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“The initial triangulation of Scotland  
from 1809 to 1822”

*David L Walker*

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## ***The initial triangulation of Scotland from 1809 until 1822***

***David I Walker***<sup>1</sup>

### ***Introduction***

Whereas detailed progress reports were published on the first Trigonometrical Survey of England and Wales,<sup>2</sup> including its extension into the Scottish Borders in 1809, little more was published on the triangulation of Scotland until the substantial report on the principal triangulation of Great Britain and Ireland<sup>3</sup> published in 1858. From this report it emerges that many of the observations made before 1823 were superseded in the 1840s or discarded by 1858. Surprisingly, the diagram of the principal triangulation shows very few of the stations adopted as county meridians for the first topographical surveys of Scotland.

*A history of the Ordnance Survey*<sup>4</sup> observes that ‘there is little detailed information about the work between 1810 and 1822’ (after which survey work was diverted into Ireland until 1838) and that ‘a complete list of the stations does not exist’ – although it does provide a provisional list of trigonometrical stations occupied in Scotland between 1813 and 1822.

This article draws upon a little noticed ‘sketch diagram’<sup>5</sup> in the National Archives at Kew to complete this list and (on pages 14-15) to illustrate these trigonometrical stations, and to explore aspects of the initial<sup>6</sup> triangulation of Scotland by reference to official reports and to the illuminating but fragmented information available from other sources.

### ***The triangulation of Scotland***

After 1809 William Mudge, then Superintendent of the Ordnance Survey, left the Scottish survey in the charge of Thomas Colby, who succeeded him as Superintendent in 1820. After Colby returned from Ireland to Scotland in 1838, the triangulation of Northwest Scotland and the Western Isles was completed within a few years. But Colby had become concerned that the triangulation of Great Britain did not meet geodetic requirements and for the 1840s set in hand a new series of observations from the peaks of Britain and fresh observations from many of the stations occupied previously.

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<sup>1</sup> The author is a retired civil engineer whose family history research has been enriched by the resources of the map library of the National Library of Scotland.

<sup>2</sup> William Mudge and Thomas Colby, *An account of the trigonometrical survey, carried on by order of the Master-General of his Majesty's ordnance, in the years 1800-1809*, London, 1811.

<sup>3</sup> *Account of the observations and calculations of the principal triangulation etc*, Drawn up by Captain Alexander Ross Clarke under the direction of Lt Col H James etc, Ordnance Survey: London, 1858.

<sup>4</sup> WA Seymour (ed), *A history of the Ordnance Survey*, Folkestone: Dawson, 1980, 37-38.

<sup>5</sup> The National Archives, MFQ 1/269/13, 1834 (described under footnote 8 below).

<sup>6</sup> Seymour defines the fieldwork largely completed by 1841 as ‘the primary triangulation’ and that added in the 1840s and recalculated in the 1850s as ‘the principal triangulation’. This article uses the title ‘initial triangulation’ to describe the work carried out before the long hiatus between 1823 and 1838.

William Yolland became responsible for bringing this work together, but, after Colby retired in March 1847, he failed to get on with Colby's successor, Lewis Hall, and Yolland was sent to Ireland in November 1852. After a gap of nearly two years, it was fortunate that the talented Alexander Ross Clarke emerged to complete the trigonometrical calculations in impressive style, but only by discarding observations from many of the stations occupied over the previous years. Hence the progress of the initial triangulation can be understood only by reference to a sequence of diagrams (*from which extracts are shown opposite*):

**Mudge 1811**<sup>7</sup> This diagram, of a very high standard, shows precise triangles extending into the Scottish Borders. It accompanied the 1811 report (*footnote 2*).

**Colby 1834**<sup>8</sup> Described as a 'sketch diagram', this accompanies an internal Board of Ordnance investigation into the progress of the survey in Great Britain.<sup>9</sup> As the trigonometrical stations (in Scotland) are annotated upon a much earlier map, it does not pretend to show the triangles accurately.

