

X-RAY FLUORESCENCE (XRF) SCANNING OF THREE IRON AGE HILLFORTS IN CEREDIGION 2011-12.

Castell Grogwynion CD012, Darren Camp CD028, Pen Dinas CD102

Interim report of fieldwork for Cadw, May 2012



Timed pXRF sampling in progress on the eastern terrace of Pen Dinas hillfort (CD102) in November 2011.



Royal Commission on the Ancient and Historical Monuments of Wales, and the Institute of Geography and Earth Sciences, Aberystwyth University

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County: Ceredigion

Community: Ceulanamaesmawr (Pen Dinas), Trefeurig (Darren Camp) and Trawsgoed (Castell Grogwynion)

NGRs: SN677876 (Pen Dinas); SN679830 (Darren Camp); SN721725 (Castell Grogwynion)

NPRNs: Pen Dinas (101990); Darren Camp (303592); Castell Grogwynion (303671)

Date of Survey: October 2011 – February 2012

Surveyed by: n/a

Report Authors: Toby Driver and Keith Haylock

Illustrations: Louise Barker, Toby Driver and Keith Haylock

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Summary

During 2011-12 the Royal Commission (RCAHMW) part-sponsored a one year KESS (Knowledge Economy Skills Scholarships) MPhil project at the Institute of Geography and Earth Sciences (IGES), Aberystwyth University. The MPhil research, undertaken by the postgraduate geography student Keith Haylock, was designed to investigate the prehistoric exploitation of metal resources by Iron Age communities in north Ceredigion, using three hillforts as case studies. Innovative sampling technology, a portable x-ray fluorescence instrument (pXRF), was used during the research for the first time on any mid-Wales hillfort. This piece of equipment, which is only just becoming known within archaeological circles in Wales, can sample the ore content of subsoil simply by taking an in-situ scan in the field, producing the type of results one could previously only obtain from bulk-sampled soil in a laboratory.

Dr Toby Driver, RCAHMW, was the supervisor at the KESS business-sponsor for this project and was able to contribute expertise on the Ceredigion Iron Age hillforts following his 2005 PhD thesis on the subject. He project also complemented RCAHMW's involvement in the Wales-Ireland Metal Links project which is focussed on the communities of former non-ferrous metal mining districts in west and north Wales, and parts of Ireland. Keith Haylock's academic supervisors at IGES were Professor John Grattan, Pro-Vice Chancellor of Aberystwyth University and Dr Harry Toland. Dr Simon Timberlake of the Early Mines Research Group was also consulted as part of the research and accompanied the team on some fieldwork. Cadw kindly granted Scheduled Monument Consent (SMC) for the intrusive sampling work and geophysical survey and the purpose of this interim report is to detail the extent, nature and initial results of this sampling to satisfy the stipulations of SMC.

The fieldwork at the three hillforts certainly demonstrated considerable potential for further work in the use of scientific sampling methods – normally confined to the fields of physical geography and environmental science – to further the archaeological study of the hillforts of Ceredigion and to further enhance our knowledge of metal extraction and working during later prehistory and the Roman period.

A note on results

As the MPhil is not due to be concluded until the autumn of 2012 this report is only intended to summarise the RCAHMW-supervised fieldwork stage on the scheduled hillforts and highlight some of the initial results, for the purposes of Scheduled Monument Consent. Results of geophysical survey of Castell Grogwynion are awaited at the time of writing, and the topographic surveys of Pen Dinas and Castell Grogwynion are to be undertaken during 2012. Final results from the pXRF sampling will only be available for publication on completion of Keith Haylocks' thesis. **For this reason, no conclusions are presented in this report.**



Figure 1. *Castell Grogwynion from the north-east, winter 2011, showing the prominent northern terrace (right) and the summit outcrop which overlooks the interior (Crown Copyright RCAHMW).*

Background to the KESS project to study prehistoric (and later) metal exploitation in three Ceredigion Hillforts

Across the UK the position and context, both architecturally and socially, of Iron Age hill forts have been extensively explored. While the archaeology, architecture and landscape settings of the Ceredigion hillforts was explored by Driver (Driver 2005; Driver 2008), comparatively little work has been undertaken to explore their relationship and role in the metal mining and working industry in the area. The only limited work has taken place at Darren camp and mine in 2005 (Timberlake and Driver 2005) which has shown considerable potential for more detailed ore sampling and remote sensing work. For soil sampling and wide area surveys these processes can be slow and time consuming resulting in limited data collection at many of these sites.

