Sheetlines

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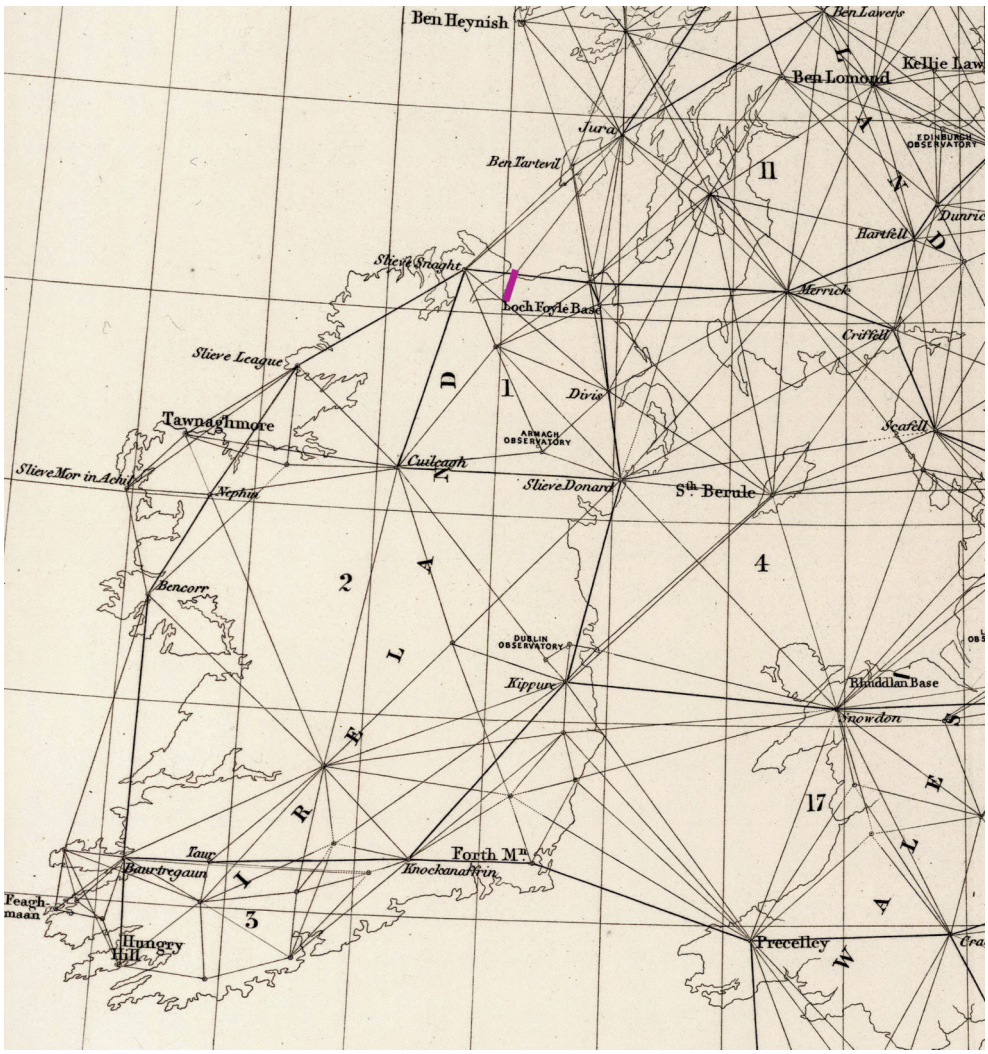
Number 130 **August 2024**



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Forty-nine members of the Society gathered at the Walton Academy in Grantham on Saturday 11 May for the Annual General Meeting. Some bullet points of interest:

- Treasurer's report : the Society had made a surplus of £1734 over the year.
- Membership Secretary's report : membership at the end of 2023 had been slightly up on that of a year before. However, subscriptions this year had been slow in coming in and fewer new members had joined. In consequence, paid-up members at the time of the AGM were some 8% down on the previous year.
- A Hodson Award was presented to Peter Gibson to mark his work over many years in putting together the collection of cover images that forms such a useful feature of the Society's website.
- The Hon Sec reported that the 2025 AGM would be at the Tiffin School, Kingston-on-Thames on 10 May. He was looking for a local organiser for the 2026 AGM; any members who would be willing to do this and who had a venue in mind were asked to contact him for a check-list of what was needed.

Gerry Zierler presents Peter Gibson with the Hodson Award

The Lough Foyle Baseline

Michael Cory

"*I made a cursory examination of the general idea of the country and to seek a proper place for the measurement of a new Baseline. The shores of Lough Foyle presented most advantageous for this purpose.*" *Thomas Colby* [1]

The view from the cliffs of Binevenagh Mountain is expansive. To the west across Lough Foyle lie the hills of Donegal, and to the north across the sea the western Isles of Scotland. The rocky escarpment rises 1,000 feet above a plain that stretches eight miles between Magilligan Point and Ballykelly, just 18 feet above sea level, intersected by hedges and walls surrounding green fields. Between the mountain and the sea, it is a landscape of great contrast and great beauty. The wide flat sandy expanses of Benone Beach to the north and Magilligan Strand to the west are edged by sand dunes that hide a prison, an army base and holiday caravan sites. A Martello Tower at Magilligan Point was built too late in 1817 to protect the wide natural harbour of the Foyle estuary from Napoleonic invasion. It mirrors a fort across the entrance of a Lough full of native oysters and the once abundant wild Atlantic salmon, swimming to their spawning grounds. Cut in half by the River Roe, the plain is now intersected by a railway considered the most scenic in Ireland.

Figure 1 : View from Binevenagh Cliffs across the plain by Lough Foyle where Colby's baseline runs. (A Cory).

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[1] *Report to Sir Henry Hardinge KCB on the Present State and Progress of the Irish Survey*, Lt Col Thomas Colby, 2 February 1826. (National Archives Ireland, OS/1/1).

Silently, below the cliffs of Binevenagh Mountain, and along the plain, stand three monuments aligned precisely to within millimetres of each other over eight miles. They form the Lough Foye Baseline, the heart of a monumental endeavour to map Ireland and Britain in the first half of the 19th century. Witnessed by eminent scientists and surveyors, the techniques pioneered here would be replicated across the British Empire by Sir George Everest on his Survey of India, and by the Astronomer at Cape Town. The distance measured between the monuments was so precise that when remeasured by microwaves in 1960 it was found to be within one inch of Colby's carried out in 1827 and 1828. They have stood for nearly two hundred years, the foundation of all distances in Ireland and Britain until satellites changed our understanding of the world.

The triangulation of Great Britain had reached Scotland by 1820, from where the hills of Ireland could be observed across the Irish Sea. Lieutenant Colonel Thomas Colby, by then the Superintendent of the Trigonometrical Survey of the Board of Ordnance, was tasked to carry out the Trigonometrical Survey of Ireland (to be used to help apportion local taxes more equitably), requiring greater accuracy and "much greater dispatch to the work than has occurred in the Trigonometrical Survey of England."[2]

So, in 1824 Colby, accompanied by Lieutenant Thomas Drummond, travelled Ireland from north to south, selecting the most suitable mountains for the Principal Triangulation stations and identifying a location for a new baseline on which the maps would be based. Visiting the plain along the shores of Lough Foyle he immediately saw its potential for a measurement that would require a "very delicate operation on which the credit of the whole survey would greatly depend."[3]

Baseline measurements

Before the Survey of Ireland, baselines had been measured by a variety of methods using fixed length rods made of glass or wood or using a version of Gunter's 100-foot chain, made of 66 iron links. The first baseline in Britain was measured by William Roy in 1784 at Hounslow Heath, using a steel chain made by Jesse Ramsden, the celebrated instrument maker, for experimental purposes. It was then remeasured with three 20-foot deal rods, but it was found that their lengths varied depending on the temperature and humidity of the atmosphere, so it was remeasured using glass rods, but these were affected by flexing between the trestles supporting either end of each rod to such an extent that it created uncertainty in the length.

It was decided to remeasure the Hounslow Heath base at the start of the Principal Triangulation, using two new 100-foot steel chains made by Ramsden, the work carried out by Major Edward Williams and Lieutenant William Mudge in 1791. A second baseline was selected on Salisbury Plain to

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[2] Report of the Select Committee of the House of Commons into a Survey and Valuation of Ireland, Chaired by Mr. Spring-Rice, 1824.

[3] Colby's first report to Sir Henry Hardinge, January 1826. (NAI/OS/1/1).

help verify the triangulation as it extended across the country west from Greenwich, also measured using Ramsden's steel chains, and the ends of both these bases were marked by iron cannons sunk into the earth. As the triangulation extended across the country, additional bases were measured using Ramsden's chains by Mudge at Misterton Carr (1801) and Rhuddlan Marsh (1806), and then by Colby at Belhevie Sands (1817).

Meanwhile, improvements to the method of measuring baselines using rods had been made in France by Jean Baptiste Delambre, Director of the Paris Observatory, and Pierre Mechain, a surveyor who had worked on the French side of the Paris – Greenwich triangulation. They had been tasked by the Paris Academy of Sciences to measure an arc of the meridian from Paris to Barcelona to determine the length of the metre, defined as one ten-millionth of the length of the meridian passing through Paris between the North Pole and the Equator. They measured their arc by triangulation from 1792 to 1799 with two baselines, one in the north of France, the other in the south, using four high-precision rods each twelve feet long and made of pure platinum, the newest and most expensive metal on earth, alongside a strip of copper so that the relative expansion of the two metals could be read with microscopic precision, and corrected to a standard length. Both bars were set in a wooden sleeve, and temperatures were measured along the length of the bars, so that their lengths could be corrected by a factor previously determined in laboratory tests. Their results, delayed by revolution in France, war with England, and affected by an error in the assumed size and shape of the Earth, led to the abandonment of chains for measuring baselines and a return to the idea that measuring baselines using rods was the best method.

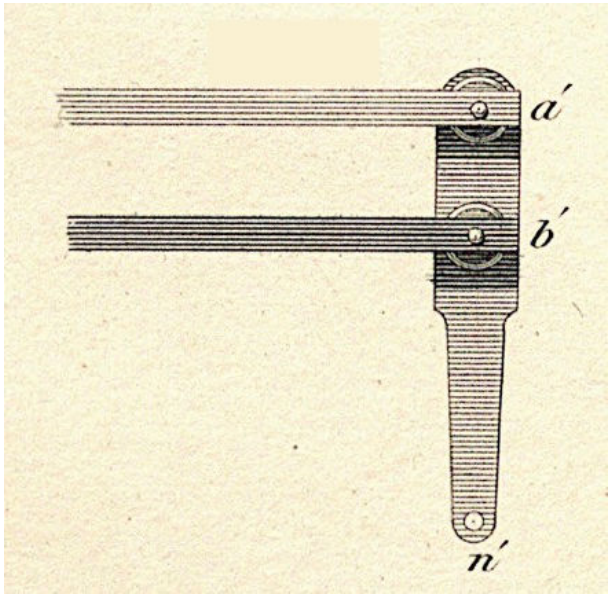
Colby's Compensating Bars

At the start of the Irish Survey, Colby considered whether Ramsden's chains or French rods were best for his Irish baseline. The effect of temperature was of greatest concern: later experiments would show that a change of 1° Fahrenheit would alter the length of a 10-foot iron bar by 0.00783 inch, a significant 1 foot over eight miles for every 4° change. The length of an Iron chain was also known to be affected by wear between the links. Although the French system clearly had merit, the rods were still expanding or contracting by differing amounts depending on the temperature, the material they were made of, their mass and the finish of their surface. Their lengths were even found to change by different amounts along their length. Colby consulted widely on the matter, including with his friend Charles Babbage, the mathematician, philosopher, and inventor of the first mechanical computer, and with "ardent zeal, and craving for improvement"[4] set his officers to the task of finding a solution. The winter of 1824-25 proved memorable for them as Thomas Drummond's quarters at Furnivall's Inn became a laboratory and workshop for developing a measuring apparatus that would address the problem. But it was Colby himself who came up with the solution. One of his

[4] Lt Col JE Portlock, *Memoir of the Life of Major-General Colby*, 1869, 267.

officers, JE Portlock describes how Colby grabbed his arm, saying “Come my boy I have something to talk to you about” [5] and practically ran him to his apartments at the Tower of London, where over dinner he outlined an idea for bars that self-compensated for changes in temperature. Colby’s principle was based on the French bars and compensating mechanisms found in clocks and their pendulums. John Harrison, whose celebrated chronometer provided a reliable method for determining longitude at sea, had designed the gridiron pendulum for clocks which moved the centre of gravity of the pendulum as it expanded or contracted due to changes in temperature so that its length remained constant, and the clock kept regular time. Similarly, the Ellicott pendulum, made of two brass rods on either side of an iron rod which expanded or contracted at different rates, depressed or released levers that raised or lowered the pendulum bob, thus maintaining its length and its timekeeping.

Colby’s approach also used two bars of different material – one of brass and the other one of iron - kept apart to avoid the effects of friction and fixed at the centre allowing the ends to expand and contract freely. His innovation was at the ends of the bars, which were connected by a tongue or a lever that would move as the bars expanded or contracted by different amounts, rotating around a “compensation point”, in such a way as to keep a constant distance from a similar compensating point on a lever at the other end of the bars.



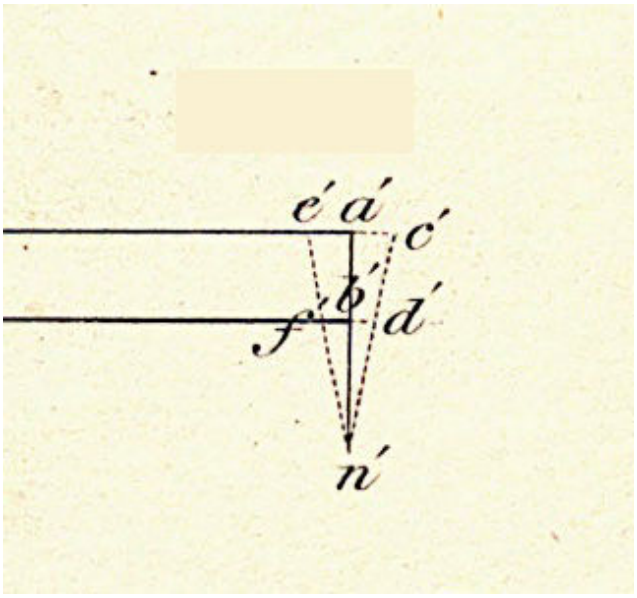


Figure 2a (left). Compensation Tongue, attached to the ends of the brass bar (at a’) and iron bar (at b’) showing the compensation point n’.
Figure 2b (right). Depicting how compensation point n’ does not move when bar a’ and b’ expands or contracts

[5] Portlock, 269

Drummond, having spent so much time working on alternative solutions using Mica measuring rods, was somewhat put out by Colby's idea, and initially resisted it. But Colby and Portlock commissioned a model 3-foot bar from Edward Troughton, the Cumberland born instrument maker, and tests on the model won Drummond over. There would later be some controversy, as to who in fact was the inventor of the bars, but this was ultimately addressed by attributing "to Colby the design, to Drummond the execution"[6].

Six pairs of bars were commissioned from Troughton, each one measuring 10 feet 1½ inch long, ½ inch broad, and 1½ inch deep. The iron and brass bars weighed 136 lbs and were placed 1¼ inches apart, on rollers inside a box constructed to protect them. Troughton was also asked to construct two standard bars, each made of iron 10 feet long, to be used to calibrate Colby's bars to a standard length at 62° Fahrenheit. These two standards were themselves extensively calibrated from ten other standard bars and used to determine the position of the compensation point – where the distance between the ends of the bars would remain constant. Colby's theory could now be put to practical use on the Lough Foyle Base.

Starting Work

The plain at Lough Foyle was ideal for the baseline, extending eight miles north to south and an average of 18 feet above sea level, surrounded by mountains on which the Principal Triangulation stations were located. But it was intersected by many hedges, walls and other obstacles, including the River Roe, all of which would have to be crossed, and the land was under cultivation too. The precise alignment of the line would depend on a detailed survey which the officers and sappers began in May 1825 and had finished by the end of January 1826.[7] The original intention was to have measured the baseline in 1826, after the corn had been harvested, but "due to the present state of scientific information",[8] Colby wished to carry out experiments perfecting the means to do it and deferring the work until he had done so. The work was delayed further as Troughton perfected the manufacture of the compensating bars. But, by the summer of 1827, preliminary work could begin and on 24 June 1827 an encampment consisting of 27 Artillerymen, 25 Sappers, and three civilian labourers was established "…. by the side of Mr. Gage's park wall, near the Roe".[9]

Monumenting the Base

The first task was to establish where the line would run, and its start and end points. The northern end of the baseline was chosen first, with the southern and intermediate points established on an alignment, "….. almost rigorously

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[6] John Andrews, *A Paper Landscape*, OUP, 1975.

[7] Ordnance Survey Progress Reports and Returns, return by Captain MA Waters RE, January 1826; NAI, OS/1/1.

[8] Colby's first report to Sir Henry Hardinge.

[9] Letter from Drummond's papers quoted in Charles Close, *Early Years of the Ordnance Survey*, 1926, 115.

directed on the trigonometrical station on Mullagh Clogher, or the Straw Mountain, one of the Sperrin Mountains, in the county of Tyrone, which is in sight from most parts of the line, at the distance of 27 miles from the North End of the base".[10]

Colby's desire for perfection extended to permanently marking the ends of the baseline, and unusual precautions were taken to ensure there was no risk to the points being lost or disturbed so that they would be available for reference in the future. Colby was taking no chances. The start and end points of the baseline, the North End and South End stations, were marked very precisely and permanently by a point marked with a needle in the end of a platina wire set in a lead filled hole 1½ inch in diameter and 6 inches deep bored into a large stone block cut from Dungiven sandstone, four foot square and 20 inches deep, laid on a cement bed over more stone blocks resting on a bed of masonry. During the measurement work the platina wire mark would have been exposed so that the instruments could be placed precisely over them. The stone block was encased in a masonry chamber which had a flagstone lid on which was marked a cross vertically above the dots in the platina wires. The design ensured stability, and much trouble was taken to ensure that each mark would be protected from accidental or malicious external disturbance, with an earth mound covering the chamber and surrounded by a circular two foot thick wall, 30 feet in diameter, topped with iron railings. The Board of Ordnance purchased the land to ensure it would remain protected.

A third mark, similarly monumented, was placed precisely along the alignment of the baseline approximately a third of the way along, just north of the River Roe, and called the Minearny Base. It was probably sited there simply because it provided a convenient point at which to pause the work during the coming winter months and it would form one end of a small 'comparative triangulation' scheme designed to verify the base once completed.

A fourth mark was similarly constructed at Mount Sandy, but has since been lost to coastal erosion. This point was established as an extension to the baseline, running almost along the same alignment to the north of the North End station. Its purpose was to form the other end of the small comparative triangulation scheme to help verify the baseline measurements and to improve the strength of the triangles connecting the baseline to the Principal Triangulation. The section between Mount Sandy and the North End station was not measured with Colby's bars as the ground between, situated on the edge of Benone Strand among the sand dunes, was too rugged and broken for the bars, and so the distance was calculated through the comparative triangulation.

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[10] Capt William Yolland, *An Account of the Measurement of Lough Foyle Base with its verification and extension by Triangulation*, 1847, 12.

Work on building and marking the stations at the North End, South End, Minearny and Mount Sandy stations was completed by the third week of August, allowing angle observations to be made to them by Portlock using Jesse Ramsden's Great Theodolite, an instrument with a three foot horizontal circle enabling very precise angles to be measured between the principal points of the triangulation, originally purchased by the Board of Ordnance for the Trigonometric Survey, and now in the Science Museum, London. These were observed from the top of Slieve Snaght in Donegal between August and September 1827 as part of the Principal Triangulation. Additional Trigonometric survey points were also established on Eskaheen Mountain, Cundtham and at Drung Point across Lough Foyle in Donegal, and at Artikelly and Gortmore to the east of the baseline. None of these points were permanently monumented.

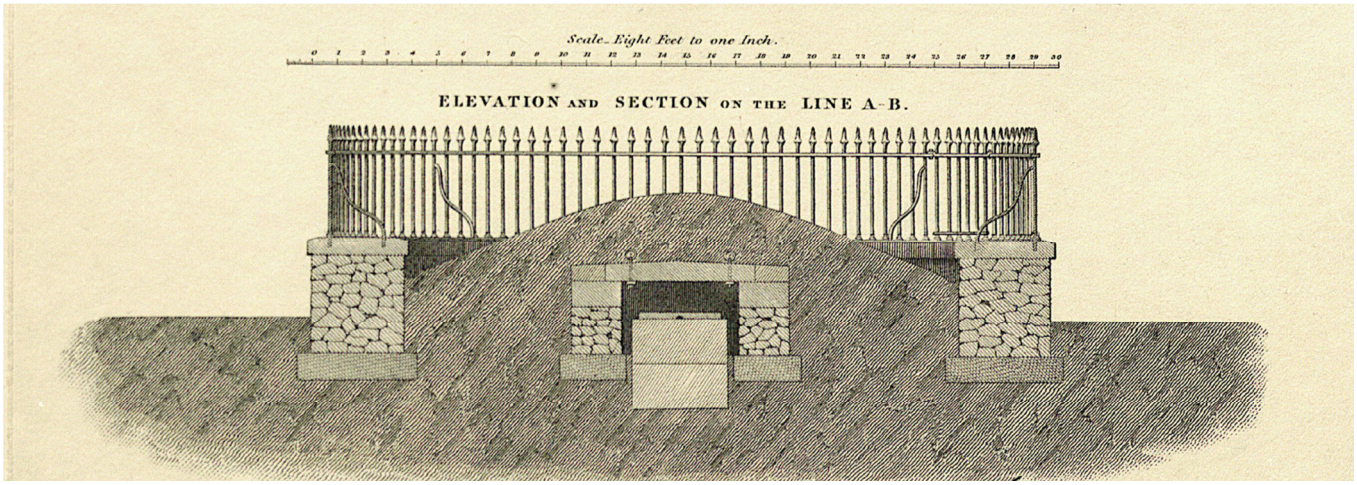

Figure 4. Section diagram showing construction of the base station.

Aligning Colby's Bars

A smaller 18-inch theodolite, also made by Ramsden, was placed over the North End Station and using either the South End station or the Minearny Station as a target (it is unclear which one, but the furthest point would have been the most accurate) the precise alignment of the baseline was set out by placing boards three-quarters of a mile apart, alternating left and right, painted black and white, either side of the line, the inner edge of the boards providing the precise alignment. These were then used to place subsidiary boards 250 yards apart so that the telescopes on the compensation bars would keep the bars aligned between the stations when placed end to end along the line. The same theodolite was then used to set out pickets driven into the ground on which three legged wooden frames sat, one placed a quarter and another at three quarters of the length along each bar.

