ALSF AGGREGATE EXTRACTION IN THE RIBBLE VALLEY

Preliminary Report Stage 2

Oxford Archaeology North

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English Heritage

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CONTENTS

1. INTRODUCTION

1.1 BACKGROUND

1.1.1 This report presents the results of the initial tasks of Stage 2 of the ALSF Ribble Valley Aggregate Extraction project. The work was undertaken as a joint project between University of Liverpool and Oxford Archaeology North (OA North), and was funded by the Aggregates Levy Sustainability Fund and under the overall management of English Heritage. The responsibility of the project was split such that the geological and geomorphological elements of the project were undertaken by Liverpool University and the archaeological elements were undertaken by OA North; the palaeobotanic work was split between both organisations.

1.1.2 The programme of work is as defined within a project design (March 2005) submitted by University of Liverpool and OA North. These tasks (20-23, as defined in the project design) represent the initial enhancement and analysis phases of the project, following on from the primary set up and data capture phases in Stage 1, for which a report was submitted in August 2005 (Liverpool University and OA North 2005).

2. AGGREGATE EXTRACTION: STAGE 2 PROGRESS REPORT

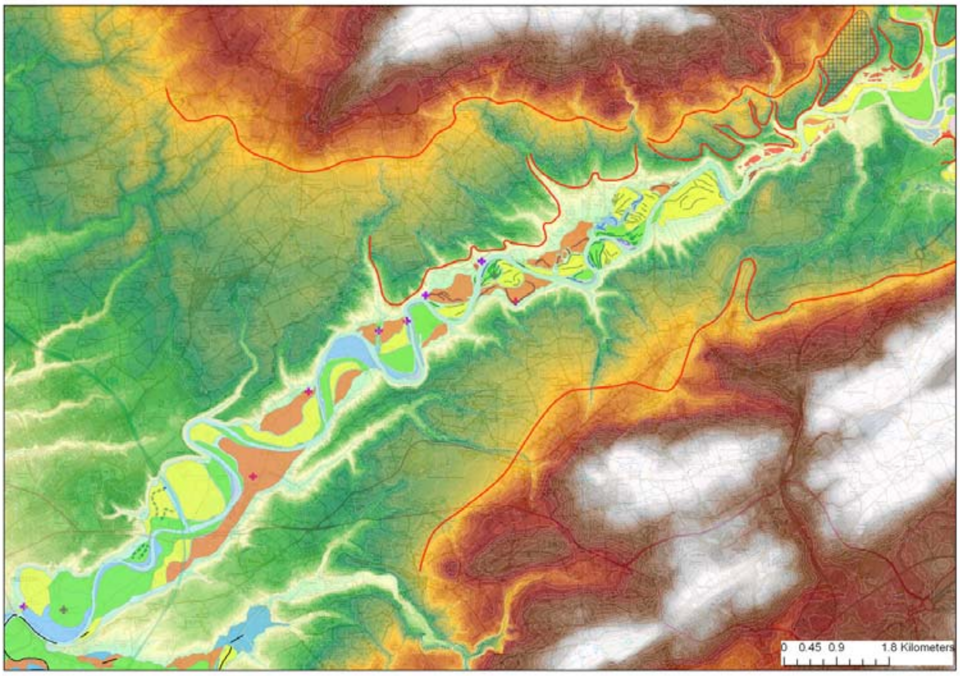
2.1 ANALYSIS OF GEOLOGICAL DATASETS (TASK 10)

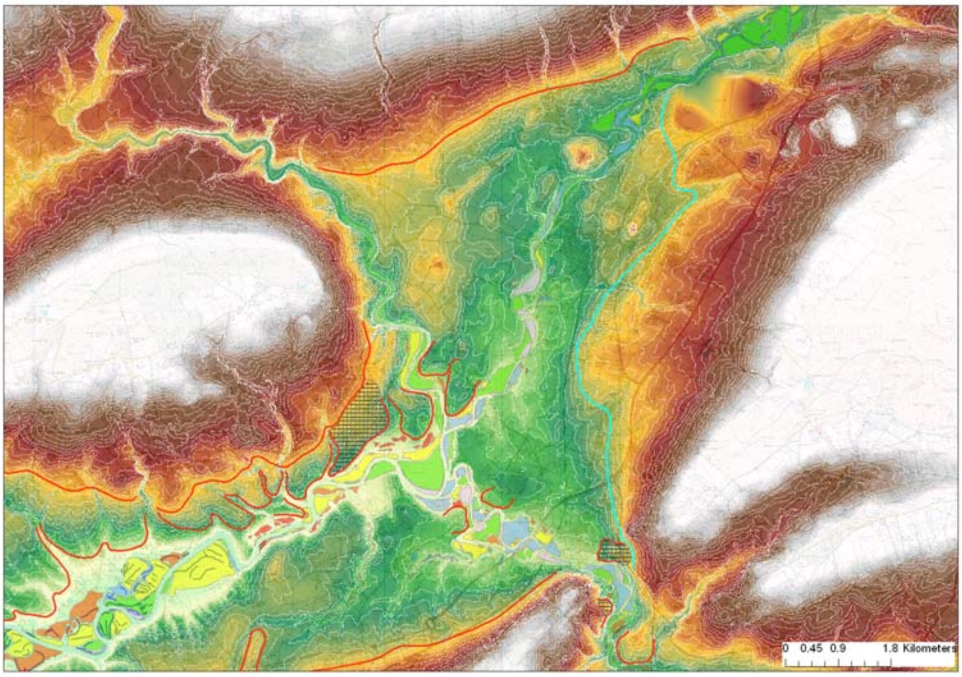
2.1.1 Understanding of the extent and nature of aggregate reserves in the Ribble Valley draws the North Yorkshire and Lancashire Minerals and Waste Local Plans. The Sand and Gravel Study for Lancashire by Entec 2004 is another source of information. Locations such as quarries, whether extinct, dormant or active have also been identified. Two main types of aggregate are exploited within the Ribble basin from sand and gravel and crushed rock sources.

2.1.2 ***Sand and Gravel Reserves:*** Sand and gravel extraction is not currently or predicted in the future to be a feature of aggregate extraction in the area of North Yorkshire within the Ribble catchment (North Yorkshire Minerals Plan). Sand and gravel has, is and probably will continue to be a feature of aggregate extraction in the lower Ribble. To date the BGS mapping and reports by consultants (Entec 2004; Allott and Lomax 1990) reflect the best assessment of the sand and gravel reserves. The programme of geomorphic mapping and field truthing (Tasks 20, 25, 26, 27 and 28) allow a re-assessment of the aggregate reserve in the Ribble. There is a history of large-scale sand and gravel extraction exploiting the river terraces of the Ribble and of smaller-scale extraction within the sand and gravel of the lowland drift plain. The new mapping data, existing borehole data and new drill-sites undertaken in this project identify that high quality aggregates from the fluvial sequence are limited to terraces 1 and 2. Terrace 1 in particular, demonstrably contains large quantities of well sorted sand. The new mapping provides a much improved estimation of the distribution and extent of these deposits and differs significantly from previous mapping. Terrace 3 offers some potential for sand and gravel extraction, but the quantity of fines is higher than for the higher two terraces. Terraces 4 and 5 are a mixture of sand and alluvium overlying relatively thin accumulations of channel gravel and so offer only limited potential for sand and gravel extraction.

2.1.3 The river terraces of the Ribble are set within a reach incised into the lowland Lancashire drift plain. However, as the bedrock relief flanking the Ribble becomes increasingly pronounced upstream, the drift plain continues, forming a flanking bench above the level of the river terracing and below the major hillslope rise. This bench is characterised by a highly diverse glacial geomorphology and by considerable variety in the drift rock geology. The BGS mapping identifies the presence of sand and gravel units within this area, but the identification of these is patchy between map sheets and the shape of these features in a number of cases does not make geomorphological sense and there is a clear need for detailed mapping. The implications of fieldwork in selected areas is that this bench reflects a stage in the deglaciation of north west England, after Heinrich event 2 ca. 24,000-22,000 years BP and before the readvance of Heinrich event 1 ca. 17,000-16,000 years BP. There is clear evidence for water-lain glacial deposits that include sandar style glaciofluvial deposits and probable glaciolacustrine (?) subaqueous fan / subaerial delta deposits. For this style of depositional environment to occur the Ribble glacier has to be in a stage of retreat and water allowed to accumulate in front of the ice margin. Two mechanisms allow this: high sea levels (unlikely); or ponding of a lake between the Ribble ice and a still advanced Irish Sea glacier. The deglacial history of this area is extremely poorly understood and the mapping and exposures within the Ribble basin offer considerable potential for addressing this. In terms of aggregates the implication of this is that considerable sand gravel reserves are present within deposits of the lowland drift plain or bench and they include well sorted sand

and gravel. These are not listed as Areas of Search, but then this is understandable given that much of the available mapping identifies the geology as undifferentiated diamict.





Figs 1 and 2: River terracing and glacial geomorphology of the lower Ribble

2.1.4 ***Solid Aggregate Reserves:*** in the Craven lowlands outside of the boundaries of the National Park and Area of Outstanding Natural Beauty the Yorkshire and Humberside Minerals Plan identified a large Area of Search for solid aggregates. This area is dominated by Carboniferous strata, but much of this is mudstone of little value for aggregates (Fig 1). However, solid rock quarries within the wider region do make use of Carboniferous limestones (Fig 2), and the Chatburn Limestone particular is currently quarried at Clitheroe.

The areas identified here are beyond the brief of the current project, which has not included solid rock reserves used for aggregates.