This project was intended to build on previous research undertaken at Aberystwyth University and RCAHMW to employ digital field surveying (for metal concentrations) and airborne laser scanning technologies (LiDAR) to understand and interpret the chronology and positioning of sites within Ceredigion in relation to known metal workings with the region. Specifically, the study intended to:

- Assess links between mineralization of Cu, Zn, Pb, Ag and Fe and the occupation of Castell Grogwynion, Pen Dinas (Elerch) and Darren camp.
- Consider the use of airborne Light Detecting and Ranging (LiDAR) datasets for mapping inaccessible and difficult to survey landscapes in order to detect and map mine workings and settlements
- Conduct ground surveys of the sites using a portable x-ray fluorescence instrument (pXRF) to assess any remnants of metal workings which may have been utilized during this period. The handheld XRF provides significant potential as a new method for assessing local mineralisation and contaminants. Previous sampling techniques required time consuming laboratory processing of samples, while the handheld XRF provides fast in-situ measurements when combined with a GPS.

- Identify areas of raised metalliferous values in soil samples (above control points). Conduct acid digestion and Atomic Absorption Spectrometry (AAS) on sub samples to correlate Certified Reference Material (CRM) to local expected range of mineral values.
- Assess the geology and the mineralogy that underlie the hillforts.
- Use Geographical Information Systems (GIS) to process and produce geochemical maps overlaid on detailed monument surveys, as well as production of LiDAR views of the hillforts, to be undertaken with the Royal Commission as part of its involvement in the project. The Royal Commission will also directly supervise the fieldwork stage of the sampling and assist with GPS locations of the sample positions and subsequent topographic surveys of the hillforts.

The project proposal received letters of support from EADS Innovation Works, Pentir Pumlumon, Environment Systems and the Dyfed Archaeological Trust.

Summary of fieldwork strategies for XRF sampling

The research project required gridded surface sampling at three Iron Age hillforts in north Ceredigion sampling both the hillfort interiors where metal ores may have been imported and worked, together with sample areas of the hillfort environs and comparative sampling of neighbouring historic lead-silver mining areas, to assess background ore levels in the soil and historic mining factors.

In-situ sampling utilised the novel field method of the portable x-ray fluorescence instrument (pXRF), namely the Niton XLt 700 analyser. This pXRF is capable of taking direct readings of the metalliferous enrichment of soils associated with fire hearths, areas of smelting and other artefacts. Furthermore, it identifies the metals that have remained *in-situ*, due to their associated phases becoming immobile in anoxic conditions, or high cation exchange capacity associated with the glacial clays.

Because the pXRF scanner has to sample bare soil, it was necessary to seek Scheduled Monument Consent (SMC) from Cadw for the removal of small squares of turf and upper topsoil across the hillforts. In practice these typically extended c.7-10cm below the ground surface. SMC was duly given by Cadw for all three hillforts, subject to direct supervision of the work at all times by a member of staff from RCAHMW and the proviso that turf 'divots' would be rapidly replaced upon sampling. In areas of higher metal response, particularly the north terrace of Castell Grogwynion, limited small (teaspoon-sized) soil samples were taken away from site to be dried and re-tested under laboratory conditions to assess the degree to which soil moisture on site was effecting the pXRF readings. Excess water content can reduce the pXRF readings by 1 - 3 times due to x-ray dispersal, as such further rigor is applied by laboratory based atomic absorption spectrometry (AAS) as a comparison. The soil was mixed to create a homogeneous matrix and the pXRF placed on to the surface. The sample was subjected to ~120 second element fluorescence back scatter which the pXRF captures. This signature is displayed on the LED screen as parts per million (ppm) for all elements.