Measuring the base

Each end of the compensation bar box was placed on a brass levelling tripod on top of the three-legged wooden frame of varying heights, to cope with the undulating terrain. The brass tripod had screws that allowed the bars to be raised or lowered vertically and for fine alignment of the box horizontally (longitudinally and transversely) and vertically (in elevation) so that they could be aligned and levelled. The start of the first bar was placed over the North End station mark, and carefully adjusted by viewing the platina wire mark through a telescope that pointed down, and its position adjusted using the brass tripod screws so that it was vertically over the mark. The far end of the bar would then be adjusted to align with the baseline, using the boards placed every 250 yards. A second bar was then placed in line precisely six inches from the first by careful observation and adjustment with a pair of compensating telescopes, designed and manufactured by Troughton specifically for this purpose.

Up to six sets of bars were laid and levelled end to end in this manner, along the line of the base. The end point of such a series of bars was transferred to the next series of bars via a "point carrier", laid on the ground beneath the end of the last bar in the series. The point carrier was a massive triangular cast iron plate, 15½ inches long on each side, with a short flat hollow tube of brass placed in the centre, enclosing a moveable disc with a fine point engraved on it, whose position could be adjusted by three screws set around the brass tube. The point carrier was viewed through the telescopic microscope at the end of the bar, pointing down, and the mark could then be adjusted to sit precisely under the end of the bar. This mark was then used as the starting point for the next series of compensation bars.

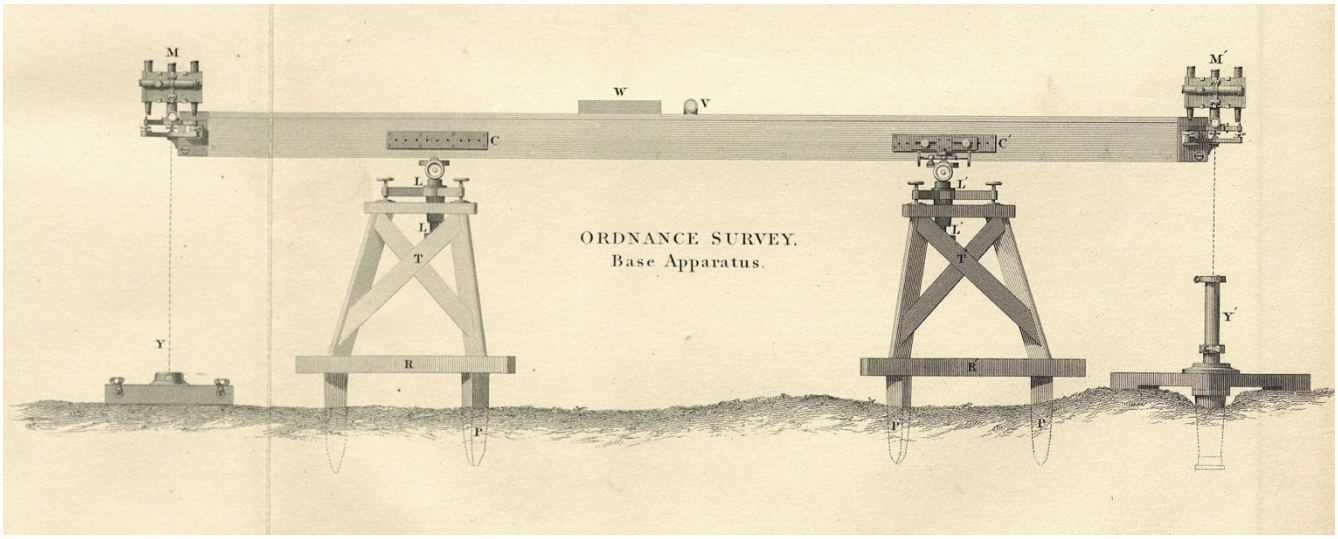

Figure 5a. Colby's Base Apparatus. Diagram showing one of Colby's Bars, with pickets P; supporting three-legged wooden Trestle (T); Brass tripod (L); Point Carriers Y and Y'; and compensating microscopes, M and M'. V is a cross level, w a longitudinal level.

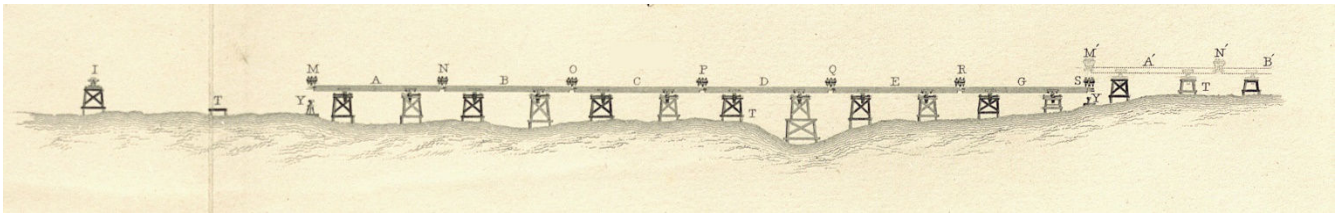

Figure 5b. Showing the six bars (A B C D E G) laid end to end with trestles dealing with undulating terrain and stepped approach for slopes.

Work began on measuring from the North End station and moved steadily southwards. But the weather was already closing in, and in the early hours of 9 September a "very violent hurricane" blew away a tent and knocked one of Colby's bars to the ground. Fortunately, no damage to the bar occurred and as this was only two days into the measurement it was easily repeated and checked. However, steps were taken to protect and guard against this happening again. Captain Pringle wrote to Colby, who was based at the "Trig Survey Camp, Magilligan", on 13 September 1827, about the severe gales frequently expected in the area during autumn, and a requirement for extra guards at night to protect the equipment. From then on, the bars were removed each night and placed on "skidding" under two tents with a guard overnight. The first 400 feet had been remeasured as a check and found to agree within 'a small segment of a dot', confirming that Colby's bars and the methods employed were operating with the precision required. By the time the work stopped at the Minearny Station on 25 October 1827, 13,250 feet (a third) of the baseline had been measured, taking 35 days including testing and remeasurements.

Figure 6. Engraving of a sketch made by Sir John Herschel when visiting the baseline, showing the tents covering the compensating bars laid out for measurement.

Crossing the River Roe

Work resumed the following year, and on 3 July 1828, Pringle writes again from Magilligan Camp, "We have been examining the Roe and considering the easiest mode to measure across it. Driving piles appears on the whole the best, so I shall order piles, etc., from Derry. We are experimenting with a frame filled with sandbags, or stones …". Actual measurement of the baseline began again on 7 July and progress was good. By 16 July Pringle writes "We now hope to pass the Roe the end of this week. We have been pushing very hard to do so, commencing at 3 a.m., as the tides will answer best – being high water at mid-day…". This suggests that measurement was dependent on the tides, not surprising given that men would have to wade into the water during the crossing. But it is unclear whether it took place at high tide or low tide, and although low tide seems more sensible there is a note with the observations that the tongues of the bar were "eight inches above the water at high tide, not being spring tides". On 18 July Lt Hastings Murphy RE writes to Colby at Magilligan Camp, "We are getting on famously, having last night reached the Roe; if this day were not so windy we should be across this evening. We have been at work 16 hours a day". The crossing of the Roe turned out to be more straightforward than expected. The bars were rested on trestles set on the piles driven into the bed of the river. Measurement was carried out twice; once on 19 and 20 July, and verified by a repeat measurement on 21 and 22 July, each a distance of 462 feet, the two measurements agreeing to within 1/37 of an inch.

Consideration had been given to buying up the crops so that measurement could continue while the weather was good, but this had been rejected as it would cause unnecessary damage, and so work was paused on 25 July until the crops had been harvested. The soldiers were then to be marched to Charlemont Fort barracks[11] once the piles in the river had been removed, but instead they were retained on half pay for six weeks until the work recommenced on 13 September. At one place along this final section of the line, on 13 October, the line passed close to the gable end of a mud cottage and a cut had to be made into the wall of the cottage so that it could continue. The measurement of the baseline was completed at the South End station by 20 November 1828, a total of 60 days measuring the 30,533 feet of the second part of the line, an average of 509 feet a day.

Somehow, in between his responsibilities on the Trigonometric Survey, climbing mountains, securing and training men, and supervising the baseline, Colby had met his future wife. Five days after the work on measuring the baseline was completed, he married Elizabeth Hester Boyd, daughter of the late Archibald Boyd, Treasurer of the City of Londonderry, at the Cathedral Church, Londonderry.[12]

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[11] Letter dated 26 July 1828 from Captain Pringle, quoted in Close,117.

[12] The Belfast Newsletter, 2 December 1828.

Verification and extension

The pursuit of accuracy and the avoidance of error was paramount and so the measurement of the base was verified in several ways. The first 400 feet were remeasured by the bars to confirm they were performing as expected and as a check of the point carrier system. Double measurements were made by different officers, such as that across the River Roe, providing an effective way to check that there was nothing immediately amiss. In one instance a remeasurement was made in the presence of Sir John Herschel, President of the Royal Astronomical Society and Charles Babbage, who "expressed themselves much pleased with the near coincidence of the two measurements".[13] Furthermore, certain sections were repeated if there was any doubt that a bar had been affected by some problem, or that an actual or suspected error had occurred. For example, there were continuing problems with wind disturbing the bars, and on one occasion it was noted that strong sunshine had warmed one brass bar more than its iron bar, and so a remeasurement was required.

The measurement of the base was also verified by a small comparative triangulation scheme established in its immediate vicinity and observed by Drummond. During the first season (1827), a series of four intermediate points between the North End and Minearny Station were used for this purpose, along with a number of temporary points either side of the line. In the second season (1828), an intermediate point was placed at Oatlands, which along with temporary stations at Artikelly, and at Cundtham and Dung Point across the Lough, formed a verification triangulation on the southern part of the line. The scheme established allowed the baseline to be split into several sections so that one part of the base could be calculated through the triangulation from another part, and then compared to its distance as measured with the bars. This provided a crude check that a single bar had not been omitted from the measurement of any section, but also helped confirm the accuracy of the method used. For example, by this means the measured line from Oatlands to the South End station agreed by about an inch with that calculated from other parts of the line, and from Minearny to the South End station agreement was better than 0.005 inch.

In addition, the baseline was extended to Mount Sandy station, and a point at Gortmore was established for this purpose. The distance from the North End to Mount Sandy was then calculated through eight different triangles agreeing within a probable error of plus or minus 0.031 foot (less than 0.4 of an inch) over its accepted distance of 11,559.8270 feet.

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[13] Yolland, 28.

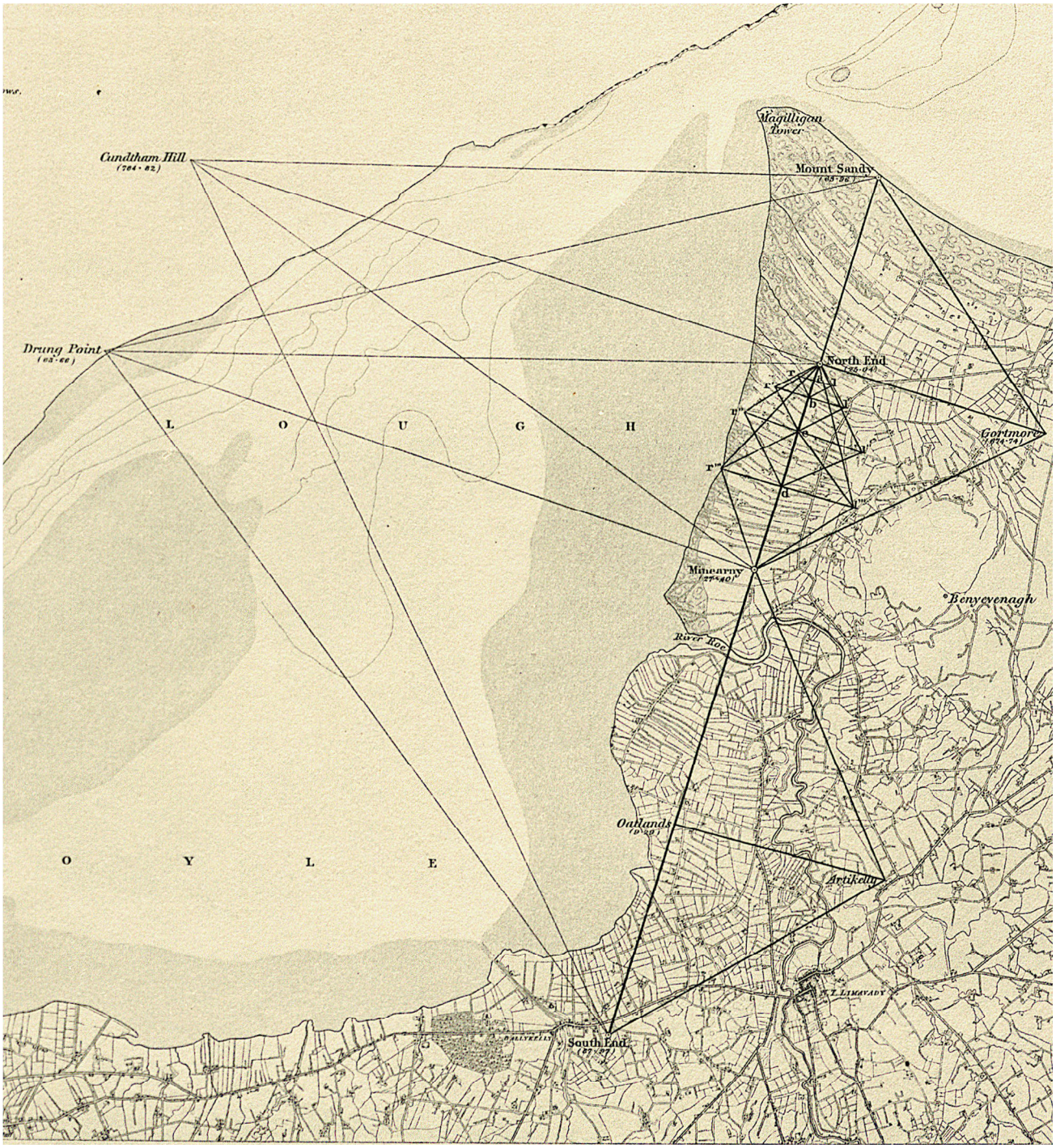

Figure 7. Plan of the Baseline near Lough Foyle showing the comparative triangulation scheme used to help verify the baseline, with intermediate points along the baseline at a-d and at Oatlands, and temporary stations either side of the line on the left at l', l", l"' and right at r', r", and r"'.

Connection to the Triangulation

As the purpose of the baseline was to provide scale and distance for the whole triangulation scheme it was necessary to accurately connect the ends of it by angular observations to the Principal Triangulation stations at the distant mountain tops. The North End and South End of the baseline was connected to the stations on the Scottish mountains at Jura and Ben Tatrtevil (Islay),

and the Irish mountains at Slieve Snaght, Sawel and Knocklayd. The additional point at Mount Sandy improved the conditioning of the triangles and was also included in these connections. Another point had been established on Eskaheen Mountain in County Donegal to help in the connection to the Principal Triangulation, but the target pole erected for the purposes of observations from the baseline stations had been found to have been disturbed by a strong wind, and while certain corrections were applied for the purposes of verifying the baseline, the observations were not suitable to use for a principal point in the final Account of the Principal Triangulation published in 1858.

The work in Ireland took time to organise and get underway, and Colby was under significant pressure to make progress, with criticisms and complaints about his methods even reaching the ears of Lord Wellington, who was by now Prime Minister.[14] Colby himself moved to Dublin in 1828 to take personal charge of the Survey of Ireland, and there was an urgency about the speed of the work. Whilst the baseline was complete, the angles of the triangulation were required so that all the observations were available to calculate the trigonometric distances for the interior survey to begin. Officers and men of the Survey camped out on the mountains, even during the winter months of 1827 and 1828, to get this work done.

Angles to the North and South End of the baseline, and the one established at Mount Sandy, had already been observed by Portlock between 24 August and 25 October 1827, using Ramsden's three-foot Great Theodolite. Once the distance measurements using the bars had been completed for the 1827 season, a two-foot theodolite was placed on the North End station in November 1827 and angles to the South End station, Sawel Mountain, Slieve Snaght, Cundtham, Drung Point, Mount Sandy and Magilligan Tower were observed by Lieutenants Henderson, Murphy and Mould, their observations completed by January 1828. The two-foot theodolite was again used to observe the angles from the South End station on completion of the measurement work there, between November 1828 and January 1829, observing the North End station and the stations on Slieve Snaght, Drung Point, Cundtham, Mount Sandy and Ballykelly church tower. Captain Pringle and Lieutenants Henderson, Murphy and Mould completed these observations. Observations were then made from Mount Sandy using the two-foot theodolite in June and July 1829 to the North and South Ends of the base, Drung Point and Cundtham, as well as Magilligan Fort and to Sawel Mountain, Slieve Snaght and Knocklayd in Ireland, and stations on the Western Isles of Jura and Islay (Ben Tartevil). The final observations involving the baseline were not made until 20 years later, in 1849, when Mount Sandy was observed from Jura using the three-foot Great Theodolite.

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[14] Wellington wrote to Lord Anglesey on 30 March 1828, instigating an inquiry into progress of the Survey, and this ultimately led to Colby being sent to Ireland to personally oversee the work there. (*Public Record Office Northern Ireland record*).

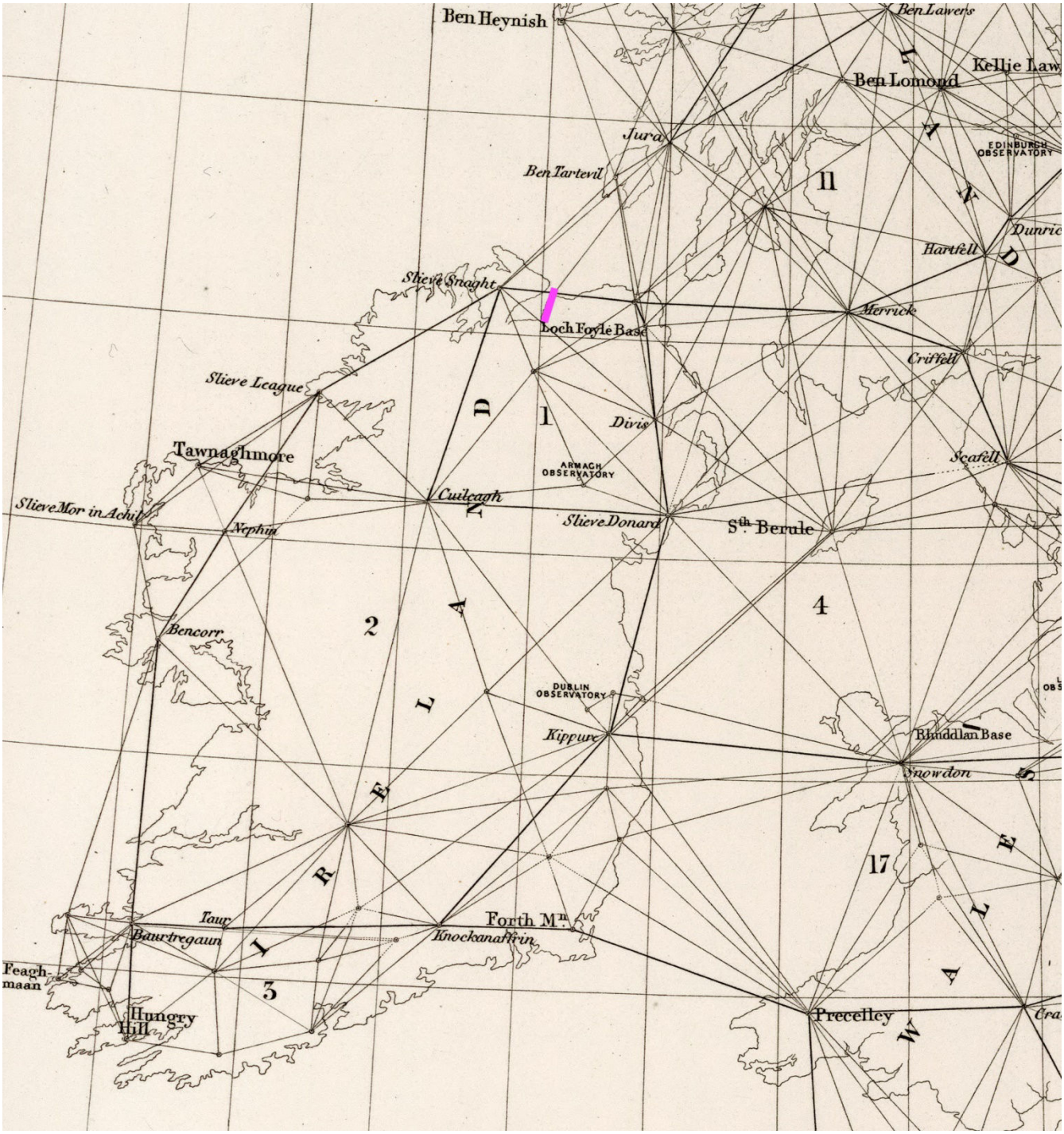

Figure 8. The Principal Triangulation of Ireland, showing the location of the baseline and its connections to Great Britain.

Results

The Lough Foyle baseline was measured as being 41,640.9228 feet long, after correction for expansion to the standard length of the Ordnance Bar O2 at a temperature 62° Fahrenheit. This distance had to be reduced to sea level for calculating the trigonometric distances through the triangulation for use in the Interior Survey. At that time the earth was assumed to be nearly a sphere coincident with sea level, and so the measured length was reduced to sea level from the heights measured to the baseline stations (although evidence was available that it was an oblate spheroid – that is a sphere flattened at the

poles – the amount of 'flattening' had not been determined and was not thought to be material enough to affect the accuracy of mapping). The height of these baseline stations had been obtained by observing vertical angles from the surrounding triangulation stations, including to a picket driven into the ground at low water mark near Drung Point in County Donegal. It is important to realise that knowledge of the shape of the Earth and of sea level as a suitable reference surface for heights was limited at this stage, and the measurement of vertical angles to determine heights, were thought to be adequate for mapping purposes. However, the large variations in measurements caused by refraction and the approximate nature of sea level, whilst acceptable for mapping purposes, was found to create uncertain results. Elsewhere it was found that the height determined for one point using vertical angles from different triangulation stations, and from different reference sea levels around the coast did not agree. So, in the 1830s sea level was measured at 32 different locations around the coastline of Ireland to determine the best reference surface for height [15] following which a single reference point was established at Poolbeg Lighthouse in Dublin. The points around the coast were then connected by spirit levelling across the island and a series of benchmarks cut into walls, bridges, and rock, leaving permanent reference points for future use. The Lough Foyle baseline was connected into this network, and heights levelled to the top of the sandstone blocks in which the platina wire mark had been embedded.[16] These new spirit levelled heights were used in Captain Yolland's 1847 Account to reduce the measured baseline to sea level, by 0.03555 feet to 41,640.8873 feet.

