

# **Laboratory assessment of Holocene sediments from Tan-y-Bwlch beach, Aberystwyth**



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**Report 2**

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## **1.0 Introduction, aims, and objectives**

This report aims to assess a sequence of sediments extracted from organic silt at Tan-y-Bwlch beach, Aberystwyth, Ceredigion. The aim is to determine if an interpretation of the sequence of deposition at the site can be given. The objectives of this report are to extract and analyse the cores of organic silts taken via loss on ignition testing, as well as prepare samples for specialist analysis, which might help explain the deposition processes found both on site, and in the broader context of coastal intertidal sequences in West Wales.

## 2.0 Site location and background to the study area

Tan-y-Bwlch beach is situated south of the confluence of the Rheidol and Ystwyth Rivers, at Aberystwyth in West Wales. The beach starts at Pen-y-Bwlch cliffs and runs north for just over 1km to the harbour (see figure 1 below). The beach is a shingle ridge which sits between the sea, and the river Ystwyth and low-lying fields behind. Figure 1 below also shows the location of test pit 2 (TP2), the site from which our cores were extracted.

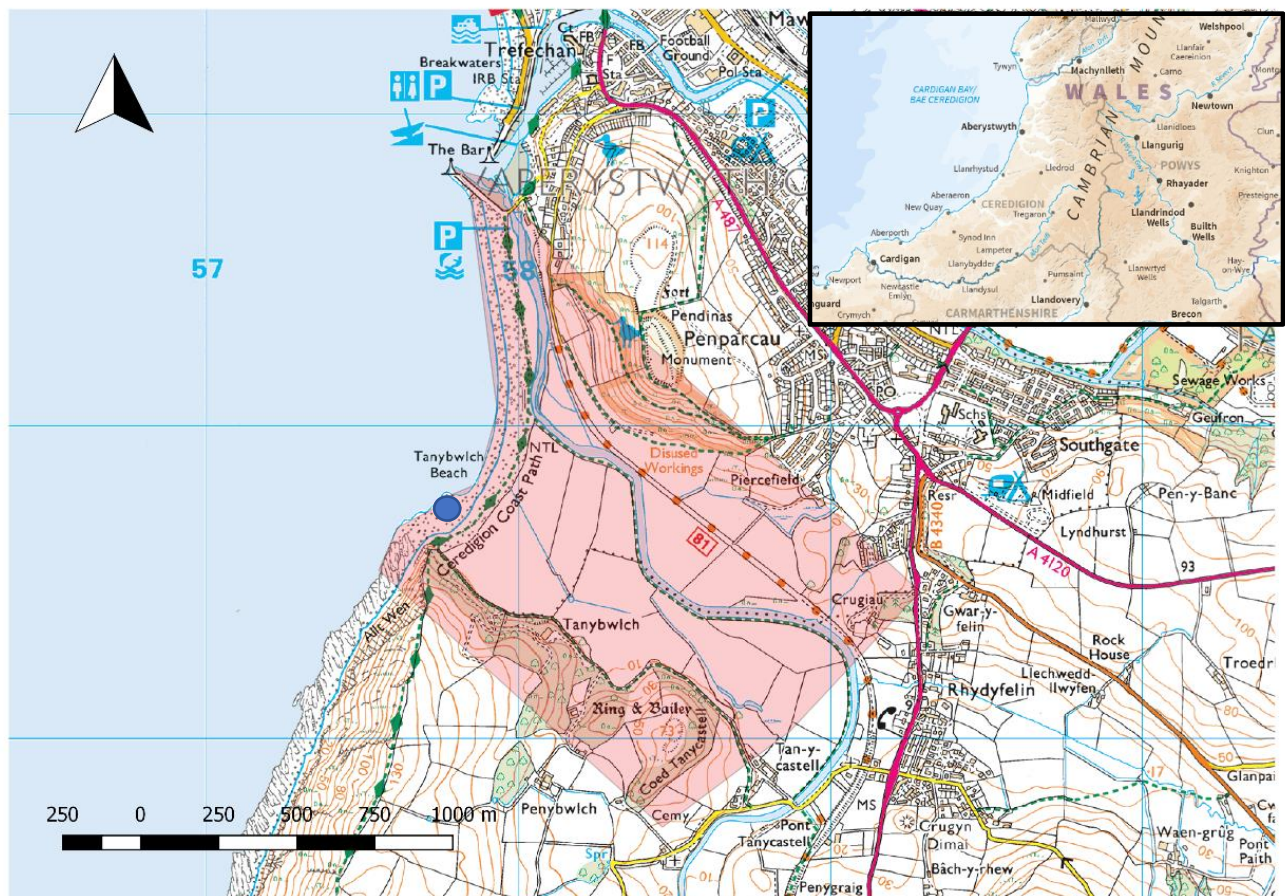


**Figure 1:** The area in red marks the end of the basin of the Ystwyth, and Tan-y-Bwlch beach. Inset: A map of the region. The blue circle marks the site of the test pit from which the cores were extracted, named as TP2.

Basemap is from Ordnance Survey via <https://digimap.edina.ac.uk/>

## 2.1 Geology and Geomorphology

The beach is west-facing from Cardigan Bay into the Irish sea, and this part of Ceredigion the bedrock is mostly Llandovery Epoch mudstone and sandstone. At the south of Tan-y-Bwlch beach at the Pen-y-Bwlch cliffs starts the beginning of the Aberystwyth Grits formation, which runs north along the coast to Borth. The Trefechan formation lies to the south. Aside from small concentrations of glacial tills, sands, and gravels on the base of some of the hills, in the main the superficial deposit covering the valley floor is Holocene alluvium (see figure 2).

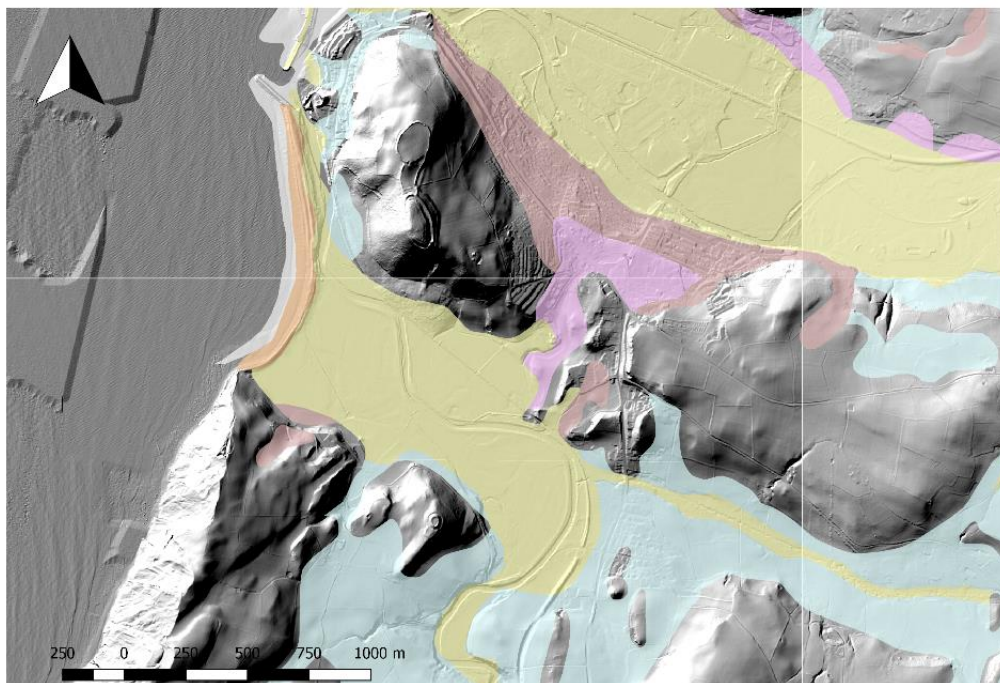


**Figure 2:** A hill shade DEM of the superficial deposits. Yellow = Holocene alluvium. Light purple = glacial till deposit. Dark purple = other glacial deposit.

LiDAR data for base map from [www.lle.gov.wales/home](http://www.lle.gov.wales/home)

## 2.2 Archaeology

Material has been excavated from the Holocene sequences in the area and include pre-historic as well as historic finds. There is a Mesolithic find spot at Pen y Angor near the harbour mouth, at the mouth of the Ystwyth river, which was investigated in the early 20<sup>th</sup> century, and included finds of flints, scrapers, microliths and arrowheads (Thomas and Dudlyke 1925) although this evidence has since been considered problematic due to the recording techniques used in initial investigations (see for example David 2004). There was also the exposure of prehistoric peat and forest beds on the beach at Tan-y-Bwlch during storms in 1974, with visible birch and one trunks (RCAHMW n.d.)

Evidence for Neolithic and Bronze Age activity is limited to two possible enclosure sites and two axe fragments at Pen Dinas, an iron age hillfort site above the town of Aberystwyth where several stages of investigations have taken place (RCAHMW n.d.). The south face of Pen Dinas looks over Tan-y-Bwlch beach.

Of historic finds in the area, Roman and Romano British evidence in this study area is scarce, with a late Roman coin c.300 the only find. On the hill above the river Ystwyth is Tan-y-Castell, the site of a 12<sup>th</sup> century castle, built by the Normans but taken by the Welsh. The church of St. Hychan in Llanachaern is thought to be contemporaneous (RCAHMW n.d.).

### 3.0 Study Methods

#### 3.1 Methods of field investigation

To retrieve the required samples, a 1m<sup>2</sup> test pit was dug, to a depth of half a meter. Then 2 monolith tins were hammered into the section wall, to remove a sample in each for the 0-50 cm depth (see plates 1 and 2). The remaining samples from 0.5 metres to 2 meters depth were recovered using a 1-meter length hand auger, two samples being taken one after the other (see plate 3). For the purposes of reporting, the tins will be referred to as core one for the remainder of this report.