Data was downloaded in NDT software package and displayed as an Excel file. The final data, when presented, will not give detail of all the metals detected however, it represents the main elements (metals which are associated to the mining and the standard back ground level of manganese and iron which are ubiquitous). Control points were also taken at and below plough depth at distance and increased height to negate any spread of contamination. This served to identify the areas of enrichment and metal types.

A general sampling strategy of 5m or 2.5m sampling points was employed in blocks across all level or open areas of the hillfort interior, and key parts of the rampart interspace and exterior of the fort. Coupled with

this, more detailed 0.25m or 0.5m sampling was guided by assumptions pertaining to likely areas for prehistoric metal working within and around the hillforts. These included prominent locations within and around the forts where wind could usefully be channelled into a prehistoric furnace and where the working process would have been highly visible from afar, based on KH's experience of surveying prehistoric metal working sites in Jordan with a team from IGES. Detailed sampling was also focussed within discrete terraced areas of hillfort ramparts where, on the basis of past excavation results from Pen Dinas hillfort Aberystwyth (Forde *et. al* 1963) one would expect craft activities to be focussed and the more 'anti-social', smoky activities of metal working to be confined outside the immediate settled area of the hillfort.



Figure 2. The handheld pXRF Niton XLt 700 analyser, at Castell Grogwyion (Crown Copyright RCAHMMW).



Figure 3. Sampling in progress at Darren Camp (north-west outer terrace) showing peg line marking sampling point, and standard 7-10cm turf removal to subsoil depth for sampling. Turf square is 'hinged' up for easy reinstatement (Crown Copyright RCAHMMW).

Topographic survey and geophysical survey

Sample points were rapidly surveyed with a Leica Differential GPS (dGPS) which allowed all points to be subsequently displayed in a GIS or against 3D modelled LiDAR data (see Figures below) acquired by KH for the Masters study. An additional RCAHMW input to the study was the new topographic survey of both Pen Dinas (Elerch) fort and Castell Grogwynion to augment the topographic survey of Darren Camp completed in 2005 during Simon Timberlakes' excavations (Timberlake and Driver 2006). This work is still in progress at the time of this interim report's completion.



Figure 4. *Louise Barker (RCAHMW) undertaking the topographic survey of Castell Grogwynion, February 2012 (Crown Copyright RCAHMW).*

A final stage in the fieldwork at these three hillforts was the commissioning, by RCAHMW, of geophysics at Castell Grogwynion to follow up particularly good metal readings from the pXRF study. Archaeophysica were recommended by Simon Timberlake for their ability to target specialised caesium magnetometry at the hillfort to highlight potential furnaces or areas of burning. This was completed on 27th March 2012 with SMC. Results are awaited but first indications are that the survey has identified buried structures in the vicinity of two house platforms on the upper terrace of the hillfort.



Figure 5. Anne Roseveare of Archaeophysica undertaking caesium magnetometry at Castell Grogwynion, March 2012 (Crown Copyright RCAHMW).

Summary of fieldwork completed at the three scheduled hillforts.

Pen Dinas CD102

pXRF sampling was undertaken at Pen Dinas hillfort on the 14th-15th November 2011. 260 sampling points were taken at a variety of points within and around the hillfort. No significant evidence for metal working or smelting, or abnormally high metal levels above the background level, were detected within the hillfort despite a 1998 find of iron slag by TD from the interior. However, a geochemical map will be produced for the hillfort by KH following the sampling programme. It may be that any future pXRF sampling with permission to undertake substantially deeper sample holes up to 20cms into the subsoil could return better data. A new RCAHMW topographic survey is planned for 2012. Areas of erosion around the southern hillfort gateway had revealed the stub of a prehistoric wall and this is an additional area was sampling was focused.



Figure 6. pXRF sampling in progress at Pen Dinas hillfort, November 2011, with KH right with pXRF gun, Dr Harry Toland centre (Crown Copyright RCAHMW).



Figure 7. Pen Dinas, showing 260 sampling points overlain on hillfort (Crown Copyright RCAHMW).