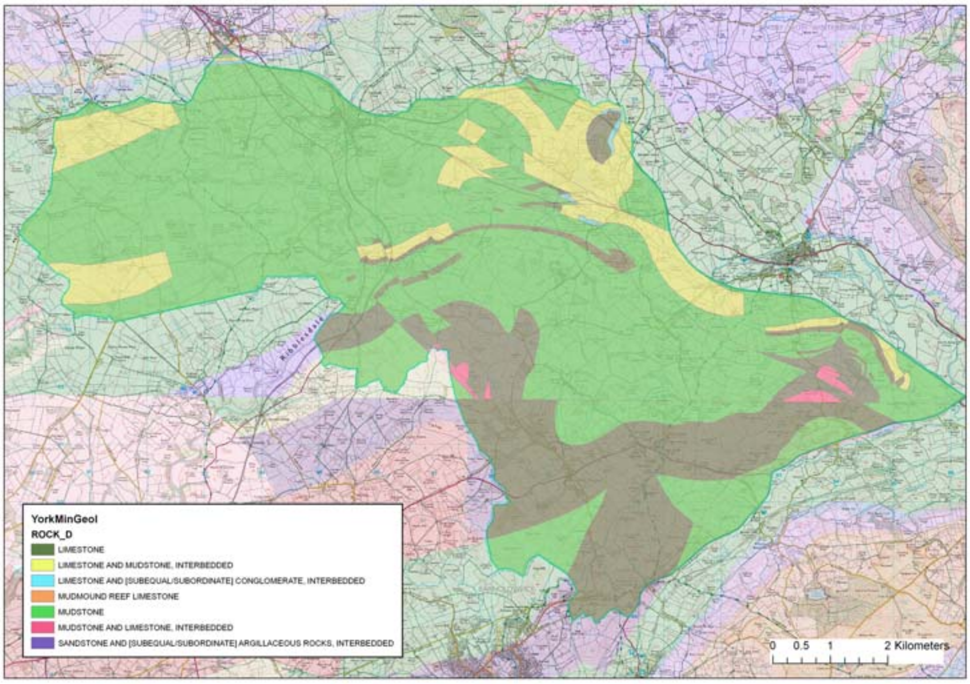


Fig 3: Solid rock types in the Craven Area of Search.

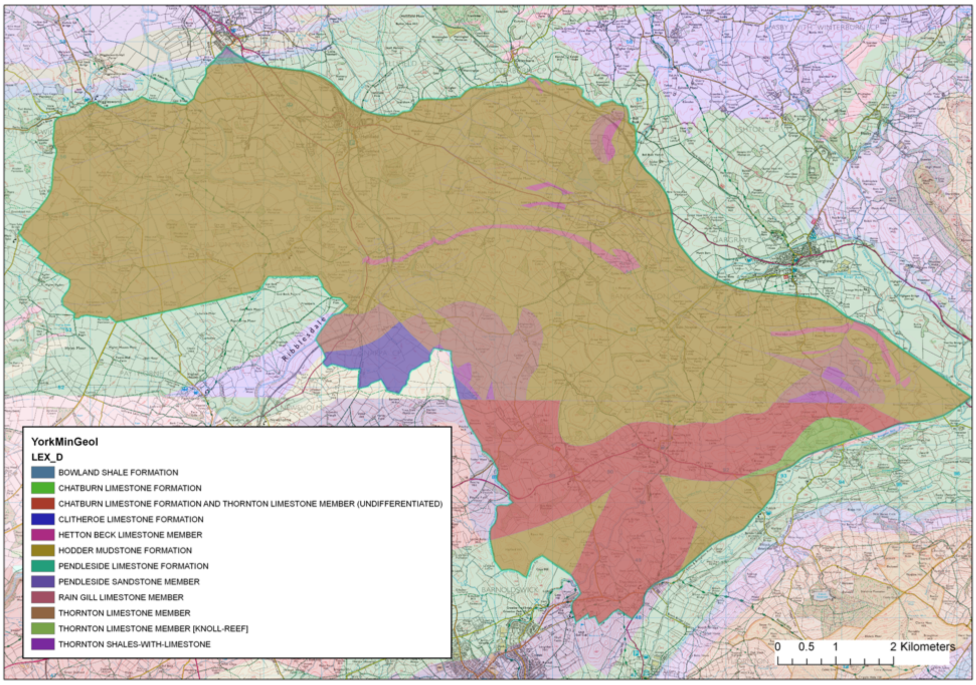


Fig 4: Solid rock formations in the Craven Area of Search.

2.1.5 There are also lithologies in the Lower Ribble that have been used for solid aggregate. However the Minerals Plan for Lancashire (adopted 2001) avoids the development of new greenfield sites for aggregate extraction and indicates that future landbank should be derived through the expansion of existing quarries. The quarries at Clitheroe have limited capacity for lateral expansion, although there is scope for limited expansion and deepening of the quarry floor.

2.1.6 In summary, the development of new solid rock quarries for aggregate extraction appears only related to the Craven area. The Minerals Plan lists a large Area of Search, of which the available mapping, British Geological Survey, shows much is mudstone and likely to be of limited use for aggregate. However, there are also large tracts of limestone, similar to that extracted at Clitheroe in Lancashire. It most be noted that some of the mapping is dated, hence the clash of boundaries at the edges of map sheets. It is possible that areas identified as mudstone may include units of limestone that might be of use for aggregates.

2.2 ACQUISITION, INCORPORATION, PROCESSING AND ANALYSIS OF LIDAR (TASK 20)

2.2.1 Lidar data has been incorporated within the GIS database and this highly resolved topographic data has allowed the production of a comprehensive geomorphological database for the Ribble. The mapping has identified a suite of, in places, up to seven river terraces and in addition the LiDAR altitude data has allowed the generation of height-range data for the Ribble river terraces. Geomorphological mapping has been completed for: the Ribble Estuary; lower Ribble to the Hodder tributary; for the Darwen, Calder and lower Hodder major tributaries of the Ribble; for the Ribble from the Hodder through the gorge to the flood-basin upstream of Hellifield; and for the Ribble flood-basin. The height-range data derived from the Lidar is also complete for these reaches, apart from the gap in the Lidar between Sunderland Hall and the M6 Motorway. The maximum number of river terraces identified is seven, but the higher two of these are relatively minor high-level terrace fragments related to the early stages of incision during early post-glacial times. Set below these fragments there are five major river terraces. This to some extent ties in with the findings of Bernardo Chiti's (2004) research, but we have modified and changed aspects of this earlier mapping. A key issue that arises from the mapping is that clearly there is some doubt over correlation of river terrace segments across nick-points and where major tributaries meet. This is something that will need to be addressed in the geochronological strategy for this project. There is a need for development of an independent chronology for the terraces present within several sub-reaches of the system: the lower Ribble, middle Ribble, lower Hodder, Calder and Ribble flood-basin. This issue is developed further in relation to the radiocarbon dating strategy and a proposed variation to incorporate more luminescence dating.

2.3 GEOMORPHOLOGICAL MAPPING: TRUTHING THE DATA (TASK 25)

2.3.1 A programme of field geomorphological mapping has been undertaken to truth the Lidar-derived data (Task 20). This geomorphological mapping confirmed the excellent and reliability of the Lidar data. The geomorphic mapping also filled the gap in the Lidar data coverage and yielded detailed terrace mapping for the reach between Sunderland Hall and the M6 Motorway. For completeness the mapping has taken in the lower Hodder, because the interplay of terraces is crucial across the confluences of major rivers. The field-truthing has also confirmed the presence of palaeochannels and exposed sections, which have formed the basis for task 28

2.4 ALTITUDINAL SURVEY (TASK 26)

2.4.1 Altitudinal Survey by Total Station has been delayed two reasons: the first was the pressing need for starting task 28 to ascertain the presence of dateable materials; and the second was that the quality of the height-range indications provided by the Lidar have far exceeded expectations. Height-range information is also available from the research of Bernando Chiti. It is still intended to carry out further fieldwork involving surveying by Total Station will confirm height relationships between the river terraces identified from the analysis of LiDAR data, particularly for the reach of the Ribble between Sunderland Hall and the M6 Motorway and for the lower Hodder beyond the Lidar limit.

2.5 BGS BOREHOLE ARCHIVES (TASK 27)

2.5.1 BGS borehole archives have been used in association with the revised geomorphological mapping to interpret the landform sequence in terms of aggregate potential. The purpose of this was to identify the composition, nature and thickness of the deposits. Additional shallow percussion drilling of palaeochannel sites during task 28 have provided additional information about the aggregate potential of terracing in the lower Ribble and Lower Calder. This compliments the good coverage of boreholes (BGS archive) for the lower Ribble.

2.6 GEOCHRONOLOGOCAL / PALAEOENVIRONMENTAL SAMPLING (TASK 28-31)

2.6.1 A field program of vibrocoring has started, with the principal aim of finding suitable dateable materials to secure the chronological framework for the Ribble terraces. Thus far drilling has focused upon two areas: the lower Ribble on the land of Lower House Farm and the lower Calder (Whittam's Farm). For the lower Ribble all five river terraces has been drilled, and for the lower four terraces drilling targeted visible palaeochannels and penetrated the entire palaeochannel fill through to underlying channel gravels. In each case wood and or organic flood-trash has been obtained from above the channel gravel / palaeochannel fill contact. This type of depositional setting is ideal for securing a river terrace chronology. Drilling of the highest terrace failed to find organic deposits, but recovered over 4 metres of high grade well sorted sands. The actually thickness of the sands were not ascertained, but there is potential to drill with a closed chamber Stitz corer to sample these gravels for OSL dating. In the lower Calder, four locations have been drilled, and in each case wood and or organic flood-trash has been obtained from above the channel gravel / palaeochannel fill contact. At this locality there is exposure of a buried peat and wood bed, with tree stumps rooting into channel or bar gravel. For both the Calder and lower Ribble there is ample material for securing a chronology for the river terrace sequence.

