Just before the *Beagle*: Charles Darwin's geological fieldwork in Wales, summer 1831

Michael Roberts

Darwin returned to Shrewsbury in mid-June 1831 and spent that summer learning geology. He made geological maps of Shropshire and visited Llanymynech and other localities. From 3–20th August he joined Sedgwick on his tour of North Wales; they geologised west of Shrewsbury before travelling through Llangollen, Ruthin, Conwy to Bangor finally reaching Anglesey. Darwin left Sedgwick at Menai and walked to Barmouth making a special visit of Cwm Idwal. He returned to Shrewsbury on 29th August to open the letter from Fitzroy inviting him to join the *Beagle*. During this summer Darwin gained skills in all aspects of geology, including chemical analysis, which were to prove vital in the development of his ideas on natural selection.

> Therefore on my return to Shropshire I examined sections and coloured a map of parts round Shrewsbury. Professor Sedgwick intended to visit N.Wales…and slept at my father's house…Next morning [5 August1831] we started for Llangollen, Conway, Bangor and Capel Curig. This tour was of decided use in teaching me a little how to make out the geology of a country… We spent many hours in Cwm Idwal… At Capel Curig I left Sedgwick and went in a straight line by compass and map across the mountains to Barmouth[1]

Thus Darwin described his early geological fieldwork in his *Autobiography*. Few writers on Darwin penetrate further in the rush to describe Darwin's voyage on the *Beagle*, and consequently ignore one the most formative aspects of Darwin's scientific development. During July and August 1831 Darwin spent about a month doing fieldwork, first alone and then with Adam Sedgwick of Cambridge.

Darwin made only a small impact on British geology, but until 1850 was known primarily as a geologist. Although his volumes originating in the work done from the *Beagle* on geology are considered classics, Darwin's British geological work has received relatively little attention. In 1974 Martin Rudwick made a detailed study of Darwin's 'greatest blunder' on the parallel roads of Glen Roy[2], which he visited in 1838. The first person to examine Darwin's 1831 geology was Paul Barrett[3] in 1973. In 1991 James Secord[4] and Sandra Herbert[5] discussed Darwin's development as a geologist. This work builds on theirs, by considering Darwin's fieldwork in detail.

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Fieldwork and manuscripts

My method has been to combine geological fieldwork with a study of Darwin's manuscripts. To this end I obtained copies of all of Darwin's Welsh geological notes, from Cambridge University Library, Sedgwick's field journals, the maps used by both Sedgwick and Darwin, including Sedgwick's annotated copy of Evans' map.

Figure 1 Darwin's sketch geological map of Shrewsbury. Reproduced from CUL DAR 265, DH/GPD 10:iv by permission of the Syndics of Cambridge University Library.

Figure 2 Geological map used by Darwin from Greenhough (1826) reproduced by permission of the Syndics of Cambridge University Library.

My aim has been to work out routes and dates and then to consider how Darwin developed as a geologist. That has not always been easy, as quarries have disappeared, roads have changed, and Darwin often gave different spellings for Welsh place names. This has involved considerable local knowledge, combined with careful study of Darwin's notes and the use of old and new, topographic and geological maps. An essential part has been to perform mobile thought-experiments and to attempt to retrace his daily routes in detail. This involved considerable driving and walking, and at one point being chased by an irate cow!

Many of Darwin's notes are undated, and neither Sedgwick nor Darwin was always clear on topography. Initially following his *Autobiography*, I thought that the sum of Darwin's work was a few days in Shropshire in July, six days with Sedgwick and then three days to Barmouth. However Clark and Hughes[6] suggested that Darwin spent two to three weeks with Sedgwick. I independently came to that conclusion and also argue that Darwin went to Anglesey with Sedgwick[7].

July days in Shropshire

Darwin returned to Shrewsbury from Cambridge in mid-June 1831 and began to study geology and Spanish for his proposed visit to Tenerife. He enjoyed the geology but not the Spanish. After he obtained a clinometer on 10th July he visited Llanymynech and made three pages of indifferent notes[8]. He drew copies of parts of Baugh's (1808) map of Shropshire at 1 inch to 1 mile to use as base-maps and began geological mapping[9]. He coloured areas orange to indicate New Red Sandstone, black for coal measures and made some geological notes (Figure 1)[10]. He also made outline maps of Llanymynech and Anglesey from Evan's map at a scale of 7/8th inch to 1 mile.