**Plate 1 (above left):** test pit 2 just after opening.

**Plate 2 (above right):** The monolith tins in situ

#### 3.2 Sample processing

The samples were tightly wrapped in cling film on site and removed to the cool store at UWTSD Lampeter Archaeology Dept., to impede sample deterioration. When ready for processing, they were opened in the paleoenvironmental laboratory at UWTSD Lampeter, and cleaned and photographed (see plate 3). Each tin and core were examined, and the sedimentology visible in the stratigraphy was described using standard recording procedures, recorded on a sediment log sheet (Appendix 1), with each visible change in horizon noted. When recording and sample extraction was completed, the samples were returned to cold storage.



**Plate 3:** The monolith tins and cores in the laboratory after being cleaned up.

### 3.3 Specialist sample selection

The samples for loss on ignition testing were taken at 1cm intervals along one of the 50cm monolith tins. For the two cores of the greater depth, the sampling had to be more considered as the available amount of sample was less than that available from the tins, and enough sample was required to send to specialists for consideration. In this case a selection from each visible horizon was taken, rather than at 1cm intervals along the length of the two cores. For the samples requiring specialist analysis, the same principle was followed, with two samples from each horizon being collected, and sent for analysis of pollen content and foraminifera content. The sampling intervals can be seen in table 1 below.

| LOSS ON IGNITION SAMPLES |                                   | FORAMINIFERA & POLLEN SAMPLES |          |                 |
|--------------------------|-----------------------------------|-------------------------------|----------|-----------------|
| CORE #                   | SAMPLE DEPTH                      | CORE #                        | SAMPLE # | SAMPLE DEPTH    |
| 1                        | 0 cm - 50 cm at 1 cm intervals    | 1                             | 1        | 0 cm - 9 cm     |
| 2                        | 50 cm-56 cm at 1 cm intervals     | 1                             | 2        | 9 cm - 17 cm    |
| 2                        | 68 cm-78 cm at 1 cm intervals     | 1                             | 3        | 17 cm - 25 cm   |
| 2                        | 89 cm -91 cm at 1 cm intervals    | 1                             | 4        | 25 cm - 31.5 cm |
| 2                        | 102 cm - 106 cm at 1 cm intervals | 1                             | 5        | 31.5 cm - 42 cm |
| 2                        | 12 cm - 129 cm at 1 cm intervals  | 1                             | 6        | 42cm - 50 cm    |
| 3                        | 140 cm - 142 cm at 1 cm intervals | 2                             | 1        | 56 cm - 65 cm   |
| 3                        | 150 cm - 155 cm at 1 cm intervals | 2                             | 2        | 80 cm - 89 cm   |
| 3                        | 166 cm - 173 cm at 1 cm intervals | 2                             | 3        | 91 cm - 101 cm  |
| 3                        | 180 cm - 185 cm at 1 cm intervals | 2                             | 4        | 107 cm - 114 cm |
| 3                        | 195 cm - 201 cm at 1 cm intervals | 2                             | 5        | 114 cm - 122 cm |
|                          |                                   | 2                             | 6        | 130 cm - 136 cm |
|                          |                                   | 3                             | 1        | 143 cm - 150 cm |
|                          |                                   | 3                             | 2        | 155 cm - 164 cm |
|                          |                                   | 3                             | 3        | 174 cm - 180 cm |
|                          |                                   | 3                             | 4        | 185 cm - 193 cm |
|                          |                                   | 3                             | 5        | 202 cm - 208 cm |

**Table 1:** Sampling intervals undertaken on TP2 cores.

### 3.4 Loss on ignition sample preparation

A set of dry crucibles were weighed ( $W_c$ ), and each of the wet samples were added to the crucibles and weighed again. They were then air dried overnight in the laboratory oven at 105°C. The crucibles were re-weighed when cool ( $W_s$ ). All weights were recorded at each step. To measure the organic content in each sample, the crucibles were placed on a tray and left in a furnace at 550°C for 4 hours. When removed from the furnace and cooled, the crucibles and remaining ash ( $W_A$ ) were re-weighed, the expectation being that the organic content had been removed.

$$\text{The calculation is therefore: Loss on ignition} = \frac{(W_s) - (W_A)}{(W_s) - (W_c)} * 100\%$$

The samples were put into the furnace for a second burning at 950°C for 1 hour, this time to obtain an estimate for the calcium carbonate content in the samples. When cooled after removal from the furnace, they are re-weighed ( $W_{co3}$ ), the expectation that the calcium carbonate content has been removed

$$\text{The calculation is therefore: } (W_{co3} - W_A) / (W_s) - (W_c)$$

### 3.5 Foraminifera sample preparation

The 17 samples selected were stored in airtight sealed wrappings and sent to Dr John E. Whittaker. who carried out the sample preparation and analysis. The processed weight of each of the samples can be seen in table 2 below. They were each processed through a 75-micron sieve and sodium carbonate was used to separate the clay from organic sediment. The full sampling strategy can be seen in appendix 2.

| CORE | SAMPLE DEPTH    | SAMPLE No | WEIGHT PROCESSED |
|------|-----------------|-----------|------------------|
| 1    | 0 cm - 9 cm     | 1         | 55g              |
| 1    | 9 cm - 17 cm    | 2         | 55g              |
| 1    | 17 cm - 25 cm   | 3         | 55g              |
| 1    | 25 cm - 31.5 cm | 4         | 60g              |
| 1    | 31.5 cm - 42 cm | 5         | 45g              |
| 1    | 42cm - 50 cm    | 6         | 35g              |
| 2    | 56 cm - 65 cm   | 1         | 40g              |
| 2    | 80 cm - 89 cm   | 2         | 35g              |
| 2    | 91 cm - 101 cm  | 3         | 45g              |
| 2    | 107 cm - 114 cm | 4         | 30g              |
| 2    | 114 cm - 122 cm | 5         | 30g              |
| 2    | 130 cm - 136 cm | 6         | 30g              |
| 3    | 143 cm - 150 cm | 1         | 25g              |
| 3    | 155 cm - 164 cm | 2         | 40g              |
| 3    | 174 cm - 180 cm | 3         | 30g              |
| 3    | 185 cm - 193 cm | 4         | 35g              |
| 3    | 202 cm - 208 cm | 5         | 30g              |

**Table 2:** processed weights of the samples for foraminifera analysis

### 3.6 Pollen sample preparation

Of the 17 samples initially taken from the three cores for pollen testing (see table 1 above), eight were chosen to be processed and converted into samples suitable for use in microscopic analysis. There were four samples taken from core 1, two samples taken from core 2 and two samples taken from core 3 (see table 3 and the pollen sample prep sheet in appendix 3). The bias for core 1 was intended to reflect the higher resolution testing also carried out on core 1 in the loss on ignition tests. The pollen samples were prepared following UWTSD laboratory procedures and were carried out by the author and Dr Roderick Bale of UWTSD. When fully prepared, the samples were sent to Dr Astrid Caseldine of UWTSD for analysis.

| CORE | ORIGINAL<br>SAMPLE No | SAMPLE DEPTH    | POLLEN<br>SAMPLE<br>NUMBER |
|------|-----------------------|-----------------|----------------------------|
| 1    | 1                     | 0 cm - 9 cm     | P1                         |
|      | 2                     | 9 cm - 17 cm    | P2                         |
|      | 4                     | 25 cm - 31.5 cm | P3                         |
|      | 6                     | 42 cm - 50 cm   | P4                         |
| 2    | 3                     | 101 cm - 102 cm | P5                         |
|      | 6                     | 129 cm - 130 cm | P6                         |
| 3    | 3                     | 173 cm - 174 cm | P7                         |
|      | 5                     | 201 cm - 202 cm | P8                         |

**Table 3:** Pollen samples processed for testing

### 4.0 Stratigraphic description

The stratigraphic sequence found within the cores was generally of one deposit type, clayey organic silts. There was slight variation in colour, friability, and the presence of organics between deposits in the sequence, as outlined in detail in the table below. There are organics visible throughout core 1 and core 2, then towards the end of core 2 (at 125cm) the visible organics disappear. It is also noticeable from the descriptions that the cuts between each visible horizon seem to go from an abrupt change to a more diffuse. Whilst the change in colour was minimal, there were some identifiable changes, which were recorded using a Munsell chart. The full set of core description sheets are available in appendix 1.