No astronomical observations were made at any station connected with the baseline at the time of the measurements in 1827 – 1828. Instead, meridional bearings were calculated from astronomical observations made at Dublin Observatory and used with the baseline distance to establish the positions of the triangulation stations used to control the interior survey. By 1843 observations for the determination of astronomical latitude of the station at the South End were made using the Airy Zenith Sector, but these were thought to be affected by significant local gravitational attraction from the nearby mountains, and its observed position differed significantly from its position calculated through the triangulation.

Salisbury Plain Remeasurement

Following the completion of the Irish Survey, work resumed in England and Scotland and Colby's Compensation bars were used in 1849 to remeasure the Salisbury Plain baseline in England. The original measurement had been found to be inaccurate when compared to the distance calculated through the Principal Triangulation from Lough Foyle. The remeasurement was carried out under the direction of Captain Yolland, and the work carried out by

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[15] GB Airy, Astronomer Royal, *On the Laws of the Tides on the Coast of Ireland….* Philosophical Transactions, 1844.

[16] Later levelling would leave a benchmark on the exterior circular wall of the baseline stations.

Sergeant Steel and a party of Sappers and Miners. The only change from the techniques used in Ireland was to increase the number of comparisons undertaken to calibrate the six-inch gap between the bars. The guns marking the ends of the baseline were found to be intact, but the North End, three miles west of Aylesbury on Beacon Hill, and the South End, 1 ½ miles from Salisbury near Old Sarum Castle, were not intervisible, therefore a theodolite at the South End had to be elevated on a tower above the mark to keep the bars aligned. The 11-degree slope at the North End also proved a challenge, but nevertheless the baseline was remeasured satisfactorily and found to be 36,577.8581 feet when reduced to mean sea level (a reduction of -0.6294 feet). The length of the remeasured Salisbury Plain baseline was then recalculated from Lough Foyle and found to differ by 0.3193 feet (3.83 inches). It is reported that the stations marking the ends of the Salisbury Plain baseline are still there, although the one at the south end of the line is buried in undergrowth and the northern one had a triangulation pillar built over it in 1936. The other four baselines measured with Ramsden's 100-foot steel chain were used to verify the distances calculated from Lough Foyle, and with the greatest difference between computed lengths and measured lengths of just three inches, these provided the verification required. Their end points were marked by wooden blocks, long since gone.

Colby was too busy progressing the maps of Ireland to write up the results of his work at the time, and Drummond was called away from Ordnance Survey work early after falling out with Colby in the 1830s, to undertake political duties – he later became Chief Secretary of Ireland, and his statue stands in Dublin City Hall. Murphy, also active in the base measurement, was called to lead the scientific operation of the Euphrates Expedition, and so it was not for another 20 years, in 1847, that an account of the measurement of the base was written by Captain Yolland. Although he was not present at the time of the original measurement he relied on Colby and Drummond's recollections for his account and had overseen the use of the bars at Salisbury Plain. Colby was not a man to boast of his achievements, but the work had been witnessed and recorded by many eminent scientists and surveyors, and word of its achievements spread widely and quickly. Sir George Everest had heard of it whilst recovering from illness in England and ordered the same bars from Troughton and Sims for use on the Great Trigonometrical Survey of India, measuring a baseline near Calcutta. Colby's bars were also sent to South Africa in 1839 where they were used by the Astronomer at Cape Town, Thomas Maclear, for the first baseline measured in Africa, and Captain Henderson, who had been employed on the Lough Foyle Base under Colby, observed the actual measurement there. The bars themselves made their way back to Southampton, where the Ordnance Survey had moved in 1841, and ultimately one was returned to Phoenix Park following a request by the Free State Government in November 1923, where it still resides. Another bar, on loan from the Greenwich Museum, London, is on display at the Tower Museum in Derry.

1858 Calculations

Observations of the Principal Triangulation covering Ireland was completed by August 1832, and by 1858 the rest of the Principal Triangulation had been completed and a detailed account of the observations and calculations used in the whole network published. The two baselines at Lough Foyle (7.89 miles) and Salisbury Plain (6.93 miles) were used to calculate all trigonometrical distances. The difference between the measured lengths and their lengths computed through the triangulation is given as +/- 0.4178 feet, or about five inches. This difference was divided in proportion to the square root of the lengths of the measured bases, from which was obtained the mean base used in the triangulation; with a probable error of +/- 0.2 feet, or 2 ½ inches.

1960 Remeasurement

In 1952 a new triangulation was observed in Northern Ireland and connected to the recently completed retriangulation in Great Britain with connections across the border to a planned new scheme in the Republic of Ireland. It was not thought necessary to remeasure Colby's Lough Foyle baseline, and instead, the positions of four of the original Principal Triangulation stations (at Knocklayd, Trostan, Divis and Slieve Donard) were kept at those calculated in 1858, thus the maps, distances and scale continued to be based on the original measurement of the Lough Foyle baseline. The development of microwave electronic distance measurement equipment after the Second World War allowed Colby's Lough Foyle baseline to be remeasured in 1960 and it was found to be 0.024 metres (less than 1 inch) longer than Colby's measurement, confirming the original measurement as a truly outstanding achievement.

Conclusion

Today the three monuments protecting the South End, North End and Minearny Base stations on the plain by Lough Foyle stand testament to a remarkable achievement. Not many who come across these monuments fully realise their purpose, their significance to the maps of Ireland, or appreciate the history behind their development. Nor is it obvious how they have contributed to the development of the work of the Ordnance Survey in Ireland and beyond, particularly in this age of satellite GPS and phone-based mapping technology, recent innovations that have profoundly affected the way in which maps are surveyed, presented and used.

The baseline marked out by the three monuments achieved a level of accuracy that was truly remarkable for its day, contributing to science and to an understanding of the world around us. It is an achievement that is even more noteworthy when considering the ingenuity of the concept behind the compensation mechanism, turning that idea into a design that worked, and the manufacture of the bars and their associated instrumentation. Along with the method of execution on the ground, designed to overcome man's inherent biases and follies, the logistics and organisation of the whole operation and

the sheer persistence and perseverance of the men involved to achieve the results they did was truly exceptional.

The Lough Foyle baseline was the basis for calculation of all trigonometrical distances across the islands of Ireland and Britain, and beyond. Its distance was used by Sir George Airy, the Astronomer Royal, to help determine the size and shape of the Earth, a Figure of the Earth that was refined by Alexander Ross Clarke, and is still in use in many countries. The baseline has stood the test of time, and although it is no longer necessary for the maps of Ireland, it was only replaced in 1995 by satellite derived measurements.[17]

There are few surviving baselines around the world. Similar monuments in India are crumbling, the material remains of an Imperial past, a sort of archaeology of Colonial Cartography.[18] In Ireland, sharing a similar imperial history, they are listed as "Special buildings of local significance", thus protected, seen to have community and tourism value, recognising their uniqueness in the heritage landscape. In so many ways the whole exercise that produced them epitomises the Imperial era of scientific discovery and innovation, and like all great achievements have stood the test of time.

The three monuments still stand silently there in a line under the cliffs of Binevenagh Mountain: but today they are monuments to a different era, silent witnesses to times past.

Fig 9. Minearny Base station today under Binevenagh Cliffs. (MJ Cory)

[17] MJ Cory, *Remeasuring the Size of Ireland*, Irish Scientist Yearbook, 1997; and MJ Cory, IC Greenway and CJ Hill, *GPS Compatible Positioning in Ireland*, Survey Review, Pt 1 October 2003 and Pt 2 January 2004

[18] Keith D Lilley, *Surveying Empires: Archaeology of Colonial Cartography and the Great Trigonometrical Survey of India*, 2020

Acknowledgements
This paper was written in support of the Mapping Monuments Project, a community heritage project led by the Causeway Coast & Glens Heritage Trust and Queen's University Belfast. The assistance of Professor Keith Lilley is gratefully acknowledged. Queen's provided a scanned copy of Yolland's account that assisted this paper and allowed some of the illustrations to be included. It should be noted that the Mineary and North Base stations are on private farmland, and permission is required from the landowners to access the site.

This paper is based on several sources:
Memoir of the Life of Major-General Colby by Lt. Col. JE Portlock, Seeley, Jackson & Halliday 1869;
An Account of the Measurement of Lough Foyle Base with its verification and extension by Triangulation, by Captain William Yolland, Board of Ordnance, 1847
Account of the Observations and Calculation of the Principal Triangulation (and of the Figure, Dimensions and mean specific gravity of the Earth as derived therefrom), drawn up by Captain Alexander Ross Clarke RE FRAS under the direction of Lt Colonel H James, RE FRS MRIA &c., Superintendent of the Ordnance Survey. Published by George Edward Syre and William Spottiswoode, 1858;
Early Years of the Ordnance Survey Colonel Sir Charles Close, Institution of Royal Engineers, 1926.

Making history in County Donegal

Karen Rann

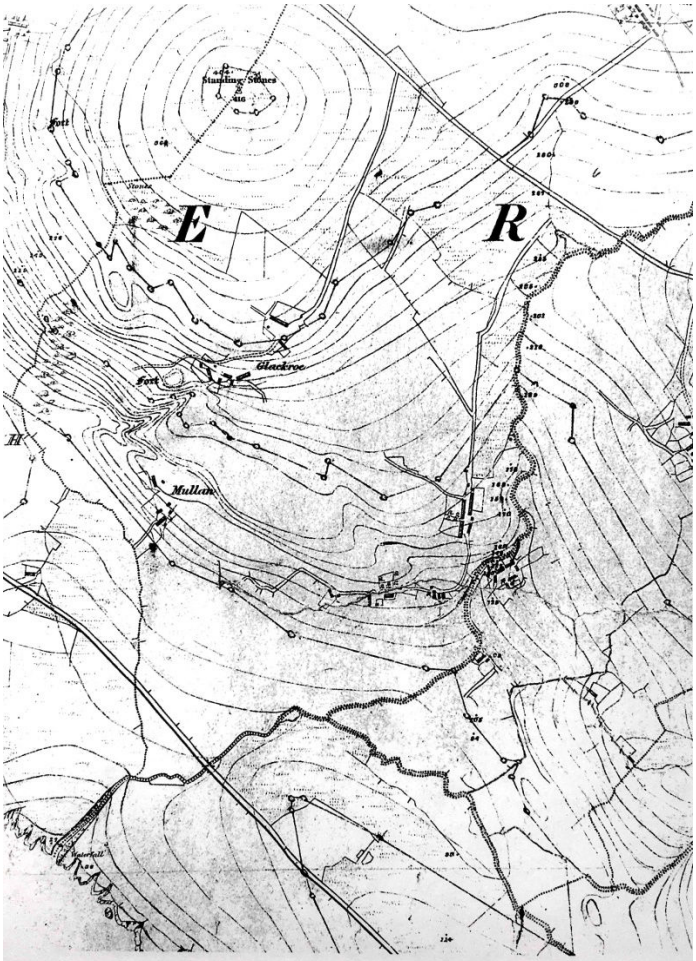
On the west coast of the Inishowen Peninsula in County Donegal lies a small hill that played a huge role in changing how relief was portrayed on Ordnance Survey maps. Apart from the megalithic tomb on Mullagharry's summit, it is unremarkable. Even locals struggle to spot it amongst the rolling hills of the parish of Desertegny, tucked between the Urris Hills to the north and Aghaweel Hill to the east. Yet it was here that the Ordnance Survey first experimented with diagrammatic contour lines – instead of pictorially sketching hills – for their maps.

Figure 1. Mullagharry viewed from the flanks of Aghaweel Hill - Lough Swilly in the distance. (Author)

It is hard to fathom why they began here (on sheet 18). Under Colby's command a 'top down' approach was taken to the survey of Ireland. Sheet number one, of both the six and one-inch series of Ireland, began with Malin Head at the tip of the Inishowen Peninsula. This northernmost point could be construed as the opening line for a 'once upon a time' story of Ireland. So why not begin experiments with contouring there? Evidence that the trial started lower down the Peninsula is given in *A Paper Landscape* by JH Andrews. Depicted in plate VI of the book is a detail from this sheet titled "The earliest Irish contours. 6–inch map, Donegal (Inishowen), part of sheet 18, engraved 1836, published 1837, with MS. contours added in 1839". The hill towards the top of the plate is Mullagharry though it remained

nameless on both the first and second editions of the six-inch map series. On the first edition of sheet 18, the Megalithic Tomb at its summit is described as Standing Stones.

Encircling the wording – and a trig point marked 416 – an instrumental contour line was added to the printed map. Rippling outwards from this, the eye tracks another five contours ringing the hill. They lend Mullagharry's flanks a bull's eye appearance, and almost inevitably, this hill became my focus for field research into the emergence of contour lines on maps.[1]



VI. The earliest Irish contours. 6-inch map, Donegal (Inishowen), part of sheet 18, engraved 1836, published 1837, with MS. contours added in 1839

Figure 2. "VI. The earliest Irish contours. 6–inch map, Donegal (Inishowen), part of sheet 18, engraved 1836, published 1837, with MS. contours added in 1839". (John H. Andrews, A Paper Landscape: The Ordnance Survey in Nineteenth-Century Ireland*, reprint, 2006).*

[1] Karen Rann, *Horizontal Hills: A Creative Historical Geography of the Emergence of Contour Lines in Nineteenth-Century Britain and Ireland* (PhD thesis, Queen's University Belfast, 2022). Just west of Mullagharry lies Fort Dunree where the art organisation Artlink is based. Since completing the PhD I have been developing the arts project *Drawing with Altitude* with them (with Arts Council Ireland funding).

My fascination with contour lines began in 2013 while I was artist in residence with the National Trust for Scotland on the Isle of Arran. One day, standing on the flanks of Goat Fell with an old pictorial map in one hand, and a modern contoured one in the other, the thought struck me: how had contour lines come into being? Why had mapmakers switched from easy-to-read pictorial hills to abstract lines? As idle curiosity turned into obsession, I quested for answers. The dichotomy between subjective pictoriality and objective abstraction (and the question of how best to flatten hills onto paper maps) is all engrossing. While pictorially sketched hills can look beautiful, contour lines present information on the heights, gradients, and positions of hills more succinctly. In a nutshell, sketched hills are easier on the eye, and contours more precise (potentially). In an era when the collection of statistics (think of Colby's Memoir project in Ireland) and diagrammatic formats for their presentation were increasing in popularity, diagrammatic contour lines came to be seen as cutting-edge mapping technology.

By the 1830s, the portability and precision of surveying equipment had improved enough for contouring with instruments to become a viable alternative/aid/addition to sketching the hills.[2] Encouraged by his superior Thomas A Larcom, in 1839, the OS's head of hill drawing in Ireland, George Bennett, tasked his sketchers with a contouring trial. As well as his drawing board, the hill sketcher would now have "three labourers under him; two acted as staff holders and chainmen, and the third carried the instrument [theodolite], from station to station, and sheltered it from the wind with a large umbrella".[3] The sketcher plotted the contour lines directly onto a six-inch printed outline map.

Circling the Standing Stones at the summit of Mullagharry, at 400ft, the positions of the staffs were marked off in six places. - Between each, the contour line was drawn ruler straight, creating a polygonal, or "unfortunate angular effect".[4] 100ft lower down the hill, another *instrumentally* measured contour was drawn onto the map.

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[2] WA Seymour ed., *A History of the Ordnance Survey,* 1980, 171–3. This article is written from an artist's perspective, I hope those among you who trained as surveyors will overlook the 'artistic licence' taken with some of my descriptions of methods and practices.

[3] Master-General and Board of Ordnance, *Abstracts of Principal Lines of Spirit Levelling in Ireland, carried on during the years 1839 to 1843, under the direction of the Late Major-General Colby* (London: G. E. Eyre & W. Spottiswoode, 1855), xvi.

[4] JH Andrews, *A Paper Landscape: The Ordnance Survey in Nineteenth-Century Ireland* reprint (Dublin: Four Courts Press, 2006), 118. This jerky style was abandoned for later contour maps.

Figure 3. The Megalithic Tomb at the summit of Mullaghary hill was marked on the first edition (published 1837) as Standing Stones. On the second (1905) edition the wording was altered to Laghty (possibly anglicised from leachtaí – memorial stones on burial mound).

Between these two polygons, the hill sketcher then added another nine curving contours by eye. These rough estimations of altitude (that came to be called *interpolated* contours) appeared as finer, dotted lines. Drawing these contours was neither complicated nor unusual for the hill sketcher. They were already using form-lines to aid drawing hills in the horizontal (hachure) style and considered their sketched lines as something akin to contours. In Ireland, they had been trained by master draftsman Robert Kearsley Dawson who, in 1833, stated:

"all hands have been engaged more or less in drawing contours".[5] Both RK Dawson and his father (and instructor) Robert Dawson were flexible in their definitions of terms: hachures were also described as form-lines, and both these were sporadically described as contour lines. On sheet 18, the sketched contours, drawn at ten-foot intervals of elevation between the instrumental lines, demonstrate a practiced fluidity, though the uniformity of their curves suggests the hill sketcher may have desired to standardise the hill rather than register its irregularities (its individuality). This thought struck me whilst making two models of the hill, one based on the hill sketcher's contours, the second on current OSI lines.

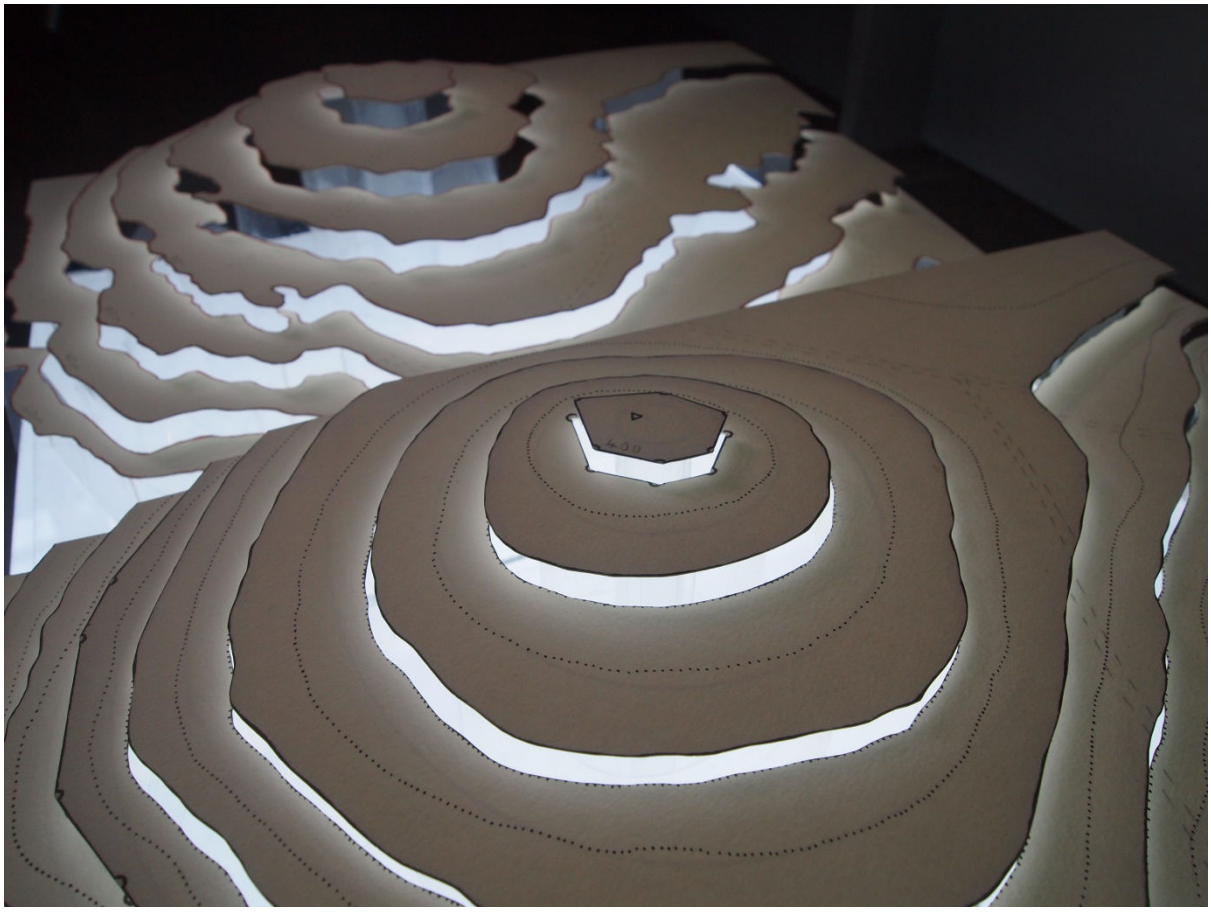

Figure 4. Two A3 contour models of Mullagharry. The foremost is based on plate VI in A Paper Landscape (circa 1839), the second model is derived from the contours on OSI map 3, discovery series, 1:50,000, 2019.

The contouring trial in Desertegny was deemed a success and "specimens of the Donegal work, … were sent to Chatham to be used in [training]… engineers." This endorsement, appears to be the only record of the first OS experiment in contours.[6] Shortly afterwards,

[5] Andrews, *A Paper Landscape*, 114. Quote from an OS Progress Report, hill department, 14 January 1833.

[6] Andrews, *A Paper Landscape*, 115, fn 3.

regular contouring began (again on the Inishowen Peninsula), and by 1841, hill-sketching was virtually abandoned, replaced by contouring with instruments and sketching intervening (interpolated) lines by eye.[7] Hill sketchers were highly skilled, and expensive to employ, and on those grounds, Larcom decided contouring work should be handed over to a cheaper workforce and "a body of sappers and mechanical assistants, [were trained to] run the contours on six-inch sheets".[8]

Although the OS began contouring in Ireland, the practice swiftly spread to northern England and Scotland and the first sheet to have contours printed on it was in Lancashire. Sadly, those initial contours, drawn around the wee hill of Mullagharry – the first ever drawn by the OS in the field – were never printed.[9]

Acknowledgments
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Permission to reproduce plate VI (initially in my thesis) was given courtesy of John H Andrews and Four Courts Press. All other images are my own.
With thanks also to David Fairbairn who was kind enough to read through and comment on the draft text.