**Yolland 1852?**<sup>10</sup> This previously undated 'Diagram showing the Principal Triangulation for the Ordnance Trigonometrical Survey of Great Britain and Ireland' has the same title and is drawn within the same coastline as *Clarke 1858* (below), but at a larger scale (c 13 miles to the inch). Those stations which are shown on both diagrams appear to be plotted in the same position. Although it includes considerably more stations than the 1858 diagram, the undated diagram appears to reflect the position in 1852, as observations made from Goat Fell in 1852 are shown but not additional observations made from Brandon Down in 1853.

The status of this excellent resource apparently remains to be determined. Perhaps it was commissioned by Alexander Ross Clarke after his arrival at Southampton in 1854. But it seems more likely that it was maintained under the direction of William Yolland until his departure in November 1852. It shows stations and observations which were discarded in Clarke's calculations and it usefully distinguishes observations made in only one direction.

**James 1856**<sup>11</sup> A small scale diagram showing 'The principal triangulation with adjustment figures' was first published in 1856 in a paper to the Royal

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<sup>7</sup> *Diagram of the great triangles in the trigonometrical survey of England & Wales, with the heights of the several stations etc*, R Wilkinson, London, 1811, © The British Library Board, Maps 1175(39).

<sup>8</sup> Maps [extracted from T 1/4060] illustrating 'Precis of the progress of the Ordnance Survey of England and Wales [sic] 1783-1834 by Thomas Colby Lt Col RE: Item 13 Bowles's New one sheet map of Scotland [Published c 1780]. Coloured MS additions show the Ordnance Survey principal triangulation. Additional MS notes by Hastings F Murphy Lt RE 9 Jan 1834. The National Archives, MFQ 1/269/13.

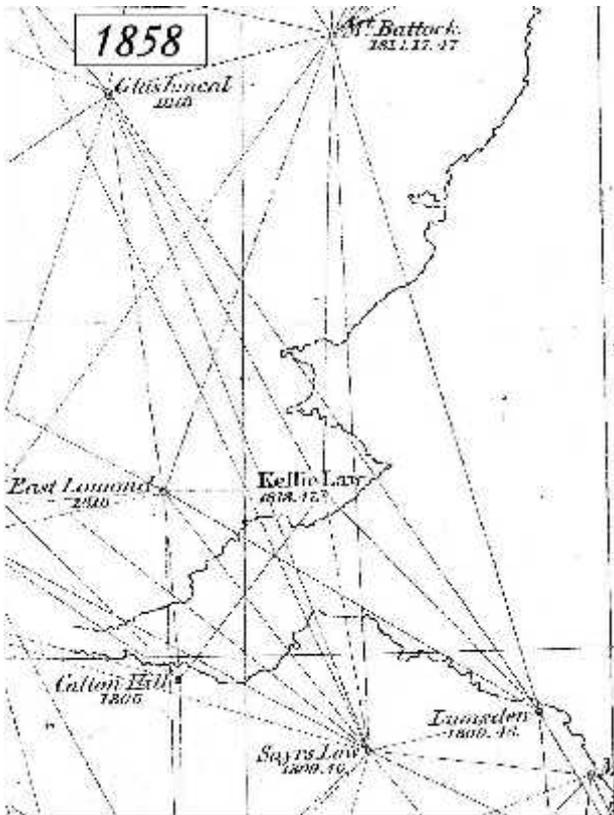
<sup>9</sup> For this (and several other corrections) the author thanks Richard Oliver.

<sup>10</sup> *Diagram showing the principal triangulation for the Ordnance trigonometrical survey of Great Britain and Ireland*, Southampton [1852], © The British Library Board, Maps 1101(15).

<sup>11</sup> *Account of the observations and calculations of the principal triangulation etc*, Drawn up by Captain Alexander Ross Clarke etc, London, 1858, © The British Library Board, Maps 207.b.5, vol 2, plate XVIII.