| CORE | DEPTH (cm) | DESCRIPTION                                                                                                                   | MUNSELL CODE                        |
|------|------------|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| 1    | 0-3        | Clayey silt with fine sand. Organics visible. Abrupt cut, firm.                                                               | 10YR 2/2 (very dark brown)          |
| 1    | 3-9        | Clayey silt, organics visible. Abrupt cut. firm. ☐                                                                            | 10YR 3/1 (very dark grey/brown)     |
| 1    | 9-17       | Clayey silt with some very fine sand. Organics visible. Sharp cut (into dark grey). Friable.                                  | 10YR 4-5/1 (greyish/brown)          |
| 1    | 17-25      | Clayey silt and fine sand. Friable. Diffuse cut. Organics possible as visible brown mottle.                                   | 10YR 3/1 (very dark grey/brown)     |
| 1    | 25-31.5    | Clayey silt and fine sand. Friable. Abrupt cut. Organics possible as brown mottling visible.                                  | 10YR 3/2 (very dark grey/brown)     |
| 1    | 31.5-34.5  | Clayey silt and fine sand. Not as friable as 25-31.5. brown mottling visible, possible organics. Abrupt cut.                  | 10YR 3/2 (very dark grey/brown).    |
| 1    | 34.5-39    | Clayey silt with fine sand. More friable than 31.5-34.5cm. Diffuse cut.                                                       | 10YR 3/1 (very dark grey/brown)     |
| 1    | 39-42      | Clayey silt with very fine sand. Possibly organics as brown mottling. Abrupt cut. Less friable than 34-39cm.                  | 10YR 2/2 (very dark brown)          |
| 1    | 42-50      | Clayey silt very fine sand. More clay than 39-42cm.                                                                           | 10YR 3/2 (very dark grey/brown).    |
| 2    | 50-75      | Clayey silt and very fine sand. Diffuse cut.                                                                                  | 10YR 3/2 (very dark grey/brown).    |
| 2    | 75-91      | Clayey silt with very fine sand. Organics visible. Diffuse cut.                                                               | 10YR 2/2 (very dark brown).         |
| 2    | 91-105     | Clayey silt with very fine sand. Abrupt cut.                                                                                  | 10YR 4/2 (dark greyish/brown)       |
| 2    | 105-114    | Clayey silt. Friable. Abrupt cut. Organics visible.                                                                           | 10YR 2/3 (very dark greyish brown). |
| 2    | 114-125    | Clayey silt and very fine sand. Not as friable as 105-114 cm. no visible organics but brown patches so possible. Diffuse cut. | 10YR 2/2 (very dark brown).         |
| 2    | 125-140    | Clayey silt. No obvious organics. Diffuse cut                                                                                 | 10YR 3/2 (very dark grey/brown).    |
| 3    | 140-150    | Clayey silt with fine sand. Diffuse cut.                                                                                      | 10YR 2/2 (very dark brown).         |
| 3    | 150-172    | Clayey silt with fine sand. Lighter patches of grey visible. Diffuse cut.                                                     | 10YR 3/2 (very dark grey/brown).    |
| 3    | 172-181    | Clayey silt and very fine sand. diffuse cut.                                                                                  | 10YR 3/1 (very dark grey/brown)     |
| 3    | 181-198    | Clayey silt and very fine sand. diffuse cut.                                                                                  | 10YR 2/2 (very dark brown).         |
| 3    | 198-208    | Clayey silt.                                                                                                                  | 10YR 4/1 (dark grey)                |

**Table 4:** Description of the stratigraphic deposit types.

## 5.0 Results

Sections 6.1 and 6.2 will discuss the results of the loss on ignition test and specialist assessments. The loss on ignition test was carried out by the author, and a full breakdown of results can be found in appendix 4. The foraminifera analysis was carried out by Dr John E. Whittaker, and the copies of the sampling strategy and findings report can be found in Appendix 2 and 5. The pollen analysis was carried out by Dr Astrid Caseldine of UWTSD, and a full copy of the pollen count can be found in appendix 6.

### 5.1 Loss on ignition test results

The graph in figure 3 below shows the results of the loss on ignition tests. In terms of the organic content of the samples, there are clearly volume peaks at depths of 23cm with a 30% organic content, 42cm with a 20% content, both from core 1, and 105cm with a 23% content and 125cm with a 26% content from core 2. The remaining samples generally fall between 9% and 15% organic content, with the lowest at 7% at the base of core 3, the greatest depths tested at 200-201 cm. The calcium carbonate content is much more stable, found to be 2%-3% of content across all samples.

### 5.2 Foraminifera Results

There was not a full analysis completed, only an interim report. Of the 17 samples processed (table 3), nine were chosen for analysis of their macrofaunal content. From core 3, sample 5 (depth 202-208 cm), sample 3 (depth 174-180 cm) and sample 1 (depth 143-150 cm) were analysed, and the residues were mainly a mixture of coarse and fine plant debris, with small seeds. Some thin iron pan present, towards the base. Sample number 1 contained more peat.

The three chosen from core 2 were sample 6 (depth 130-136 cm), sample 3 (depth 91-101 cm), and sample 1 (depth 56-65 cm). As in the core 3 examples described above, these also contained plant debris and small seeds with a little iron panning at the base. Samples 3 and 1 contained insect remains (*chironimid*) and beetle fragments. These remains are the first indication of calcium carbonate preservation.

The core 1 residues chosen for analysis were sample 6 (depth 42-50 cm), sample 4 (depth 25-31.5 cm) and sample 2 (depth 9-17 cm). Analysis found that sample 6 was much like those found in core 2 and 3 in terms of plant debris and seeds. The residue in sample 4 contained agglutinating foraminifera belonging to the family *Jadammina macrescens*, and a marsh agglutinating foraminifer

*Miliammina fusca*. In addition to many small bugs, sample two also contained *jadammina macrescens*.

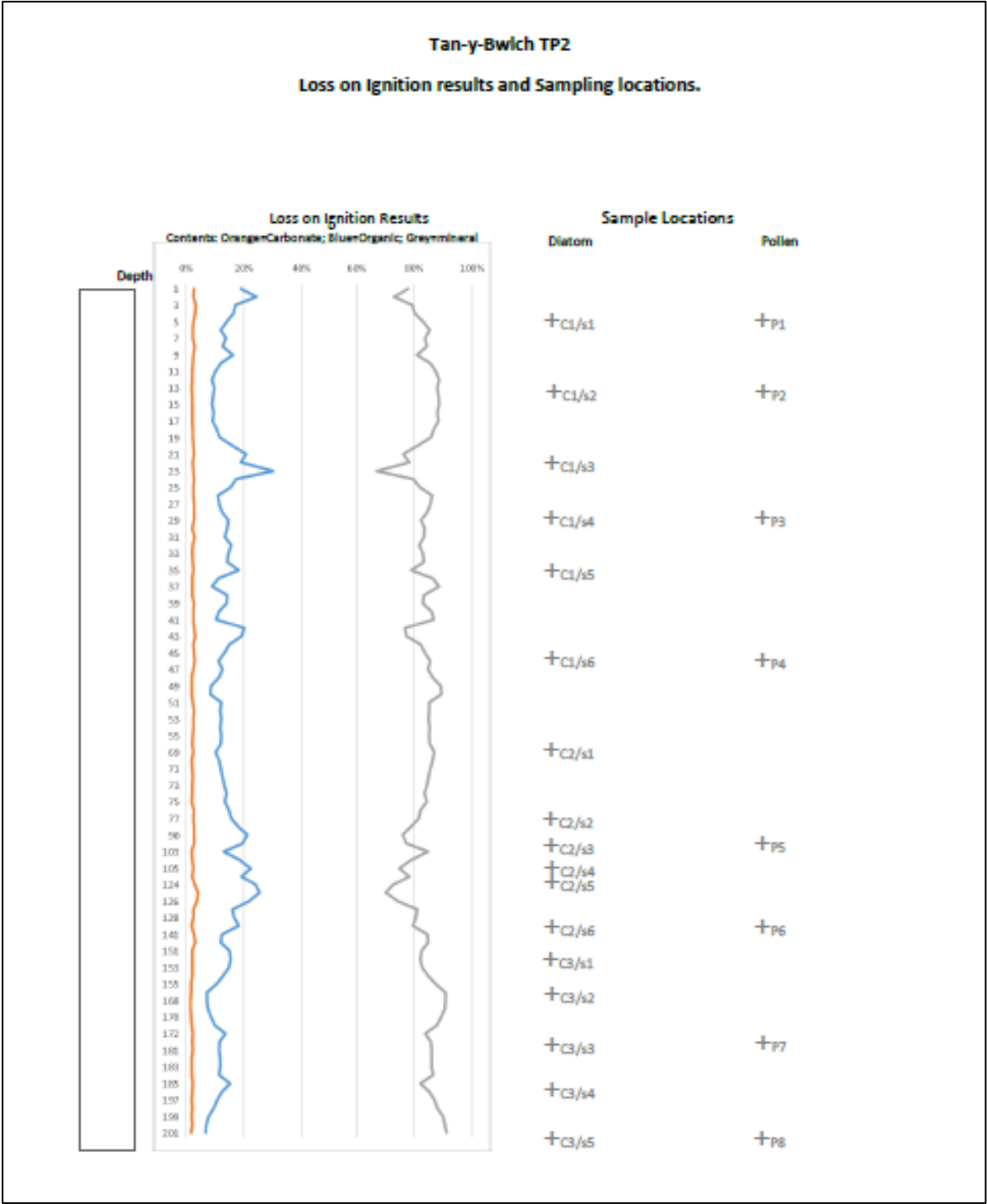


**Figure 3:** Loss on ignition test results

### 5.3 Pollen results

A full pollen count was not completed, only a count of 50 carried out, whereas at least 100 should normally be counted for a complete assessment. All the tree, shrub and herb species are discussed in % of total pollen for that group only. The aquatics and spores are discussed as a total of themselves plus the trees, shrubs and herb groups. The totals can be seen in figure 4 below. Due to the limited nature of the pollen count undertaken, the pollen chart has not been split into zones for discussion at this stage, this should be undertaken when a more in-depth pollen survey is completed.

In the lowest sample of core 3, pollen sample number P8 (depth 202-208 cm), we find a woody sample, with trees (including hazel) accounting for 84% of the tree, shrub and herb species total, alder (*Alnus*) with the most at 64%, hazel (*Corylus*) with 14%, oak (*Quercus*) at 4% and just 2% of elm (*Ulmus*). Grassy species account for just 10%. There is a small number of fern species (10.5%), and bracken (1.8%).