2.6.2 The radiocarbon dating is not costed and would come from a central EH budget subject to approval by Alex Bayliss (EH). A meeting has been scheduled with Peter Marshall and Derek Hamilton for the 26th January to discuss the scientific dating programme for the Ribble Valley project. This project will incorporate ^{14}C and OSL, and possibly dendrochronology (although looking unlikely), and this is an initial exploratory meeting with dating experts at EH to ensure everyone is clear what will be expected from all sides. By this meeting the samples required to secure a chronology for the river terrace sequence will have been obtained

2.6.3 The current budget for OSL runs to ten assays, and the analysis of two types of test sample has been undertaken to assess whether the deposits are sufficiently sensitive. The OSL dating has been undertaken at the new 'state of the art' OSL facility in the Department of

Geography, University of Liverpool. A summary of the results of the OSL dating is presented below and a full breakdown of the methodology and results is presented as an appendix (*Appendix 1*).

2.6.4 ***Summary of OSL dating (Task 31):*** Optically Stimulated Luminescence (OSL) dating of sand sized quartz grains allows determining the time when sediment was deposited. Here we test if sediments from the Ribble catchment fulfil all prerequisites for successful OSL-dating. Two samples were taken and prepared following standard procedures. OSL intensities were generally low, resulting in rather low signal/nose ratios and thus rather large uncertainties. Ages obtained are consistent with established sediment stratigraphy: modern sediment returned an equivalent dose of ~ 2 Gy and a sample from the mid Holocene terrace returned an age of ~ 4.5 ka. The results show that sediments from the Ribble catchment are suitable for OSL dating and that the project's OSL-component can progress as initially planned.

3. ENHANCEMENT AND INITIAL CHARACTERISATION OF THE ARCHAEOLOGICAL AND HISTORICAL RECORD

3.1 ENHANCEMENT OF THE ARCHAEOLOGICAL RECORD USING AERIAL PHOTOGRAPHIC AND LIDAR DATA (TASK 21)

3.1.1 The LIDAR data supplied by the Environment Agency was integrated into the GIS as georeferenced raster images created from basic Ascii data. These rasters are very precise surface models that can be examined in 3D within the GIS package. Hillshade models were also created to enhance the contrast between the different topological features. This process highlighted small changes in altitude, causing previously unidentified sub-surface features to become visible.

3.1.2 The LIDAR data was combined with the historic mapping and air photographic data, and the entirety of the two study areas were examined for new features. Using this process, a total of 161 new features were identified. These are shown in the table below.

Monument Type	Quantity
Barn	2
Boundaries	1
Cropmark	1
Drainage	1
Earthwork	77
Earthwork?	2
Enclosed field system	1
Farmhouse	1
Field boundary	5
Fold	1
Footpath	1
Gravel bank	1
Linear feature	8
Millpond	1
Mossland	1
Palaeochannel	10
Palaeochannel?	7
Quarry	1
Race Course	1
Reclaimed Land	1
Ridge and Furrow	32
Ridge and Furrow?	3
Road	1
Site	1
Total	**161**

Table 1: Features identified from LIDAR or Air Photographic sources during Task 21

3.1.3 The monuments in Table 1 were digitised by hand within the GIS, both as simple polygon extents and as sketch plans. By computing the centroid of each polygon extent, the new monuments were added to the database created in Stage 1 as point data, with attribute and positional information.

3.1.4 ***Results:*** many of the features shown in Table 1 consist of fields of 'ridge and furrow', identifying areas where ploughing has taken place. However, in the North Yorkshire study area, a previously unknown potential deserted medieval settlement was identified, within a curve of the River Ribble. This was initially identified by the field systems and cultivation ridges extending out from the settlement, and then from closer examination the extent of a putative croft and toft was identified.

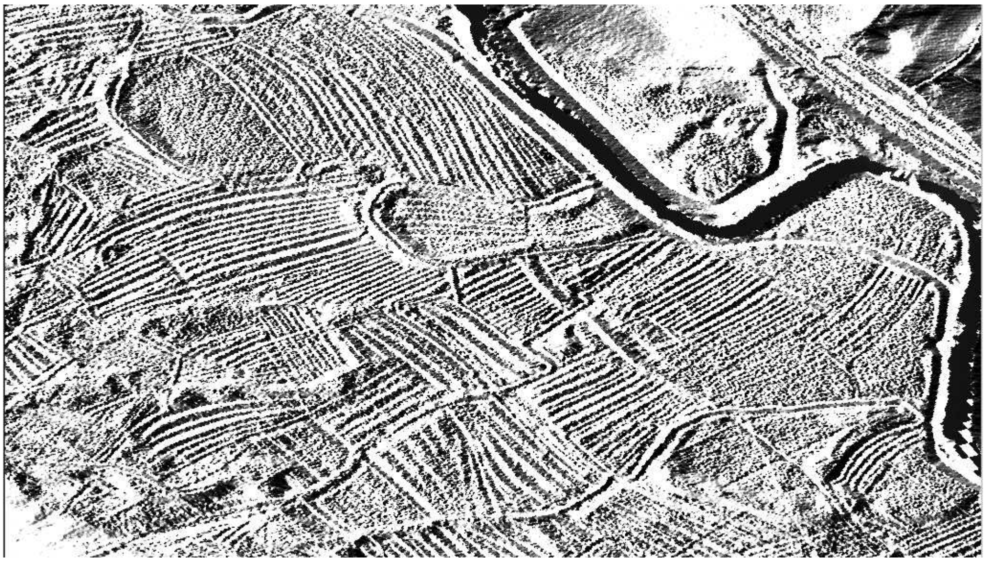


Fig 5: LIDAR data for Rathmell area, North Yorks

3.1.5 The northern study area was also subject to new oblique aerial photography, which was taken in the winter with a relatively low sun, which was intended to accentuate earthworks. This new photography was set alongside earlier photography which (Fig 6) was taken when there was a light cover of snow and also the Lidar data (Fig 5). As such this provided an opportunity to assess the effectiveness of the three sources of data. While all three mediums revealed the earthworks, there were considerable differences in how effectively these were revealed. The least clear was the new oblique photography (Fig 7), which although taken with a low sun, had less clarity than the photography taken with light snow. As such this demonstrates the need to exploit the light snow covered aerial photography conditions as and when they occur. Significantly the LIDAR provided the most powerful depiction of the earthworks, and produced the most clearly defined representation of the putative croft (Fig 5). The results of the present study have effectively demonstrated that the preferred medium for remote sensing of the earthwork remains is the LIDAR.

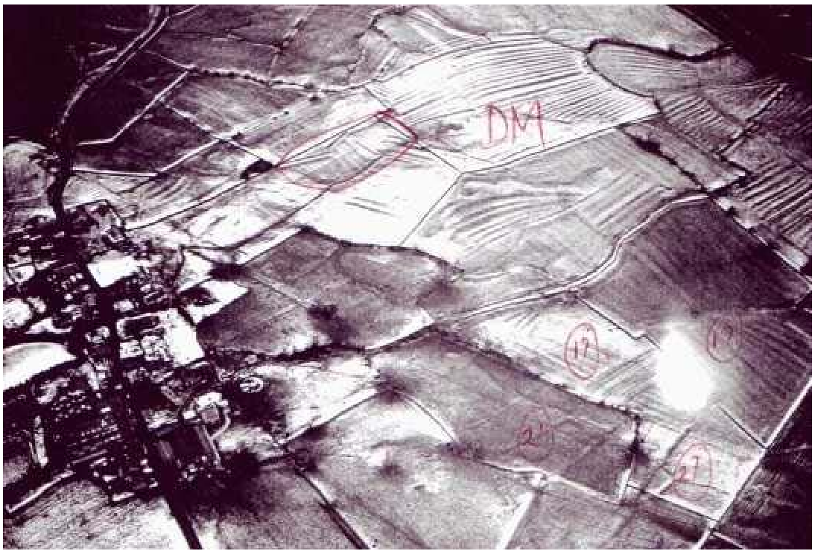


Fig 6: Rathmell area taken with a low light and a covering of snow

Fig 7: the same area of Rathmell taken recently with a low sun

3.1.6 ***Cropmarks*****:** the Lidar Data was also compared to sites which had been previously accessioned into the archaeological record as cropmarks to assess its ability to pick up and refine subtle surface features. A site, two kilometres west of Preston Docks, near the site of Old Lea Hall, was used as an example as it was defined in the HER as a cropmark site.

Fig 8: Oblique and vertical photographs of a site near Old Lea Hall showing sub-rectangular cropmarks

3.1.7 The photo held in the Lancashire HER (PRN 3146) shows a site which is described as 'Vague sub-Rectangular Cropmarks', and can also be clearly seen on the vertical aerial photographs (Fig 8) (Lancashire County Council 2000). In both instances it is easy to see the basis of the initial interpretation. In contrast to this the Lidar data shows that the area contains a series of palaeochannels and flood defence banks (Fig 9). As with the earthwork sites, this highlights the ability of Lidar to clarify the nature of a site, even if just to separate natural and anthropogenic origins.