[7] Andrews, *A Paper Landscape*, 115.

[8] Thomas Larcom in *Report of the Commissioners Appointed to Inquire into the Facts relating to the Ordnance Memoir of Ireland, together with the minutes of evidence…* (London: Her Majesty's Stationary Office, 1843), 61–62.

[9] Neither the first edition of Sheet 18, nor the second (printed in 1905) included contour lines for the parish of Desertegny.

The Ordnance Survey and the Guide Post

Richard Oliver

What is often referred to as a 'signpost' has, at any rate since *circa* 1851, been referred to by the Ordnance Survey as a 'guide post': this form, always abbreviated from the late 1880s as '*G.P.*', is familiar on six-inch and larger-scale mapping. From 1963 guide posts pointing to paths and tracks, as distinct from public carriage roads, were no longer mapped, and since 2002 guide posts have been effectively excluded from the National Topographic Database.[1] Guide posts were shown on the 1:25,000 Provisional Edition or First Series (1945-92), but these were derived from pre-1945 County Series six-inch (1:10,560) mapping, are no evidence of post-1940 survival, and will not be considered here.[2] The revision made primarily for the one-inch Seventh Series in 1947-58 that was also applied to the 1:25,000 did not include guide posts and, with apparently a single early exception, guide posts have not been indicated on either the one-inch or its 1:50,000 successor. The exception is one on Southampton Common that appears on Old Series sheet 11, published in 1811: was it a landmark, or an aberration? Both milemarkers and guide posts were enjoined in legislation from 1697 onwards, but whereas milemarkers were widespread by the late eighteenth century, guide posts were evidently more exiguous: a letter to the *Northampton Mercury* in 1787 asked for these to be erected, and there were apparently none in Devon in the 1790s.[3] The lack of them well into the nineteenth century was commented on by Richard Barham in one of his Ingoldsby Legends: 'It's a "fashious" affair when you're out on a ride, / … And you come to a place where three cross-roads divide, / Without any way-post, stuck up by the side / Of the road to direct you and act as a guide, / With a road leading here, and a road leading there, / And a road leading no one exactly knows where.'[4]

Direction boards affixed to buildings (*figure 1**) have not been shown at all on Ordnance Survey mapping, and therefore any study of the distribution of assistance to travellers at road junctions that concentrates on guide posts may give a misleading impression in more built-up areas. Presumably the Survey's attitude was that free-standing guide posts were landmarks, whereas boards attached to buildings were not.

**Editor's note: See conclusion of text for all figures*

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[1] Richard Oliver, *Ordnance Survey maps: a concise guide for historians*, third edition, London: Charles Close Society, 2013, 121.

[2] They were also shown on the predecessor 1:20,000 and 1:25,000 series, GSGS 2748 and GSGS 3906, but not on the earlier 1:25,344, GSGS 3036. All these were six-inch derivatives, and are not independent sources for the presence of guide posts.

[3] Letter from Mr Winslow in *Northampton Mercury*, 27 February 1787; W.G. Hoskins, *Devon and its people*, Exeter: Wheaton, 1959, 119, quoting William Marshall, *Rural economy in the West of England*, 1796.

[4] In 'The Blasphemer's Warning. A lay of St. Romwold' [originally published posthumously in third series, 1847], in [(Rev.) Richard H. Barham], *The Ingoldsby Legends*, London: Macmillan [1898], 1906, 461.

The depiction of guide posts seems almost unknown on the one-inch and similar scale commercial county maps of the later eighteenth and early nineteenth centuries: the legend of Henry Beighton's map of Warwickshire (*circa* 1727-8) shows 'Crosses of Direction', though very few appear to be indicated on the map itself.[5] Perhaps there were few to be shown? Hardly any guide posts or milemarkers appear on enclosure mapping of *circa* 1750-1840 or on the tithe surveys produced from 1837 onwards: this is unsurprising, as these were irrelevant to the purpose of these maps. The apparently comprehensive mapping of guide posts therefore began effectively with the introduction by the Ordnance Survey of the six-inch scale in 1841.[6] At first the terminology varied: *Direction Post*, *Finger Post*, *Sign Post* and *Guide Post* are all found on the six-inch first edition maps of Lancashire and Yorkshire prepared in 1841-51, but thereafter *Guide Post* was standardized.[7] It was Ifan Shepherd and Steve Chilton's pointing out, in a draft of their study of the first-edition six-inch mapping, the various forms used in Lancashire that was the prompt for the present article. Though the term 'guide post' seems hardly to be used outside the Survey latterly, it is encountered in Patterson's *Roads*, and in Surtees.[8] The term 'way-post' is also occasionally encountered in the earlier nineteenth century, as witness the quotation above, but does not appear to have been employed by the Survey. Usage may not be consistent: in the 1820s Paterson's *Roads* uses both 'Direction Post' and 'Guide Post'. Paterson also suggests erratic national distribution, though this may be partly the result of local road patterns. Guide-posts were almost invariably made of wood, possibly not always well seasoned, and the survival rate was not good: of fifteen posts mentioned in Paterson that were checked on the first edition of the six-inch (*c.*1850-84), posts were still present at only five locations.[9]

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[5] *A mapp of Warwickshire exactly describing the boundaries and divisions, all the rivers, brooks and rivulets, the roads in measur'd and computed miles, the parish churches, chapels, depopulated places, seats of the nobility & gentry, chaces, parks, kings houses, baronies, monasteries, castles, Roman ways, stations, etc. battels, garrisons, mines, medicinal waters. Actually survey'd in the years 1722, 1723, 1724, 1725*, n.d., *circa* 1727-8.

[6] The OS had introduced the 6-inch scale in Ireland from 1825; guide posts are not known to be shown on this mapping, but it awaits thorough investigation in this regard.

[7] The transition is evident in the south-east of the East Riding of Yorkshire, where the manuscript maps were certified fit for publication in 1851-2: *Guide Post* is the usual form, but a *Direction Post* appears on sheet 198, in the extreme north-west corner.

[8] *Paterson's Roads*, 16th edition, revised Edward Mogg, London: Longman, etc, 1822; R.S. Surtees, *Mr Facey Romford's Hounds* (1865; Oxford University Press, 1984: Chapter LX), 415.

[9] Paterson mentions 'Direction Post' or 'Guide Post' at seventeen places on pp 1-344, as follows (* = shown on OS 6-inch 1st edition; † = 'Direction Post'; ‡ = 'Guide Post'; q = 6-inch 1st not checked): 14†, 31‡, 44†q, 134†q, 166‡, 216‡, 251*‡, 280‡, 303‡, 304‡, 305*‡, 312*†, 313†, 321‡, 323*†, 325*†, 328‡. They usually seem to be shown where the road forked, or at a T-junction. Paterson's use of both 'direction post' and 'guide post' may be the result of compilation from disparate sources.

A preliminary study by the writer of originals and (mostly) copies of six-inch sheets in his collection suggested a very erratic distribution (see *figures 2, 3, previous page*). This prompted further investigation over more areas. Is the Ordnance Survey first edition six-inch and 1:2500 likely to be a reliable source for the distribution of guide-posts?

A problem with the large scales is the prolonged period of initial survey: 1841 to 1888, with much of the earlier work (1841-*circa* 1870) in 'upland' Britain, with a relatively more sparse road network. Therefore a national tendency to increase the provision of guide posts may be obscured by fragmentary or non-synchronous cover. However, it is noticeable that there is a relatively high density in the south-east part of the East Riding of Yorkshire (surveyed *circa* 1851), east Surrey (*circa* 1867-8), south Bedfordshire (*circa* 1878-80) and north-east Lincolnshire (*circa* 1886-8). The data for the East Riding sample is roughly contemporary with three areas in east Scotland (*circa* 1852-6), in two of which no guide-posts at all are shown, and only two in a third.[10] Table 1 (*opposite)* and *figure 4* summarise the depiction of guide posts on the first edition six-inch and subsequent revisions, and show that consistently more guide posts appear in lowland than in highland Britain.[11] Further, it is striking that 49 per cent of rural road junctions in the north-east Lincolnshire study area were equipped with guide posts in *circa* 1886-8 compared with 32 per cent across the Humber in the East Riding in 1888-9. From all this it seems a fair conclusion that first, guide posts were more widespread, proportionate to the number of rural road junctions, in lowland Britain, and second, that Ordnance Survey maps are reliable sources for guide post distribution.

Therefore it would seem that an apparent tendency for guide posts to be more numerous on large-scale maps in lowland rather than in upland Britain is that there were simply more of them, and that in that respect the maps represent 'ground truth'. Support for the lack of guide posts in east Scotland is that two of the three counties sampled, west Haddingtonshire (later East Lothian) and east Fife, were surveyed in the early 1850s by a division based in Edinburgh; the Divisional Officer was Captain Henry James, who was promoted in July 1854 to be Director of the Survey. In 1870-71 James told a departmental committee investigating the Survey that questioned the incorporation of minor detail that it was cheaper for surveyors to include everything, rather than to train staff to use their discretion.[12] By the early 1850s James was an experienced divisional officer, and it seems reasonable to suppose that, had there been guide posts to record in the areas being mapped by his division, they would have been recorded. A study of the northern part

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[10] And one of those only appears on the 1:2500: Berwickshire sheet 17.11, Hutton parish. A check of all the 1:2500s in the Berwickshire study-area failed to reveal any more guide posts.

[11] This is loosely supported by Paterson: there are concentrations in the east part of the East Riding (pp 303, 304, 305) and Norfolk (pp 312, 313, 321, 323, 325).

[12] Copy of report of committee of enquiry with comments by James in The National Archives [TNA] T1/7261A.

Table 1

	Area examined (sq km)	*Public road junctions*	*Date*	*% juncs with GPs*	*Date*	*% juncs with GPs*	*Date*	*% juncs with GPs*	*Notes*
Bedfordshire SE – NW Herts	249	129	1878	19	1900	39	1922	50	1
Berwickshire east	280	120	1856	1.6	1897	14	1906	20	2
Cornwall south-east	88	133	1857	2.2	1892-3	11	1905	14	3
Devon east - Exeter	305	536			1888	18	1904	26	4
Dvon – Plymouth	179	180	1855-63	7	1892-3	12	1905	33	5
Devon - Torbay	47	42	1862	5			1905	17	6
Fife east	212	76	1852-3	0	1893	9	1911	26	7
Haddingtonshire west	308	108	1852	0	1892	13	1906	22	8
Lincolnshire NE	590	253			1886-7	48	1905	62	9
Northumberland north	1634	482	1859-64	5.3	1896-7	21	1921-2	34	10
Surrey east	215	201	1868	14	1894-5	25	1910	40	11
Yorkshire East Riding SE	880	440	1850-1	22	1888-9	30	1908-9	47	12

Notes

1 Area defined by 1:10,560 sheets Bedfordshire 29, 30, 32, 33, and Hertfordshire 11, 19.
2 Area defined by 1:10,560 sheets 2, 5, 6, 11, 12, 17, 18, 23, 29.
3 Area defined by 1:10,560 sheets 45, 46, 54, 55.
4 Area defined by 1:10,560 sheets 68, 69, 80, 81, 92NW, 92NE, 93NW, 93NE.
5 Area defined by 1:10,560 sheets 117, 118, 123, 124, 129, 130: a portion on the NE surveyed in 1880s, but does not contain any GPs.
6 Area defined by 1:10,560 sheets 116 (south part only), 122, 128, 134
7 Area defined by Fife part of 1:63,360 sheet 41.
8 Area defined by 1:10,560 (old series) sheets 8-10, 13-15.
9 Area defined by 1:63,360 New Series sheets 81, 90, 91.
10 Area defined by 1:63,360 New Series sheets 1-6.
11 Area defined by 1:10,560 sheets 14, 20, 21, 27, 28.
12 Area defined by 1:10,560 sheets 197, 210-213, 224-228, 238A, 239-242, 254-257, 268, 269, 269A.

of Northumberland, adjoining the Berwickshire sample, indicated that there in the early 1860s guide posts were few, and tended to be concentrated in particular areas (*figure 5*).

The picture is not entirely clear, however, and there are a few problems. One of them is guide stones. There are a number of these in the south Pennines and west Cornwall. Some of the south Pennines guide stones appear on the six-inch first edition, and are unproblematic, but some do not (*figures 6A, B, 7A, B*). Why? Other likely guide stones may be described by the Survey as milestones: an indicator of guide stone status is that they are not at one-mile intervals (*figure 8).*

Another instance of a problematic distance marker is the cast-iron guide post south of Wold Newton in Lincolnshire, of 'antique' appearance, apparently stolen in 1991. The lettering suggests that it was cast well before 1887 – something more like 1847 or 1857 seems possible – but it is absent from the six-inch and 1:2500 first edition.[13] (*figures 9A, 9B*)

A third problem concerns the distinctive multi-distance cast-iron guide posts unique to east Fife. Some of them bear the name of a foundry in Cupar that is known to have moved to Kirkcaldy in 1855. The name 'CRAIL' in *figure 10* is in a style similar to that of the Wold Newton guide post; the remainder of the text is in a much more modern style of the sort likely to be encountered on cast-iron street furniture manufactured after *circa* 1890. None of these distinctive Fife guide posts appear on the six-inch first edition, surveyed in 1853-4: a couple, including that outside Crail, appear on the resurvey of *circa* 1893, and all of them appear on the revision of *circa* 1911. The writer's contention is that, on the basis of map evidence and font, they were cast after 1890, but it does leave the mystery of the responsible foundry being apparently in Cupar.[14]

The dates 1888-9 are significant, in that Local Government Acts were passed then, setting up County Councils in England and Wales and in Scotland. Responsibility for ex-turnpike and main roads was transferred to the newly-created councils. There ensued considerable activity in erecting and replacing milemarkers and guide posts: the wholesale replacement of milemarkers in the West Riding and Cheshire is well known, and elsewhere, for example in Cornwall and Somerset, milemarkers were provided where there had either been none before, or else they had rotted away.[15] There was

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[13] Stuart Squires, note in *Lincolnshire Past & Present* 7, Spring 1992, 22. A guide post is shown at this location on the second edition of the large scales, revised in 1905.

[14] Alex Darwood and Paula Martin, *The Milestones of Fife*, Standing Council of the East Fife Preservation Societies, 2005, 14, date these posts to 1851-4, and by implication of inclusion evidently consider them at least as much 'mile' as 'guide' posts: the present writer's view is that this dating is highly improbable on the grounds of the lettering employed, quite apart from the OS evidence.

[15] J.B. Bentley & B.J. Murless, *Somerset roads: the legacy of the turnpikes, Phase 1 – Western Somerset*, __: Somerset Industrial Archaeological Society, 1985, 11; John Bentley to Richard Oliver, 10 January 1991, in Charles Close Society Archive, Cambridge University Library, CCSA.RRO_644_11.

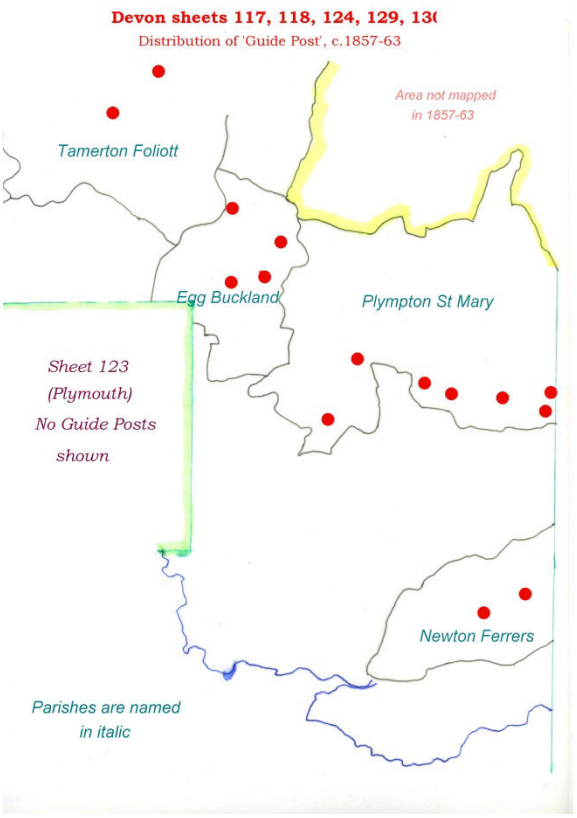
also considerable growth in the provision of guide posts. (Table 1) In 1888 general revision of the large scales began, and whilst after 1914 this became fragmentary, with consequent attenuation of the record, every county was revised at least once and some were revised twice between 1888 and 1922. The growth in the provision of guide posts is very obvious from the cartographic record, even in areas such as north-east Lincolnshire which were already relatively well provided for. The fragmentary cartographic record indicates a continued increase after 1914.

This study generated a number of distribution maps: an example is shown in *figure 11*. This intentionally includes an area of which only part underwent a second large-scale revision. Areas mostly or wholly covered by three revisions, notably east Surrey, are unusual. However, the general tendency for the population of guide-posts to grow is evident. A survey of 118 square miles around Exeter in the summer of 2023 confirms a continued expansion of guide post provision during the twentieth century: 96 *circa* 1888, 139 *circa* 1904 and 233 in 2023.[16]

Figures

Figure 1. Distance board at Beaulieu, Hampshire, about SU 387022, probably 1930s; photographer unknown. The distances shown appear to be: Bucklers Hard 2 ½ miles; Sowley 5; Brockenhurst 6; Lymington Town Hall 7.

[16] This survey covered 536 public 'rural' road junctions, all of which were in being by 1900: it therefore excludes motorway and other junctions that have come into being during the twentieth century, and would complicate long-term comparison. It also excludes guide posts for footpaths and other routes which are not 'public carriage roads'. The total of 233 in 2023 includes large signs on two poles which are a substitute for 'finger posts', particularly at junctions on nationally numbered roads, but which serve the same purpose.



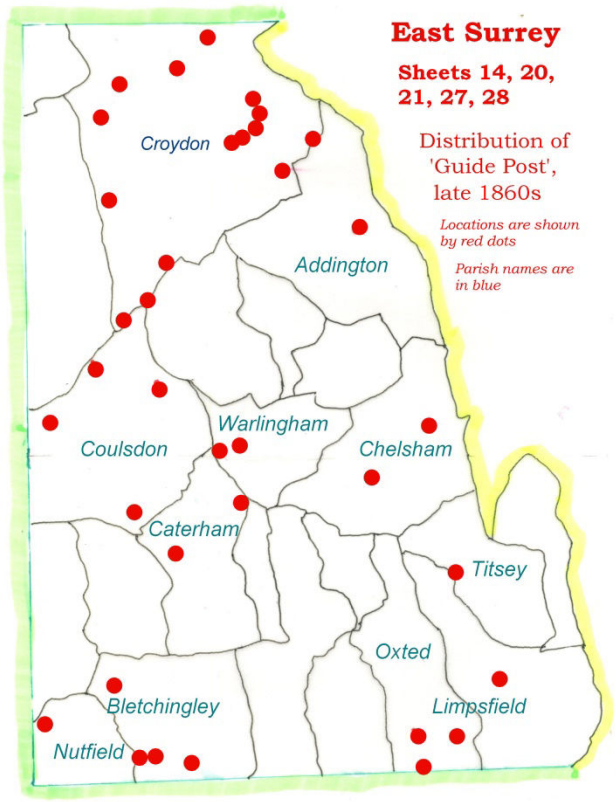


Figure 2 (L). The distribution of guide posts around Plymouth, as shown on Ordnance Survey 1:10,560 mapping surveyed 1857-63. Figure 3. (R) The distribution of guide posts in east Surrey, as shown on Ordnance Survey 1:10,560 mapping surveyed 1867-8.

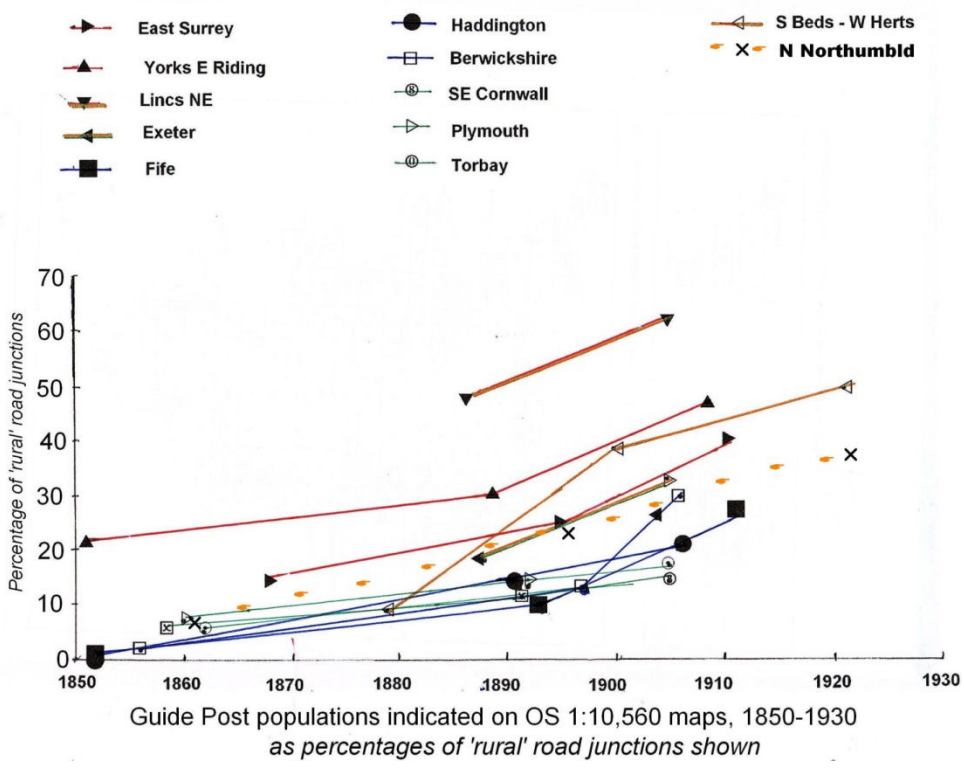


Figure 4. Guide post populations in selected areas as shown on Ordnance Survey 1:10,560 mapping, 1850-1930.