Further up core 3, at 174-180 cm, sample P7 reveals a still woody sample of the trees, herbs and shrubs, with the total at 76%, again alder the most dominant at 50% and hazel at 14%, but we see a rise in oak from 4% to 12%. Grass species increase to 16%. There are small amounts of sedge species present (2%), as well as *Plantago lanceolata* (2%) and *Pteridium* (1.7%), as well as ferns (12%).

At the bottom of core 2, pollen sample P6 (depth 130-136 cm) again remains woody at 84%, with grasses dropping back to 10%. The alder and oak totals remain as those at earlier depths as above, but oak increases to 18%. There is still sedge (2%) found, and bracken (*Pteridium*) increases to 3.4%. In this sample we find aquatic examples of *Lemna*, a floating duckweed (2%).

In sample P5 (depth 91-101 cm) the nature of the sample changes, where trees (including hazel) drop to 64% of the total pollen in this group. The biggest drop is the amount of alder pollen (down 12% to 38%). The grass total increases to 18% of the total. We also find examples of *Rubiaceae* (wild flower species) with 10% of the total pollen found. Ferns dropped to 4.6% of the total, while the bracken pollen dropped to 1.5% of the total.

In the lowest sample of core 1, sample P4 (depth 42-50 cm), we gain find that tree pollen has dropped to 58% of the total, alder and oak like sample P5 above, but a reduction in hazel (from 16% in P5 to 8% here). We find the only example of ash in our samples here at 2% of the total. The amount of grass pollen increases to 24%. We also find *Bidens* in this sample, making up 4% of the total pollen in the sample.

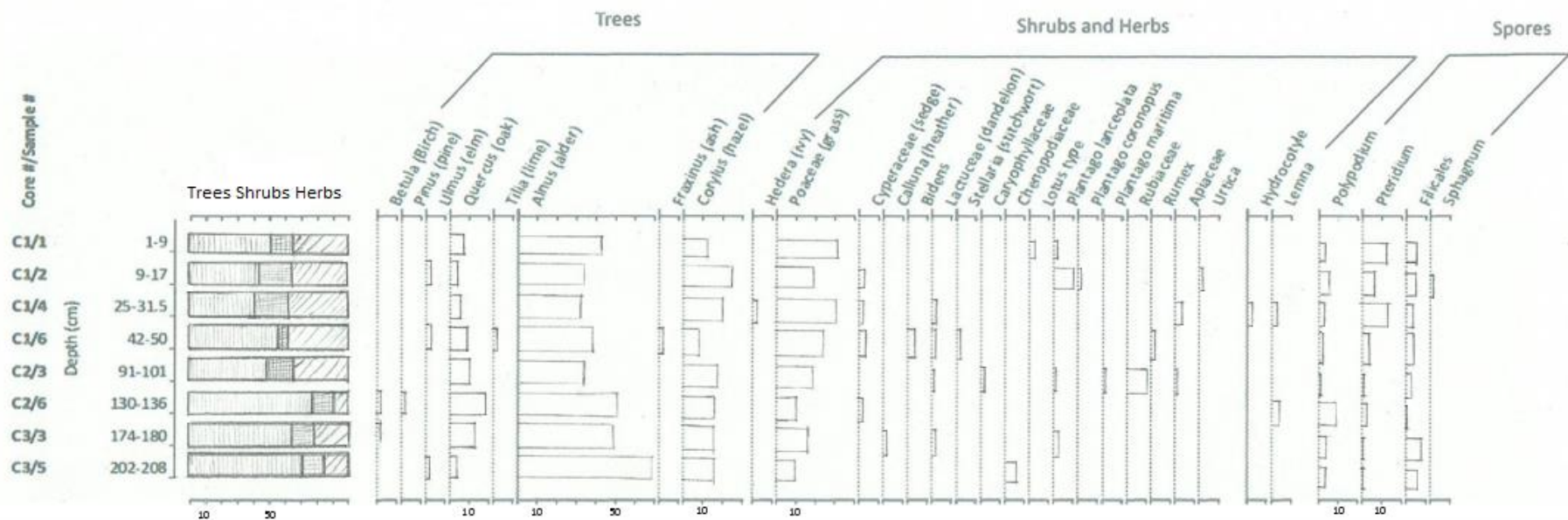


**Figure 4:** Pollen chart, indicating the pollen types found from the samples in TP2.

Sample P3 (depth 25-31.5 cm) retains the similar numbers of tree pollen accounting for 58%, but alder and oak are less, with hazel increasing from 8% to 20%. One of the alder species can be recognised as *Fraxulus alnus*, a species found in carr woodland environments. There is a further increase in the presence of grass species at 32% of the total. There is a notable representation of *Pteridium* at 13%. There is also a small amount of aquatic species present with *Hydrocotyle* and *Lemna* visible in the sample (both 2% of the total).

The tree species rises a little for the later sample, the total in sample P2 (depth 9-17 cm) being 66%, with a rise in hazel to 26%. There is a significant amount of *Plantago lanceolata* at 10%, the highest in any of the samples in which it has been found. The amount of grass pollen has decreased to 18% of the total, down from 32% in the earlier sample. There is some *pteridium* present at 6.5%.

The latest sample from the top of core one (depth 0-9cm) has similar tree pollen totals as the earlier depth. In this sample the amount of alder and oak has increased, whilst hazel has decreased. The amount of grasses increased to 32%. The *Pteridium* remains visible and increases slightly to 11%. There is still *Plantago lanceolata* visible but has dropped to 2% of the total.

## 6.0 Discussion

The earliest of our deposits from core 3 indicate perhaps a cooler freshwater climate, indicated by the lack of foraminifera evidence and the thin layer of iron pan at the base of the core. The loss on ignition tests show that the organic content increases as the depth decreases, and the pollen records show a decrease in alder and an increase in oak species, remaining woody.

This decrease in alder continues throughout core 2, and here this is coupled with an increase in grassland. The amount of oak also continues to rise. We find at the bottom of core 2 the highest number of organics from the loss on ignition tests, and we also find another layer of iron pan, perhaps indicative of drying out. Insect remains begin to appear in the samples. Later in the core hazel pollen numbers increase, and flowering shrubs appear. All these things perhaps indicate an environment that is moving into a more established and warmer freshwater environment.

The foraminifera results from core 1 indicate a move from freshwater to brackish conditions. The pollen samples in the middle of the core show high levels of *Plantago lanceolata* in comparison with the other samples, which may indicate human activity, such as clearance and the *Pteridium* perhaps indicating abandonment as the salt-marsh and tidal access take over.

Other studies in West Wales have been carried out at these intertidal zones, for example at Borth where the sedimentology has been described (Shi & Lamb 1991), as well as the paleoenvironmental evidence reviewed (Taylor 1973), and foraminifera studies undertaken (Adams & Haynes 1965). There is also the study by Heyworth et al (1985), who investigated the Holocene sediments at Clarach bay, through the sampling of pollen, diatoms and from carrying out carbon dating. I would suggest it is difficult to compare our results with those of other sequences found in West Wales, as this study is limited in scope. However, our evidence chimes with that of the Clarach bay study of 1968-1960 by Taylor (1973). Here we see the fall of *Alnus*, contemporary with the major *Alnus* decline, and the rise in *Plantago lanceolata*, with forest clearances being at post elm-decline (Taylor 1973: 285).

Further study in the area is recommended, through series of targeted test pits. Several cores taken from each test pit, and a full pollen count and foraminifera study, as well as loss on ignition on the sediments, should be carried out. This should be accompanied by radiocarbon dating to try and provide a likely age range for the sediments. The test pit locations should be targeted by carrying out geophysical survey in the water meadows behind the beach which will perhaps identify palaeochannels of the river Ystwyth, the banks of which may contain evidence of human activity, as well as evidence which can help to re-create the palaeoenvironment of this area, which this study has shown to be possible.

It is when these tasks have been carried out that the sequence is re-assessed and compared to others along this coastline, that we might understand more not only of this site, but the broader context of coastal inter-tidal sequences in West Wales.

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## Appendix 1: Sediment log sheets