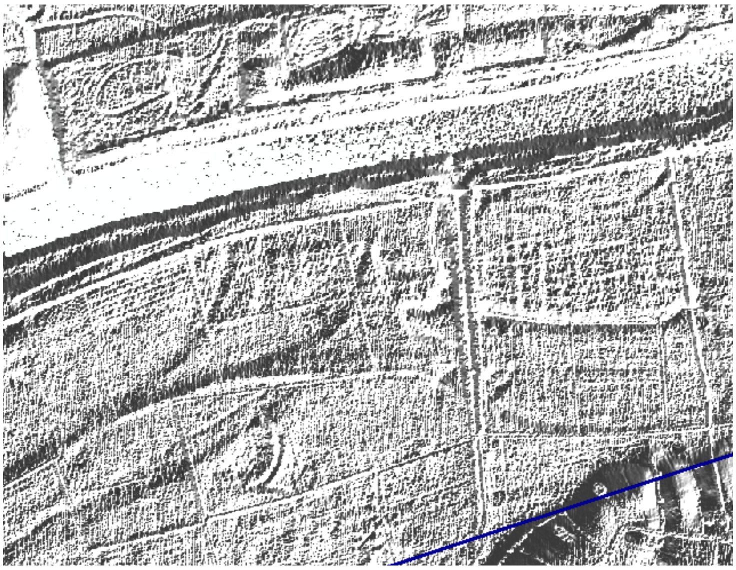


Fig 9: The same site near Old Lea Hall, showing that the cropmark feature is a part of a complex of palaeochannels

3.2 INITIAL CHARACTERISATION OF DATASETS (TASK 22)

3.2.1 ***Classification***: once the monuments identified in Task 21 had been incorporated into the database it was necessary to characterise the entire monument dataset by NMR Class List, Type and Period. In many cases, where the data had been supplied from the Lancashire and North Yorkshire HERs, or from the NMR, this had already been done, and all that was necessary was to check for consistent use of terms and any mistakes. New monuments were characterised, where possible, using the NMR Thesaurus of Monument Types as reference (RCHME 1995).

3.2.2 It was decided that the NMR Class List would be the characteristic used for the initial cell-based analysis rather than period, because it was considered that there would be some correlation of the landscape types favoured by similar types of monument, but different periods. The alternative was to make the assumption that all site types within a single period (such as prehistoric) would favour the same landscape characteristics, and evidently this is not the case as within the context of the prehistoric period settlement and funerary activity will commonly favour very different locations.

3.2.3 By calculating the percentage of the total number of monuments for each study area represented by each class list, it was possible to identify those groups that were most common (Tables 2 and 3 below). Those classes for which there were less than 2% of the total monuments for each area were then discounted from the analysis as they contained too few sites for reliable statistical analysis to take place. The classes "unassigned" and "monument <by form>" were also excluded as they do not represent a particular monument type.

NMR Class List	**Quantity**	**Percentage of Total**
Industrial	165	14.59
Agriculture and Subsistence	142	12.56
Domestic	131	11.58
Unassigned	98	8.66
Water Supply and Drainage	98	8.66
Transport	96	8.49
Monument <By Form>	88	7.78
Religious Ritual and Funerary	75	6.63
Findspot	63	5.57
Gardens Parks and Urban Spaces	39	3.45
Defence	38	3.36
Commercial	34	3.01
Maritime	24	2.12
CUT OFF POINT		
Education	21	1.86
Recreational	10	0.88
Health and Welfare	6	0.53
Civil	2	0.18
Commemorative	1	0.09
	1131	**100.00**

Table 2: Breakdown of monuments in Lancashire transect by class list and percentage

Nmr_class_list	**Count**	**Percentage of Total**
Agriculture and Subsistence	89	27.38
Monument <By Form>	53	16.31
Unassigned	37	11.38
Domestic	35	10.77
Industrial	32	9.85
Water Supply and Drainage	18	5.54
Transport	16	4.92
Commercial	11	3.38
Religious Ritual and Funerary	11	3.38
CUT OFF POINT		
Civil	5	1.54

Nmr_class_list	Count	Percentage of Total
Communications	4	1.23
Education	4	1.23
Findspot	4	1.23
Gardens Parks and Urban Spaces	4	1.23
Recreational	2	0.62
	325	**100.00**

Table 3: Breakdown of monuments in North Yorkshire transect by class list and percentage

3.2.4 ***Methodology***: using the spatial analysis extension within ArcGis 9, a cell-based map of the distribution of each of the most common class lists was created for each study area. A cell size of 5m was decided upon, as the best trade-off between unmanageable file size (with a smaller cell size) and the risk of grouping more than one monument into the same cell (with a larger cell size).

3.2.5 In order to compare the distribution of the different classes of monument against factors thought to affect their location, it was necessary to create cell-based maps of slope, aspect, elevation and distance from water in both study areas. The cell-based rasters comprised a grid laid across the two study areas, in which each cell was assigned the value of the environmental factor at that point. The slope, aspect and elevation maps were created using contour data supplied during Stage 1 of the project. It was considered that LIDAR, whilst more accurate than conventional contour data, would be unmanageable during this initial characterisation process due to the large file sizes generated.

3.2.6 The distance from water mapping was created from the Ordnance Survey Mastermap vector mapping supplied during Stage 1 of the project. Within Mastermap, features were classified by type, so it was possible to extract all features of type "water" into a separate layer. This later comprised all forms of water feature, such as modern ponds or reservoirs, as well as streams and rivers. Therefore, it was necessary to manually remove all unwanted features from the layer prior to using it for analysis.

3.2.7 Once the water layer had been reduced to features such as rivers or streams, buffers of 100, 200, 500 and 1000m were created around each feature. This was then used to generate the cell-based map necessary for the analysis.

3.2.8 Using the powerful Raster Calculator function within ArcGIS 9 it was possible to produce new cell-based maps that represented a combination of each class list map and each environmental parameter in each of the study areas. This resulted in a total of 88 new cell-based maps. Each new map contained a record for each combination of monument and environmental factor, with a count of how many cells this represented. This data could then be read in Microsoft Excel and used in the statistical analysis.

3.2.9 The technique used to establish whether or not there was a correlation between the distribution of monuments and each environmental factor was the Kolmogorov-Smirnov Goodness-of-Fit Test. This is an established statistical technique that is particularly suitable for comparing the distribution of a single sample (such as the location of monuments) to the distribution of continuous data (such as environmental factors) (Wheatley 1995).

3.2.10 ***Results - Lancashire***: in this initial characterisation, no single monument type correlated with every environmental factor. However, the classes "defence", "industrial" and "water supply and drainage", correlated with three of the factors, implying that these environmental parameters do have an effect on the site location for monuments of those classes.

3.2.11 ***Defence:*** the factor that the defence class correlated most highly with was elevation, with the greatest correlation between 0 and 50m. The second highest was with distance from water, with the greatest correlation between 100 and 200m away from water. The third was with aspect, with the greatest correlation being the south-east and east facing slopes. Zones within the study area that meet those environmental conditions might, therefore, be considered as having a higher potential for the discovery of archaeological sites relating to defence.

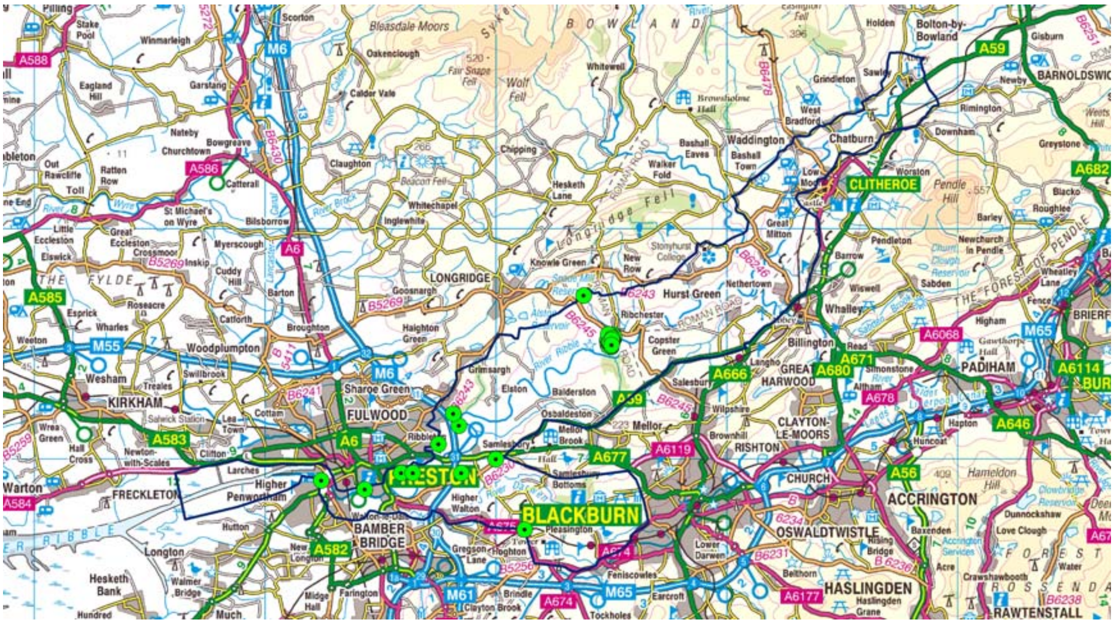


Figure 10: Monuments of the denfence class within the southern study area

3.2.12 There were 42 known monuments from the defence class within the Lancashire study area (Fig 10), of which 29 referred to parts of the Roman fort at Ribchester. However, this tight geographic cluster does not fully explain the strong correlation between this class and the environmental factors described above. For example, all but three of the monuments lie within the elevation range of 0-50m above sea level, and 31 of the sites lie within 100-200m of water. This would imply that the factors influencing the location of the fort at Ribchester were just as important to the builders of the possible prehistoric promontory forts along the north of the Ribble and the builder of the Motte and Bailey at Penwortham Castle.

3.2.13 Using the results of the statistical analysis, a map showing the areas of greatest combined potential for monuments of the defence class was constructed. This highlights the floodplain of the Ribble as the area of highest potential, with zones of medium potential extending up the valleys of the tributary rivers and streams, and the zones of lowest potential representing the north and north-west facing slopes on the southern face of the Ribble Valley (Fig 11). The reason for the siting of most of the monuments of defence class on the north side of the river is unknown, and will be investigated further in the course of the refinement stage of the characterisation, but maybe due to better visibility of the approaches up the river from the estuary at Preston.

