

# Survey of the Basteir Tooth

**13<sup>th</sup> September 2013**

The Team:

SMC: Andy Nisbet, Noel Williams

TMS: Alan Brook, Colin Walter

G&J Surveys: John Barnard, Graham Jackson, Myrddyn Phillips

## 1) Introduction

The Basteir Tooth (NG465252) is in Section 17B of the list of Munros in the 1997 SMC publication of Munro's Tables, where it is given as a Munro Top of Am Basteir. It was not included in the first edition of Munro's Tables in 1891, but first appeared in the 1921 Tables and has been in all subsequent editions. It is found on OS 1:50k Map 32 and 1:25k Map 411 and neither map gives a spot height for the summit. Originally its height was given as 3000ft app from careful aneroid measurements made by Dr Norman Collie and others and this height was reproduced in subsequent Tables until 1974, when heights of 3000ft app (1 inch map) and 3005ft (6 inch map) were given. The 1981, 1984 and 1990 Tables all give c914m. Finally the 1997 Tables list the height as 916m. It may be concluded that the Basteir Tooth is very close to 3000ft (914.4m) and that no photogrammetric height measurement is available on modern maps. The summit position of the Basteir Tooth is not in doubt. Its precipitous rock walls converge at an acute angle to a very sharp point and provide a very exposed position from which to view the complexity of the northern section of the Skye Black Cuillin ridge.

The purpose of this survey was to determine the height of the Basteir Tooth accurately using the technique of differential GPS, which is capable of determining heights to less than 0.1m.

## 2) Equipment used and Conditions for Survey

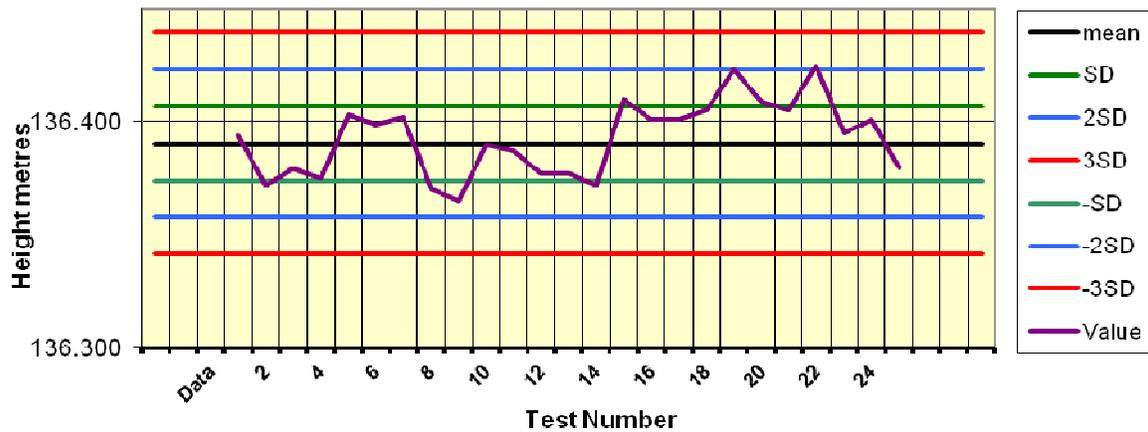
An Abney level was used to set up the GPS receiver to the summit position. We usually use a Leica NA730 automatic level and staff for this purpose but for the Basteir Tooth this equipment was not carried; the bulky tripod and staff were not compatible with the terrain of the chosen approach route.

Absolute heights were measured using a Leica Geosystems Viva GS15 Professional receiver. This is a dual-frequency, multi-channel instrument, which means it can lock on to a maximum of 12 GPS and 8 GLONASS satellites and receive two signals (at different frequencies) from each of these satellites. The latter feature reduces inaccuracies that result from atmospheric degradation of the satellite signal. 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 a hand-held GPS receiver can only receive up to 12 GPS satellites and each at a single frequency and therefore it has a poorer positional accuracy of +/-5m and a height accuracy of no better than 10 metres. Some recently produced hand held GPS Garmin receivers can also receive signals from GLONASS satellites which greatly improve the speed at which these units can achieve a satellite "fix". Despite the on-board features of the Viva GS15 receiver, there are still sources that create residual errors. To obtain accurate positions and heights, corrections were made to the data via imported RINEX files from Ordnance Survey which were post-processed using Leica Geo Office 8.3 software. Heights were also determined by Ordnance Survey who processed the data

using Bernese Software. This is state-of-the-art software and is recognised to produce definitive results, but the differences between results calculated by Bernese and by Leica Geo Office 8.3 are usually no more than 2-3cm for height measurements. Both ours and the Ordnance Survey results are given in this report.