Darwin struggled with his geology and was pleased that Henslow had asked Adam Sedgwick to take him on a tour of North Wales. In 1831 Sedgwick was a leading British geologist, and with Murchison, who started out in south Wales, began their work on Welsh geology, which gave us first the Cambrian and Silurian, and much later the Ordovician[11].

Southwest of Shrewsbury, 3rd and 4th August

Sedgwick left Cambridge at the end of July in his gig and travelled west. He spent a day at Dudley and arrived in Shrewsbury on 2nd August to stay at the Mount. On 3rd and 4th August Sedgwick's notes describe forays to the south-west of Shrewsbury, looking mostly at Carboniferous strata, including the Cardeston limestone. He also visited some 'Transition' limestone outcrops above Pontesbury, but his notes are extremely brief. He climbed Pontesford Hill, and regarded these volcanic rocks as younger than the New Red Sandstone, although they were later recognised as Pre-Cambrian. There is no indication in the notes that Darwin accompanied him, nor are there extant notes of Darwin's for this foray; however, it would be unlikely for Darwin to remain in Shrewsbury while Sedgwick geologised. On 7th August Darwin did refer to the Cardeston conglomerate in his notes on the Pen Stryt Quarry near Ruthin, which supports the idea that he accompanied Sedgwick on this earlier trip.

The Darwin–Sedgwick tour, Shrewsbury to Bangor: 5th–11th August

In many ways this is the most well-documented part of Darwin's British geological work, as Sedgwick's notes for this period are dated and fairly detailed, and Darwin's are very similar, but after 8th August are undated. The elucidation of Darwin's precise route was difficult at times because the notes diverge whenever Darwin went off on a traverse on his own. Both men left Shrewsbury on 5th August and spent a week trying to find Old Red Sandstone between the Greywacke and Mountain Limestone lying between Llangollen and Bangor, and their route lies close to the Old Red Sandstone marked on Greenough's map (Figure 2). It was important to them to find the Old Red Sandstone, as below that lay the Transition strata. To find the boundary would have given an upper marker for unknown strata of North Wales, but as it happened Sedgwick and Darwin failed to find any Old Red Sandstone in the area.

After a few hours journey in a gig they arrived in Llangollen, where Sedgwick spent some time discussing geology with Robert Dawson, who was mapping for the Ordnance Survey. Before meeting Dawson, they ascended Castell Dinas Bran, a ruined 13th century Welsh castle 230 metres above Llangollen. They also searched vainly for Old Red Sandstone below the Eglwyseg escarpment of Mountain Limestone.

Next day they travelled over the Horseshoe Pass to Ruthin, stopping briefly at Valle Crucis Abbey and the syncline in the Greywacke opposite. While crossing the pass they were 'almost drowned in a thunderstorm', but the weather cleared and Sedgwick was able to survey the distant scene. Darwin and Sedgwick descended past limestone outcrops by the tollhouse on the Wrexham road through Nant y Garth to Llysfasi. Despite Llysfasi being only 6 km from Ruthin, one cannot be certain of their routes. Possibly Sedgwick looked at limestone outcrops on his own and sent Darwin on ahead to look for Old Red Sandstone alleged to lie to the west of Ruthin. There he found Pen Stryt quarry, the composition of which con-