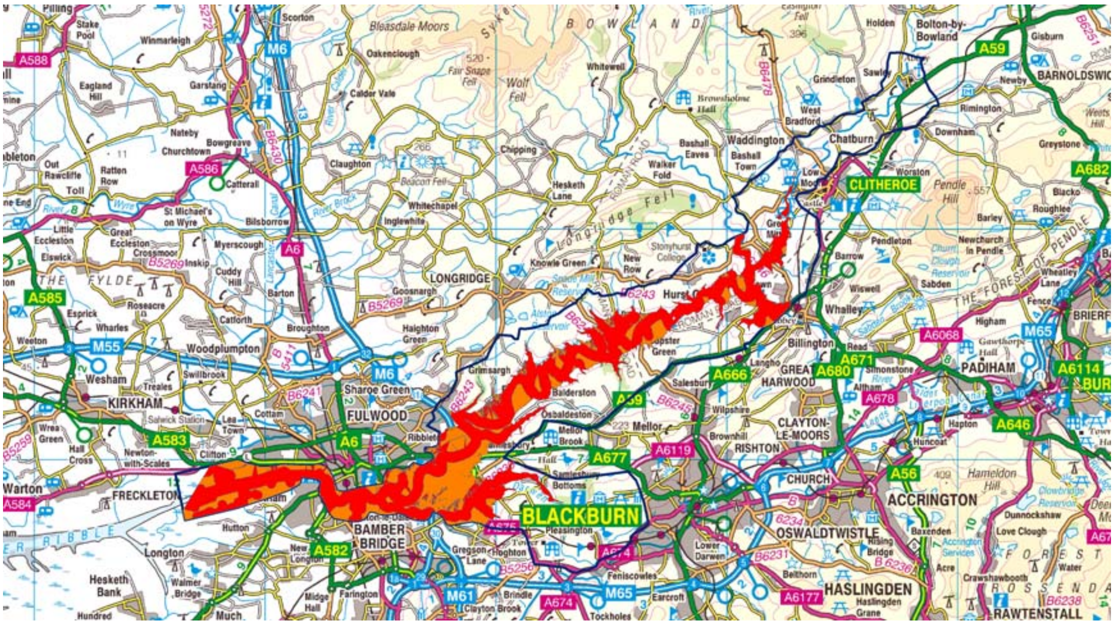


Figure 11: Map of medium to high potential for defence class monuments

3.2.14 ***Industry*****:** the factor that the industry class correlated with most highly was the distance to water, with the greatest correlation being between 100-200m. The second highest was with slope, and the greatest correlation was on slopes of between 5 and 10 degrees from horizontal. The third highest was with elevation, with the greatest correlation being between 0-100m above sea-level. There are 169 known monuments of the industrial class within the Lancashire transect (Fig 12), comprising 55 different types. The most numerous were clay pits (21 sites) and quarries (31 sites), which were located relatively evenly across the study area, with no obvious clustering, and comprise mainly medieval, post-medieval and modern sites; however, there are also some roman sites related to Ribchester Roman fort and its *vicus*.

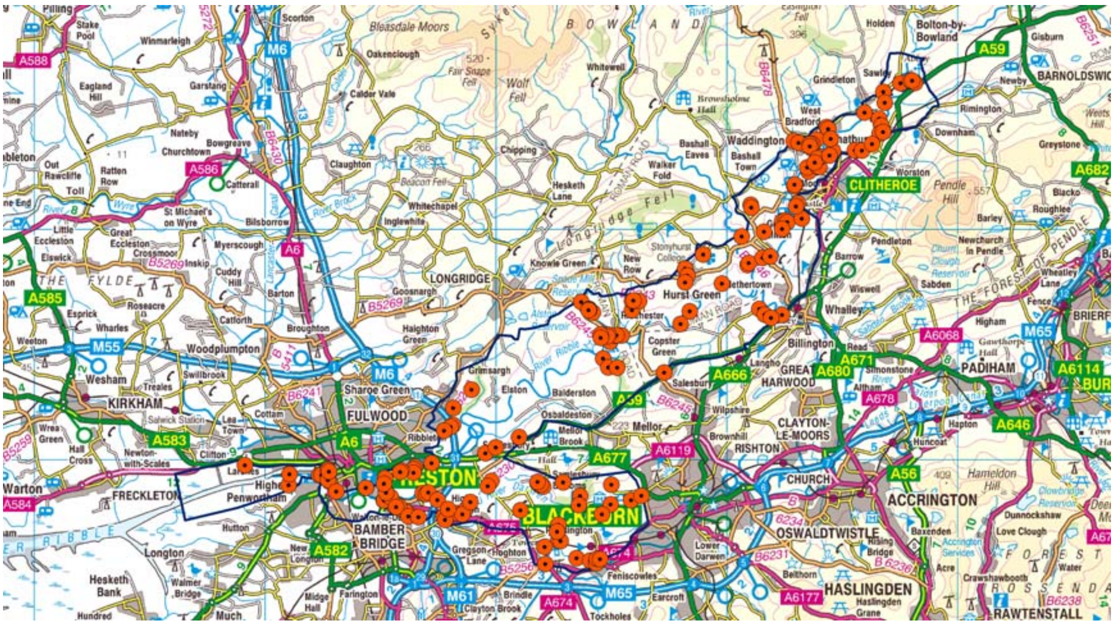


Figure 12: Monuments of industrial class within the southern study area

3.2.15 When a map showing the areas of greatest potential for industrial sites was constructed, most of the area was shown as being of medium to high potential (Fig 13), and reflects the wide spread distribution such of sites. There are also some areas that are of medium to high potential that do not, as yet, contain any industrial sites, the most obvious area being to the west of Ribchester.

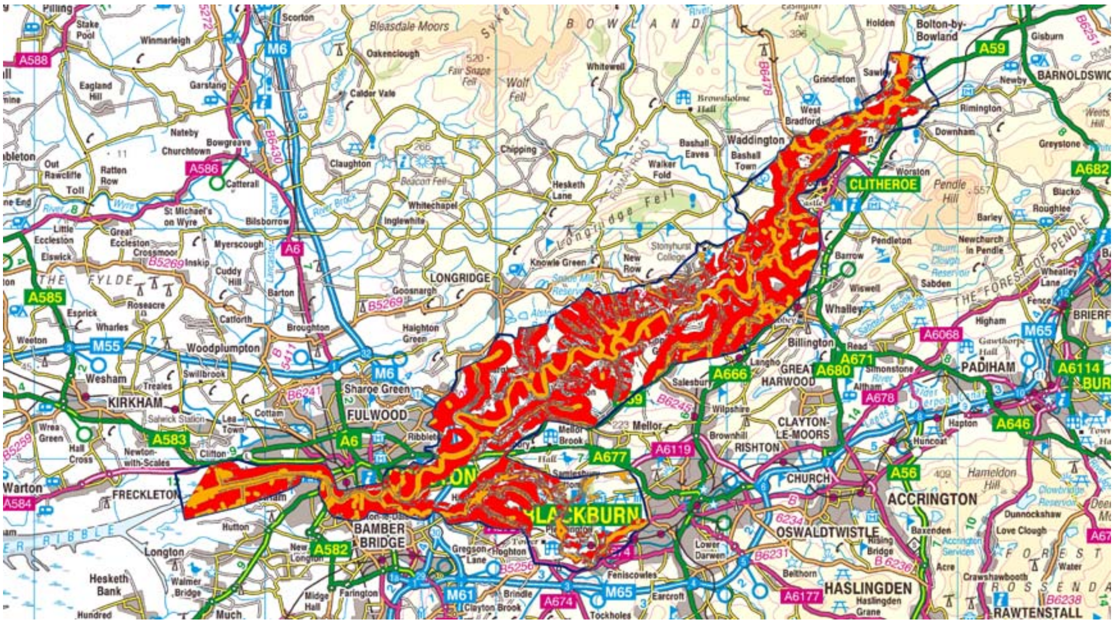


Figure 13: Map of medium to high potential for monuments of industrial class

3.2.16 ***Water Supply and Drainage:*** unsurprisingly, this class correlated most highly with the distance from water factor, with the greatest correlation between 100 and 200m. The second highest correlation was with slope, with the greatest correlation between 10 and 20 degrees from the horizontal. The third highest was with elevation, with the greatest correlation between 0-50m. There are 99 monuments from this class within the study area (Fig 14), all of which are medieval or later in date, and include 70 wells and 13 weirs. The wells are fairly well spread across the study area, whereas the weirs are obviously clustered on the rivers and tributaries, and 10 of them are on the River Darwen. Again, perhaps unsurprisingly, the map of potential for sits of this class highlights the majority of the area as being of low potential (Fig 15), with only the zones close to the rivers and streams being of medium or high potential.