We regularly check the functioning of the Leica Viva GS15 against Statistical Quality Control (SQC) charts generated for a marked position. The chart associated with height measurement is shown below. The mean height above Ordnance Datum Newlyn (ODN) for a fixed point (measured on 20 different occasions for 30mins of data collection at each time) was calculated to be 136.391m. Further height measurements have been made at this point on separate occasions over a period of 12 months using the same process parameters. The last and penultimate measurements were carried out after and before the mountain surveys described in this report. The results shown on the graph are all within a range of +/- two SD (Standard Deviation), in this case one SD is +/-0.016m. This demonstrates that our Leica Viva GS15 receiver is giving consistently precise results within the expected range of uncertainty for the measurements.

**SQC Chart for GS15 Height Measurement**



In addition, we check the instrument periodically by taking measurements on an Ordnance Survey Fundamental Bench Mark, processing the data and comparing it with the OS derived values. Height should agree within about 0.05m. The latest two measurements are given in the table below.

Processing	Height(m)
OS measurement	73.24
JB/GVJ GeoOffice 7	73.22
JB/GVJ GeoOffice 7	73.22

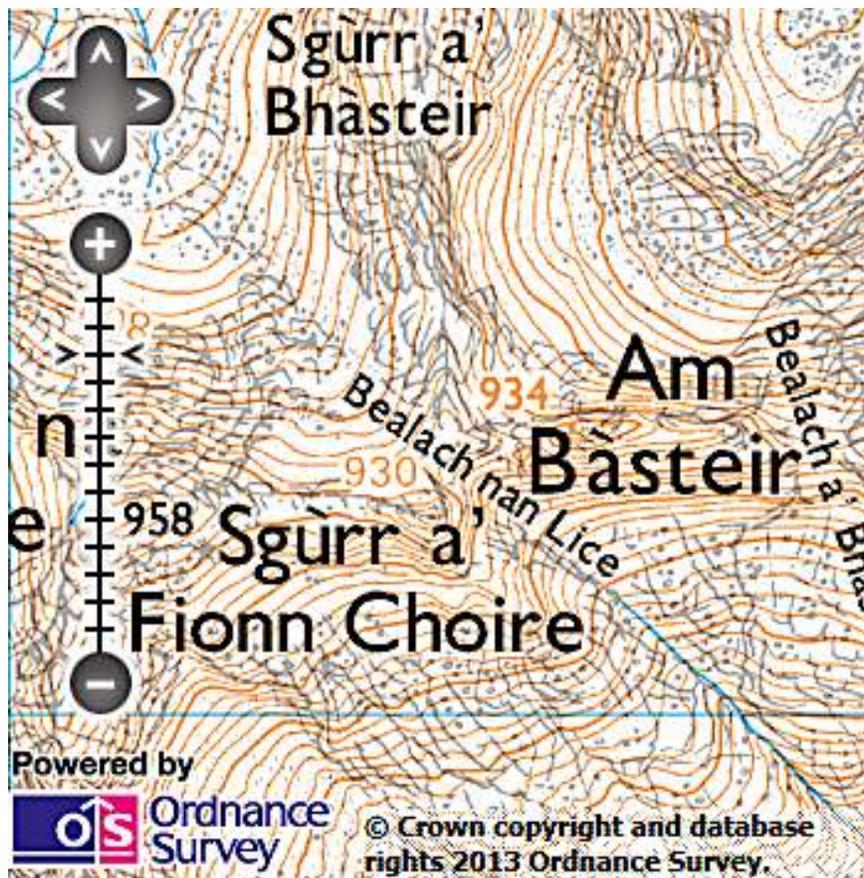
Conditions for the survey, which took place between 13.00hr and 15.00hr, were fair. Mist covered the upper regions of the mountains at first and there were two light showers of rain, but in between the showers conditions were clear. It was also mild with a temperature of about 12 degrees Celsius and crucially the wind was light. Even moderate winds would have curtailed the survey because of the exposed position in which the GPS receiver was placed.

### 3) The Survey

#### 3.1) Character of the Mountain and Route

The Basteir Tooth is part of the Black Cuillin of Skye, a 12km long ridge of black gabbro which provides excellent rock climbing and arguably the finest mountain scenery in Britain. The rock is magnetic and the terrain complex and consequently route finding can be a major problem in mist for those unfamiliar with the ridge.