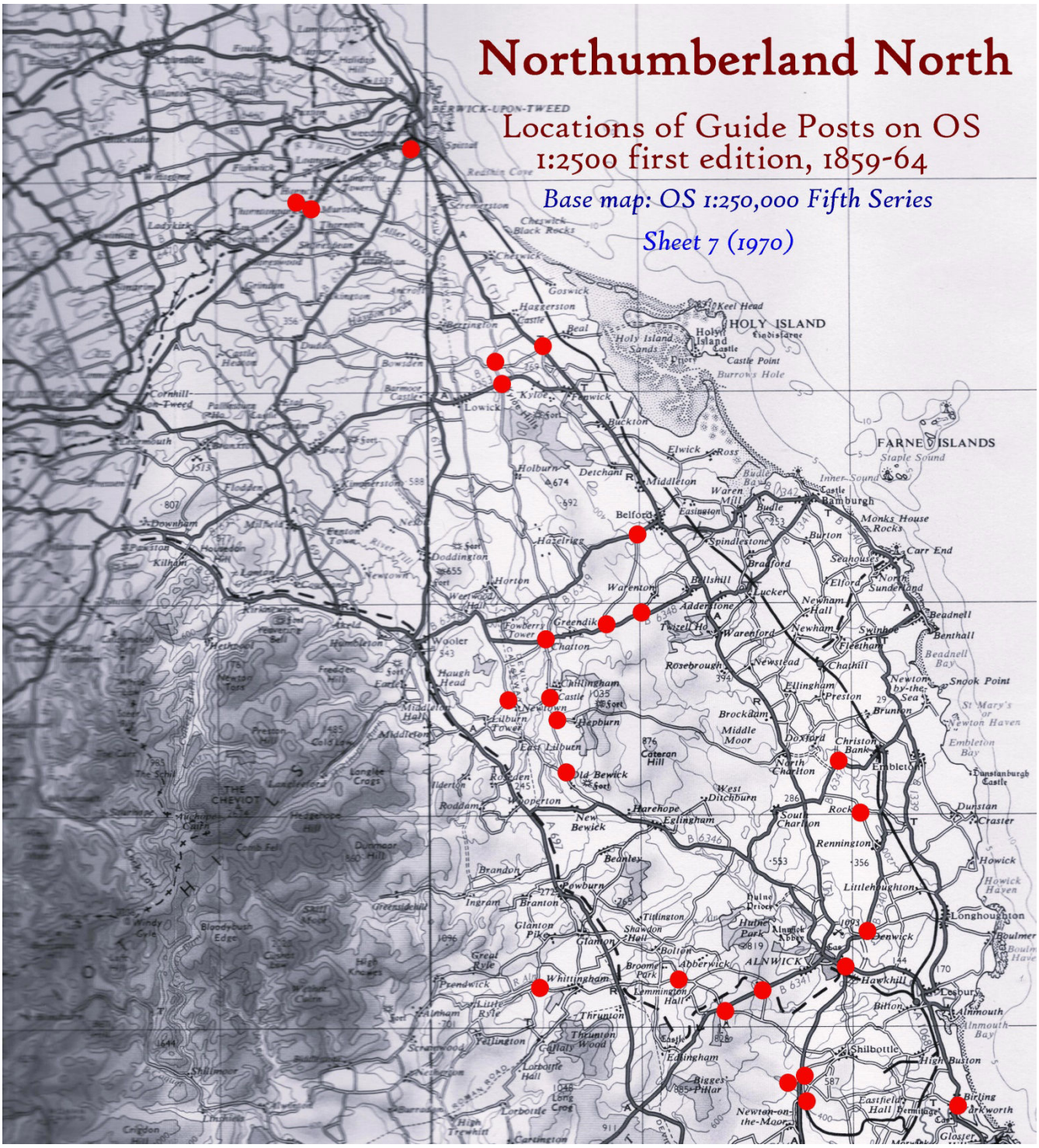


Figure 5. The distribution of guide posts in north Northumberland as shown on Ordnance Survey 1:10,560 mapping, 1859-64.

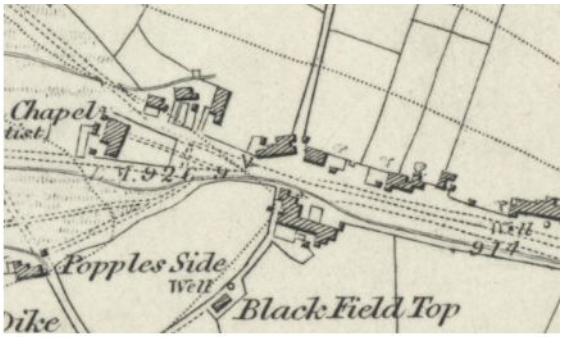


Figure 6. The guide-stone at Heptonstall, Yorkshire, SD 976287: A, as photographed on 24 August 2004; B, the site shown on Yorkshire 1:10,560 first edition sheet 214, surveyed c.1850 (courtesy National Library of Scotland). Does the benchmark arrow signify the presence of this stone?

Figure 7. The guide-stone at Smallfield, Yorkshire, SK 245947: A, as photographed on 24 August 2004; B, shown as 'Stone' on Yorkshire 1:10,560 first edition sheet 287, surveyed c.1851(courtesy National Library of Scotland). Was the inscription illegible in 1851?

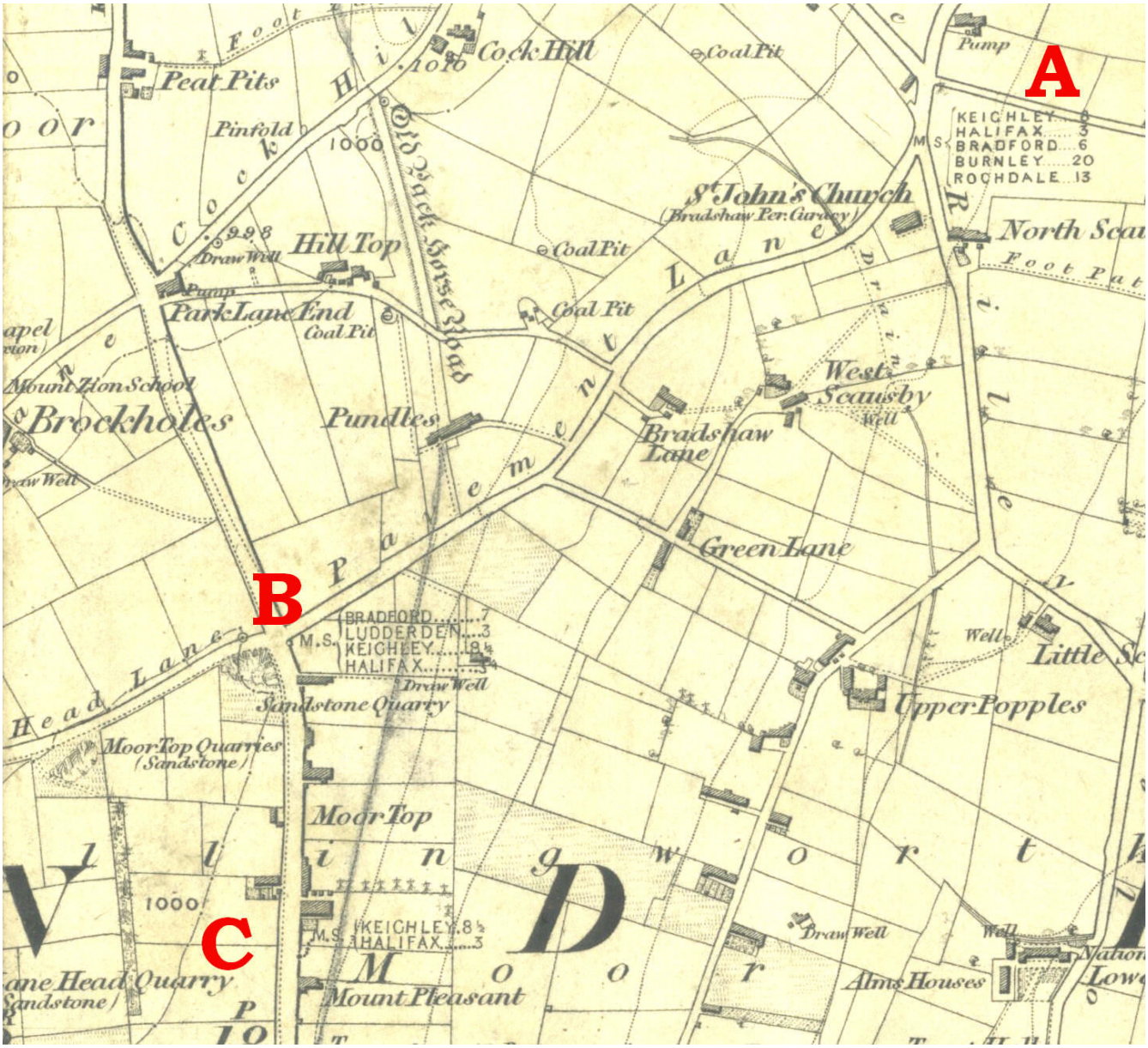


Figure 8. 'Milestones' on Yorkshire 1:10,560 first edition sheet 215, surveyed c.1850. Those at 'A' and 'B' may in fact be guide-stones: by 1892 they had been replaced by guide posts.

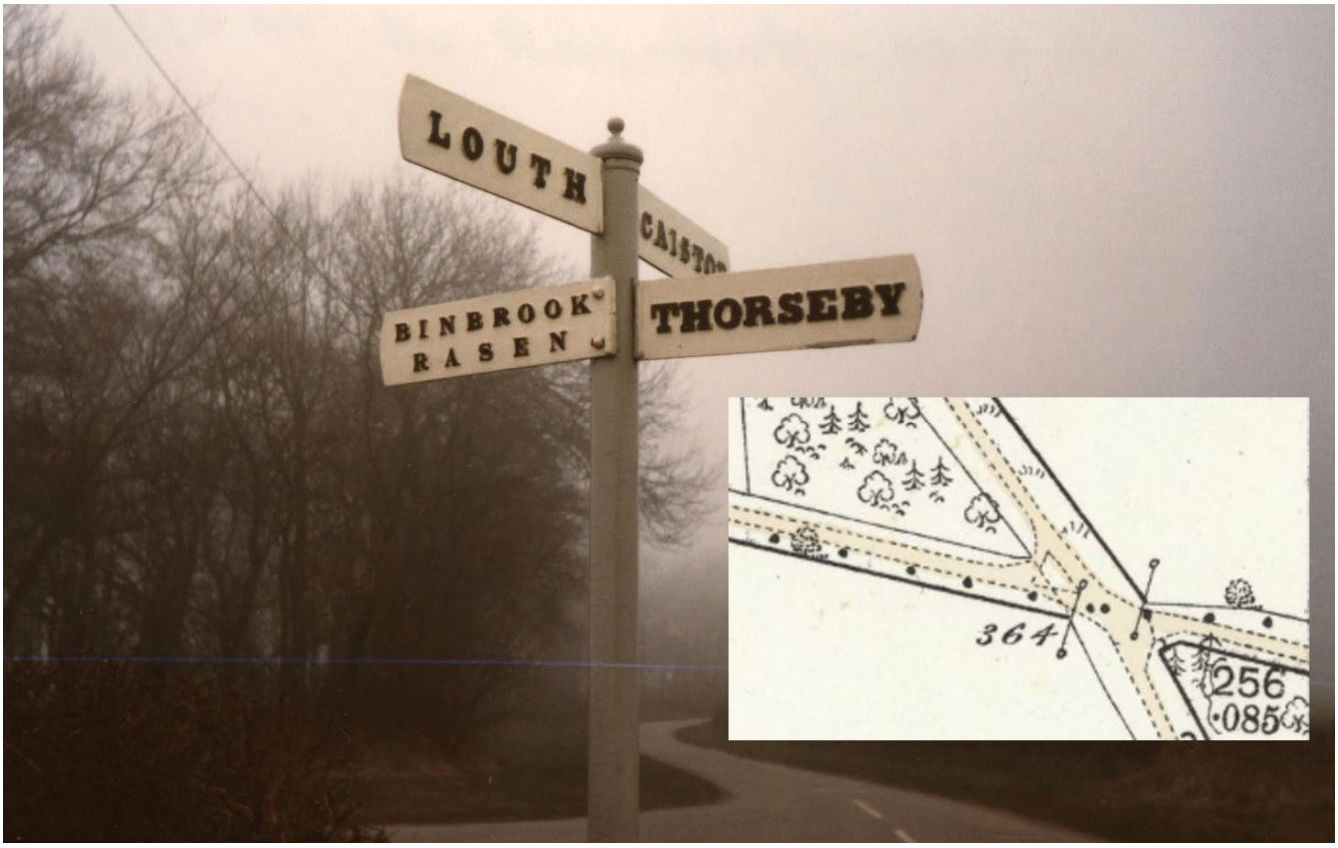


Figure 9. The cast-iron finger-post formerly south of Wold Newton, Lincolnshire, TF 241972, photographed in April 1984; and (inset), omitted from Lincolnshire 1:2500 sheet 39.13, surveyed 1887 (courtesy National Library of Scotland).

Figure 10. Milepost at Crail, Fife, NO 607081. (Photo by Elizabeth & Michael Spencer.)

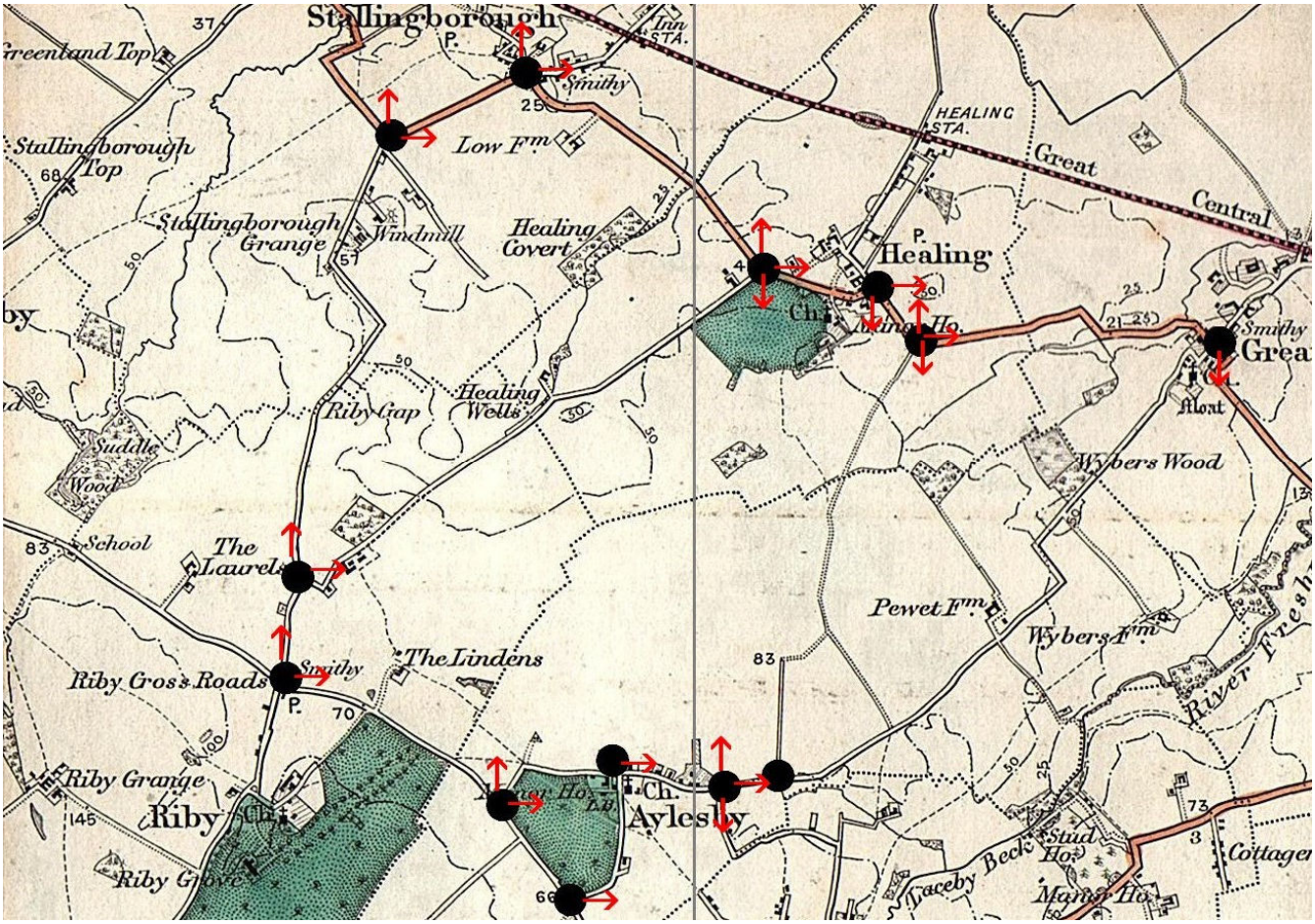
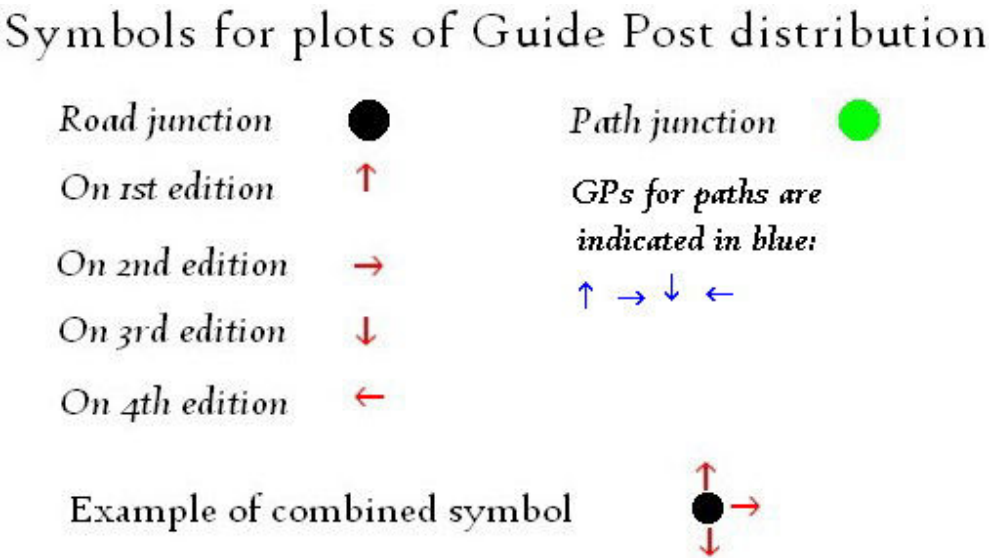


Figure 11a. (above): An extract from combined distribution map of guide-posts in north-east Lincolnshire: the area to the west of the grey dividing line was revised at 1:2500 only in 1905; that to the east of the line was also revised in the early 1930s. Figure 11b (below): Symbols used by the author for guide-post distribution maps.



Looking at paper

Rob Wheeler

There is a lot that could be said about the Survey's endeavour to procure paper economically that would meet the needs of its printers and of its varied users. The purpose of this article is more limited. It sets out to describe why it can be important in looking at maps not to forget the 'white bits' and to explain how fairly straightforward observations can help one to understand the maps

I shall be writing about machine-made papers. Hand-made papers account for a tiny percentage of OS maps and there are numerous accounts of how such paper is made. In contrast, little has been written about machine papers.

These are made by pumping *stock* (that is, wet pulp) onto one end of a wide conveyor-belt woven from wire (and called, simply, the *wire*). The excess water drains away and further water is removed by compression between rollers. By the time it reaches the end of the wire section, the resulting web is strong enough to be transferred to a belt of cloth (called the *felt*). As it progresses along the felt the web is dried still further until, at the far end it is dry enough to be slit and cut to produce the particular sizes that have been ordered and it can be stacked in reams (traditionally of 480 sheets), wrapped and despatched. In the course of its passage through the machine, the web tends to be stretched and the fibres in the pulp tend to become aligned with the direction of motion. This direction is called the *grain*. Paper tears most readily along the grain. (Try it on a sheet of unwanted A4: the grain on A4 (or A2, or A0) normally runs lengthways - known as 'grain-long'; on A3 etc it runs crossways - grain-short.) Paper folds most neatly with the grain parallel to the fold. (So modern OS maps use paper that is grain short for the sake of that first top-to-bottom fold. If paper takes up water from the atmosphere, the fibres swell, but they don't extend significantly. Thus paper is dimensionally more stable along the grain.

Recognising the Grain

Every printer knows the importance of grain and how to recognise it. Some of the tests (like tearing) are destructive. Others (like the droop test) work with a flat sheet of paper straight from the supplier but not where the paper has been rolled or folded at some time in the past. My preference is to view the paper illuminated at a very shallow angle by the pencil beam of an LED torch.

For the purpose of illustrating this article I took *figures 1 and 2* using a filament inspection lamp at an extremely shallow incidence angle, and it produces a more complicated picture because one sees phenomena at several different scales. At a scale of about 1cm, *figure 2* shows regular ripples. This is the result of its physical maltreatment in the past and need not concern us. (As a sort of scale, the (latitude) gradations in *figure 1* are about 3mm apart, those in *figure 2* (longitude) about 2mm.) At a scale of around 0.1mm, both views show a lot of grit and what may be seeds embedded in the surface and

sometimes casting shadows. Sherlock Holmes would no doubt be fascinated, but they do not concern us here. What matters is the scale of around 0.5 to 1mm, where *figure 1*shows a pronounced ripple pattern, whilst *figure 2* is bland by comparison. That is the contrast we are looking for: *figure 1* is illuminated cross-grain, *figure 2* along-grain.