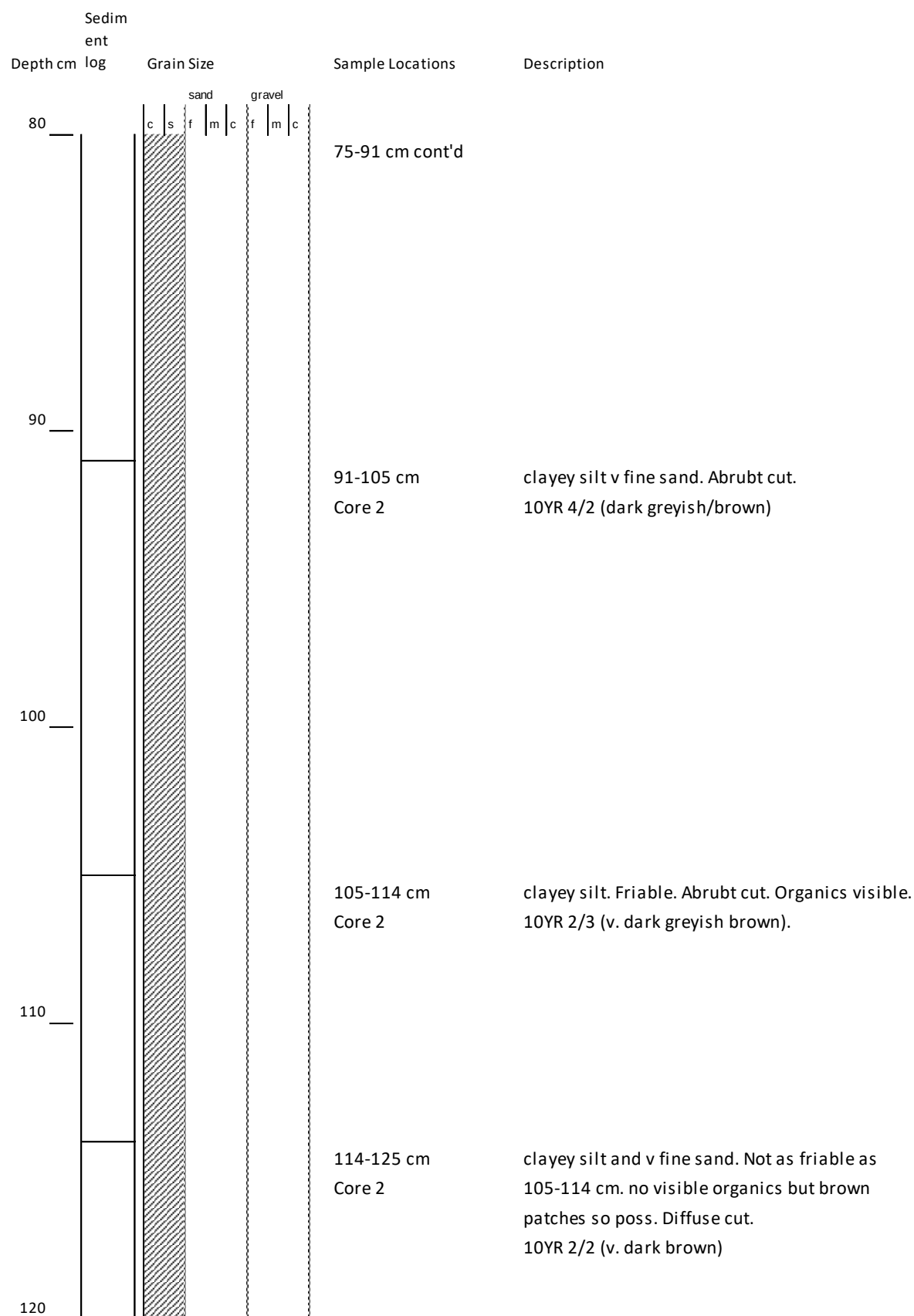
|             |                 |                               |            |
|-------------|-----------------|-------------------------------|------------|
| Project     | MA Project      |                               | DB Ref no. |
| Site Code   | Tan-y-Bwlch TP2 |                               |            |
| Core Number | 1               | Date drilled                  | 25/10/2018 |
| Grid ref.   |                 | Datum/Ground level            |            |
| Borehole    |                 | *All sediments are silty clay |            |

| *Sedi<br>ment |     | Grain Size                                                                          |   |   |   |   |        |   |   |  |  | Sample Locations | Description                                                                                |
|---------------|-----|-------------------------------------------------------------------------------------|---|---|---|---|--------|---|---|--|--|------------------|--------------------------------------------------------------------------------------------|
| Depth cm      | log | sand                                                                                |   |   |   |   | gravel |   |   |  |  |                  |                                                                                            |
|               |     | c                                                                                   | s | f | m | c | f      | m | c |  |  |                  |                                                                                            |
| 0             |     |    |   |   |   |   |        |   |   |  |  | 0-3 cm           | Clayey silt with fine sand. Organics visible.                                              |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
|               |     |    |   |   |   |   |        |   |   |  |  | 3-9 cm           | Clayey silt, organics visible. Abrupt cut. firm.                                           |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
| 10            |     |    |   |   |   |   |        |   |   |  |  | 9-17 cm          | clayey silt with some v. fine sand. Organics visible. Sharp cut (into dark grey). Friable. |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
|               |     |  |   |   |   |   |        |   |   |  |  | 17-25 cm         | Clayey silt and fine sand. Friable.                                                        |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
| 20            |     |  |   |   |   |   |        |   |   |  |  | 25-31.5 cm       | Clayey silt and fine sand, friable.                                                        |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
|               |     |  |   |   |   |   |        |   |   |  |  | 31.5-34.5 cm     | Clayey silt and fine sand. Not as friable as 25-31.5. browns visible - organics?           |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
|               |     |  |   |   |   |   |        |   |   |  |  | 34.5-39 cm       | clayey silt with fine sand. More friable than 31.5-34.5cm. Diffuse cut.                    |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
| 30            |     |  |   |   |   |   |        |   |   |  |  | 39-42cm          | clayey silt with v. fine sand.                                                             |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
|               |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |
| 40            |     |                                                                                     |   |   |   |   |        |   |   |  |  |                  |                                                                                            |

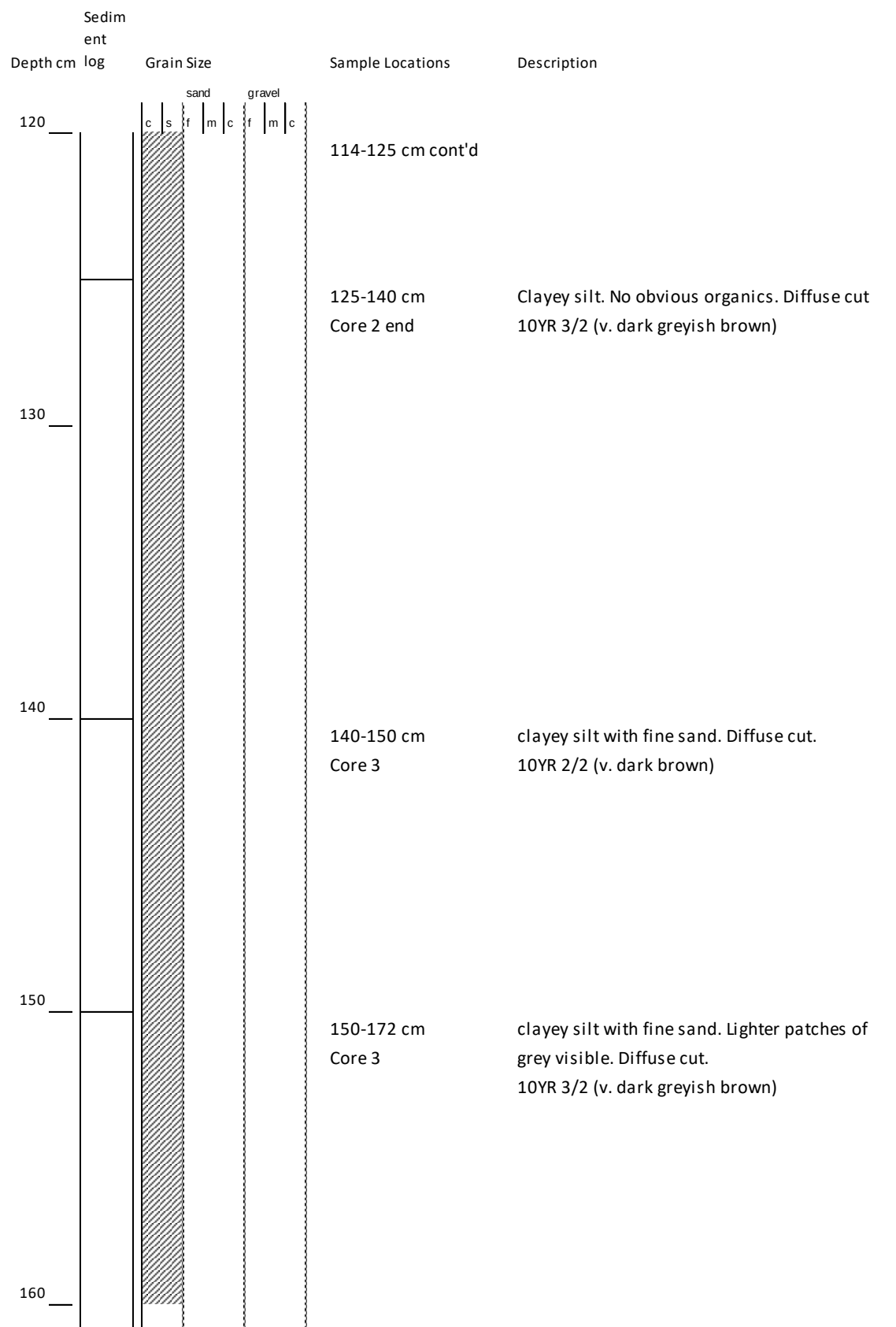
|             |                 |                    |            |
|-------------|-----------------|--------------------|------------|
| Project     | MA Project      |                    | DB Ref no. |
| Site Code   | Tan-y-Bwlch TP2 |                    |            |
| Core Number | 1-2             | Date drilled       | 25/10/2018 |
| Grid ref.   |                 | Datum/Ground level |            |
| Borehole    |                 |                    |            |

| Depth cm | Sediment log | Grain Size |   |   |   |   |        |   |   |  |  | Sample Locations         | Description                                                                                   |
|----------|--------------|------------|---|---|---|---|--------|---|---|--|--|--------------------------|-----------------------------------------------------------------------------------------------|
|          |              | sand       |   |   |   |   | gravel |   |   |  |  |                          |                                                                                               |
|          |              | c          | s | f | m | c | f      | m | c |  |  |                          |                                                                                               |
| 40       |              |            |   |   |   |   |        |   |   |  |  | 39-42cm cont'd<br>Core 1 | brown visible organics? Abrupt cut. Less friable than 34-39cm. 10YR 2/2 (v. dark brown)       |
|          |              |            |   |   |   |   |        |   |   |  |  | 42-50 cm<br>Core 1       | clayey silt v. fine sand. More clayey than 39-42cm. 10YR 3/2 (v dark greyish/brown)           |
| 50       |              |            |   |   |   |   |        |   |   |  |  |                          |                                                                                               |
|          |              |            |   |   |   |   |        |   |   |  |  | 50-75cm<br>Core 2        | clayey silt and v fine sand. Diffuse cut. 10YR 3/2 (v dark greyish brown).                    |
| 60       |              |            |   |   |   |   |        |   |   |  |  |                          |                                                                                               |
|          |              |            |   |   |   |   |        |   |   |  |  |                          |                                                                                               |
| 70       |              |            |   |   |   |   |        |   |   |  |  |                          |                                                                                               |
|          |              |            |   |   |   |   |        |   |   |  |  | 75-91 cm<br>Core 2       | clayey silt with v fine sand. Brown visible organics?. Diffuse cut. 10YR 2/2 (v. dark brown). |
| 80       |              |            |   |   |   |   |        |   |   |  |  |                          |                                                                                               |
|          |              |            |   |   |   |   |        |   |   |  |  |                          |                                                                                               |
|          |              |            |   |   |   |   |        |   |   |  |  |                          |                                                                                               |
|          |              |            |   |   |   |   |        |   |   |  |  |                          |                                                                                               |