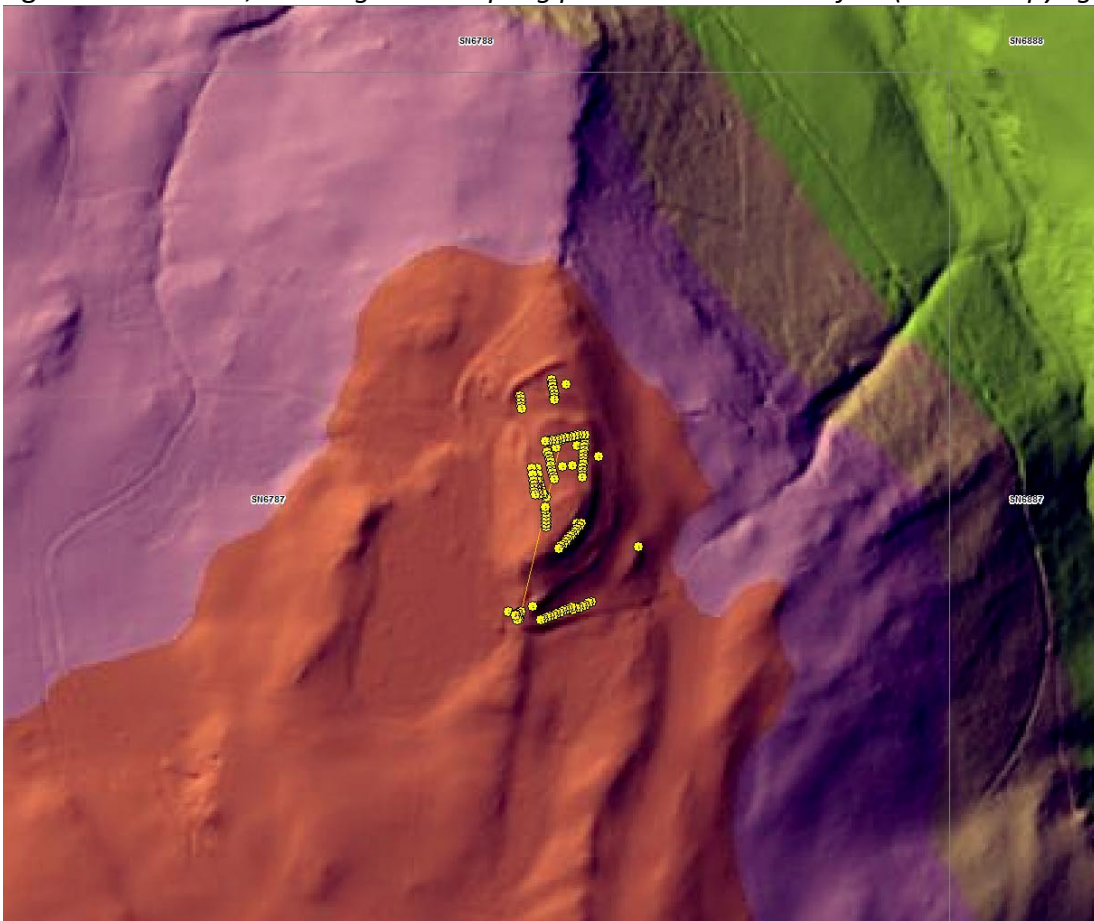


Figure 8. Pen Dinas. pXRF sampling points projected against 2m LiDAR data. (c) Crown. All rights reserved. Environment Agency, 2011. LiDAR data Environment Agency Geomatics Group. LiDAR view generated by RCAHMW. (Crown Copyright RCAHMW).

Darren Camp CD028

Darren Camp is the best studied and explored of the three hillforts under study (see Timberlake and Driver 2006), and previous work has included a new topographic survey by Louise Barker RCAHMW in 2006. Fieldwork was undertaken on the 7th-8th November 2011. Some 352 pXRF points were sampled in and around Darren Camp, with particular reference to the context of the surrounding mine opencuts and spoil tips. No significant evidence for metal working or smelting, or abnormally high metal levels above the background level, were detected within the hillfort despite the proven evidence for prehistoric exploitation of metal ores from the hillfort ditch. However, a geochemical map will be produced for the hillfort by KH following the sampling programme. It may be that any future pXRF sampling with permission to undertake substantially deeper sample holes up to 20cms into the subsoil could return better data.

