation in the intervening time.

**Acknowledgements**

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