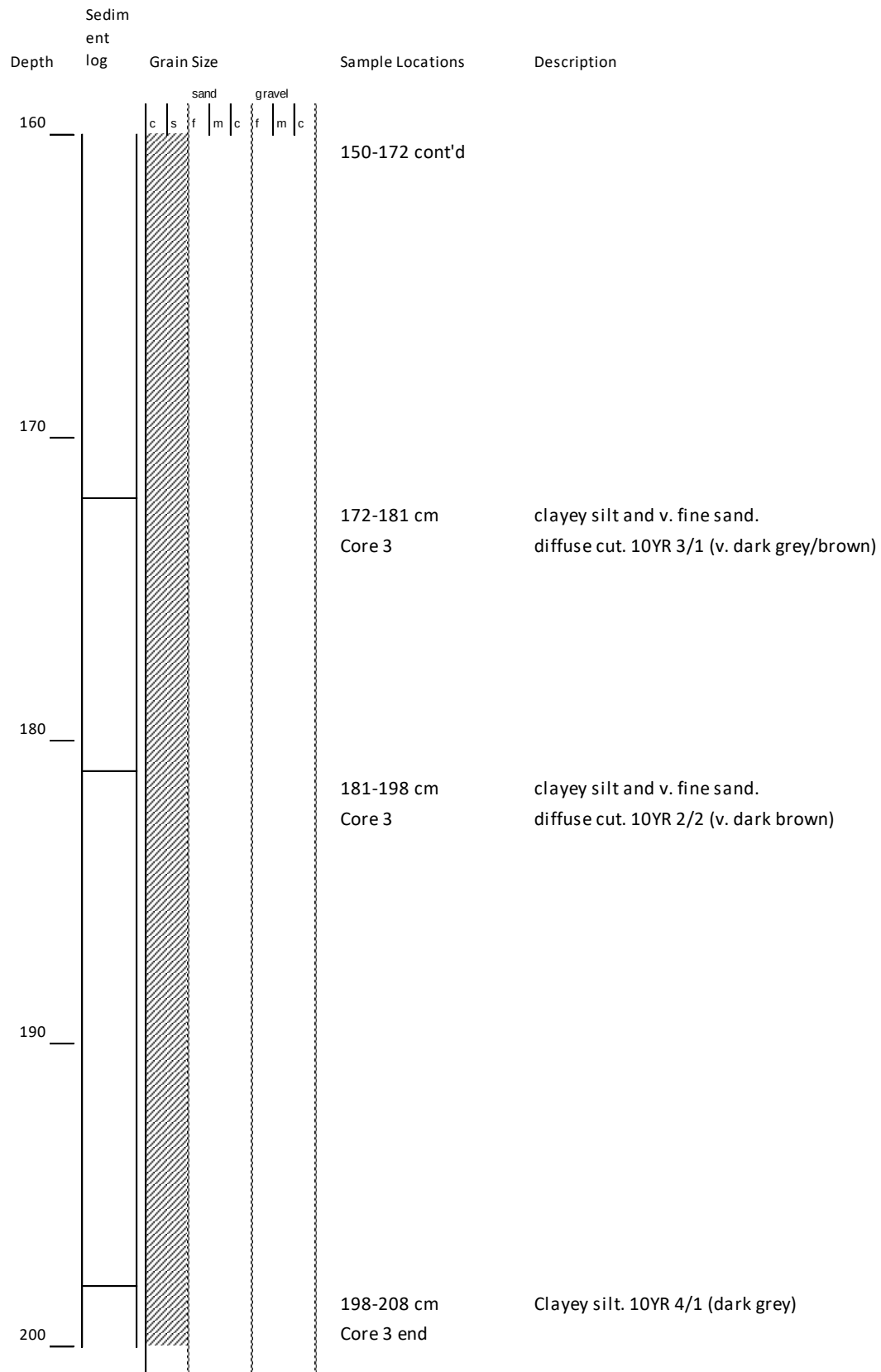
|             |                 |                    |            |
|-------------|-----------------|--------------------|------------|
| Project     | MA Project      |                    | DB Ref no. |
| Site Code   | Tan-y-Bwlch TP2 |                    |            |
| Core Number | 2               | Date drilled       | 25/10/2018 |
| Grid ref.   |                 | Datum/Ground level |            |
| Borehole    |                 |                    |            |



|             |                 |                    |            |
|-------------|-----------------|--------------------|------------|
| Project     | MA Project      |                    | DB Ref no. |
| Site Code   | Tan-y-Bwlch TP2 |                    |            |
| Core Number | 2-3             | Date drilled       | 25/10/2018 |
| Grid ref.   |                 | Datum/Ground level |            |
| Borehole    |                 |                    |            |



|             |                 |                    |            |
|-------------|-----------------|--------------------|------------|
| Project     | MA Project      |                    | DB Ref no. |
| Site Code   | Tan-y-Bwlch TP2 |                    |            |
| Core Number | 3               | Date drilled       | 25/10/2018 |
| Grid ref.   |                 | Datum/Ground level |            |
| Borehole    |                 |                    |            |



## Appendix 2: Foraminifera Sampling strategy by Dr John Whittaker.

### TAN-Y-BWLCH, ABERYSTWYTH

Seventeen samples were received from Dr Martin Bates on February 3rd 2018. They were from Test Pit 2, at Tan-y-Bwlch on the foreshore in front of what is now a storm beach. To the east is the River Ystwyth, which having left its valley then turns north and runs behind this storm beach until it finally enters the sea on the south side of Aberystwyth Harbour. At the site of Test Pit 2 a sequence of organic deposits were found, whose age and depositional environment are not known for certain, but may be part of an earlier Ystwyth estuary when sea-levels were lower.

Three cores were taken in Test Pit 2, in ascending order - Core 3 (5 samples with sample 5 at the base), then Core 2 (6 samples in ascending order from 6 through to 1), and finally, Core 1 (6 samples, again in ascending order 6 through to 1). So Core 3, sample 5 is the lowest and oldest, whilst Core 1, sample 1 is the uppermost.

Residues are enclosed herein, having been scanned for foraminifera. The samples had been processed through a 75 micron sieve, using only sodium carbonated as a medium for dispersing the clay from the organic sediment.

Samples and weights processed are as follows.....

#### TEST PIT 2, CORE 1

| sample | weight processed |
|--------|------------------|
| 1      | 55g              |
| 2      | 55g              |
| 3      | 55g              |
| 4      | 60g              |
| 5      | 45g              |
| 6      | 35g              |

#### TEST PIT 2, CORE 2

| sample | weight processed |
|--------|------------------|
| 1      | 40g              |
| 2      | 35g              |
| 3      | 45g              |
| 4      | 30g              |
| 5      | 30g              |
| 6      | 30g              |

#### TEST PIT 2, CORE 3

| sample | weight processed |
|--------|------------------|
| 1      | 25g              |
| 2      | 40g              |
| 3      | 30g              |
| 4      | 35g              |
| 5      | 30g              |

John E. Whittaker ([jewhittaker06@aol.com](mailto:jewhittaker06@aol.com))

19th February 2018

**Appendix 3:** Pollen Prep Sheet.

**PREP DATE:** 26/02/2018

**PROJECT/SITE:** TAN-Y-BWLCH, TEST PIT 2

**SAMPLES PREPARED BY:** R BALE & S WILLIAMS

| <b>SAMPLE No</b> | <b>DETAILS</b> | <b>DEPTH (cm)</b> | <b>AMOUNT PREP'D</b> | <b>LYCOPODIUM<br/>AMOUNT (batch no<br/>3862)</b> | <b>MICROSIEVED</b> |
|------------------|----------------|-------------------|----------------------|--------------------------------------------------|--------------------|
| P1               | TP2 C1/S1      | 1-9               | 1 mm                 | 2                                                | Y                  |
| P2               | TP2 C1/S2      | 9-17              | 1 mm                 | 2                                                | Y                  |
| P3               | TP2 C1/S4      | 25-31.5           | 1 mm                 | 2                                                | Y                  |
| P4               | TP2 C1/S6      | 42-50             | 1 mm                 | 2                                                | Y                  |
| P5               | TP2 C2/S3      | 91-101            | 1 mm                 | 2                                                | Y                  |
| P6               | TP2 C2/S6      | 130-136           | 1 mm                 | 2                                                | Y                  |
| P7               | TP2 C3/S3      | 174-180           | 1 mm                 | 2                                                | Y                  |
| P8               | TP2 C3/S5      | 202-208           | 1 mm                 | 2                                                | Y                  |