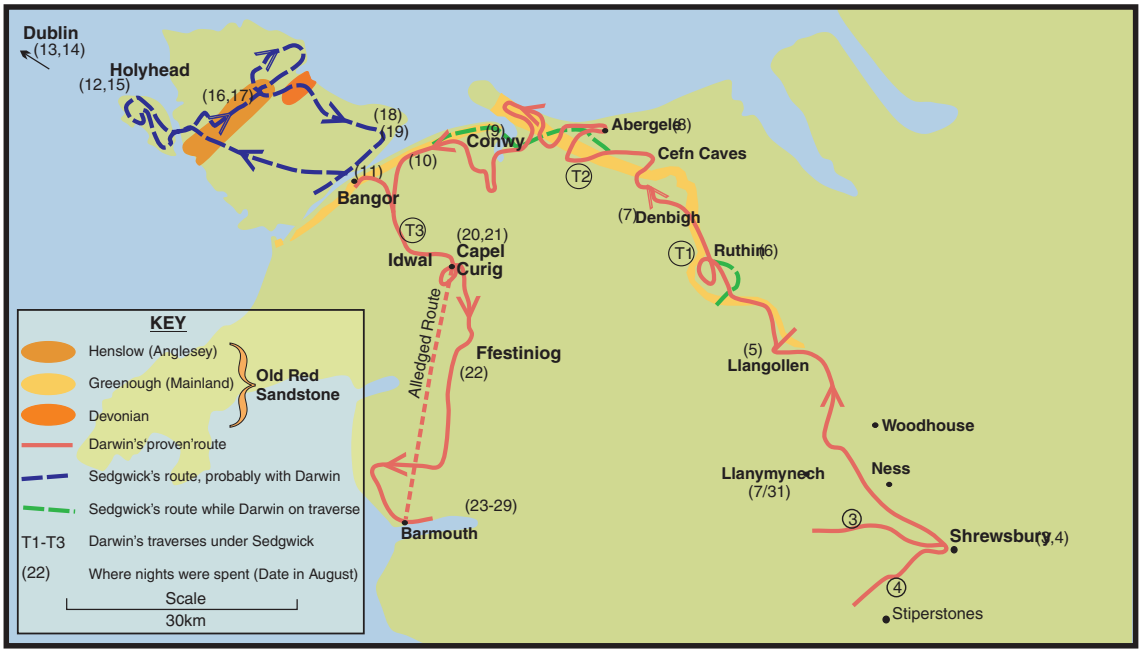

Figure 3 Map showing the localities of Darwin's field work in July 1831 and his route around North Wales. Note especially how his route closely followed the alledged Old Red Sandstone of Greenough and Henslow.

fused both at first, but as they travelled beyond Denbigh they came to question the existence of the Old Red Sandstone in the area. Hence, just west of St Asaph, Darwin was sent on a meandering traverse to see whether or not the Old Red sandstone marked on Greenough's map actually existed. Sedgwick went on to Conwy and Darwin arrived next day having walked over 45 km in less than two days (Figure 3). He had completed his task and rejected the local existence of the Old Red Sandstone. Ironically, it took until 1900 before the Geological Survey also consigned their records of the Old Red Sandstone in northern Wales to the basal Carboniferous. Meanwhile, Sedgwick had been to Llanfairfechan.

The next day (10th August) showed an unreasonable side to Sedgwick's character. Sedgwick had sent his gig to Aber and he and Darwin walked south along the Conwy valley. As Darwin wrote to Hughes (Sedgwick's biographer) in 1875, 'We left Conway early in the morning, and for the first two or three miles of our walk he was gloomy, and hardly spoke a word. He then suddenly burst forth: I know that the d-d fellow never gave her the sixpence. I'll go back at once;' and turned round to return to Conway,'[12] Sedgwick thought that the waiter had not given the chambermaid a tip. However, Darwin persuaded him to continue and they proceeded to have an excellent day. They visited the ancient chapel at Caerhun and then struck north over Foel Lwyd, where they found igneous rocks with the Greywacke. Darwin's notes for this day are often verbally similar to Sedgwick's, indicating Sedgwick's tutelage. From there they descended to Aber for the night and next day they looked briefly at the geology of Aber Falls before going to the Bethesda slate quarries where they spent considerable time. Darwin's notes for these two days show a sound understanding of both geology and mineralogy. His notes give no indication where they spent the night, but Sedgwick wrote, 'Descend to Bangor Menai Bridge etc.'

A problem: Anglesey, 12th–20th August

In his *Autobiography* Darwin wrote, 'At Capel Curig I left Sedgwick'. If that statement be true then they visited Cwm Idwal together and separated at Capel Curig. That makes reasonable sense if one refers only to the *Autobiography* and Darwin's notes, as the latter recorded an apparent sequence from the slate quarries, Cwm Idwal, Capel Curig and then through to Barmouth. However, when consulting both Sedgwick's journal and his letters to Darwin in September 1831, it becomes clear that Darwin visited Cwm Idwal on his own and Sedgwick did not go there until 31st August. Barrett was aware of these contradictions and suggested that Darwin had wandered around North Wales on his own while Sedgwick went to Ireland and met up again on 21st August. Barrett suggests this, as in his letter of 4 September Sedgwick mentions his route only after 21st August and concludes that Darwin knew where he had been before. After that Sedgwick began his work on Snowdonia and Darwin walked off to Barmouth.

The key to what happened in mid-August comes from Darwin's notes on the geology of Quail Island, made on 17th January 1832, where he wrote of a recent shoreline conglomerate, 'as hard as the conglomerates of older formations (*viz* of red sandstone formation of Anglesey)'[13]. Henslow nowhere mentioned the hardness of his Old Red Sandstone. A few days later Darwin rewrote this description, 'When breaking it I was forcibly reminded of the very tough conglomerates of the old red sandstone formation.'[14] These two references show that Darwin actually visited Anglesey in 1831.