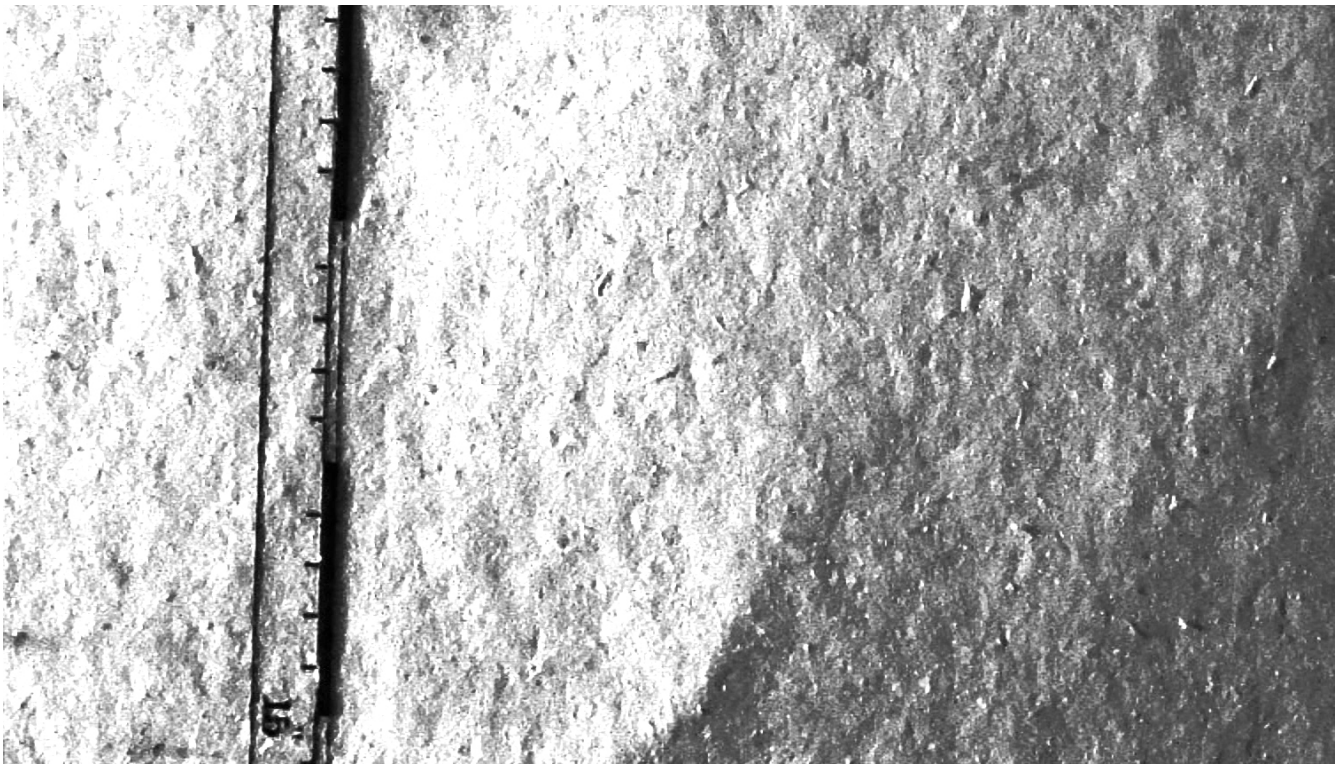


Figure 1

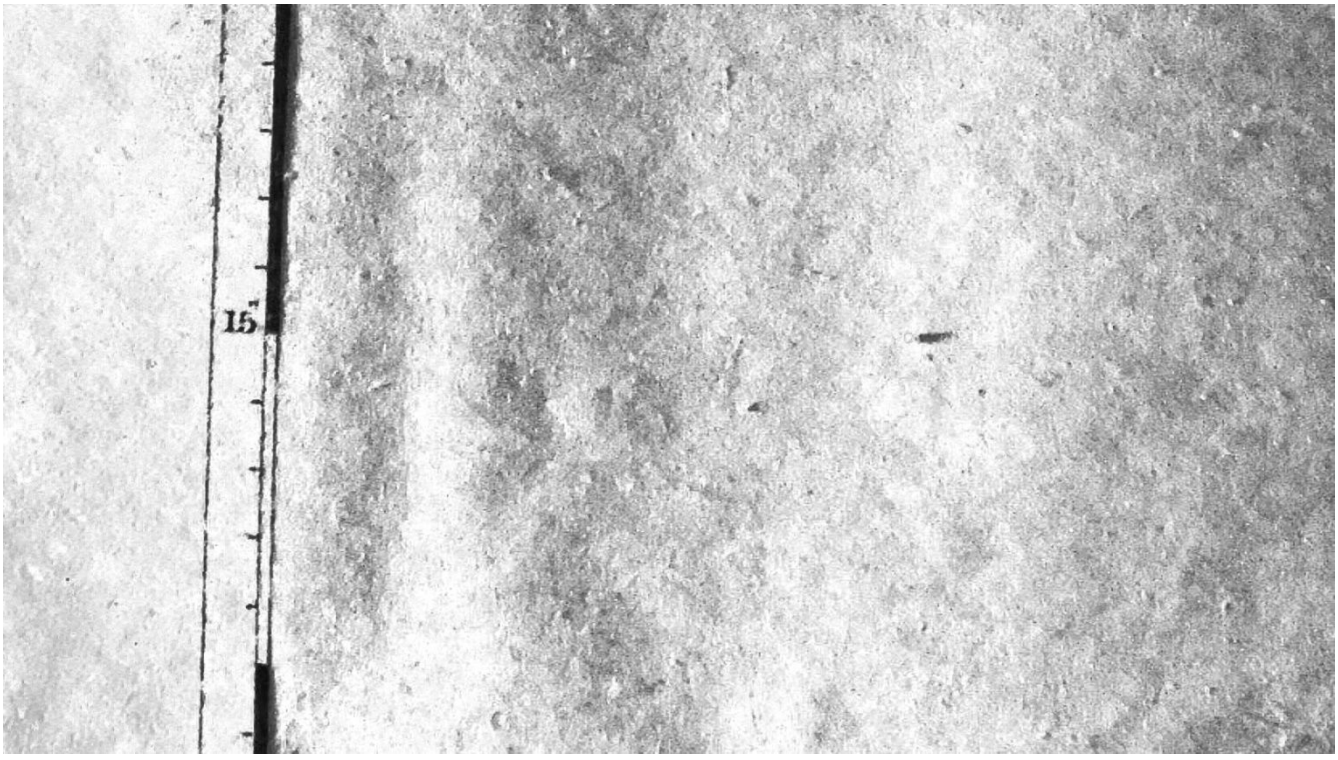


Figure 2

These images show T&JH paper, by far the commonest supplier from the 1860s to the end of the century. With experience one learns to recognise other suppliers, or at least to see that they are different. And if there is no difference between the two directions, especially if you see a swirling pattern, then there is a fair chance you are looking at hand-made paper.

Example 1: Portsmouth

Let us see how such things can be of use.

As a result of concerns about the adequacy of Portsmouth's defences, survey was authorised of an area that corresponds to Hants 75 and 83, the eastern halves of 74 and 82, and the western halves of 76 and 84. The survey was undertaken in 1856-59. (The dates are known from later maps, which oscillate between quoting the dates of this survey and the next one.) It would appear from the Area Books that all this survey was published in 1860.

Following the authorisation of a general resurvey of southern England in 1863, the whole of Hampshire was surveyed, including the parts that had recent military surveys. Thus the Portsmouth area was re-done in the second half of the 1860s. I shall term these surveys *the 1850s survey* and *the 1860s survey*. There was a further full revision 1872-75. This can normally be recognised from the marginalia. The problem lies in distinguishing the two earlier surveys, because in this era maps - at least, parish sets - came with a title page that gave the date of survey and the name of the surveyor. The individual maps simply had two mile-long scale-bars in the lower margin, the upper one graduated in chains, the lower in feet and in yards. Maps tend to become separated from their title pages - indeed just what form the title pages took in the 1850s survey is an open question. So how can one tell which survey a map is from?

a. The first point to look at is the embossed printing date (epd). Unfortunately this is sometimes illegible and there are cases where what should be a '5' looks convincingly like a '6'.

b. The second point - once one has discovered it - is that the 1860s survey was published by parishes, the 1850s survey in complete sheets; but there are ambiguous cases, eg when a single parish fills the entire sheet.

But what always serves to distinguish the surveys - and can be applied even with cropped and mounted specimens - is that up to 1860 the paper used was always grain-long, whereas from 1866 it was always grain-short. I have not encountered any lithographed sheets of the Portsmouth area that were printed in the years 1861-65.

Watermarks

Watermarks in machine-made paper were impressed into the top surface using pre-formed metal letters attached to an unpowered roll made from some form of wire mesh and known as a *dandy roll*. The mark normally extended over two lines. The upper line identified the manufacturer; the lower, at least until 1861, gave the year when the paper was made. Until 1861 there was an excise duty on paper; to make evasion more difficult there was a requirement

that a certain proportion of the sheets in every ream must bear a date. If the dandy roll had a diameter of 12 inches - which was a common size for thickish papers - its pattern would repeat about every 38 inches. This would bear no relation to the cutting process, so it would have been unreasonable to require every sheet to bear a date. For most of the ordinary papers used for books and suchlike, the watermark ran parallel to the axis of the dandy roll. It would typically be placed in the middle of the paper web, and would be balanced by another mark opposite it on the roll. Thus, with a 12-inch roll there is a water mark running across the grain in the middle of the paper web, and it repeats every 19 inches. But the effect of the cutting scheme is that such a watermark occurs at a totally unpredictable position on the supplied sheet.

The papers used for maps were also used by artists. A water-colourist who had created a beautifully limpid sunset was liable to be upset if he saw the name of the paper's manufacturer blazoned in the sky. Artists wanted watermarks at the edge of a sheet. This could be achieved if the watermark ran around the circumference of the dandy roll close to its edge, or, better, next to both the edges. Whatever the cutting scheme used these watermarks would end up on the edge of the delivered sheet.

The great majority of the papers delivered to the OS were of this form. Such watermarks run along the grain. On a grain-long sheet, they will be at the top or bottom edge; on grain-short, on one side or the other. Exactly how far from the edge will depend on how much of the edge of the web has been trimmed off as waste. The date is always closest to the edge and sometimes the bottoms of the figures are lost, but the date usually remains legible. Unless an illuminated panel is built into the working surface (as in the best-equipped map rooms) finding watermarks is not easy, so it is well-worth establishing the grain direction prior to searching, so that one knows where to look.

Dire warnings have been given about paper being used for printing maps long after it was made. Certainly the very early papers seem to have been procured in highly optimistic quantities and to have been managed in a disorganised way. A further problem was caused by the Railway Mania of 1845-6: map demand increased; supplies of all sorts became difficult; the Survey over-reacted, and found itself with excessive stocks when map demand returned to normal levels. Sanity was restored from about 1853-57, with most papers being used within a year or so of manufacture.

The removal of paper duty in 1861 had strange repercussions. It may be that duty-paid reams were retained by manufacturers hoping to reclaim the duty and eventually offered for sale when they had lost hope of a refund. At any rate papers of 1859 and 1860 (and occasionally 1858) appear with epds up to four years later. Meanwhile there is a dearth of watermarks of 1861-64. What seems to have happened is that, freed from the legal obligation to watermark papers, most manufacturers ceased to apply watermarks. And one finds quite a few maps printed in these years on unwatermarked paper, often on paper whose appearance strongly suggests it is from the usual suppliers.

And then, in 1865, dated watermarks re-appear. For quality control, there is no need for a watermark if a defect is discovered before or during printing: one can simply look at the wrapper. If a defect becomes apparent at a later stage, it becomes a challenge to decide what the paper was. So perhaps the OS re-imposed the requirement as a condition of contract. And then, after 1870, the OS seems to have decided there was no need for the date. So, after this date, watermarks become rather less useful.

Watermarks are often presented as the one attribute of a paper that matters. I would argue that what is really important is to look for the grain and look at the texture. That will, amongst other things, make it easier to find a watermark. If you do find a dated watermark, that is certainly of value, not least because it can sometimes show that an epd has been mis-read or perhaps is simply wrong. But an awful lot of watermarks are only of limited assistance.

When the OS introduced the lithographed six-inch, it dropped the requirement for a watermark on these papers. Watermarks remained on the papers used for engraved maps until as late as 1909. But, in general, for 20th century maps, one has to do without them.

Example 2: 'Special Revision'

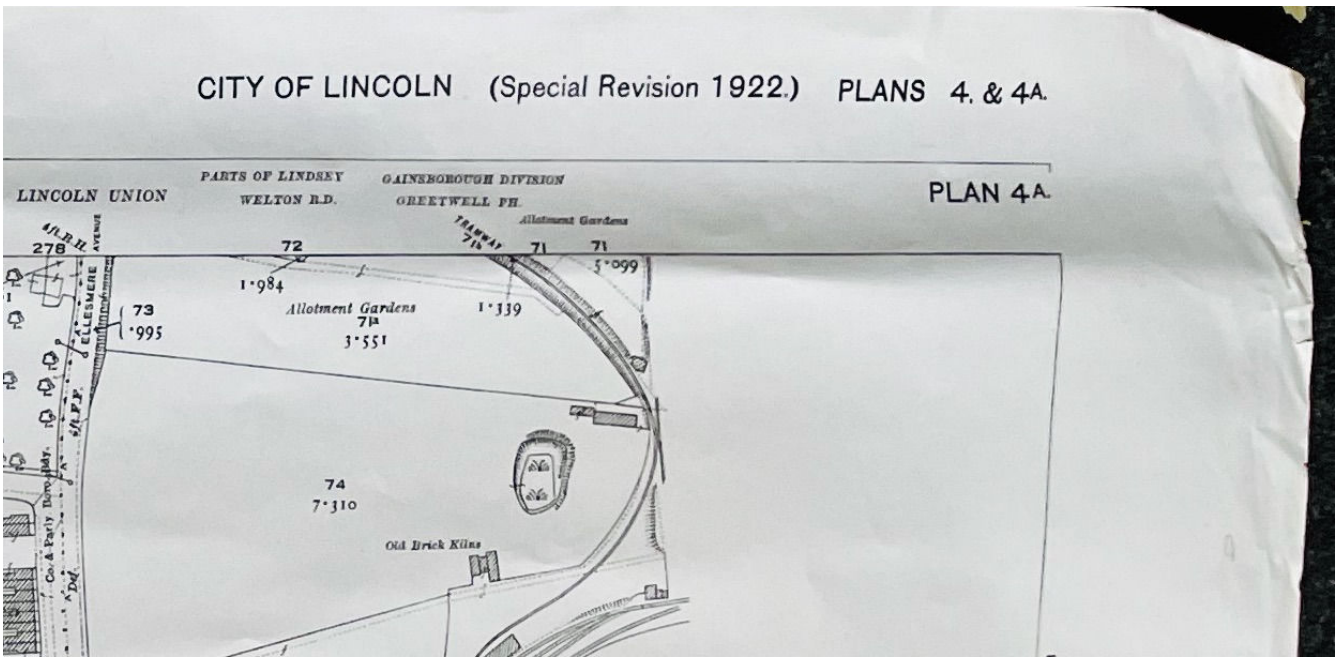


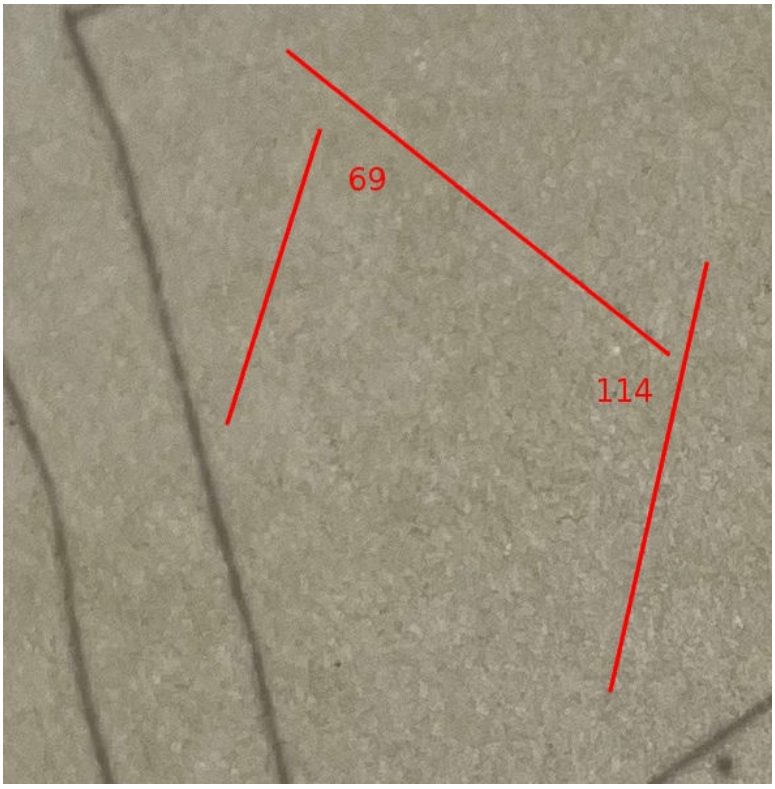
Figure 3 (*above*) is an extract from a map found in City Hall at Lincoln. In general, it seems to be an OS product; but although it is the normal size for a 25-inch map, it is portrait-format, detail stops at the city boundary, and this sheet consists of two irregularly-shaped areas crammed together so tightly that the detail actually touches. Another sheet (also with two irregular areas) has one rotated through 90 degrees in order to fit. Such practices seem to be unrecorded in any other OS output.

The map is in a collection that includes at lot of material from the Planning Department. One learns to be wary of Town Planning staffs: they attracted geographers, they often employed good draughtsmen, and they had

access to high-quality facilities for copying maps of this size - notably the services of Cook, Hammond, & Kell. By way of example, the earliest depiction at the 25-inch scale of Cambridge University Library is on a version of Cambs 47.2 revised by Cambridgeshire Planning Department. That origin is acknowledged in the marginalia (twice); without that, few users would not suppose it was not an OS product.

So how confident are we that *figure 3* is really a 'pure' OS job? It is on thin paper, might it be a modern photocopy rather than an original, especially as there were multiple copies rolled together?

The updating of maps by local authorities was enjoined by the Local Government Board as early as 1910 in regulations it issued in expansion of the 1909 Housing, Town Planning, etc, Act;[1] but there was never any suggestion that such updates should extend to Area Computation functions and it is unlikely that any authorities possessed the knowledge of this activity found within the OS. Therefore it is a good rule of thumb that any updating which has led to fresh area-computation has been done by the OS; any updating which violates the rules for showing areas has been done by someone else. If one compares *figure 3* with the previous edition (revised 1904) one finds that all the areas have been re-calculated and a new parcel number ('Tramway 71b') has appeared; therefore this is an OS product - presumably a 'repayment job'. But is the thin paper original or the result of modern photocopying?



The way to answer this is to look at the map in transmitted light (*figure 4, left*). One sees dots (or small blotches) aligned in rows that form a lozenge pattern. They are clearer in some areas than in others. The red lines have been drawn in *figure 4* to show the alignment of the dots; the angles between them have then been measured with a protractor: 69° and 114° (the latter having a complement of 66°). Of course, one weakness in measuring angles from a photograph, especially a close-up, is that there will be a certain amount of distortion so these angles may be out be a couple of degrees.

1 EG Bentley & S Pointon Taylor, *A Practical Guide in the Preparation of Town Planning Schemes*, 1911. (Available online)

Nevertheless , the angles do appear larger than 60º. They are probably felt marks, reflecting the way the felt is woven; and what might have originally been 60º has perhaps been increased by the stretching of the felt with use. Marks like this are characteristic of a wide range of papers up to the 1960s. Modern papers usually exhibit an unstructured blotchiness; if a linear pattern is visible it tends to be parallel to the grain. Incidentally, with a felt mark, the alignment of the paper ought to intersect the two directions marked. That is indeed the case here: the paper when it was photographed was at an arbitrary angle. Drawing the red lines without knowing the paper direction can help preclude wishful thinking.

It will be apparent that this test is not very informative as to date, but it does rule out the period of readily-available, high-quality office photocopiers. The map is almost certainly of the date it appears to be.

Example 3: Place's Waterproof Paper

The one type of 20th century paper for maps that is widely known is that developed by Col Place, RE. Much has been written about it, which it would be superfluous to repeat. However, no means has been given by which it can be definitively recognised. It has a waxy feel and water droplets tend to remain droplets on the surface rather than soaking in; but there are other papers used by the OS for which this is true. So far as civil maps are concerned, we recognise Place's paper by a statement on the map cover, or a sticker on the map itself. It is military issues that are the problem, issued paper-flat. There are numerous such maps on waxy paper that have been tentatively identified as Place's - but how do we know?

After attempts to devise a protocol for introducing water droplets and measuring their behaviour - a practice which collectors may be persuaded to tolerate but which few map librarians will countenance - the answer turned out to be the same as for Example 2: view the map in transmitted light. Specimens on Place's paper are translucent without any pronounced colouring, except where acid has penetrated at folds and turned the paper brown. The dots or blotches making up lozenge patterns that one sees in *figure 4* and which are found to some extent on all other OS papers of this era are never seen on Place's paper. What one can see on close inspection is a rectilinear pattern of lines at about 30 to the inch, that run vertically and horizontally. This is shown (*following page*) on *figure 5* (which also includes a portion of the kilometre scale). The figure does not, of course, bring out the translucent appearance: the brightness and contrast have been set specifically to bring out this barely perceptible grid of lines. As for the cause of this grid, it may well be the impress of the wire belt from the 'wet end' of manufacture, but that is speculation. What matters is that we have a straightforward way of distinguishing Place's paper from everything else.

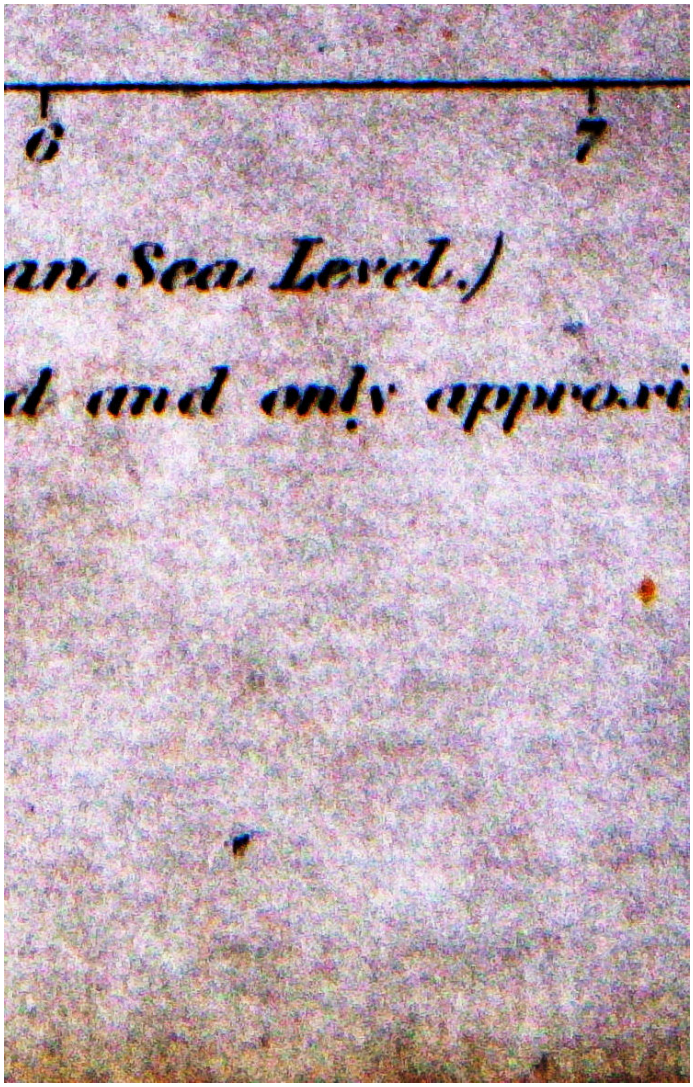


Figure 5. Place's paper in transmitted light

Conclusion

It would be tempting to sum up by declaring that every collector needs a back-lit panel and that one should always have an LED pencil torch to hand when examining a map. A rejoinder to this would be that the examples above are quite exceptional. Sub-editions within the 25-inch '1st edition' are known from elsewhere but is there anywhere other than Portsmouth where they cannot be distinguished by their marginalia?[2] My second case, of a map which might not be what it seems to be, is perhaps not so very uncommon, though the test described here offers limited discrimination. The third example is somewhat specialist, but it does offer a powerful test that is easy to apply. One does not really need a back-lit panel: just lift a corner of the map and look through it.

