Survey of Pen-y-gelli & Moel-dda

25 February 2022 & 15 March 2022

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1) Introduction

Pen-y-gelli (hill number 14710), or Pen-y-parc as it is labelled on the 1:50k Ordnance Survey map, lies about 5 kilometres west of Holywell. It is recorded as a Tump (a hill of thirty or more metres of prominence) in the Database of British and Irish Hills (DoBIH). The 1:50k map, (Fig1: courtesy Ordnance Survey) shows a 230m contour ring but no spot height while the 1:25k map (also courtesy Ordnance Survey) gives a 233m spot height. About 1km to the South-East lies another summit, Moel-dda, that also bears a 233m spot height on the 1:25k map. The col lies 2km to the East of Pen-y-gelli and is close to or within an area of housing in the village of Gorsedd. Figure 1 shows the relative positions of the two summits and the col while figure 2 is detail from the 1:25k map that shows the two spot heights.

Figure 1: The Relative Positions of Pen-y-gelli, Moel-dda and the Col

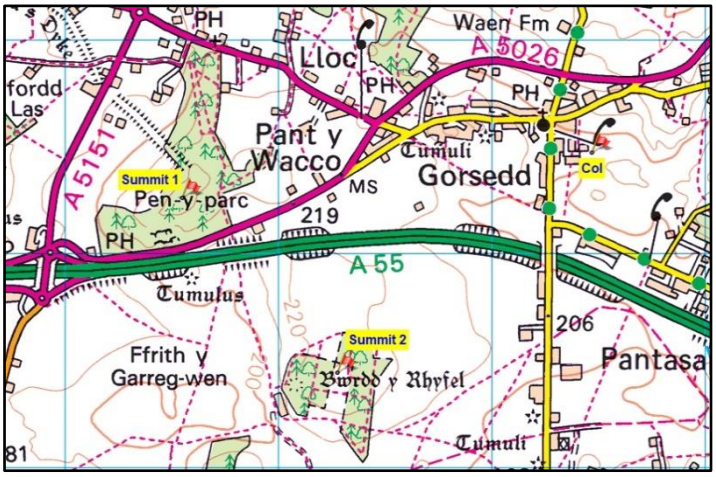
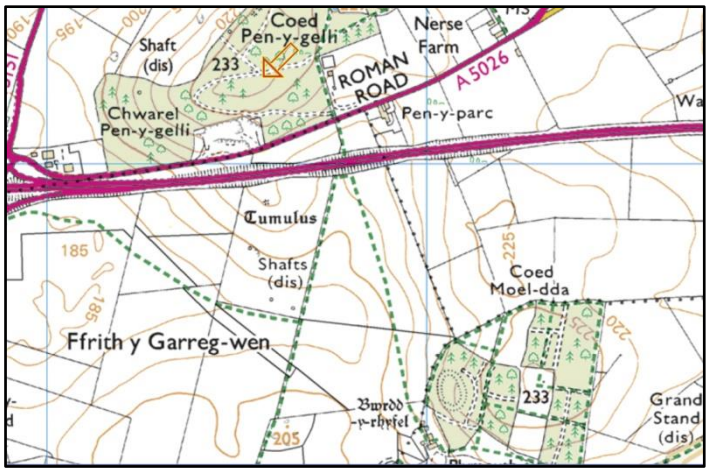


Figure 2: Relative Positions of Pen-y-gelli and Moel-dda with 233m Spot Heights



While both summits bear 233m spot heights, the drop between them is less than 30m so only one summit can have Tump status. Moreover, the drop to their nearest higher neighbour, as measured from maps, is only 30m, so whichever of these two hills is the higher, then that summit is on the borderline of qualification as a Tump. The purpose of this survey was to measure accurately the heights of the two summits and the drop in order to determine which hill is the higher and whether it qualifies as a Tump.

2) Equipment used and Conditions for Survey

A Leica NA730 Professional Automatic level (X30 telescopic system)/tripod system and a "1m" **E**-staff extendable to 5m were used to determine accurately the positions of the two summits and the position of the col.

Absolute heights were measured using a Leica Viva GS15 receiver. This receiver is a dual-frequency, multi-channel instrument, which means it is capable of locking on to a maximum of 12 GPS, 8 GLONASS satellites and Galileo satellites as availability dictates, and receiving two signals (at different frequencies) from each of these satellites. The latter feature reduces inaccuracies that result from atmospheric degradation of the satellite signals. As a stand-alone instrument, it is capable of giving position and height to an accuracy of about two metres and five metres respectively.

Note that small hand-held GPS receivers used for general navigation can only receive up to 12 GPS satellites 8 GLONASS satellites and each at a single frequency and therefore these instruments have a poorer positional accuracy of +/-5 metres and a height accuracy of no better than +/-10 metres.