The geology of Anglesey, and especially Henslow's geological Memoir[15], held a great fascination for Darwin. Darwin's copy of the Memoir was heavily annotated and shortly after leaving the Falklands in 1834 he wrote a long reflection on it. Darwin found many parallels between the geology of the Falklands and Anglesey. Several aspects of Darwin's early geological work on the *Beagle*

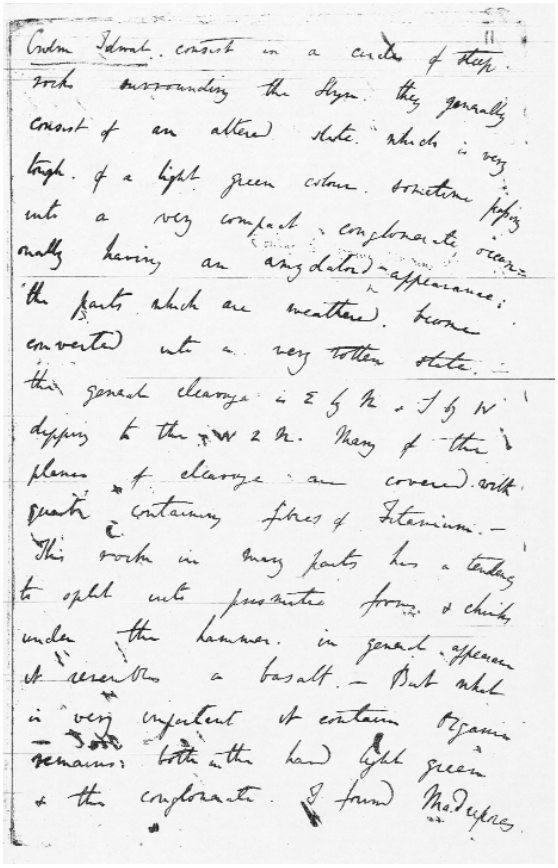

Figure 4 Darwin's notes from Cwm Idwal. Reproduced from CUL DAR 5, fol. 11 by permission of the Syndics of Cambridge University Library.

voyage, including the Falklands, make good sense if he had spent time on Anglesey. He correctly identified St Paul's Rocks as Serpentine and not volcanic – a considerable achievement. (These rocks were later understood to be tectonically emplaced mantle.) Unfortunately no notes similar to those of the rest of his Welsh tour have been found in the Cambridge collection. However, there are two pages of rock listings entitled 'Trap' on identical paper to his Welsh notes, indicating that they were made between July and September 1831. This lists 20 specimens, including three 'traps' (basaltic dikes), Clay Slate, white sandstone and quartzite, granites and Serpentine. The last is most significant, as in England and Wales, Serpentines are found only on the Lizard and on Anglesey. In combination with the other samples and especially the 'traps' these are undoubtedly a list of rock specimens from Anglesey.

When Darwin arrived at Barmouth he met up with Whitley and the Lowe brothers. The Lowes' diary record that Darwin arrived in Barmouth on 23rd August[16]. Using Lowes' date of 23rd August and working backwards, using Darwin's notes to give the route, it becomes clear that he would have visited Cwm Idwal on 20th August and thus had left Sedgwick by then. The evidence perfectly meshes together. The simplest solution is that Darwin accompanied Sedgwick around Anglesey and possibly went to Dublin as well.

Assuming that Darwin accompanied Sedgwick, they must have travelled the Menai–Holyhead road on 12th August, geologising a little, and caught a midday steam packet to Dublin, which would have taken seven hours. They returned on 15th August, with time enough to traverse Holyhead Mountain. Next day they visited the Serpentines at Rhoscolyn and then followed Henslow's Old Red Sandstone to Llannerchymedd. On 17th August, Parys Mountain was visited en route to the gneiss, and similar rocks, near Dulas harbour. The next two days they worked across to Beaumaris and then down to Plas Newydd to study the igneous dike, having crossed the ferry at Bangor and returned over the Menai Bridge. On 20th August they crossed the Menai Bridge where Darwin left Sedgwick. Darwin then went to Cwm Idwal, while Sedgwick travelled to Caernarfon to begin his work in Snowdonia after 18 days chasing non-existent Old Red Sandstone.

Across the Welsh mountains, Bangor to Barmouth 20th–23rd August[17]

From Menai, Darwin made his last Welsh traverse – Cwm Idwal and Moel Siabod – before taking an indirect route to Barmouth. The journey from Menai to Barmouth took four days, fitting in both with Lowe's diary and reasonable walking stamina. On the first two days, Darwin made detailed studies of the geology of Cwm Idwal and Moel Siabod and then walked the 36 miles to Barmouth from Capel Curig in two days staying at Ffestiniog.