It may however be worth making the point that maps are physical objects, and there are occasions when even the very best digital image is no substitute for looking at the map itself.

2 The 1850s survey of the Aldershot area carries a title identifying it as such, along with a local sheet number.

Charles Close and Eugenics

Peter Wynn

The "science" of eugenics was introduced by Francis Galton in 1883.[1] It was based on a theory that social ills could be eliminated by selective breeding using methods such as involuntary sterilization. The development of eugenics in Britain was discussed by MacKenzie.[2] A hint that Close was involved in this science was contained in the anonymous *Sheetlines* article on Close where mention was made that the Secretary of the Eugenics Society wrote to him saying 'I had no idea you were 87 years old; the quality of the articles you send us shows that you carry your years exceptionally well'; and the mention in the same article that an obituary had appeared in the *Eugenics Review*.[3] That obituary revealed that Close had served on the council of the Eugenics Society from 1927 to 1929 and after 1930 on its consultative council. At the outbreak of World War Two he was again elected to the society's council.[4] A later *Sheetlines* article by O'Brien mentioned that Close was deeply concerned about world population and the demands this would make on resources.[5] Both *Sheetlines* articles understated Close's involvement in the eugenics movement.

In his presidential address to the Geographical Association in 1927, he insisted that Great Britain was over-populated and argued for the encouragement of emigration to other countries within the British Empire.[6] In the same year whilst still President of the Association, he attended the Geneva Conference on World Population.[7] In 1931 he was elected as president of the International Union for the Scientific Investigation of Population Problems (IUSIPP). He stated that

> "the Union desires the assistance of all those men and women of science, all over the world, who are disposed, by joining its counsels, to help in the work of the scientific examination of the many difficult and pressing problems of population".[8]

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[1] F Galton, *Inquiries into Human Faculty and its Development* London: Macmillan, 1883.

[2] D MacKenzie, 'Eugenics in Britain', *Social Studies of Science* 6 (1976), 499 – 532.

[3] *Sheetlines* Issue 2.

[4] Anon., 'Obituary Col. Sir Charles Arden-Close, K.B.E., C.B., C.M.G., F.R.S.' *Eugenics Review* 45 (1953), 11 – 14.

[5] *Sheetlines* Issue 34.

[6] Sir C Close, 'Population and migration: a statistical study with special reference to the English-speaking peoples', *Geography: Journal of the Geographical Association*, 14 (1927), 1 – 24.

[7] PM Roxby, The Geneva conference on world population *Geography*, 14 (1927), 207 – 210.

[8] Quoted in BW Hart, *George Pitt-Rivers and the Nazis* London, Bloomsbury Academic, 2015, 89.

The IUSIPP, with Close still as its President, held a congress and general assembly at Berlin in 1935. As well as attempting to justify its use of eugenic measures, the German Minister of the Interior also emphasised the need for an increased birth rate.[9] Hart stated that in his opening address Close attempted to state that the event was purely scientific rather than political, but no one seems to have been fooled by that declaration, with dozens of papers praising German racial policies.[10]

Close remained President of the IUSIPP until 1937 when he became one of its eight Vice-Presidents. Throughout Close's presidency, the Secretary General and Treasurer of the organisation was General Pitt-Rivers. Pitt-Rivers was interned during the Second World War as a Nazi sympathiser.

In 1936 the Society set up a Population Investigation Committee to examine the reasons for a decline in birth-rate. This is ironic, in view of Close's 1927 concern about over-population. Was the concern a decline in birth-rate amongst the elite? The committee members included Julian Huxley, representing the Eugenics Society, and Charles Close representing the British Population Society.[11] The latter body shared premises with the Eugenics Society. The Population Investigation Committee still exists as a research group based at the London School of Economics.

Later in 1936 *The Times*, uncritically, reported on Julian Huxley's Galton Lecture to the Eugenics Society. Close proposed the vote of thanks. The Times reported Close as stating that 'Present-day Germany must be regarded as a vast laboratory where a eugenics experiment was going on. It was of the greatest importance. Things were being done in Germany of which none of them could approve, but other experiments were taking place which ought to be watched with the greatest interest.'[12]

It is perhaps worth noting that in his lecture Huxley recognised that social environment as well as genetics needed to be considered.

Close wrote a number of letters to the editor of *Eugenics Review* concerning the statistics of population during and just after the Second World War.[13] His letters included one criticizing the report produced in 1936 by the Population Investigation Committee, of which he had been a member. None of his letters suggest a strong eugenics viewpoint. Indeed in his final letter concerning the family background of prominent mathematicians, he noted that 'so far as the evidence goes it would appear that the most original and distinguished mathematicians were well spread among the professional classes and lower social groups; there seems to be little or no heredity in the

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[9] *The Times* 28 August 1935.

[10] BW Hart, *George Pitt-Rivers and the Nazis* London, Bloomsbury Academic, 2015, page 107.

[11] Anon., 'Population investigation committee', *British Medical Journal,* 2-3958 (1936), 989.

[12] *The Times* 18 February 1936.

[13] CF Arden-Close, 'Letter to the Editor', *Eugenics Review*, 35 (1943), 47 & 94, 38 (1946), 156 and 39 (1947), 127.

subjects; and even the labouring classes with all their social disadvantages did produce some of the most eminent'; which hardly reflects the attitude of a hardened eugenicist.[14]

Between the end of the war and his death he published six papers on the demography of Great Britain. The first concentrated on availability of food supplies in the context of population projections.[15] In the second he examined projected changes in the age pyramid over the following decade.[16] The next paper considered the highlights of the recently produced report of the Royal Commission on Population.[17] The fourth paper returned to the question of food supplies, including the balance between home-grown and imported produce.[18] Next he explained how the average age of the population of England and Wales had increased since the census of 1841.[19] Still topical today is his comment in that paper that "we are fitter than we used to be at middle age and in old age, and it is for consideration whether our various schemes for retiring ages and pensions do not need revision." His final paper outlined the summary reports issued following the 1951 census.[20] All these papers appear to present an unbiased scientific approach, with suitable warnings given by him on projections for the future.

In conclusion it appears that although Close was a member of organisations whose membership included those with what would now be considered extremely unpleasant views, his role was generally to provide factual input to their activities.

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[14] CF Arden-Close, 'Letter to the Editor', *Eugenics Review*, 39 (1947), 127 – 128.
[15] CF Arden-Close, 'Our crowded island' *Eugenics Review*, 40 (1948), 23 – 30.
[16] CF Arden-Close, 'The age-structure of our population', *Eugenics Review*, 40 (1948), 137 – 139.
[17] CF Arden-Close, 'The Royal Commission on Population', *Eugenics Review*, 41 (1949), 117 – 122.
[18] CF Arden-Close, 'A satisfactory population for Britain', *Eugenics Review* 42 (1950), 23-24.
[19] CF Arden-Close, 'Our average age', *Eugenics Review*, 42 (1950), 155 – 156.
[20] CF Arden-Close, 'Social statistics of Britain', *Eugenics Review* 44 (1952), 141 – 142.

War Office geographical intelligence product

Crispin Jewitt

The Society's recently published carto-bibliography *Maps for Empire* covers War Office production for the years covering the height of imperial activity, from 1881 to 1905. The book reflects an aspect of the close relations between the Ordnance Survey and the War Office, and represents a contribution to the continuing effort to document the history of official cartography in this country. The present article is about the rationale for the book, the research behind its compilation, and the character of the cartographic material covered.

Rationale and scope

The basic concept behind the book is to extend the coverage of systematic documentation of British official cartography. Thanks largely to the efforts of our Society the output of the Ordnance Survey is increasingly well covered, while the Hydrographic Office has routinely issued comprehensive sales catalogues of its production of hydrographic charts. So War Office material could be considered as the 'third leg' of British official cartographic production, and as such, a worthy subject for research and publication.

That said, the wide scope of this material poses numerous challenges to the carto-bibliographer. The material is significantly more heterogeneous than the product of Ordnance Survey and the Hydrographic Office, ranging from prints of sketch maps through to fully fledged systematic series mapping, and occasionally including drawings and topographic views. Further, as the 20th century progressed, a multiplicity of map-producing agencies was created within the ambit of British military geography to meet the needs of specific operational and strategic intelligence requirements.

War Office numbering system

The story preceding this material during the 19th century has been dealt with elsewhere.[1] To summarise, since the Crimean War the value of topographical intelligence was increasingly recognised, and gradually accorded more prominence within the administrative structures of the War Office. By 1881 the Intelligence Department, established since 1875 under the Quarter-Master General's Department was producing 50 maps annually and it was decided to establish a numerical register of this material. A running number was allocated to each new cartographic product with a prefix indicating the changing name of the issuing department, thus: 'Intelligence Dept No. 17', 'Intelligence Branch No 379', and 'Topographical Section General Staff No 1939', with the prefixes reduced to initials when cited. This numerical sequence continues in use to the present day.[2]

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[1] Jewitt, *Intelligence Revealed*, London: British Library, 2011.

[2] Use of GSGS nos is now limited to material of exclusively UK relevance. British material for use across NATO has been designated since the 1950s under the Standard Series Designation (SSD) system.

What's in the book?

The book seeks to describe all of the material first created and issued under numbers ID 1 to TSGS 2000, from January 1881 to March 1905. The larger part of the book comprises a sequence of detailed descriptions arranged in numerical order:

1452 Map of the Island of Grenada Divided into Parishes and including Plan of the Harbour of St George. — BL Maps MOD IDWO 1452
I.D. W.O. No 1452. Lithod at the Intell: Div: W.O., Feby 1900.
1:31,680. 65 x 97cm.
Inset: The Harbour of St George, 1:9,000.
"Sd W.J. Lawrence Supdt of Works 1899."

[Another state.] First edition – G.S.G.S. Geographical Section, General Staff No. 1452. Reproduced by War Office, 1951. — BL Maps MOD GSGS 1452

1453 China, Shantung. Capt. R.P. Lee R.E. — Data from TNA WO 408/44
GSGS no. 1453.
1:63,360. 9 sheets (MS). Index (tracing).
War Office reference: Originals of GSGS Maps. 343. "Destroyed 1940".

1454 Sketch Map to illustrate Italian Manœuvres 1899.
I.D.W.O. No 1454. Photozincographed at the Intell: Div. W.O. Jan: 1900.
1:125,000. 32 x 39cm.
Shows Turin, and the area southwards to Bra.
In: *Foreign manœuvres, 1899. Extracts from the reports … on … Austria-Hungary, Denmark, Germany, Holland, Italy, Russia, and Switzerland.* London: War Office, 1900. pp.57. Confidential. ([A 634].) — BL Maps DMO/6/14

Figure 1. Sample descriptions from the book.

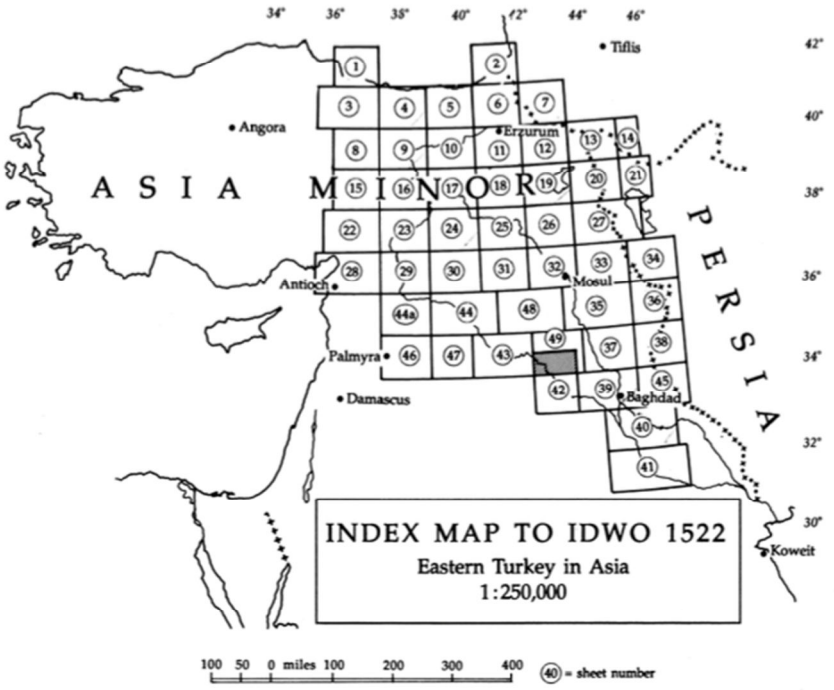

Figure 2. From Appendix VIII: Index to IDWO 1522.

Access for researchers to these descriptions is provided by geographic and personal name indexes. Also included are an index by military campaigns, selected graphic indexes (*Figure 2*), and a concordance for the large number of natural scales indicated in the descriptions as representative fractions. These sections are complemented by 16 coloured illustrations and a 20 page introduction.

This second edition of the book includes the results of research, since the first edition in 1992, on the items which had not been found at that time. The successful identification of many of these was enabled by consultation with more recently available archival resources, and also the growing availability of institutional legacy catalogues online. This has enabled the number of 'fugitive' items to be reduced from 300 to 31. Also, since 1992 major transfers of material have taken place; the record set of these maps held at Tolworth by MCE RE MRLG[3] was transferred into the custody of the BL during 2000-2002, and the legacy holdings of the MOD (Whitehall) Library were dispersed in the early 1990s. The series of documents now held at *BL Maps DMO*, transferred as part of this latter dispersal, includes a number of uniquely held items. These various changes are incorporated in this new edition.

Research methodology

The underlying research began when the author (the present writer) was employed at the British Library Map Library during the early 1980s. Inheriting *inter alia* a vestigial card index of a small number of GSGS numbers, and with responsibility for routine business with MRLG Tolworth, there was an opportunity to investigate a relatively unexplored area of cartographic production. To begin with, many 'easy-to-find' items were identified by trawling through hard-copy catalogues, in particular the 1967 fifteen volume *British Museum Catalogue of Printed Maps, Charts and Plans*, and volumes 2, 3, and 4 of *Maps and Plans in the Public Record Office*.

The more recent advent of online library and archives catalogues has enabled such searches to become more fruitful. This has also enabled the review of downloaded file schedules for relevant classes of documents held by the National Archives (TNA). The TNA series most relevant to the primary research for this book were FO 925 (the Foreign Office map library), CO 700, 1047 & 1054 (the Colonial Office map library), and WO 33 & 106 (War Office confidential printed reports). A further resource of particular relevance is the series WO 408 which includes GSGS numbers allocation registers, the record set of the IDWO catalogue of maps[4] which started life in 1890 and lasted until the introduction of the Parsons cataloguing system in 1943, and the WO 'Confidential' catalogue[5] which ran from 1870 to 1944. Both of these catalogues include much material within the scope of *Maps for Empire*, as one would expect. However, items produced solely as illustrations for official reports and papers were commonly not included in these two important

[3] Mapping and Charting Establishment (RE) Map Research and Library Group.
[4] TNA WO 408/34-37
[5] TNA WO 408/38

resources. 'Hard-to-find' items were also revealed by working through the BL holdings of contemporary Parliamentary Papers and the BL set of Foreign Office confidential printed reports. Repositories visited in the course of research included principally TNA at Kew throughout the period, and MCE RE MRLG at Tolworth during the 1980s. Other site visits included Bodleian Library, Cambridge University Library, Royal Geographical Society, Royal United Services Institution, and the Ministry of Defence (Whitehall) Library.

Geographic range of the material

As befits the British geopolitical footprint during the period covered by these maps, the coverage extends worldwide. Africa predominates, due to recurrent military activity in the north east (Sudan) and in South Africa, but also in relation to competition between the European powers for influence and control, often leading to joint boundary surveys. Europe is represented by reports on foreign defences and military resources, while coverage in Asia focusses on the Near and Middle East, Central Asia, and South-east Asia. (The Government of India was served by its own Intelligence Branch: in consequence coverage of India was generally excluded from the output of the War Office.) The Americas are represented principally by Canada, British Honduras (Belize) and British Guiana (Guyana).

Series maps

A small but important proportion of the material comprises series mapping. In 1898 production began with *IDWO 1281 Upper Egypt and the Sudan* (32 sheets), which was superseded by *IDWO 1489 Egyptian Sudan*, the latter reaching 63 sheets over the period 1900-1906. Other series during this period were *IDWO 1367 Transvaal and Orange Free State* 1899-1900 (28 sheets) and *IDWO 1479 British Central Africa* (now Malawi) 1901-1904 (11 sheets). From 1904 all of these series were superseded by *IDWO 1764 Africa 1:250,000* which eventually ran to 180 sheets for the 'old series' and 161 sheets for the 'new series'.[6] The small scale series of Africa at 1:1,000,000 (IDWO 1539, 50 sheets, 1901-1907) could be considered a precursor to the International Map of the World.

IDWO 1522 Eastern Turkey in Asia in 39 sheets, was produced from 1901 to 1920. Covering Eastern Anatolia and contemporary northern Iraq, the series was extended to the tip of the Persian Gulf by GSGS 1522a which comprised a further 11 sheets, issued from 1915 to 1940. [*Figure 3, following page*].

[6] The 'old series' sheet lines were based on 1° 30' longitude; the 'new series' on 1° longitude.

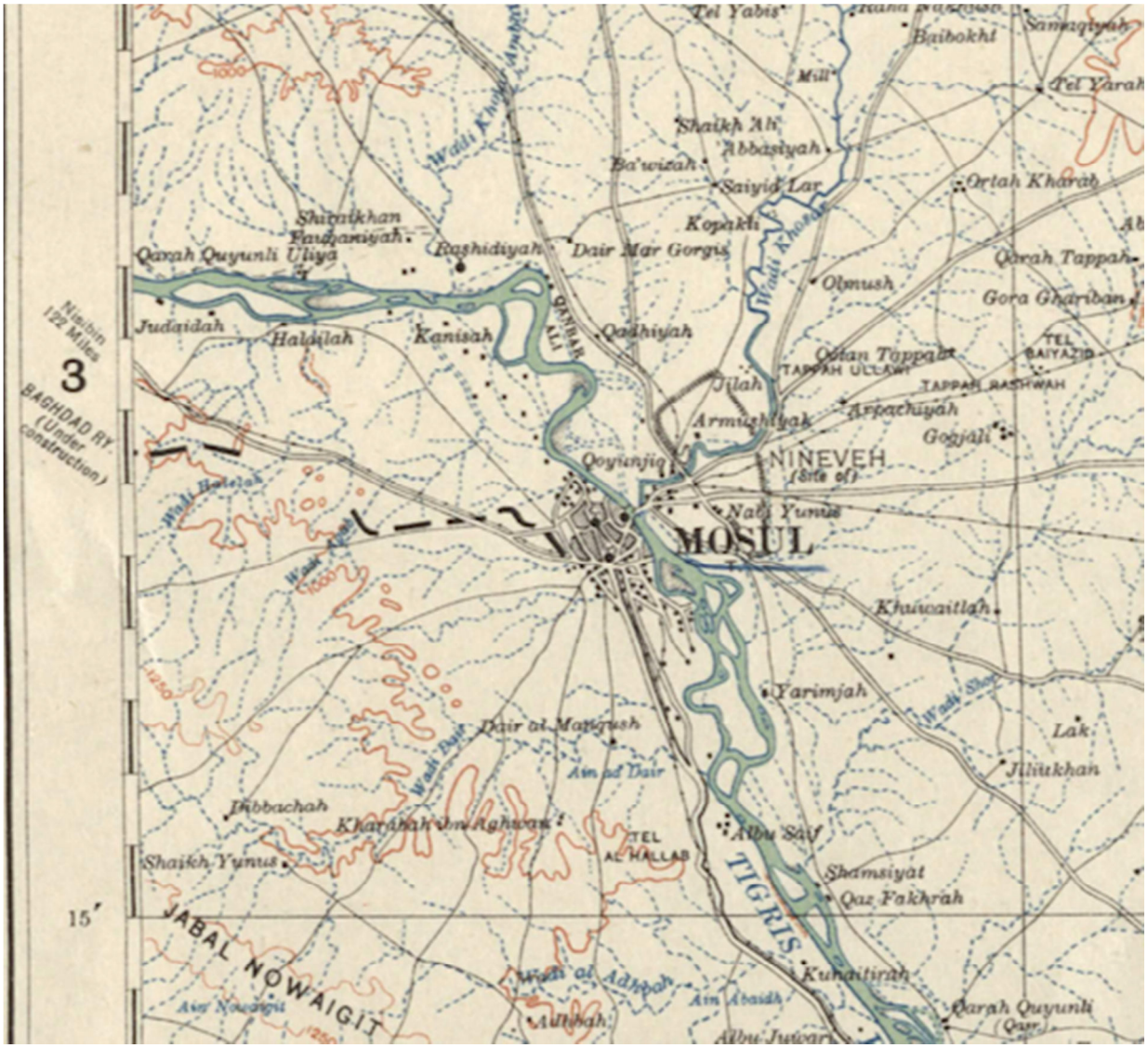

Figure 3. GSGS 1522a: Eastern Turkey in Asia. Sh. J-38/T Mosul. War Office, 1921.

Boundaries

Maps relating to international boundaries range from those illustrating competing spheres of influence to the products derived from bilateral surveys, documenting agreed borderlines. The 1904 Nigeria-Kamerun Boundary Commission Survey (IDWO 1902), endorsed by Captain GFA Whitlock RE and Oberleutnant Hugo Marquardsen provides an example of the latter, a necessary precursor to the formal Agreement signed in London two years later.