Despite the on-board features of the Leica Viva GS15 receiver, there are still sources that create residual errors. To obtain accurate positions and heights, corrections were made to the GNSS (Global Navigation Satellite System) data via imported RINEX data from Ordnance Survey, which were post-processed using Leica Infinity v3.6.1.35335. Repeated 1hr measurements with the Leica Viva GS15 on the same position give a height precision of +/-0.06m (to three standard deviations).

The survey of the two summits took place on 25 February between 11.00hr and 15.30hr GMT. The weather was cool, 8 degrees Celsius, with a light wind. The survey of the col took place on Tuesday 15 March under similar conditions.

3) The Survey

3.1) Character of Hills

Pen-y-Gelli lies in a rural area that is used primarily for grazing cattle and sheep. The summit of the hill is covered in deciduous woodland and is a nature reserve. The reserve also encompasses an old limestone quarry which is home to a variety of lime-loving plants. A small parking area (for two cars) is situated on the A5025. The tree-cover on the summit is quite open and with a sparse understorey, thus allowing ready access. There are also several indistinct paths within the woodland which are not shown on either the 1:50k or 1:25k maps. Leaf litter is quite thick over many areas of the wood and this presents a challenge for locating candidate summit positions and for line surveying.

Moel-dda also lies within a rural locality and the summit, although itself open grazing land, is surrounded by conifer forest. Our route of access was from the East along public footpaths, also on grazing land which is used mainly for sheep, and then on an indistinct path through trees to emerge about 200m South of the summit, which is pasture. Note that the network of paths within the trees no longer exists despite the existence new stiles over the barbed wire fences.

3.2) The Summit of Pen-y-gelli

We first visited the grid reference given in DoBIH and set up the Leica NA730 level nearby. We then took a staff reading on this position and several other locations in order to determine the summit position. It was quickly determined that land to the East was gradually falling away as was ground to the West. Having thus established that the summit lay nearby we concentrated our efforts on finding the highest point in our immediate vicinity. We marked this summit position with a flag and took grid references with our hand-held Garmin receivers. Regrettably, the summit lay in a thicker area of trees and therefore we set up the Leica GS15 about 20m away by a wide pathway and measured the height difference (0.486m) between the two positions. At the set-up position there was a better view of the sky, although there were still tall trees in the vicinity (see photograph in the Appendix). We did consider setting up the Leica GS15 on a footpath about 700m to the east and out of the trees and carrying out a line survey between summit and set-up position. However, this would have been a significant challenge considering the softness of the ground and the thick layer of leaf litter. The Leica GS15 was set up on a tripod with an offset of 0.654m plus 0.255m for the tape holder (see photograph in the Appendix) and data collected for 1hr. It was noted that the Leica GS15 took a few minutes to lock on to satellites and start collecting data, due to the presence of the trees. GNSS data were collected for one hour with an epoch time of 15 seconds. The data were processed in Leica Infinity version 3.6.1.35335 using the ten nearest base stations.

Regrettably, the presence of the trees had affected data collection and automated processing gave a result calculated only from the St Asaph base station. Consequently, the data were interrogated in more detail and results from each of the ten base stations calculated. The results are shown in the table below.

Base Station	GS15 Ortho Height	Ht Correction	Ortho Ht Summit
(m)	(m)	(m)	(m)
ASAP	232.8609	0.486	233.3469
BLAP	233.2932	0.486	233.7792
CREW	233.1791	0.486	233.6651
DARE	233.0000	0.486	233.4860
HOLY	233.2043	0.486	233.6903
LEEK	233.0567	0.486	233.5427
MACY	233.1731	0.486	233.6591
MANR	233.1440	0.486	233.6300
SHRE	233.0841	0.486	233.5701
STON	233.2147	0.486	233.7007

Clearly there is much more spread in the results than there would be under clear sky conditions with the mean value being 233.607m. The standard deviation for the full dataset is 0.12m.

Regrettably, the presence of the trees has had a significant effect on the quality of the data as we would normally expect a 1SD of about 0.02m for height measurements from a 1-hour collection time.

Hand-held GPS readings for the summit position are:

Garmin Oregon 450: SJ 13542 76250 SJ 13540 76247
Garmin Oregon 450: SJ 13545 76250 SJ 13543 76247

3.3) The Summit of Moel-dda

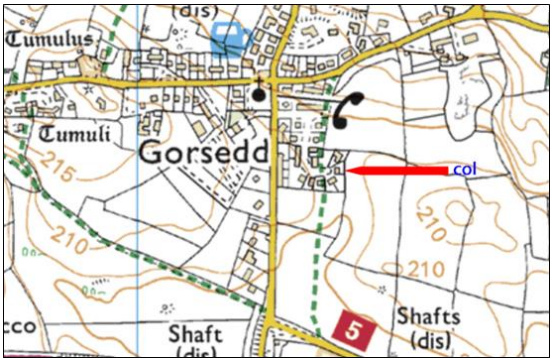
Moel-dda was approached from the east on the footpath that leaves the road south from Gorsedd at SJ 1526 7516. The path crosses fields to enter the trees that surround the hill at SJ1443 7517. After 150m of scrub and trees a style gives access to the hill the summit which is then just 200m to the north. The summit itself is on well cropped grass and well clear of the surrounding forestry. The level and staff were used to locate the exact summit position and then the Leica GS15 was set up over the summit. The offset was 0.583m plus 0.255m for the tape holder (see photographs in Appendix 1) and data collected for one hour with an epoch time of 15 seconds. The data were processed in Leica Infinity version 3.6.1.35335 using the ten nearest base stations.