The Basteir Tooth lies just to the west of Am Basteir and is a prominent feature from Sligachan where it is seen as a sharp projection jutting at an improbable angle from its parent. It was first climbed from Lota Corrie in 1889 by Dr Norman Collie and this route now bears his name. It is classed as a Moderate rock climb and follows a gully all the way to the bealach between The Tooth and Am Basteir. There are several slabs and chimneys to be negotiated on the ascent of just over 100m and the route is the easiest, but longest, that gives access to the summit. The route chosen for



this survey was more direct and therefore quicker, but it was also more technical and was chosen by Andy Nisbet and Noel Williams as being within our capability. We started on the 'tourist path' for Sgurr nan Gillean that leaves the road just south of the Sligachan Inn and passes over a bridge across the Allt Dearg Mor. After 1.5km and 100m of gentle ascent the path then uses a bridge over the Allt Dearg Beag before ascending once more to a cairn and a fork in the path. The right fork is taken up a faint but obvious path over outcrops of rock towards the base of Pinnacle Ridge. It then bears right under the ridge on steep scree. Although an apparently improbable route the path is in

fact well marked and remarkably stable underfoot and gives quick access to the ridge just above the bealach between Sgurr nan Gillean and Am Basteir. From here it is a steep but straightforward climb to the ‘bad step’ on Am Basteir. This was negotiated with the aid of a rope and the summit of Am Basteir then attained. From the summit the route descends for about 10m to a gully from which we abseiled to a position just above the bealach between Am Basteir and The Tooth and from here it was just a short, steep walk to the summit of The Tooth. The route down after completion of the survey was via King’s Cave Chimney. King’s Cave is to be found at the bealach between Am Basteir and The Tooth where a narrow entrance between large boulders gives access. A few metres of subterranean scrambling then leads to a chamber overlooking Coire a’ Bhasteir, from which an 80ft abseil leads to the corrie below. From there a path beneath the cliffs of Am Basteir leads into the corrie and thence to a path on the west side of the Allt Dearg Beag. The outward route is finally rejoined after a further 2km.

**3.2) Summary of Survey Method**

The summit of the Basteir Tooth is obvious and the detail of the survey is described in the next section.

**3.3) The Survey of the Basteir Tooth**

On reaching the summit our first task was to assess the options open to us in the limited space available. The summit comprises a boulder perched on the bedrock of The Tooth. This boulder has approximate dimensions of 1m by 0.6m by 0.6m and probably weighs about two metric tonnes. Consequently, it cannot be moved by unaided human effort and was therefore deemed to be part of The Tooth. Those wishing to learn more about our protocols for dealing with situations such as this one, and where man-made features are to be found at a summit or col, are referred to our document ‘Summits and Cols’. Recognising that some may challenge this assessment, we also measured the height difference between the summit of the boulder and the highest point of the bedrock. It was not possible to set up the GPS receiver on the summit of the boulder and so it was mounted on a small tripod adjacent to the boulder. An Abney level was used to determine the height difference between the set-up position of the receiver and the summit and the height difference between the receiver and the highest point of the bedrock. The horizontal distance between the receiver and the top of the boulder was less than a metre.

In all, 2hr of data were collected on the summit.

The ten-figure grid reference for the summit using hand-held GPS is:-

Garmin Etrex 20	NG 46513 25268	Accuracy 4m Height = 919m
Garmin Oregon 450	NG 46513 25268	Accuracy 4m Height = 921m

The GPS data were processed with the Leica GeoOffice Version 8.3 Software. RINEX correction data were imported from the Ordnance Survey Website for the 6 nearest Active Base Stations (Loch Carron – LCAR 48km, Arisaig – ARIS 43km, Fort Augustus – FAUG 92km, Tiree - TIRE 93km, Barra – BARR 85km and Benbecula – BENB 75km). We used Broadcast Ephemeris data received by the GPS during the survey rather than Precise Ephemeris data, since we have found this makes little difference to the height results. The computed Tropospheric model was chosen for the calculations to suit the data collection times and the wide difference in height between the base stations and the summit of the mountain.



## 5) Summary and Conclusions

The **summit** of the Basteir Tooth is a boulder at grid reference \* NG 46513 25268. The height of the Basteir Tooth is **917.16+/-0.06m or 916.55+/-0.06m** if the bedrock is taken.

The survey has shown the Basteir Tooth to be above 3000ft and so on this criterion should retain its status as a Munro Top.

\* NB for the convenience of walkers using a hand-held Garmin/Magellan GPS, grid references quoted in the summary are from these instruments.

John Barnard, Graham Jackson and Myrddyn Phillips, 21 September 2013.

### Acknowledgement

Thanks are due to The Munro Society who commissioned the survey and to Ordnance Survey and especially Mark Greaves for processing our data files through Bernese software to give us the most accurate solution to the datasets. We are also indebted to Andy Nisbet and Noel Williams whose leadership and expertise on the climb made the survey possible.

**Appendix 1 – Photographs of the GPS receiver set up on the summit of the Basteir Tooth**

**Alignment of Leica Viva GS15 on summit**



**Leica Viva GS15 in position**



**The team setting out for the Basteir Tooth**



**King's Cave Chimney**



**The team on the Tooth**