North-east Africa was the focus of rivalry for influence between several powers during this period, largely in relation to control of the headwaters of the River Nile. The map at IDWO 1300 illustrates the complex position in 1898, which involved France, Germany, Italy, Belgium, Egypt, Congo Free State, and Abyssinia. This map was printed in February 1898: later in the same year there was the stand-off between Britain and France known as the 'Fashoda Incident'. (The crisis was resolved without loss of life when the French withdrew.) Many other boundaries were negotiated or surveyed during this period including the Anglo-Siamese on the Malay Peninsula, the Anglo-Portuguese in south-east Africa, the Anglo-German in east Africa, the

changing boundary between Turkey and Greece, and the line of the north-western boundary of Afghanistan. All of these, and others are represented in the material described in the book. [*Figure 4*].

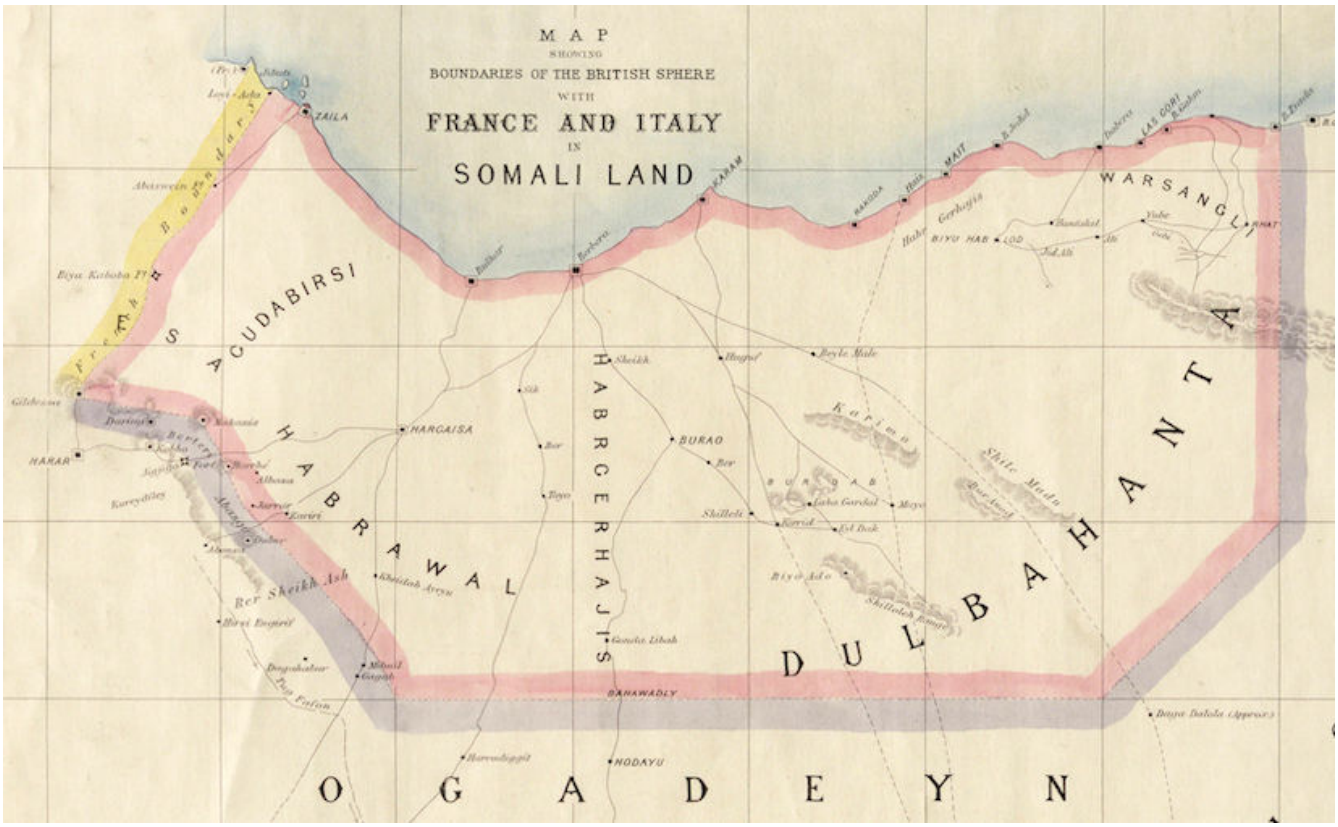

Figure 4. IDWO 1037: Map showing boundaries of the British sphere with France and Italy in Somali Land. Ordnance Survey, 1894.

Also worthy of note here is a portfolio of historic maps (IDWO 1141 & 1142a-i), the earliest dating back to a Dutch chart of 1635 and a 1640 map of Guiana by William Blaeu, produced to illustrate the question of the boundary between British Guiana and Venezuela in 1896.

Defence schemes

Defence scheme maps (*Figure 5, following page*) were produced with IDWO numbers from the late 1880s. These included regional UK defence scheme maps, often over-printed on sections of the Ordnance Survey 10 mile to one inch map, and also larger scale maps commonly centred on important ports, produced at the War Office and regularly updated from the turn of the century onwards. Colonial defence schemes were also regularly updated with the consequent production of successive states of the original map. *IDWO 1134a Singapore*, was originally issued in 1896: by 1906 nine later states had been issued. The maps for heavily defended ports sometimes required complex draughting as evidenced in GSGS 1418b, part of the defence sheme for Malta. [*Figure 6, p57*].

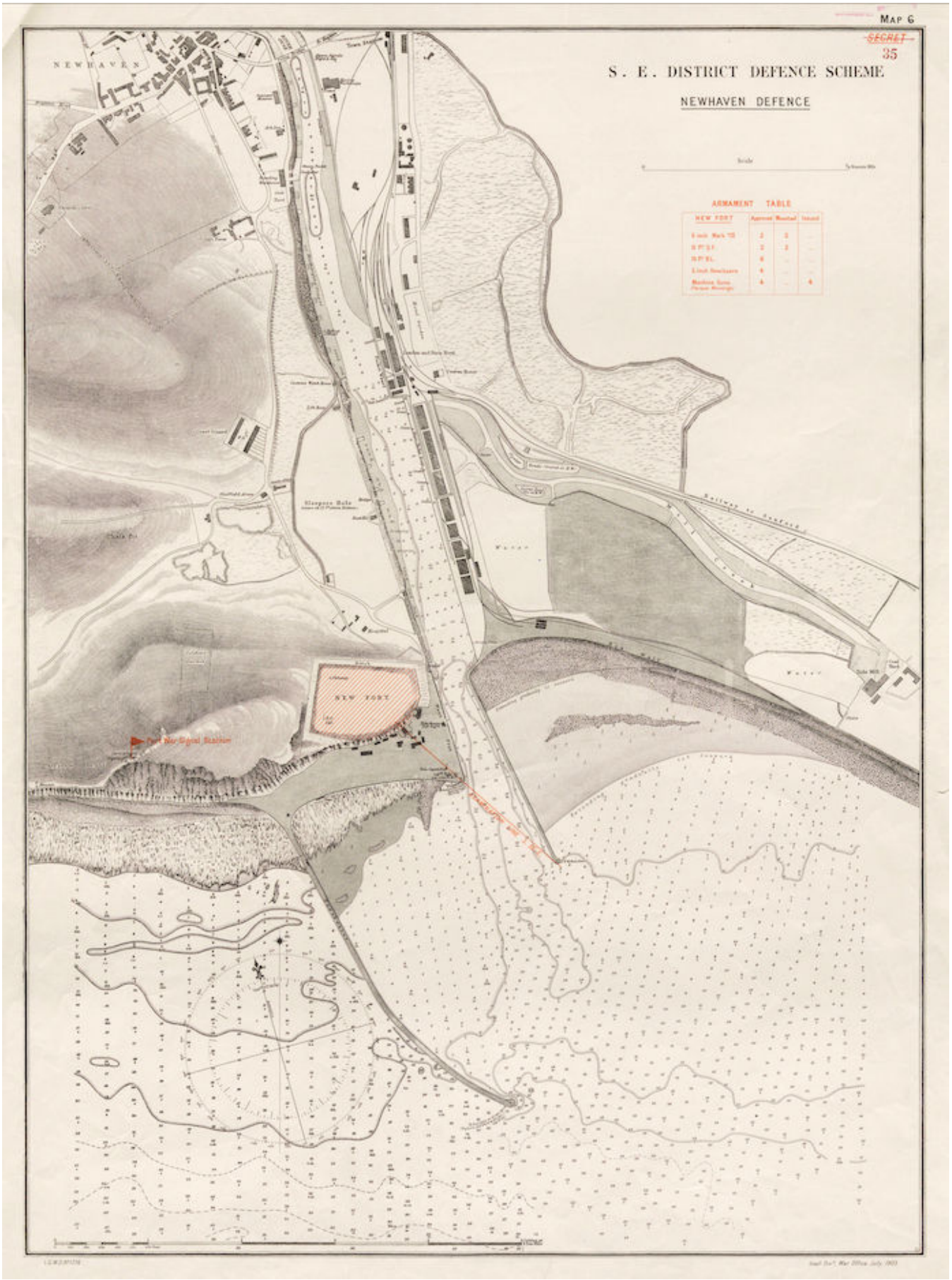

Figure 5.IDWO 1776: S.E. Defence Scheme. Newhaven Defence. War Office, 1903.

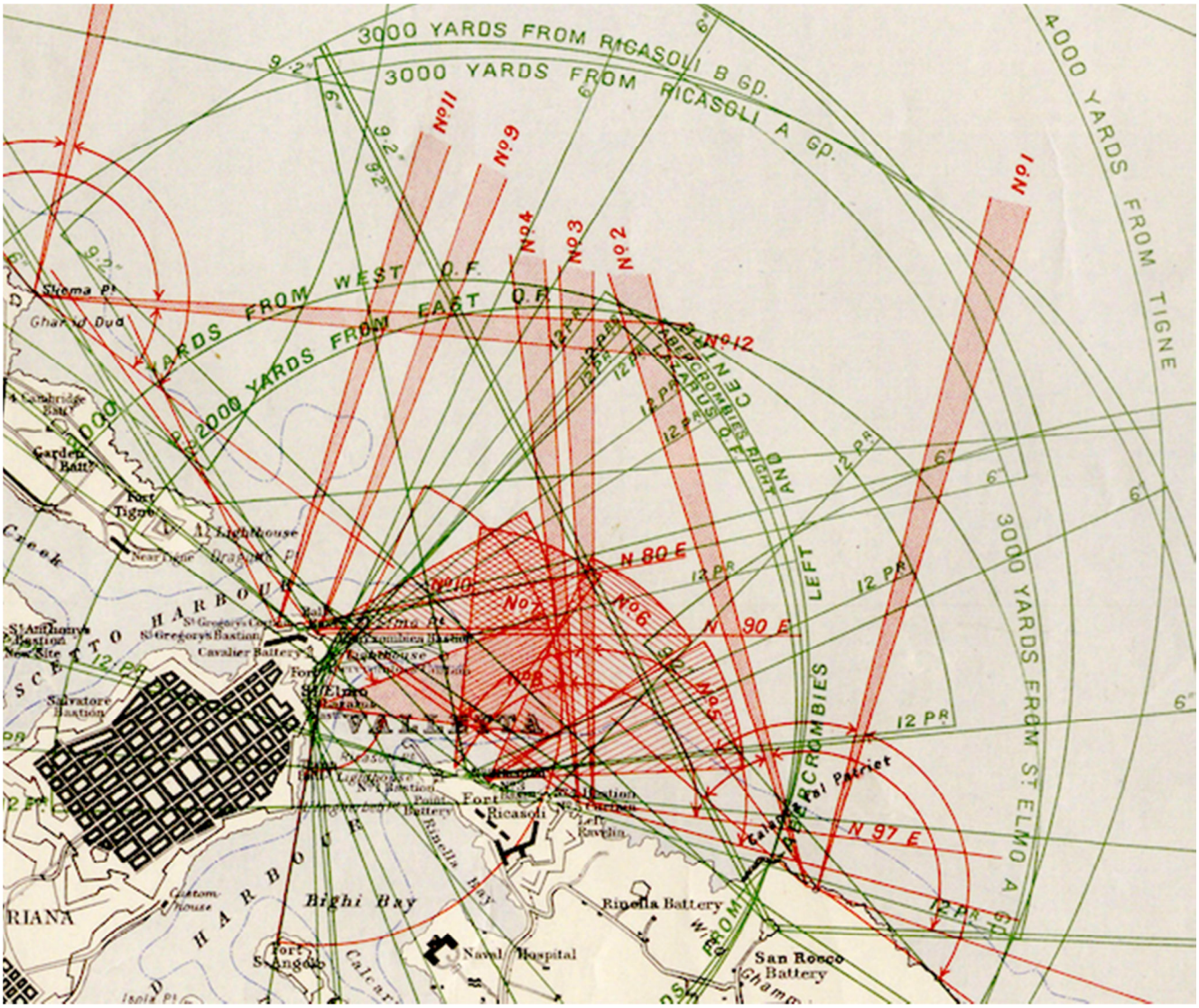

Figure 6. GSGS 1418b: Malta. Coast Defences No 1 Section. War Office, 1912.

Official reports

Much of the material (including the defence scheme maps mentioned above) was produced as illustrations for official reports. Among these are country-by-country reports on the annual military manoeuvres by foreign countries, *eg IDWO 1585 Russian Manoeuvres 1901*, which were produced from 1890 to 1907. Between 1882 and 1891 maps were produced for the regular 'armed strength' series, such as *IB 670 Defences of Lisbon 1887*, made for *The Armed Strength of Portugal*, and *IDWO 935 Sketch map of Korea*, made for *The Armed Strength of Corea*. A set of 14 maps (IDWO 1634a-n) was produced for the *Official Account of the Military Operations in China, 1900-1901*, which provided a detailed account of the siege and relief of the foreign legations in Peking. [*Figure 7*].

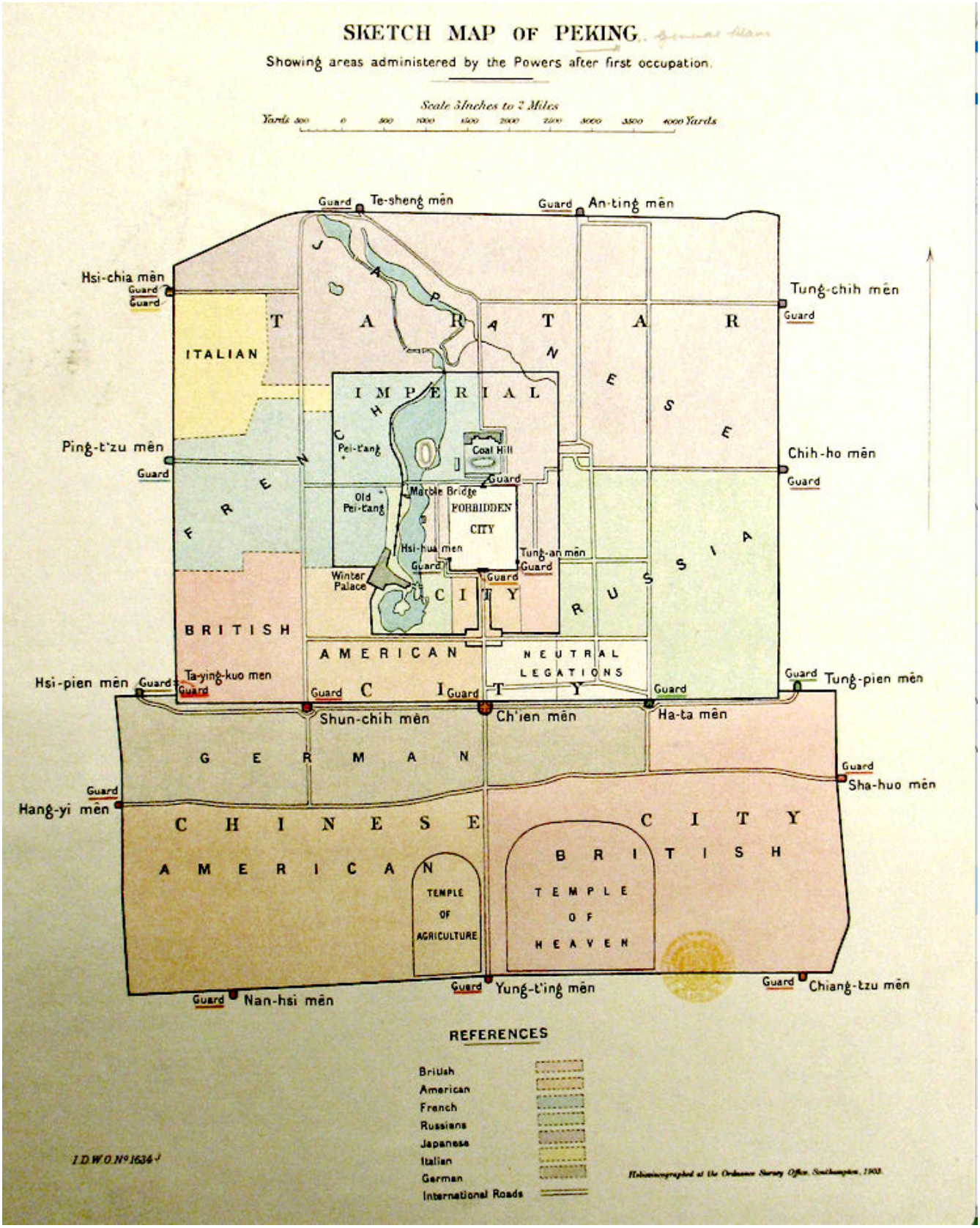

Figure 7. IDWO 1634j: Sketch map of Peking. Showing areas administered by the Powers after first occupation. Ordnance Survey, 1903.

Foreign intelligence

Intelligence reports on foreign countries range from reports on expeditions or journeys in remote but strategically important regions, through comprehensive descriptions of specific territories, to detailed documentation of defensive installations such as the position and construction of gun emplacements. The first kind is well represented by ID 1572a which illustrates the route taken by the expedition led by Herbert Henry Austin RE travelling from Khartoum to Lake Rudolf in northwestern Kenya in 1901. *IDWO 1614 Tamatave defences. Madagascar,* one of the maps included in *Military Report on Madagascar and adjacent French Islands* (1902) provides an example of the second kind of report, while the series of items described at IDWO 775 (produced for *Report on the Coast Defences of Algeria ...* 1889) includes large scale plans of artillery batteries along the coast of French north Africa.

Security classification

Many of the items described in the book, or their containing documents, bore a 'Secret' classification when originally issued. This was routinely, but not exclusively, used for home, colonial, and foreign defence scheme maps. 'Confidential' was applied to items deemed less sensitive, with 'strictly confidential' occasionally appearing. These classifications appeared on map sheets from the mid-1880s onwards. From 1904 the formulation 'for official use only' came into use and was continued throughout the twentieth century. Items that were publicly available are indicated by the presence of a sales note, usually Edward Stanford, London S.W. Variant states of the same map were sometimes produced, one state for sale, and the other state with a defence overprint and 'Secret' classification.

Production agencies

Calculating on the basis of the 2,000 designated numbers, it would appear that some 70 percent of production was done in London at the War Office, with most of the remainder printed at Southampton by the Ordnance Survey. However, an alternative analysis, on the basis of numbers of sheets printed in each place, would be likely to significantly reduce, if not reverse, this ratio. The War Office production was lithographed, while the Ordnance Survey production was photo-zincographed: the decision to use one or the other is likely to have taken account of the anticipated print run.

Five items were printed at Chatham by the School of Military Engineering, one item by the Ordnance Survey at Phoenix Park, Dublin, and one item by J. Bartholomew in Edinburgh[7].

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[7] This last mentioned item is IDWO 1539. Bartholomew produced the first 4 sheets in 1901. Later sheets in this series were printed by W. &. A.K Johnston and Ordnance Survey.

What next?

The logical continuation of this work would suggest the preparation of a sequel volume covering the War Office production period covered by TSGS/GSGS numbers 2001-4000. Whether it would be realistic to use the same format, considering the increasing prevalence of series maps over the period, would be open to question. It would also be necessary to undertake a major task relating the very large volume of Western Front 'trench maps' to respective GSGS numbers, which were often allocated by production units in the field with inadequate central control. There is also evidence of duplicate use of GSGS numbers during this period: this would need to be addressed.

There are however many other related fields in the carto-bibliography of British official, or military mapping, which await systematic documentation. A reference work comprehensively covering the production of the Directorate of Colonial/Overseas Surveys, or of the cartographic production of Far Eastern Land Forces (FARELF) would be just two examples.

In any event, it is to be hoped that this new edition of *Maps for Empire* will provide a valuable resource for students of official cartography, colonial history, and defence studies.

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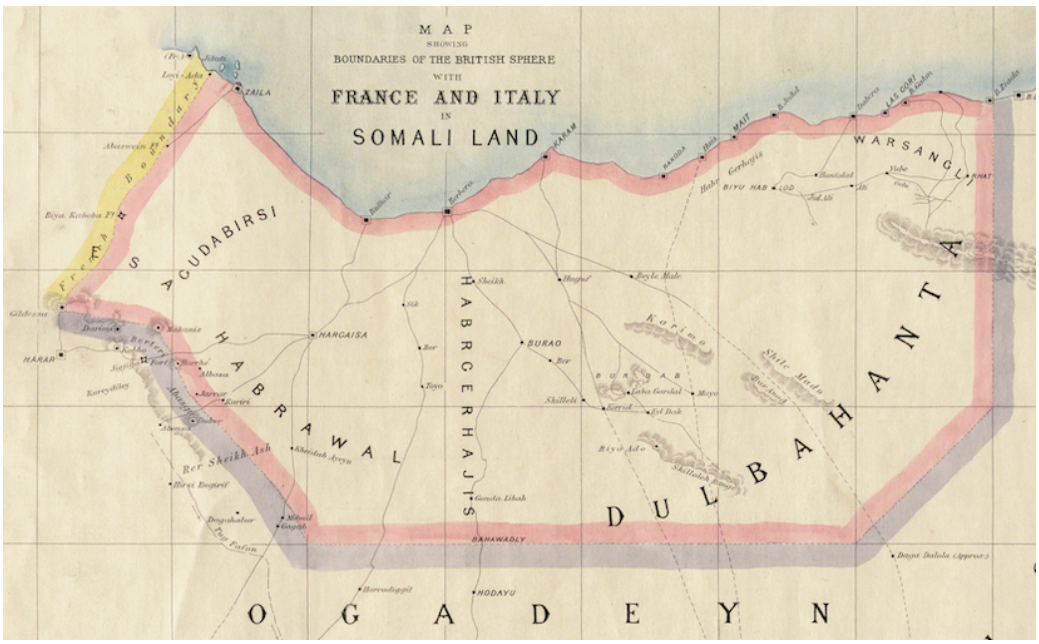

Somali Land, 1892 (p50)

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