System	Easting	Northing	Height(m)
GS15	314,277.585	375,441.784	231.903

The height of Moel-dda is 231.90m. This is 1.7m lower than the measurement for Pen-y-gelli.

3.4) The Col of Pen-y-gelli

The survey of the col took place on 15 March 2022. On our previous visit to survey the two summits, we sought permission to survey the col from the owner of the land on which the col stood. Permission was granted and after approximately three weeks of waiting for a suitable window in the weather we returned to investigate the col. The area in which the col lies comprises fields of grass and housing.



It was quickly established from a visual inspection that the col lay close to the fence bordering the houses on the eastern or southern boundary of the complex. The col position was then found using the level and staff and it lay on the eastern edge and by the fence. Ground just over the fence in the garden of the adjoining property was flat and of the same height by visual inspection. A reconnoitre of the boundary to the housing led us to the conclusion that, prior to the development, the col might have lain a few metres further to the west of our position. In the process of building the houses however, the ground in the area had been flattened in preparation for building. The photograph in the Appendix shows our set-up position for the Leica GS15 over the position of the col and close to the boundary of the adjoining bungalow. The offset was 0.683m plus 0.255m for the tape holder

(see photograph in Appendix) and data were collected for one hour with an epoch time of 15sec. The data were processed in Leica Infinity version 3.6.1.35335 using the ten nearest base stations.

System	Easting	Northing	Height(m)
GS15	315,392.419	376,506.451	202.989

The drop measured for Pen-y-gelli is 233.607 – 202.989 = 30.618 +/- 0.38m (to 3SD**)**.

4) Summary of Operating Conditions

	GS15
Data Collection at col (min)	72
Data collection on Pen-y-Gelli (min)	79
Data collection on Moel-dda (min)	64
Number of Base Stations used in Processing (9 for Pen-y-gelli)	10
Epoch Time (sec)	15
Tropospheric Model	VMF with GPT2
Cut off Angle (degs)	15
Geoid Model	OSGM15

5) Discussion of Results

For GNSS results from the Leica Viva GS15, a 1-hour data collection time gives results with a measurement uncertainty of +/-0.06m (3SD) where there is a clear view of the sky. This measurement uncertainty applies to Moel-dda and to the col. For Pen-y-gelli the measurement uncertainty is +/-0.12m (1SD) and +/-0.36m (3SD) the higher value is the result of the trees interfering with reception of the satellite signals. The measurement uncertainty in height associated with the location of the summit is estimated to be +/-0.01m for Moel-dda, +/-0.1m for the col (the housing development could not be investigated rigorously) and +/-0.05m for Pen-y-Gelli (leaf litter).

Combining the uncertainties estimated above we give the overall values as: -

Pen-y-gelli – [square root (0.36^2 +0.05^2] = +/-0.36m (3SD)

Moel-dda – [square root (0.06^2 +0.01^2] = +/-0.06m (3SD).

Col - [square root (0.06^2 +0.1^2)] = +/- 0.12m (3SD).

Drop - [square root (0.36^2 + 0.06^2 +0.12^2)] = +/-0.38m (3SD).

The drop for Pen-y-gelli calculates to be 233.607m – 202.989m = 30.62m with an uncertainty of +/- 0.38m (to 3SD).

6) Summary and Conclusions

The **summit** of **Pen-y-gelli** is at grid reference * **SJ 13542 76247** and is ground within trees with no distinguishing feature. Its height is **233.61m+/-0.36m**.

The **col** of **Pen-y-gelli** is at * **SJ 15392 76506** and is unfeatured ground by a fence. Its height is **202.99m+/-0.06m**.

The **drop** for **Pen-y-gelli** is **30.62m+/-0.38m** and consequently this hill remains classified as a **Tump.**

The **summit** of **Moel-dda is at grid reference *SJ 14277 75441** and is ground in a field of well cropped grass**. The height of Moel-dda is 231.90m+/-0.06m** which is lower than **Pen-y-gelli** and therefore **Moel-dda** is unclassified.

- NB: Grid references for OSTN15 are quoted in the summary.

John Barnard and Graham Jackson, 23 May 2022

Appendix 1

The set-up position of the Leica GS15 on Pen-y-gelli

(the true summit is 20m to the left of the set-up position above)

Tape reading for Leica GS15 on Pen-y-gelli

Leica GS15 collecting data on Moel-dda

Tape Reading for Leica GS15 on Moel-dda

The Leica GS15 set up on the col

Tape reading for Leica GS 15 set up on col