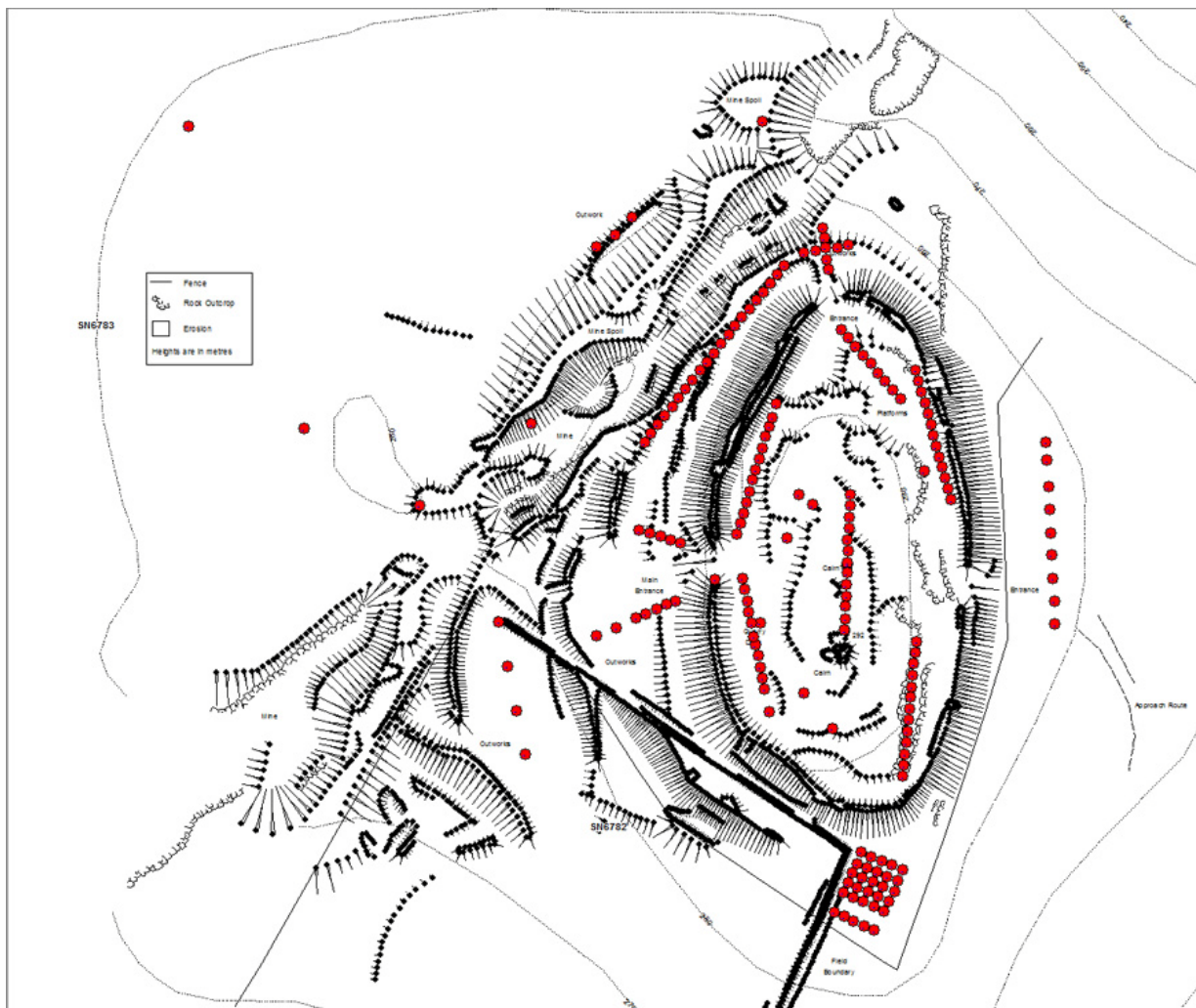


Figure 9. Darren Camp. pXRF sample points overlain on RCAHMW topographic survey (Crown Copyright RCAHMW).