Society attributed to Lt Col James<sup>12</sup>. It was reprinted (slightly amended) as plate XVIII of the 1858 report (*footnote 3*) and much later as plate 11 of Seymour (ed), *A history of the Ordnance Survey*, 1980.



**Clarke 1858**<sup>13</sup> (*extract left*)

Of a similar cartographical standard to *Mudge 1811*, this diagram shows the stations selected by Clarke for his recalculation of the principal triangulation and the dates they were occupied, but it does not show the many stations which were discarded, even those that are listed in the 1858 report (where it is published as plate XXVIII)..

**Diagram of the initial triangulation (as now illustrated)**

The following rules have been adopted in preparing the diagram on pages 14-15 to illustrate the chronology of the initial triangulation from 1809 until 1822:

1. The 'great stations' marked **●** (already observed) or **+** (proposed for completion) are exactly those shown on MFQ 1/269/13 (described here as *Colby 1834*).
2. Sides of triangles shown in full lines are exactly those shown on *Colby 1834*.
3. The coastline and location of stations shown on *Clarke 1858* accords with *Clarke 1858*.
4. Other relevant stations marked **x** are added to show links with England and Ireland.
5. Stations 'proposed for completion' are named (or not) in accordance with *Colby 1834*.
6. The names and location of other stations were deduced from the bearings detailed in the Report of 1858, aided by *www.trigpointinguk.com* website (for the current status of these sites, and for grid references and spot heights, assistance which is gratefully acknowledged).
7. Dates of occupation (by the theodolite) were taken from Seymour (where listed), and from *Yolland 1852?* and *Clarke 1858*, and in a few cases deduced as described below.

<sup>12</sup> Plate following 'On the figure, dimensions, and mean specific gravity of the Earth, as derived from the Ordnance trigonometrical survey of Great Britain and Ireland communicated by Lt Col James RE FRS &c Superintendent of the Ordnance Survey', *Phil. Trans. R. Soc. Lond.* 1856, vol 146, 607-626.

<sup>13</sup> *Diagram showing the principal triangulation for the Ordnance trigonometrical survey of Great Britain and Ireland*, Southampton, around 1858, © The British Library Board, Maps X.8003.

8. A few 'sides', not shown on *Colby 1834*, but found to have been observed by 1817, have been added (in broken lines) to show how some early triangles were completed.

### ***Colby's modus operandi***

In 1805 Mudge had instructed Colby 'Don't make a practice of going to all three points of every triangle, if observations made at two of them will be sufficient. Work round spires, staffs on mountains or any other proper objects, that the Survey may get on rapidly'<sup>14</sup> Thus, in 1808 and 1809, both Skiddaw and the Cheviot provided 'pivot points' which were observed from several directions without being occupied by the theodolite. Apparently a single artilleryman had to journey ahead to set up each staff, until in 1818 Colby decided that 'I have been compelled to send two men together instead of one to erect the objects, and the allowance of 2s 6d each object heretofore granted is become obviously too small. I have, therefore, to request that you will sanction me to raising it to 3s 6d each object.'<sup>15</sup>

Dawson<sup>16</sup> provides a useful clue to Colby's reconnaissance of potential survey stations. On the mail coach 'neither rain nor snow .... would induce him to take an inside seat .... but muffled in a thick box coat [he travelled] with his servant Fraser, an old artilleryman, at his side'. But Colby also travelled astonishing distances on foot, as described below for 1819.

### ***Trigonometrical survey of Scotland 1809-1814***

From the detailed information in the report of 1811 it is possible step by step to trace and, for those so inclined, to re-calculate the extension of the triangulation from northern England into Scotland in 1809, when observations were made from Criffel, Wisp Hill, Sayrs Law and Lumsdane Hill, reaching as far north as East Lomond and Largo Law beyond the Firth of Forth.