#### Appendix 4: Loss on ignition test results.

| CORE 1     |       |        |       | CORE 2     |       |        |       | CORE 3     |       |        |       |
|------------|-------|--------|-------|------------|-------|--------|-------|------------|-------|--------|-------|
| Depth (CM) | Org % | Carb % | Min % | Depth (CM) | Org % | Carb % | Min % | Depth (CM) | Org % | Carb % | Min % |
| 1          | 19%   | 3%     | 78%   | 51         | 12%   | 2%     | 85%   | 141        | 13%   | 3%     | 85%   |
| 2          | 25%   | 3%     | 73%   | 52         | 12%   | 3%     | 85%   | 142        | 12%   | 3%     | 85%   |
| 3          | 17%   | 3%     | 79%   | 53         | 12%   | 3%     | 85%   | 151        | 15%   | 2%     | 83%   |
| 4          | 17%   | 3%     | 80%   | 54         | 12%   | 3%     | 86%   | 152        | 15%   | 2%     | 82%   |
| 5          | 14%   | 3%     | 83%   | 55         | 12%   | 3%     | 85%   | 153        | 15%   | 2%     | 83%   |
| 6          | 12%   | 2%     | 86%   | 56         | 12%   | 2%     | 86%   | 154        | 13%   | 2%     | 85%   |
| 7          | 14%   | 2%     | 84%   | 69         | 10%   | 3%     | 87%   | 155        | 11%   | 2%     | 88%   |
| 8          | 13%   | 3%     | 84%   | 70         | 12%   | 2%     | 86%   | 167        | 7%    | 2%     | 91%   |
| 9          | 16%   | 3%     | 81%   | 71         | 12%   | 2%     | 86%   | 168        | 7%    | 2%     | 91%   |
| 10         | 12%   | 2%     | 86%   | 72         | 13%   | 2%     | 85%   | 169        | 8%    | 2%     | 91%   |
| 11         | 10%   | 2%     | 88%   | 73         | 13%   | 2%     | 85%   | 170        | 9%    | 2%     | 90%   |
| 12         | 9%    | 2%     | 89%   | 74         | 14%   | 2%     | 84%   | 171        | 10%   | 2%     | 88%   |
| 13         | 10%   | 2%     | 88%   | 75         | 13%   | 2%     | 84%   | 172        | 14%   | 2%     | 84%   |
| 14         | 9%    | 2%     | 88%   | 76         | 15%   | 3%     | 82%   | 173        | 12%   | 2%     | 86%   |
| 15         | 9%    | 2%     | 89%   | 77         | 16%   | 3%     | 82%   | 181        | 12%   | 2%     | 86%   |
| 16         | 10%   | 2%     | 88%   | 78         | 18%   | 3%     | 79%   | 182        | 12%   | 2%     | 86%   |
| 17         | 9%    | 2%     | 88%   | 90         | 21%   | 3%     | 76%   | 183        | 12%   | 2%     | 86%   |
| 18         | 11%   | 2%     | 87%   | 91         | 20%   | 3%     | 77%   | 184        | 11%   | 2%     | 87%   |
| 19         | 12%   | 2%     | 86%   | 103        | 13%   | 2%     | 85%   | 185        | 15%   | 2%     | 82%   |
| 20         | 16%   | 3%     | 81%   | 104        | 19%   | 2%     | 79%   | 196        | 12%   | 2%     | 85%   |
| 21         | 21%   | 3%     | 76%   | 105        | 23%   | 3%     | 75%   | 197        | 11%   | 2%     | 87%   |
| 22         | 19%   | 2%     | 78%   | 106        | 19%   | 2%     | 78%   | 198        | 10%   | 2%     | 88%   |
| 23         | 30%   | 3%     | 67%   | 124        | 24%   | 3%     | 73%   | 199        | 8%    | 2%     | 90%   |
| 24         | 17%   | 3%     | 80%   | 125        | 26%   | 4%     | 70%   | 200        | 7%    | 2%     | 91%   |
| 25         | 16%   | 3%     | 82%   | 126        | 22%   | 4%     | 74%   | 201        | 7%    | 2%     | 91%   |
| 26         | 11%   | 3%     | 86%   | 127        | 16%   | 3%     | 81%   |            |       |        |       |
| 27         | 12%   | 3%     | 86%   | 128        | 17%   | 3%     | 81%   |            |       |        |       |
| 28         | 12%   | 3%     | 85%   | 129        | 18%   | 2%     | 80%   |            |       |        |       |
| 29         | 15%   | 3%     | 82%   |            |       |        |       |            |       |        |       |
| 30         | 14%   | 2%     | 84%   |            |       |        |       |            |       |        |       |
| 31         | 14%   | 3%     | 84%   |            |       |        |       |            |       |        |       |
| 32         | 16%   | 2%     | 82%   |            |       |        |       |            |       |        |       |
| 33         | 15%   | 2%     | 83%   |            |       |        |       |            |       |        |       |
| 34         | 14%   | 2%     | 83%   |            |       |        |       |            |       |        |       |
| 35         | 18%   | 3%     | 79%   |            |       |        |       |            |       |        |       |
| 36         | 11%   | 2%     | 87%   |            |       |        |       |            |       |        |       |
| 37         | 9%    | 2%     | 89%   |            |       |        |       |            |       |        |       |
| 38         | 14%   | 2%     | 84%   |            |       |        |       |            |       |        |       |
| 39         | 14%   | 3%     | 83%   |            |       |        |       |            |       |        |       |
| 40         | 11%   | 3%     | 86%   |            |       |        |       |            |       |        |       |
| 41         | 11%   | 3%     | 87%   |            |       |        |       |            |       |        |       |
| 42         | 20%   | 3%     | 77%   |            |       |        |       |            |       |        |       |
| 43         | 19%   | 3%     | 77%   |            |       |        |       |            |       |        |       |
| 44         | 15%   | 3%     | 82%   |            |       |        |       |            |       |        |       |
| 45         | 13%   | 3%     | 84%   |            |       |        |       |            |       |        |       |
| 46         | 11%   | 3%     | 86%   |            |       |        |       |            |       |        |       |
| 47         | 13%   | 3%     | 85%   |            |       |        |       |            |       |        |       |
| 48         | 11%   | 2%     | 87%   |            |       |        |       |            |       |        |       |
| 49         | 9%    | 2%     | 89%   |            |       |        |       |            |       |        |       |
| 50         | 8%    | 2%     | 90%   |            |       |        |       |            |       |        |       |

## **TAN-Y-BWLCH, ABERYSTWYTH**

Seventeen samples were received from Dr Martin Bates on February 3rd 2018. They were from Test Pit 2, at Tan-y-Bwlch on the foreshore in front of what is now a storm beach. To the east is the River Ystwyth, which having left its valley then turns north and runs behind this storm beach until it finally enters the sea on the south side of Aberystwyth Harbour. At the site of Test Pit 2 a sequence of organic deposits were found, whose age and depositional environment are not known for certain, but may be part of an earlier Ystwyth estuary when sea-levels were lower.

Three cores were taken in Test Pit 2, in ascending order - Core 3 (5 samples with sample 5 at the base), then Core 2 (6 samples in ascending order from 6 through to 1), and finally, Core 1 (6 samples, again in ascending order 6 through to 1). So Core 3, sample 5 is the lowest and oldest, whilst Core 1, sample 1 is the uppermost.

As this was a preliminary assessment in association with a student project and involved other specialist attention, just 9 samples were initially chosen for examination of their microfauna/flora under the microscope: 1, 3 and 5 from Core 3; 1, 3 and 6 from Core 2; and 2, 4 and 6 from Core 1.

All 17 samples were processed, however, and their residues can be made available for further analysis, if required. The fact that they were washed through a 75 micron sieve should be borne in mind.

### **Core 3**

The lowest part of the sequence at Tan-y-Bwlch. The three residues examined (5, 3 and 1) were all composed of plant debris, sometimes coarse, sometimes fine with small seeds. There was some iron mineral in the form of a thin iron-pan, especially towards the base, suggesting some initial soil formation or drying out and weathering perhaps in a cold climate. Sample 1 was more peaty. All had small stones in the residue. Nothing else was found.

## Core 2

The three residues (6, 3 and 1) all had much plant debris and some small seeds. There was still a little iron towards the base of the core. This time, samples 3 and 1 also contained insect remains – often chironomid (midge) remains and fragments of beetles. So far in Test Pit 2 there had been no calcium carbonate preservation and in the absence of anything to the contrary (e.g. brackish agglutinating foraminifera), the ecology is assumed to have been freshwater.

## Core 1

Three residues were initially chosen for examination (6, 4 and 2). Sample 6 had much plant debris and small seeds, as before. When sample 2 was examined, however, in addition to a great many insects (small “bugs”) some agglutinating foraminifera were found, belonging to *Jadammina macrescens*. This is a herbivore and detritivore which lives and feeds on decaying vegetation. It makes a test of mineral grains which it assembles with organic cement on an organic template, but it readily collapses on death and is very difficult to readily identify amongst the organic “dust” that comprise these residues! Its presence, though, immediately indicates brackish saltmarsh and hence tidal access. Following this discovery its occurrence was also confirmed in sample 4 (in association with another marsh agglutinating foraminifer, *Miliammina fusca*). In order to tie down further its first occurrence in Core 1, sample 5 was then examined and after a careful search *J. macrescens* was also found, albeit rarely and of a very small in size. It is now therefore possible to state that tidal access was first achieved between samples 6 and 5 in Core 1, this being due, no doubt, to some major coastal geographic change, in association with or without sea-level rise.