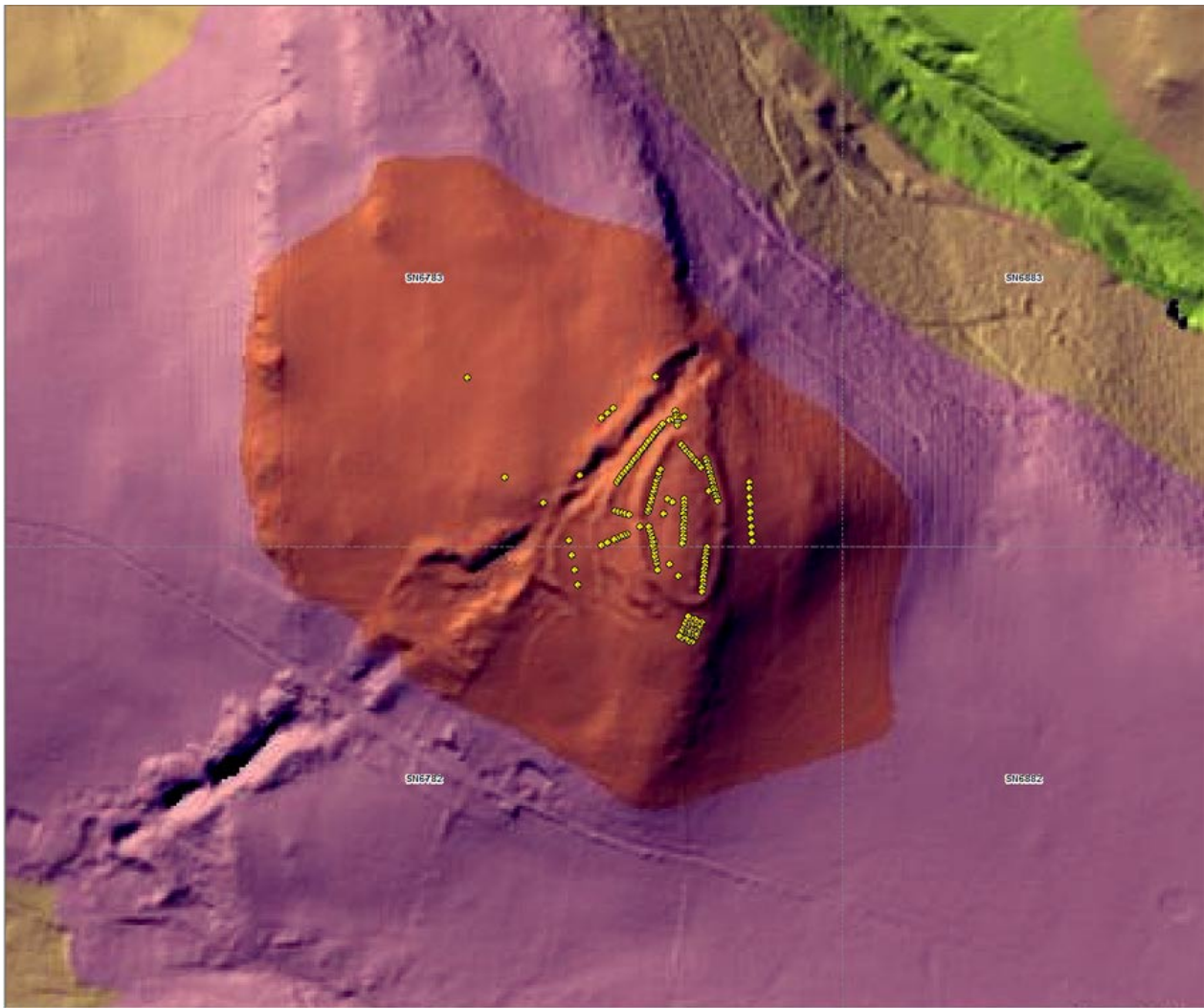


Figure 10. Darren Camp. pXRF sampling points projected against 2m LiDAR data. (c) Crown. All rights reserved. Environment Agency, 2011. LiDAR data Environment Agency Geomatics Group. LiDAR view generated by RCAHMW. (Crown Copyright RCAHMW).