When the Scottish survey was resumed in 1813, Colby was at first mainly pre-occupied with 'sector observations' – the measurement of latitude by stellar observations – at Kellie Law, north of the Firth of Forth, and Cowhythe, south of the Moray Firth. In the following year, Colby with James Gardner linked up these stations by triangulation, for which the stations listed by Seymour as observed in 1814 would have been insufficient without the addition of Bruxiehill and The Buck, both shown on *Colby 1834*. Alva (now Hill of Alvah) and Manar Lee (now Hill of Maunderlea) were also occupied in 1814, apparently in support of the sector station at Cowhythe.

### ***Trigonometrical survey of Scotland 1815-1818***

In 1815, Colby remained in London, putting Gardner in charge of observations which 'commenced on Bengairn Hill, near Kirkcudbright, and concluded on the Black [sic] Carrick Hill, near Ayr; thus completing the connection between

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<sup>14</sup> Mudge to Colby, 9 July 1805, quoted in Sir Charles Close, *The early years of the Ordnance Survey*, 1926; republished with an introduction by JB Harley, Newton Abbot: David & Charles, 1969, 56.

<sup>15</sup> Colby to Mudge, 24 July 1818, quoted in Close, *The early years of the Ordnance Survey*, 86.

<sup>16</sup> As reported in JE Portlock, *Memoir of the life of Major-General Colby*, London, 1869, 132.

Cumberland, the Isle of Man, part of the coast of Ireland, and the south-west of Scotland as far as Ayr.<sup>17</sup> As Seymour's list shows only Glasserton and Brown Carrick occupied in 1815, and as Gardner's work provided the basis for the first topographical surveys of Scotland<sup>18</sup>, the following description is of interest in illustrating the strategic position of Bengairn:

'The great road from London to Portpatrick runs along the north-western margin of the Carlinwark Loch ... with the magnificent background of Dungyle, the Skreel, and Bengairn. .... From Bengairn, when the state of the atmosphere is favourable, the view is remarkably beautiful and extensive..... the eye naturally rests upon the lofty Cairnsmuir of Carsphairn, overlooking the Kells range of mountains, which separates the stewartry from Ayrshire .... on the east and northeast are seen Criffel and Queensberry Hill .... to the west Cairnharra and Cairnsmuir of Fleet and the Isle of Man ... and to the south the bold outline of the Cumberland mountains and the towns and villages that adorn the coast of England.'<sup>19</sup>

To triangulate Brown Carrick from Glasserton, Gardner needed to occupy intermediate stations (shown on *Colby 1834*) at Mull of Galloway, Carn Piot, Benereard and Saugh, making good use of volcanic outcrops within sight of the coach road, together with more remote stations on the summits of Merrick and Cairnsmore of Deugh (later known as Cairnsmuir of Carsphairn). Whereas Merrick may have been used only as a 'pivot point' (until it was occupied for ten weeks in 1852) confirmation that Cairnsmuir of Deugh was in fact occupied in 1815 or thereabouts<sup>20</sup> is provided by the report of the Minister for Carsphairn (which incidentally lay on the coach route between Ayr and Dumfries) that:

'The highest mountain in the parish is Cairnsmuir, which rises to an elevation of about 2696 feet above the level of the sea. It was chosen by Captain Colby as one of his stations for the trigonometrical survey in this part of Scotland, about 1814. From the summit of this mountain, when the atmosphere is clear, a most extensive view is obtained in every direction, except where it is intercepted by a mountain called Carline's Cairn, on the south-west side of the parish, which is nearly of an equal height.'<sup>21</sup>

According to Portlock, Colby in 1816 planned to determine the positions of the observatories of Edinburgh and Glasgow and, using Ben Lomond to the north

<sup>17</sup> JE Portlock, *Memoir of the life of Major-General Colby*, London, 1869, 61

<sup>18</sup> Richard Oliver, Unfinished business: the lost Ordnance Survey two-inch mapping of Scotland 1819-1828 and 1852, *Sheetlines* 78, 9-31 (2007) available online at [www.charlesclosesociety.org/SheetlinesArchive](http://www.charlesclosesociety.org/SheetlinesArchive)

<sup>19</sup> Rev Samuel Cowan, *Parish of Kelton*, Jan 1841, 145 and 147, from Statistical accounts online service © University of Glasgow and University of Edinburgh, available online at <http://edina.ac.uk/stat-acc-scot/>

<sup>20</sup> A letter from Mudge to Colby dated 10 September 1816 (in Sir Charles Close, *The early years of the Ordnance Survey*, 65) suggests that 'the conclusion of your operations will be found on Cairnsmuir'.