Much more information will be achieved on this sequence, time permitting. A palynological analysis ought to provide a great deal more. The organic content (plant remains) appears to vary between samples – some is very coarse, in other cases it is fine and fibrous. Insect remains may also provide some environmental information, although I did not see a single one in Core 3. Finally, in order to further clarify the onset of brackish conditions (and tidal access), a look-out for the organic linings of foraminifera ought to be made in the palynological preparations. It is assumed at a further stage, radiocarbon dating will aim to provide an age-range for these sediments, thus greatly increasing our knowledge of the coastal changes in this part of the Welsh coast.

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13th February 2018

**Appendix 6:** pollen count by Dr Astrid Caseldine.

| TAN Y BWLCH                       | C1/1      |            | C1/2      |            | C1/4       |            | C1/6      |            | C2/3      |                  | C2/6       |            | C3/3       |            | C3/5       |            |
|-----------------------------------|-----------|------------|-----------|------------|------------|------------|-----------|------------|-----------|------------------|------------|------------|------------|------------|------------|------------|
|                                   | 1-9 cm    | %          | 9-17 cm   | %          | 25-31.5 cm | %          | 42-50 cm  | %          | 91-101 cm | %                | 130-136 cm | %          | 174-180 cm | %          | 202-208 cm | %          |
| Betula (birch)                    | 0         | 0          | 0         | 0          | 0          | 0          | 0         | 0          | 0         | 0                | 1          | 2          | 1          | 2          | 0          | 0          |
| Pinus (pine)                      | 0         | 0          | 0         | 0          | 0          | 0          | 0         | 0          | 0         | 0                | 1          | 2          | 0          | 0          | 0          | 0          |
| Ulmus (elm)                       | 0         | 0          | 1         | 2          | 0          | 0          | 1         | 2          | 0         | 0                | 0          | 0          | 0          | 0          | 1          | 2          |
| Quercus (oak)                     | 4         | 8          | 2         | 4          | 3          | 6          | 5         | 10         | 7         | 11.47541         | 9          | 18         | 6          | 12         | 2          | 4          |
| Tilia (lime)                      | 0         | 0          | 0         | 0          | 0          | 0          | 1         | 2          | 0         | 0                | 0          | 0          | 0          | 0          | 0          | 0          |
| Alnus (alder)                     | 21        | 42         | 17        | 34         | 16         | 32         | 19        | 38         | 22        | 36.065574        | 26         | 52         | 25         | 50         | 32         | 64         |
| Fraxinus (ash)                    | 0         | 0          | 0         | 0          | 0          | 0          | 1         | 2          | 0         | 0                | 0          | 0          | 0          | 0          | 0          | 0          |
| Corylus (hazel)                   | 7         | 14         | 13        | 26         | 10         | 20         | 4         | 8          | 10        | 16.393443        | 7          | 14         | 7          | 14         | 7          | 14         |
| Hedera (ivy)                      | 0         | 0          | 0         | 0          | 1          | 2          | 0         | 0          | 0         | 0                | 0          | 0          | 0          | 0          | 0          | 0          |
| Poaceae (grass)                   | 16        | 32         | 9         | 18         | 16         | 32         | 12        | 24         | 11        | 18.032787        | 5          | 10         | 8          | 16         | 5          | 10         |
| Cyperaceae (sedge)                | 0         | 0          | 1         | 2          | 1          | 2          | 2         | 4          | 0         | 0                | 1          | 2          | 0          | 0          | 0          | 0          |
| Calluna (heather)                 | 0         | 0          | 0         | 0          | 0          | 0          | 0         | 0          | 0         | 0                | 0          | 0          | 1          | 2          | 0          | 0          |
| Bidens                            | 0         | 0          | 0         | 0          | 0          | 0          | 2         | 4          | 0         | 0                | 0          | 0          | 0          | 0          | 0          | 0          |
| Lactuceae (dandelion)             | 0         | 0          | 0         | 0          | 1          | 2          | 1         | 2          | 1         | 1.6393443        | 0          | 0          | 1          | 2          | 0          | 0          |
| Stellaria (stitchwort)            | 0         | 0          | 0         | 0          | 0          | 0          | 1         | 2          | 0         | 0                | 0          | 0          | 0          | 0          | 0          | 0          |
| Caryophyllaceae                   | 0         | 0          | 0         | 0          | 0          | 0          | 0         | 0          | 1         | 1.6393443        | 0          | 0          | 0          | 0          | 0          | 0          |
| Chenopodiaceae                    | 0         | 0          | 0         | 0          | 0          | 0          | 0         | 0          | 0         | 0                | 0          | 0          | 0          | 0          | 3          | 6          |
| Lotus type                        | 1         | 2          | 0         | 0          | 0          | 0          | 0         | 0          | 0         | 0                | 0          | 0          | 0          | 0          | 0          | 0          |
| Plantago lanceolata               | 1         | 2          | 5         | 10         | 0          | 0          | 0         | 0          | 1         | 1.6393443        | 0          | 0          | 1          | 2          | 0          | 0          |
| Rplantago coronopus               | 0         | 0          | 1         | 2          | 0          | 0          | 0         | 0          | 0         | 0                | 0          | 0          | 0          | 0          | 0          | 0          |
| Plantago maritima                 | 0         | 0          | 0         | 0          | 0          | 0          | 0         | 0          | 1         | 1.6393443        | 0          | 0          | 0          | 0          | 0          | 0          |
| Rubiaceae                         | 0         | 0          | 0         | 0          | 0          | 0          | 0         | 0          | 6         | 9.8360656        | 0          | 0          | 0          | 0          | 0          | 0          |
| Rumex                             | 0         | 0          | 0         | 0          | 0          | 0          | 1         | 2          | 0         | 0                | 0          | 0          | 0          | 0          | 0          | 0          |
| Apiaceae                          | 0         | 0          | 0         | 0          | 2          | 4          | 0         | 0          | 1         | 1.6393443        | 0          | 0          | 0          | 0          | 0          | 0          |
| Urtica                            | 0         | 0          | 1         | 2          | 0          | 0          | 0         | 0          | 0         | 0                | 0          | 0          | 0          | 0          | 0          | 0          |
| <b>Total Trees, Shrubs, Herbs</b> | <b>50</b> | <b>100</b> | <b>50</b> | <b>100</b> | <b>50</b>  | <b>100</b> | <b>50</b> | <b>100</b> | <b>61</b> | <b>100</b>       | <b>50</b>  | <b>100</b> | <b>50</b>  | <b>100</b> | <b>50</b>  | <b>100</b> |
| <b>Total Trees</b>                | <b>25</b> | <b>50</b>  | <b>20</b> | <b>40</b>  | <b>20</b>  | <b>40</b>  | <b>27</b> | <b>54</b>  | <b>29</b> | <b>47.540984</b> | <b>37</b>  | <b>74</b>  | <b>32</b>  | <b>64</b>  | <b>35</b>  | <b>70</b>  |
| <b>Total Shrubs</b>               | <b>7</b>  | <b>14</b>  | <b>13</b> | <b>26</b>  | <b>11</b>  | <b>22</b>  | <b>4</b>  | <b>8</b>   | <b>10</b> | <b>16.393443</b> | <b>7</b>   | <b>14</b>  | <b>7</b>   | <b>14</b>  | <b>7</b>   | <b>14</b>  |
| <b>Total Herbs</b>                | <b>18</b> | <b>36</b>  | <b>17</b> | <b>34</b>  | <b>19</b>  | <b>38</b>  | <b>19</b> | <b>38</b>  | <b>22</b> | <b>36.065574</b> | <b>6</b>   | <b>12</b>  | <b>11</b>  | <b>22</b>  | <b>8</b>   | <b>16</b>  |
| Hydrocotyle                       | 0         | 0          | 0         | 0          | 1          | 1.9230769  | 0         | 0          | 0         | 0                | 0          | 0          | 0          | 0          | 0          | 0          |
| Lemna                             | 0         | 0          | 0         | 0          | 1          | 1.9230769  | 0         | 0          | 0         | 0                | 2          | 3.84615385 | 0          | 0          | 0          | 0          |
| <b>Total Aquatics</b>             | <b>0</b>  | <b>0</b>   | <b>0</b>  | <b>0</b>   | <b>2</b>   |            | <b>0</b>  | <b>0</b>   | <b>0</b>  | <b>0</b>         | <b>2</b>   |            | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>   |
| Polypodium                        | 2         | 3.2258     | 4         | 6.45161    | 2          | 3.2258065  | 1         | 1.818182   | 1         | 1.5384615        | 6          | 10.1694915 | 2          | 3.44827586 | 2          | 3.508772   |
| Pteridium                         | 7         | 11.29      | 4         | 6.45161    | 8          | 12.903226  | 2         | 3.636364   | 1         | 1.5384615        | 2          | 3.38983051 | 1          | 1.72413793 | 1          | 1.754386   |
| Filicales                         | 3         | 4.8387     | 3         | 4.83871    | 2          | 3.2258065  | 2         | 3.636364   | 2         | 3.0769231        | 1          | 1.69491525 | 5          | 8.62068966 | 4          | 7.017544   |
| Sphagnum                          | 0         | 0          | 1         | 1.6129     | 0          | 0          | 0         | 0          | 0         | 0                | 0          | 0          | 0          | 0          | 0          | 0          |
| <b>Total Spores</b>               | <b>12</b> |            | <b>12</b> |            | <b>12</b>  |            | <b>5</b>  |            | <b>4</b>  |                  | <b>9</b>   |            | <b>8</b>   |            | <b>7</b>   |            |
| Lycopodium (exotic added)         | 5         |            | 12        |            | 17         |            | 20        |            | 3         |                  | 12         |            | 12         |            | 14         |            |