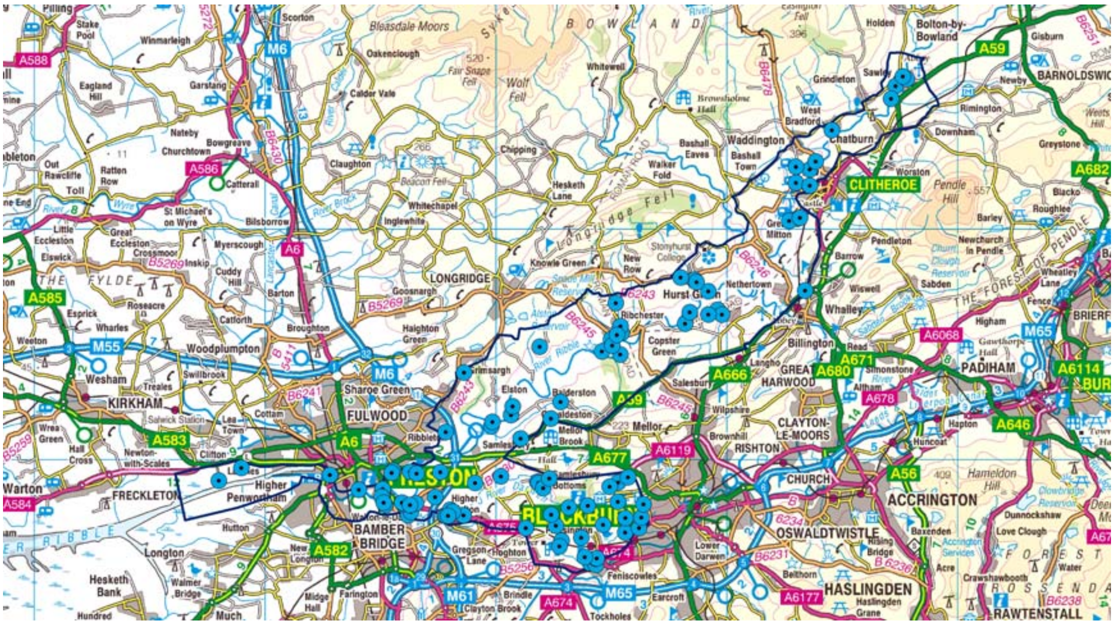


Figure 14: Monuments of water supply and drainage class within the southern study area

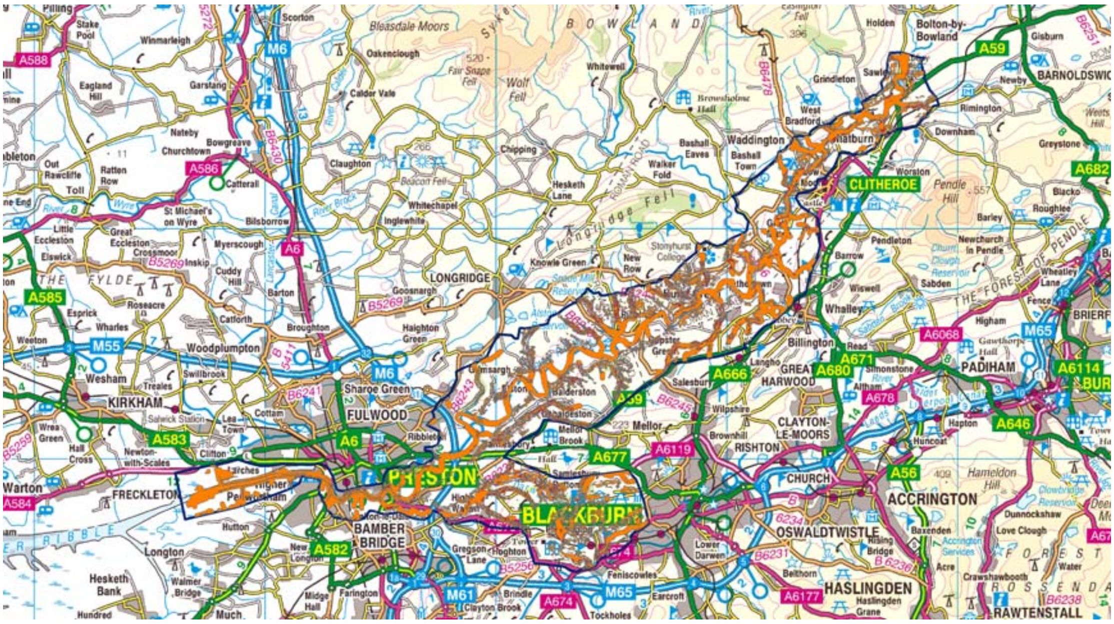


Figure 15: Map of medium to high potential for monuments of water supply and drainage class

3.2.20 ***Results - North Yorkshire***: In the North Yorkshire transect there was less correlation between environmental factors and class; the "domestic" class correlated with two environmental factors and the "commercial" class correlating with only one. Consequently it was not possible at this stage to construct maps of archaeological potential for this transect.

3.2.21 ***Conclusion:*** the initial characterisation exercise showed that there was some correlation, in the Lancashire transect, between various classes of site and environmental factors. Maps of potential based on the statistical analysis had varying degrees of success, which suggested that the process could be further refined (Task 24) so as to look into the location of some classes of monument in more detail.

3.3 GROUND TRUTHING (TASK 23)

3.3.1 Initially two areas have been chosen for the ground truthing exercise, an area around Osbaldeston Hall (Fig 16), immediately south of Ribchester (NGR 36438 43441).

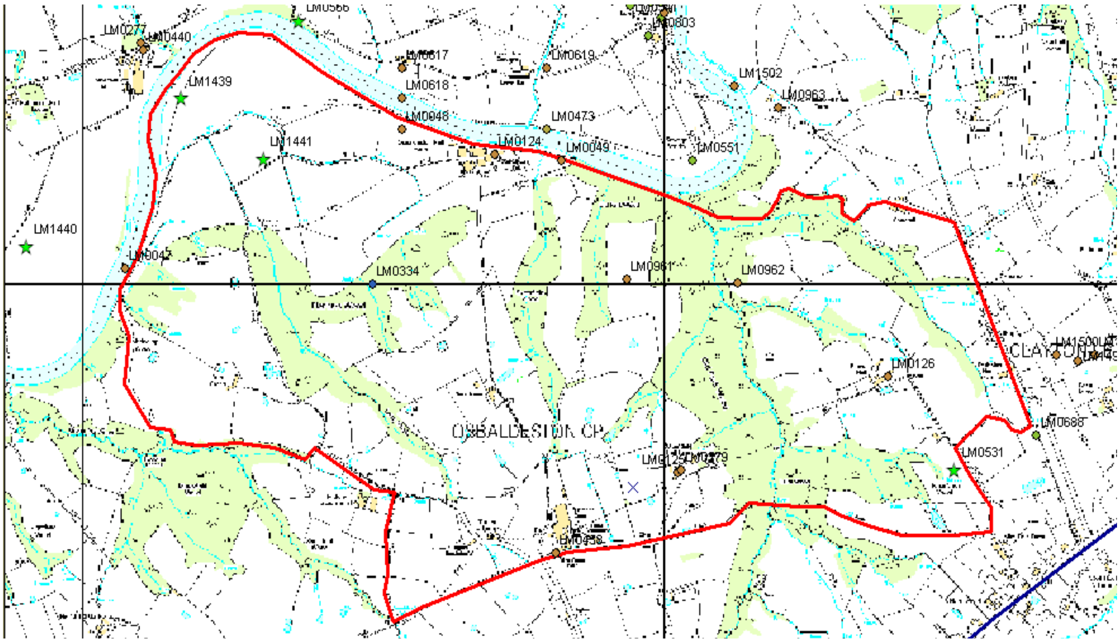


Fig 16 Osbaldeston Hall Farm Ground truthing area

and a second As a linear corridor running north from the village of Rathmell (NGR 380423 459957) to the junction with the A65, south of Giggleswick station (NGR 38067 46244) (Fig 17).

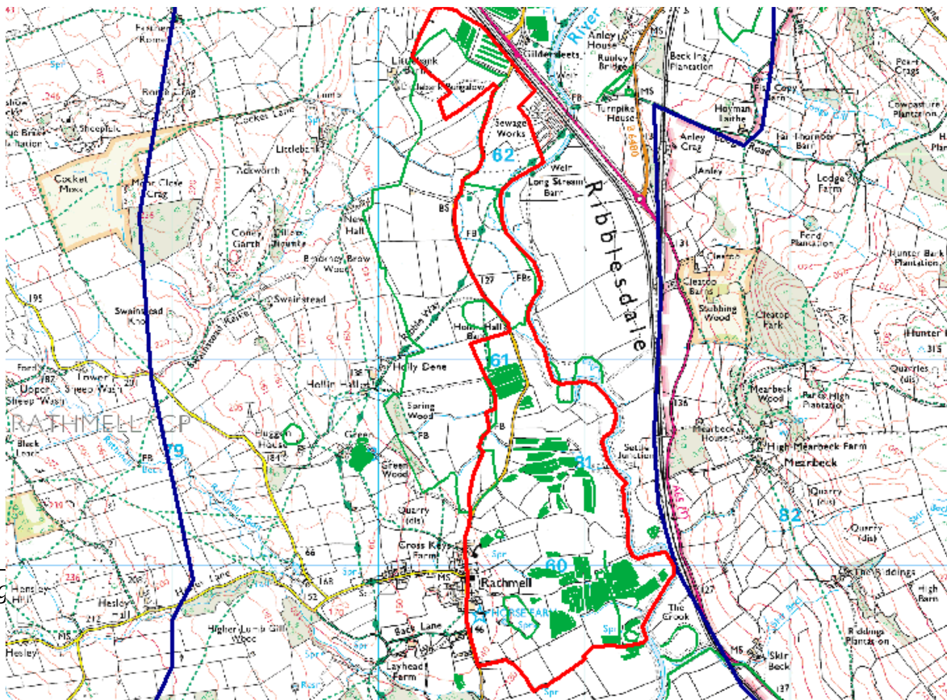


Fig 17 North Yorkshire Groundtruthing area

3.3.2 The area round Osbaldeston Hall farm was chosen for several reasons, partly as it was one of the locations of geological drilling and could therefore link in to the geological analysis. It also has varied topography and land use, there are areas of known archaeology, new sites, and was an area for which there was no Lidar data available. The most significant results from this area were the sites which had been identified by Lidar, comprising a series of long, wide and low linear features (Fig 18) located in the north west of the area, on the low lying river terrace (LM1439, LM1441).