<sup>21</sup> Rev David Welsh, *Parish of Carsphairn, Kirkcudbright*, 1839, 274 and 279, from Statistical accounts online service © University of Glasgow and University of Edinburgh, available as above.

and Dunrick hill to the south, to compute their distance from each other, and during the year visited nine stations in Scotland. Seymour lists seven: from east to west, Calton Hill, Allermuir, Dunrich, Hart Fell, Tinto Hill, Wisp, and Hill of Stake. *Yolland 1852?* and *Clarke 1858* show Ben Lomond occupied in 1818 but neither shows the ‘observatory of Glasgow’.

1817 was a busy year for Colby and Gardner, starting with the measurement of the Belhelvie baseline and the extra stations associated with it, and going on to what turned out to be an unhappy visit to the Shetlands. Seymour (with dates confirmed by the 1858 Report) lists visits to Craigowl (just north of Dundee, 5 June-4 July) and Mount Battock, occupied on the way to and from Belhelvie; and Tarbathy (7-30 May), Layton (7-9 June), Dudwick (10-12 June), Over Hill (15 June) and Brimmond (17 June) associated with the new baseline; and Balta (10-27 August) and Saxavord (28 August) in the Shetlands.

Eager to extend their measurement of the meridian, the French *Bureau de Longitudes* in 1817 sent Monsieur Jean Biot to engage in joint observations in the Shetlands, intended to compare measurements of latitude deduced from pendulum frequency, the French ‘repeating circle’, by stellar observations (the sector) and by triangulation. Portlock provides a lively description of the unfortunate tensions arising in the course of this expedition, to which additional perspectives have been added recently by Rachel Hewitt.<sup>22</sup>

1818 saw observations from Ben Lomond, Ben Cleugh, East Lomond and Largo Law, and from Glashmeal in Perthshire (once again near to the coach route). Colby and Gardner then nicely avoided the challenge of Goat Fell by placing a station (Carn na Leagh) near to the lighthouse track established 30 years earlier across the tip of the Mull of Kintyre. In nine productive days<sup>23</sup> they observed ‘backwards’ to their Ayrshire stations and forwards into Northern Ireland, to Islay and Jura, and as far as Mull and Tiree. It is unclear whether the station at Ben Turc, north of Carn na Leagh, was occupied or only a ‘pivot point’.

### ***Trigonometrical survey of Scotland 1819-1822***

In 1819 Colby’s enthusiasm for fieldwork was demonstrated in his remarkable forays<sup>24</sup> on foot in the hazy summer months from Corriehabbie in Banffshire westwards to the Isle of Skye and the Western Highlands and northwards to place observation staffs in the Orkneys, and then under the clearer autumn skies to position these future stations from observations made from Ben Wyvis, Ben Cheilt, Ben Lundie and Balnaskerrish.<sup>25</sup>

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<sup>22</sup> JE Portlock, *Memoir of the life of Major-General Colby*, London, 1869, 71-85 recounts this episode and Rachel Hewitt, *Map of a nation*, Granta Books, 2010, 226-233 adds extra detail from French sources.

<sup>23</sup> *Account of the observations and calculations of the principal triangulation etc*, Drawn up by Captain Alexander Ross Clarke etc, Ordnance Survey: London, 1858, 93.

<sup>24</sup> Dawson’s first-hand account is in Portlock’s *Memoir* 131-155 and is mentioned in Seymour, 30-31.

<sup>25</sup> Seymour’s list shows Ben Hutig occupied in 1819 but *Colby 1834* shows it observed only from afar.