Castell Grogwynion CD012

pXRF sampling was completed within the hillfort 31st Oct-1st Nov and on two subsequent visits. Around 200 sampling points were taken across the hillfort. High metal readings were noticed particularly on a prominent earthwork platform on the northern terrace of the fort, which coincided with a low earthwork mound within the terrace. This was re-sampled at a closer spacing given its potential as a focus for prehistoric metal working. The length of the northern terrace and upper west terrace of the hillfort interior, below the outcrop, were both surveyed with geophysics to follow-up the pXRF scanning and results are awaited (Figure 5). It is hoped that the denuded remains of two house platforms on the upper interior terrace will show more clearly from this geophysical survey.



Figure 11. Castell Grogwynion. 1:1000 GIS view of sampling points projected against the Iron Age hillfort. Only the 10m sampling intervals are shown for the main part of the hillfort interior and the north-west part of the terrace, but 2.5m samples were taken inbetween these points (Crown Copyright RCAHMW).

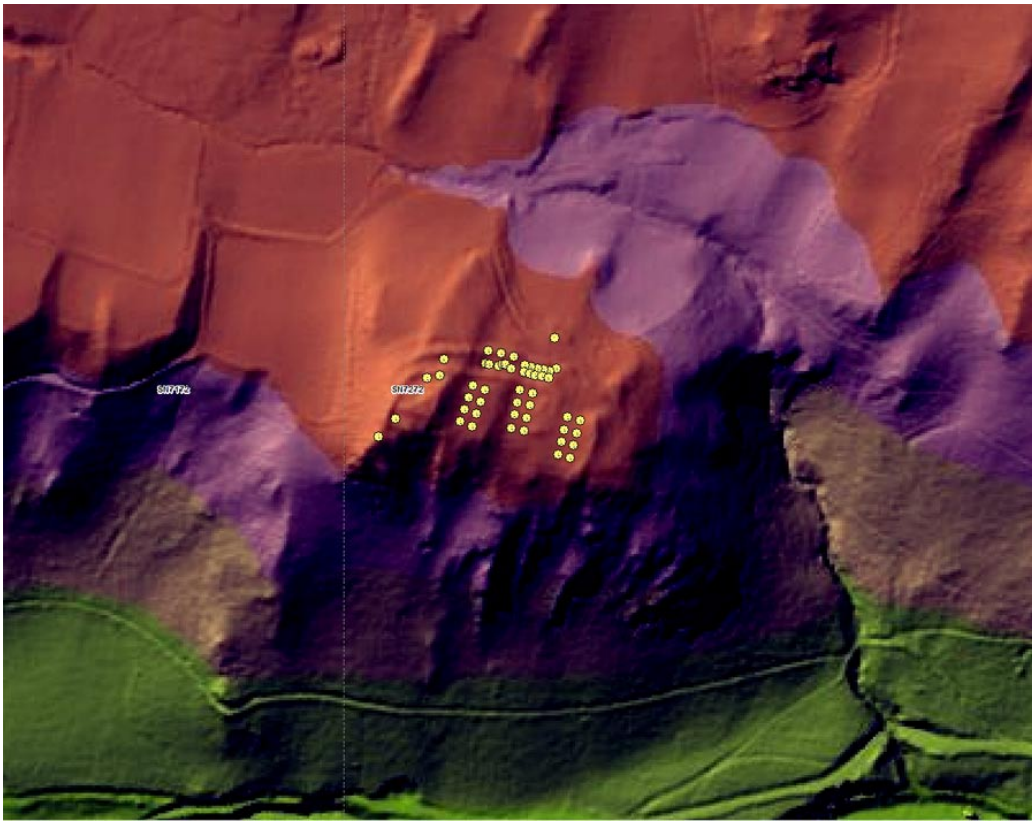


Figure 12. Castell Grogwynion. pXRF sampling points projected against 2m LiDAR data. (c) Crown. All rights reserved. Environment Agency, 2011. LiDAR data Environment Agency Geomatics Group. LiDAR view generated by RCAHMW (Crown Copyright RCAHMW).



Figure 13. Castell Grogwynion. KH undertaking pXRF sampling on the northern terrace. Sample points were excavated along a pegged and taped line (Crown Copyright RCAHMW).

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