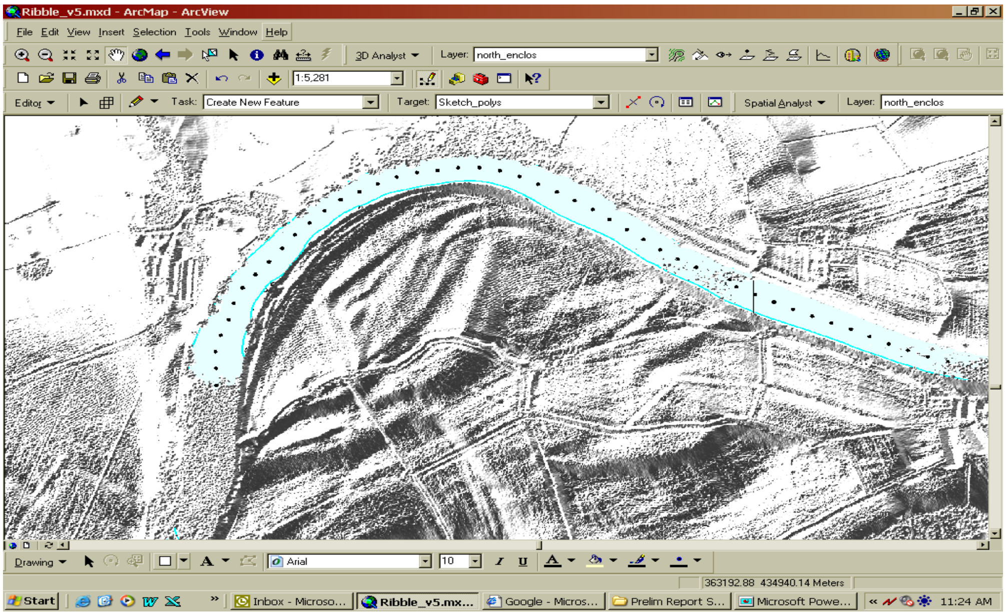


Fig 18 North West section of Osbaldeston Hall study Area

The current land owner had no knowledge of there being any drainage or flood alleviation works being undertaken during his time there (C Bargh *Pers Comm*), nor was there any photographic or HER information for the area. The field inspection confirmed the existence of long linear banks, though in places so subtle as to be barely perceptible (Fig 19).

Fig 19 Subtle Linear Features North West of Osbaldeston Hall Farm

It was found that a sheepfold (LM0048), located to the west of Osbaldeston Close to the river bank and a series of stepping stones (LM0047) were no longer extant. New discoveries included a disused engine mounted on sandstone blocks and with a brick built foundation, located in the Old Park Wood east of Oxendale Hall (NGR 365406 433551). A field of regular though well defined ridge and furrow was located west of Oxendale Hall (NGR 364895 433344) in an area that did not have LIDAR coverage.

3.3.3 The Second area, between Rathmell and Giggleswick (Fig 17), was in the northern area, it was also subject to geological testing and contained many known areas of ridge and furrow ploughing, which had been significantly enhanced from study of the Lidar data (YM1391). Ground truthing revealed that the central trackway of site YM1391 was visible though in places obscured by vegetation (Fig 20).

Figure 20 Trackway east of Rathmell Village North Yorkshire

The ridge and furrow could be seen to the east and west of the trackway; however, the putative platforms east of the trackway were not clearly visible on the ground. The ridge and furrow was found to stop where the Lidar indicated it did, but the features between the track and the ridge and furrow were not visible. At the west of the trackway a hollow and marshy area, which was ill defined at its northern edge, again clearly matched the Lidar image. The remaining field systems were as shown on Lidar, the baulks between ploughing could be seen, with the distance between ridge crowns being typically 6 to 8 meters across. The later drainage features (Shown at 1850) could also be seen to clearly cut the ridge and furrow.

3.3.4 Further north, towards the A65, the fields without exception contained the traces of ploughing as shown by the Lidar . The ridges which were noted on either side of present day drystone walls and it was evident that the walls were superimposed upon an earlier area of ridge and furrow.

3.3.5 At the northern extent of this area a field was noted as containing very regular wide ridge and furrow from the Lidar data (Fig 21).

Figure 21 Lidar data showing cropmarks, Giggleswick North Yorkshire

3.3.6 The visual assessment, however, found that this area had no observable extant earthworks, and, at the time, no differential vegetation coverage to hint at subsurface features. It is probable that the Lidar had recorded cropmarks at a time of the year when there was a high crop.

3.3.7 ***Conclusion:*** in conclusion the ground truthing has confirmed that the LIDAR is identifying those features that are evident from the ground, and is capable of showing features which photographic evidence and even site inspections may not be able to identify.

3.4 FINAL CHARACTERISATION (TASK 24)

3.4.1 It was not possible to complete all elements of the initial characterisation as the geological data provided for the project required considerable updating and this has only been completed and become available in the last week. Without up to date geological data, it was impossible to incorporate accurate information on threats from extraction into the maps of archaeological potential. Consequently, in order to most efficiently utilise the time available, refinements have begun on the archaeological characterisation, as described below. Now that up to date geological data is available, this data will be integrated into the refined characterisation rather than the initial one, with no overall delay to the project.

3.4.2 For the defence class, the characterisation refinement involves visibility studies such as viewshed analysis, to determine whether this is a factor in determining the location of most defensive monuments on the north side of the river. More detailed examination of changes in topography will also be useful in this case.

3.4.3 The industrial class contains the most monuments, and shows a generally even spread across the study area. The map of potential for this class has consequently highlighted most of the study area as being high or medium potential. Subsequent characterisation work includes repeating the statistical tests to see if there is any correlation between individual types of monument in this class and environmental factors.

3.4.4 The water supply and drainage class was perhaps the most obvious of the classes, in that correlation logically needed to occur between monuments of this type and certain environmental factors such as distance from water. Again, by splitting this class into its individual types, it will potentially be possible to refine the correlation of, for example, wells.

3.4.5 For those classes where no correlation occurred, some refinement of the environmental parameters has the potential to provide some information. For example, concentrating on small changes in slope or elevation on the flood plain adjacent to the river might highlight correlations that were not obvious when considering the entirety of the study area. Similarly this approach may highlight correlations in the North Yorkshire study area that were not obvious in the initial characterisation.

3.5 PALAEOECOLOGICAL PROGRESS

3.5.1 An on going dialogue has been maintained between project staff from the University of Liverpool and OA North. In addition two site meetings took place in the Calder Valley (NGR SD 763331centred); the first of these followed the discovery of an intercalated band of wood peat by the project staff from Liverpool University in the river banks of the Calder, a short distance north-west of the A59. This was sampled by Richard Chiverrell and his team and a section of wood was removed to OA North for analysis. The wood has been identified as *Alnus* (alder) and by analogy with a radiocarbon dated pollen diagram at Red Moss, Nr Bolton, Greater Manchester gives an approximate *terminus post quem* date of c6000-6500 cal BC for the overlying terrace deposits. A second site meeting took place in early December 2005 during the Liverpool University's cobra coring, ground truth programme of the River Calder palaeochannel sequences to the south-south-east of the A59. Here there was minimal organic preservation in the deposits cored on this visit suggesting that there may be little palaeoecological potential here.

3.5.2 ***Proposed programme of palaeoecological ground truthing fieldwork***: the next phase of the palaeoecological work will focus on a limited programme of ground truthing and will develop out from the LIDAR analysis and the programme of coring undertaken by University of Liverpool. In the first instance, following a recommendation by Bernardo Chiti (2005), it is proposed to investigate a palaeochannel, at Flashers Wood (SD638341 centred) approximately 1.5 km SSW of Ribchester. He recorded the depositional sequence at this site and suggested that it might have a good potential for further palaeoecological research as a comparison to the pollen record from his Higher Brockhole sites. At Flasher's Wood Chiti describes an actively growing peat unit in the central deposits of a palaeochannel. The site will be visited in January 2006 and will be cored with a gouge auger to select a coring site or sites for palaeoecological assessment. If this site proves to have good organic accumulation/preservation it will be an important palaeoecological site because of its proximity to Ribchester.

3.5.3 In other parts of the study area site visits will be made to selected representative sites shown on the LIDAR data. It is proposed that the OA North project staff will target areas where there is little evidence for archaeological sites as this may possibly record, indirectly, archaeological sites which leave no footprint in the landscape. Gouge augering will be undertaken at these sites and environmental samples will be collected in the field to be assessed as to their potential for palaeoecological analysis.

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APPENDIX 1
OSL DATING OF FLUVIAL DEPOSITS FROM THE RIBBLE VALLEY – A FEASIBILITY STUDY

MOTIVATION

In order to successfully apply quartz OSL-dating in an environment for which so far no OSL-results are available a series of tests has to be carried out to check if all prerequisites of OSL-dating are fulfilled. The quartz OSL needs to be (i) free of any feldspar component; (ii) dominated by the fast component; and (iii) show insignificant thermal transfer and recuperation during the SAR protocol.

Additionally it has to be checked that pre-depositional light exposure during erosion and transport was sufficient to significantly reduce the OSL signal. This can be tested by studying a modern analogue sample and by analysing dose distributions.

THE SAMPLES

OSL-sampling took place on the 07 July 2005. As sampling location natural outcrops along the meander bend just upstream of Ribchester were chosen. Two OSL samples were extruded from the sediments using opaque sampling tubes. Additionally bulk samples were taken for determination of moisture content and for radionuclide analysis. The two samples are:

LV 187: taken from the lowermost accessible part of the modern floodplain deposits; 2.5 m below terrace surface: alternating layers of silt-clay and sand; rich in organics. Sand: manly fine sand rather well sorted; some clay. Estimated age: maximum 100 years.