Then in 1820 Colby decided to stay in London, awaiting a decision on the succession to William Mudge as Superintendent of the Ordnance Survey, which Colby duly secured after the Duke of Wellington's concise consultation<sup>26</sup> with Professor Charles Hutton.

In April 1821 Colby obtained agreement from the Admiralty<sup>27</sup> to the use of HM brig *Protector* for the trigonometrical survey of the Orkney and Shetland Islands, for which the 'great stations' shown on *Colby 1834* match those listed by Seymour. In support of Colby, Vetch and Drummond, sixteen artillerymen were employed under a sergeant and two bombardiers. The perceived need to ensure that the Admiralty paid victualling money only for days spent on board and the War Office only for days spent in camp means that, using also the ship's log and muster rolls, this expedition can be reconstructed in some detail.<sup>28</sup>

On 16 May 1822 the *Caledonian Mercury* reported that Major Colby was embarking from Greenock for Islay on HM cutter *Bat* with two other commissioned officers and a party of 18 artillerymen to commence his survey of the west coast. After assisting Colby at the Oa of Islay, Dawson and Vetch were entrusted to complete observations from Mull, Tiree and Jura. With only Northwest Scotland and the Outer Isles unreachable, the 36 inch theodolite was put to work in England in 1823. In 1824 the resources of the trigonometrical survey were removed to Ireland, where revision of the tax base had secured a greater priority than the Scottish survey.

### **Outcomes**

It was not until 1838 that Colby returned to Scotland, where with Robe and Robinson he observed from Ben Hutig in the far North West before handing the next stage of fieldwork over to them. It seems that the nine year old Alexander Ross Clarke was living with his grandmother in the nearby village of Eriboll,<sup>29</sup> and it is an attractive thought that watching Colby's survey party at work in 1838 may have inspired the career of the man whose tireless mathematics eventually brought Colby's work together in 1858.

Colby was more effective in making observations than he was in computing his results. Even Portlock regretted his 'indisposition to publish the details of the survey, and morbid apprehension of criticism'.<sup>30</sup> *Yolland 1852?* shows a maze of accumulated observations which it must have proved impossible to reconcile precisely, especially as the ellipsoidal figure of the earth apparently was both an input to and an output of the calculations.

Alexander Clarke in his calculations of the principal triangulation published in 1858 resolved the maze he had inherited by relying mainly upon the long distance observations accumulated in the 1840s and discarding twenty-six of the

<sup>26</sup> Nicely described by Rachel Hewitt in *Map of a nation*, 235-236.

<sup>27</sup> *Ordnance Survey Manuscript letter book 1799-1822*, The National Archives, OS 3/260, f 258.

<sup>28</sup> OS 3/260, f 431; with ADM 52/3951 *Master's Log: Protector*; and ADM 37/6466 and 6467 *Muster Books*.