Cwm Idwal was one of Darwin's favourite haunts, and forms the high point of this tour. It is a mile from the road at Idwal Cottage and contains a beautiful glacial lake surrounded by rugged cliffs. Considering that Darwin had no geological guides or memoirs to assist him, his notes are exceptionally sharp and profound, in contrast to those made at Llanymynech in July (Figure 4). Darwin identified igneous rocks, found some corals (possibly *Serpulites*) and interpreted the syncline at Devil's Kitchen as an inverted cone of igneous rock, rather like Arthur's Seat above Edinburgh. (In 1842, the ailing Darwin returned to Cwm Idwal to study the glaciation.) Darwin spent the next two nights at the coaching inn at Capel Curig (now Plas y Brenin) and on maybe this or some other occasion, scratched his name on a window pane, as did a certain Victoria R.

In his *Autobiography*, Darwin wrote, 'At Capel Curig I left Sedgwick and went in a straight line by compass and map across the mountains to Barmouth.' In fact, when his route is plotted from sites recorded in his notes, it was anything but direct; to follow a compass bearing to Barmouth would be an exhausting experience. Before that, on 21st August, Darwin ascended Moel Siabod, a rugged mountain of 872 metres, by the north side and descended by the northeast ridge to Pont Cyfyng. Darwin competently worked out the relationship of volcanics to Greywacke[18]. Next day he followed the well-worn track to Dolwyddelan and thence over moorland to an inn at Ffestiniog. From there he crossed the Bwlch Drws Ardudwy and descended Cwm Nantcol to the Harlech–Barmouth road. His final notes described the steeply dipping Cambrian sandstones just north of Barmouth, as 'porphyritic slate'. He took brief, but good, notes of several localities, but none are more than a

few lines: notably of Carreg y Fran, a volcanic outcrop. Little is known of his stay at Barmouth and he left on 29th August for Shrewsbury. The rest is history.

To the *Beagle* and chemistry: September

In the final month before leaving to join the *Beagle* Darwin was travelling between Shrewsbury, Cambridge and London buying equipment and meeting future shipmates. Yet he had time to test his chemical skills and performed tests with 'muriatic acid' and a blowpipe on several rock specimens. His Welsh geological apprenticeship was complete.

While Darwin was waiting for the *Beagle* to sail from Plymouth he geologised inland. The first stop on the voyage, was the Cape Verde Islands, where Darwin noted the volcanic rocks. After Cape Verde, the *Beagle* stopped at St Pauls Rocks, where Darwin watched the seabirds and recognised the rocks as Serpentine. He concluded that, unlike most oceanic islands, they were not volcanic. From there he worked on some of the gneisses of South America and then on to the Falkland Islands, where he compared the 'Ordovician' quartzites to those of Holy Island and the rock glaciers to a similar feature just north of Barmouth (which he had probably seen in 1828 rather than 1831). Soon after he wrote a 'discussion paper' on Henslow's *Memoir of Anglesey*. From Darwin's geological notes it is clear he began to use Lyell's *Principles of Geology* only after he left the Falklands.

Darwin's geological fieldwork in 1831 scarcely advanced geology, but it gives a window into how he learnt his craft and his development as scientist. Sedgwick introduced Darwin to careful note taking and field work and taught him aspects of sedimentary, igneous and metamorphic geology, mineralogy and structural geology, as well as how to resolve problems of stratigraphy.

It would be difficult to devise a better three-week geological trip for any trainee geologist, yet its route was dictated by Sedgwick's own concerns – his abortive attempt to locate the Old Red Sandstone in north Wales. It is Sedgwick and Henslow, rather than Lyell who should be credited for Darwin's geological skills.

Acknowledgements

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N. Wales maps	CUL DAR 265, DH/GPD 10, I –iv
Notes for map	CUL DAR 210.17
Darwin–Sedgwick tour	CUL DAR 5, fols 5–10
Anglesey notes	CUL DAR 5, fols 3–4
Cwm Idwal to Barmouth	CUL DAR 5, fols 11–14
Chemical notes	CUL DAR 5, fols 15

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Annotated copy of Evan's *Map of the Six Counties of North Wales*.

Darwin's maps

Darwin had access to several topographic and geological maps and information about these can be gleaned from notes or maps made in 1831. He most probably took Evans' map on his tour and his route from Capel Curig to Barmouth is clear from using the map.

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