LV 188: sand layer; intercalated in fluvial gravel underlying terrace 4; rather well sorted coarse sand, layer c. 40 cm thick; 2.0 m below terrace surface; Estimated age: Late Pleistocene – Mid Holocene.

SAMPLE PREPARATION

Samples were prepared using conventional techniques to extract quartz grains in the size of 150 – 250 µm from the sediment (Mauz *et al* 2002). This comprises removal of organics and carbonates by means of H_2O_2 and HCl treatment, grain-size separation, density separation, etching with HF to remove the grain's outer layer and deposition on stainless steel discs. To avoid bleaching of OSL all work was carried out in tested subdued save-light conditions (filtered light from low pressure Na-lamps; Mauz *et al* 2002)

MEASUREMENTS

All OSL measurements were performed at 125˚C readout temperature using a Risø DA-15 automated TL/OSL reader equipped with a β-source (~ 0.7 Gy min^{-1}), and blue LEDs (470D20 nm, ~ 30 mW cm^{-2}) for stimulation.

Due to low OSL intensities full-sized aliquots (7 mm of the 10 mm diameter disc covered) were used for equivalent dose (D_e) determination. For D_e-estimation a single-aliquot regenerative-dose protocol (SAR, Murray and Wintle 2000) was applied. Preheats of 230°C to 250°C for 10 s were chosen on the basis of results from preheat test that included monitoring D_e, recycling ratio and thermal transfer.

The OSL of the first 5 s of stimulation was used after subtracting the background obtained from the last 5 s of stimulation. The purity of the quartz was checked using the IR-OSL depletion ratio (Duller 2003) and techniques developed by Mauz and Lang (2004).

The amount of thermally transferred OSL was assessed using the ratio $\frac{L_0}{T_0} / \frac{L_N}{T_N}$, where $\frac{L_0}{T_0}$ is the corrected OSL recorded after 0 Gy dose and $\frac{L_N}{T_N}$ is the corrected OSL of the natural dose.

For analysis of De distributions only D_e-values were used when (i) recycling ratios fell within 1.0±0.1; (ii) thermal transfer was insignificant (< 5% of the natural OSL); (iii) the natural dose was bracketed by at least two regenerated dose points; and (iv) the dose response curve was linear.

RESULTS

Quartz Luminescence Poperties: In general the OSL intensities of the samples are very low, resulting in low signal/noise ratios and rather large uncertainties (Figure 1). This is due to the relatively young ages and rather insensitive quartz grains.

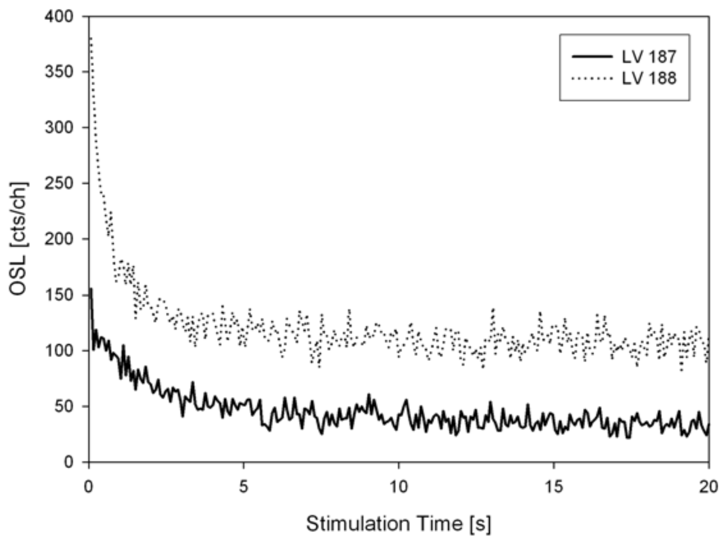

Figure 1: OSL curves of natural aliquots from samples LV 187 and LV 188. The low signal to noise ratio is obvious from the large scatter (noise) in the data.

Many aliquots (~ 30%) showed signs of feldspar inclusions and, thus, had to be rejected from further analysis. The different components underlying the OSL signal were analysed using linearly modulated OSL (LM OSL; Bulur *et al* 2000). Despite low intensities OSL signals both samples are dominated by the fast component. Figure 2 shows an example of LM OSL curves of sample LV 188 after regeneration with 12 Gy and a 220 C preheat. Based on preheat tests a 220 C preheat was chosen and a cut heat at 180 C. Thermal transfer was negligible (4±2% at 220 C preheat) and recuperation on an insignificant level only.

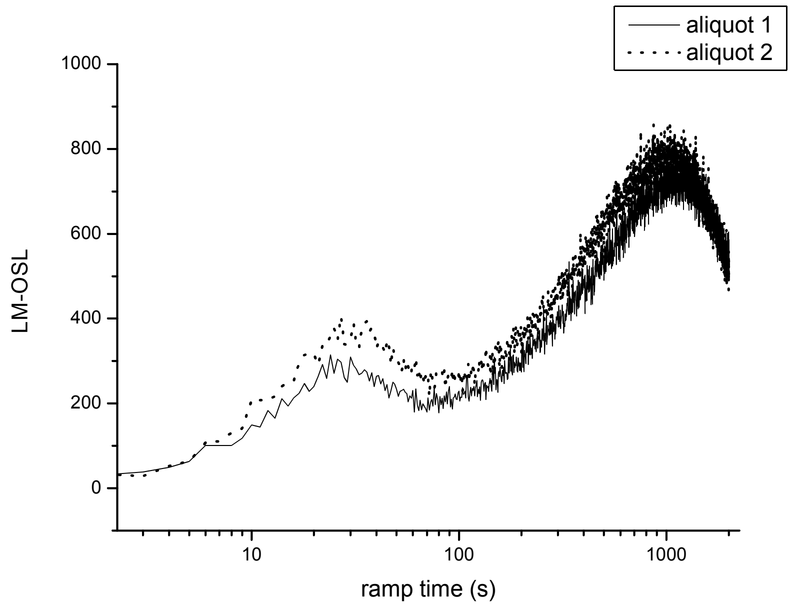

Figure 2: LM OSL curves of sample LV 188 showing a fast component (peaking at ~ 30 s) and slow components dominating beyond 80 s.

Equivalent dose estimates

The low signal/noise ratio is hindering to obtain well defined SAR growth curves for the modern sample LV187. Statistical analysis of the De values using the minimum age model (MAM; Galbraith *et al* 1999) reveals the presence of several components. The MAM equivalent dose of 2.08 / + 0.24, -0.26 Gy corresponds to an residual OSL-age of 500 – 1000 years. From the dose characteristics it is clear that this residual is not due to poor bleaching but due to the low OSL sensitivity of the sample, and precludes obtaining meaningful OSL-ages for the last ~ 1000 years.

Equivalent dose estimates for sample LV188 are shown as radial plot in Figure 3. As expected for fluvial samples large variations in equivalent dose estimates exist (probably due to heterogeneous bleaching), De values are 44% over-dispersed and the dose distribution is positively skewed. The MAM has no solution and for age determination the median De was chosen.

Sample LV188: Median De = 4.70±0.44 Gy (n=44)

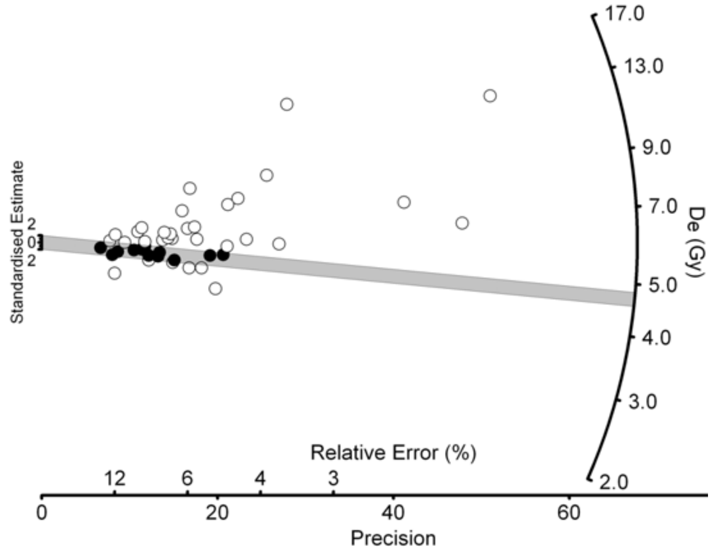

Figure 3: De radial plot for sample LV188

Environmental dose rate and age estimates: for OSL age calculation the equivalent doses have to be divided by the effective dose rate to which sediment grains were exposed in the sediment. Radioisotope concentrations were determined using low-level high-resolution γ-spectrometry. In none of the samples was radioactive disequilibrium detected. Water content measured on the sample was low (~8 %). As representative water content 15±5% was taken as realistic for the burial period for both samples.

Table 1: Dosimetric data

Lab code	Depth below surface	Grain size (µm)	U ($\mu g\ g^{-1}$)	Th ($\mu g\ g^{-1}$)	K (%)	dD/dt cosm ($Gy\ ka^{-1}$)	dD/dt effective ($Gy\ ka^{-1}$)
LV 188	2.0	150-250	0.962 ±0.039	3.505 ±0.158	0.537 ±0.018	0.158 ±0.009	1.042 ±0.02

Age estimate for LV 188: 4.52±0.43 ka

CONCLUSIONS

OSL-properties of samples from the Ribble catchment are not ideal. Especially, the low OSL sensitivity of the quartz extracts needs careful consideration and only allows OSL dating of sediments older app. 1000 a. The presence of a feldspar contribution led to the rejection of ~30% of aliquots and therefore requires increased measurement efforts. Despite these difficulties, the OSL properties are sufficient to warrant the project's OSL-component to progress as initially planned.