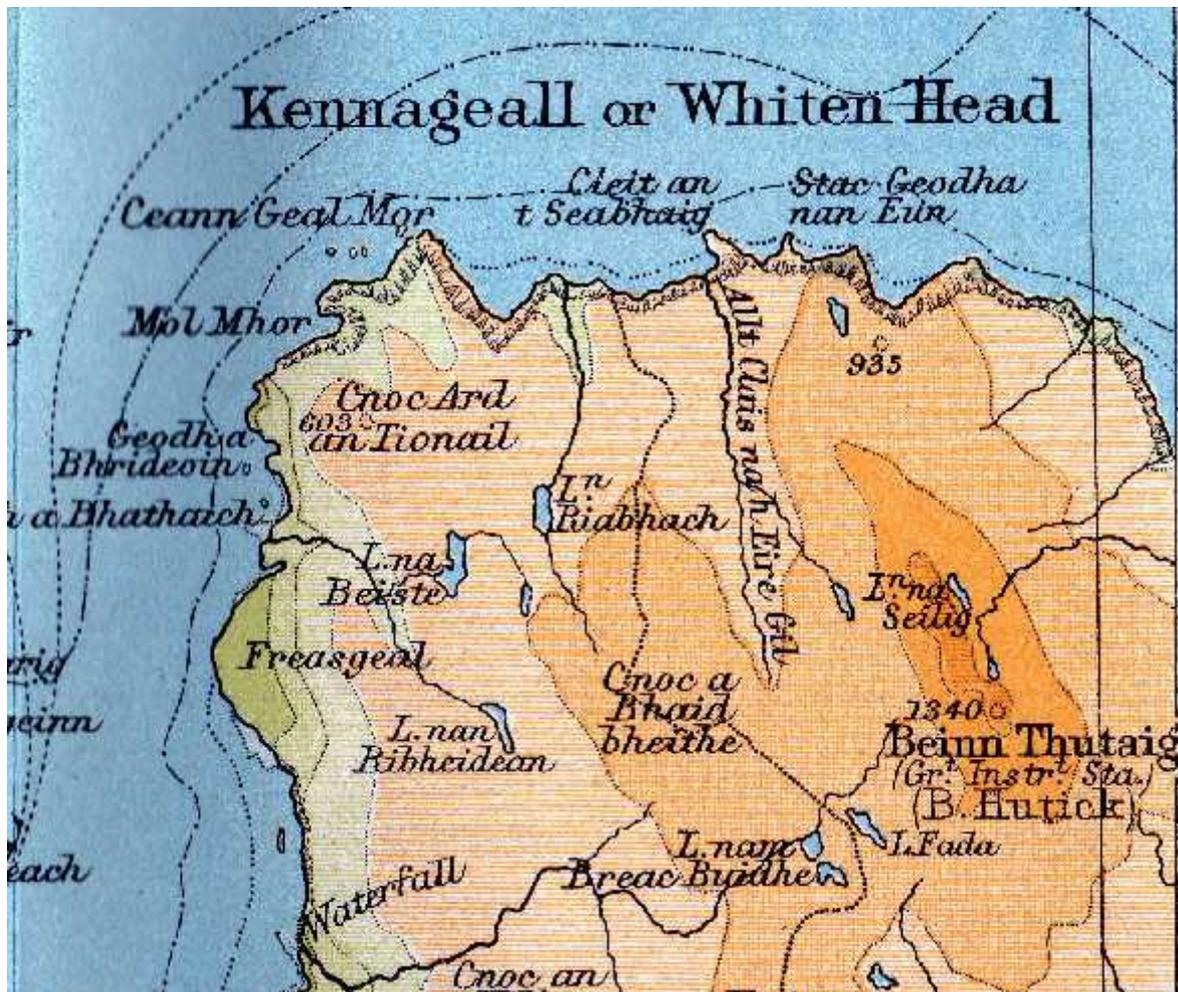
<sup>29</sup> Actually we can be sure only that Alexander Ross Clarke lived in Eriboll at the time of the 1841 census.

<sup>30</sup> JE Portlock, *Memoir of the life of Major-General Colby*, London, 1869, 3.

'great stations' observed by 1834. Clarke's calculations, which he published in detail, are enormously impressive and provided new estimates of the figure of the earth – yet any influence of this work in bringing together the 'county meridians' adopted by the Ordnance Survey is by no means certain.

To conclude, it is a tribute to Colby's vision of the initial triangulation that, of the twenty-six of his stations discarded in 1858, no less than eleven were re-adopted as primary stations in the re-triangulation which was put in hand in 1935. It can also be argued that the pattern of medium sized triangles adopted for this work resembles Colby's initial triangulation of Scotland much more closely than it resembles Clarke's principal triangulation.

I would like to thank Richard Oliver for reading the draft of this paper and for his many helpful suggestions.



*Rob Wheeler points out that Ben Hutig in Sutherland (NC 539 653) appears to be unique in that it is labelled on OS First edition and on Bartholomew (Scotland sheet 26) as 'Great Instrument Station'*



