

THE SEDGWICK-DARWIN GEOLOGIC TOUR OF NORTH WALES

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IN AUGUST, 1831, Charles Darwin accompanied Professor Adam Sedgwick on a geologic tour of North Wales. Twenty pages of notes made by Darwin during the tour,¹ and two letters written by Sedgwick to Darwin in September of that year² have been preserved, and are published here for the first time. These papers, which are now in the Cambridge University Library, are extremely valuable because they provide firsthand insight into both Darwin's geological knowledge and his scientific philosophy at the time in his life when he was about to embark on one of the most important ventures in the history of mankind. When Darwin returned from the North Wales tour to his home at Shrewsbury, in Shropshire, he received Captain FitzRoy's offer for the position of naturalist on board H.M.S. *Beagle*. Unfortunately, two original letters from Darwin to Sedgwick, to which Sedgwick replied, are lost.

The circumstances which led to the joint tour in Wales were fortuitous and are somewhat puzzling. Sedgwick was forty-six years old and professor of geology at Cambridge. He had just finished two terms as president of the Geological Society of London. In previous years he had geologized in Scotland, the Alps, Cumberland, and South Wales, and in 1831 was anxious to extend his studies into North Wales. In contrast, Darwin had just graduated from Cambridge University in the spring of 1831. When a student at Edinburgh University during the years 1825-1827, he had been repelled by geology while attending Professor Robert Jameson's classes. To Darwin, Jameson's explanation of igneous veins being filled from above seemed absurd. As a result, Darwin resolved at that time never again to study the subject. That he had indeed been "turned off" by Jameson is evident, for in his three years at Cambridge he never enrolled in the "eloquent" and popular lectures of Professor

Sedgwick. Certainly Sedgwick's reputation for having supported both Wernerism and the Noachian Deluge theory would not have lessened Darwin's antagonism toward geology. Sedgwick's outspoken religious opinions and his frequent references to the glory of God being reflected in nature could not have led to an improved attitude about geology by Darwin. Dr. Robert Darwin, Charles's father, considered himself a "freethinker"; Charles's mother had taken him when he was a youngster to the Unitarian Church. With that background, although then trained for the ministry, Darwin would not have considered himself, as would Sedgwick, a religious fundamentalist.

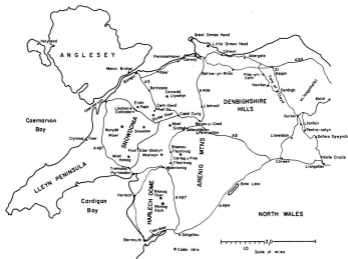
It is unlikely, therefore, that Darwin and Sedgwick would have gone together on such a tour had it not been for the timely intervention of John Henslow, professor of botany at Cambridge. Henslow, himself an excellent geologist, had taken Darwin on innumerable natural history walks around Cambridge. Darwin would obviously have learned much geology from Henslow, and of course Henslow would have become well acquainted with Darwin's geological abilities. We know from Darwin's early correspondence, when he was a schoolboy in Shrewsbury, of his precocity in chemistry and mineralogy. One letter, which is now preserved in Cambridge University's Robln Darwin Collection, illustrates these early interests.³ The letter, from Charles's older brother Erasmus, gives him detailed instructions in mineral identification. At this time Charles was only thirteen years of age. It is evident therefore that by 1831 Darwin was no stranger to the use of the goniometer and the blowpipe. We may also assume, from the content of his North Wales notes, that, although repulsed by Jameson, he had at Edinburgh nevertheless learned well the fundamentals of both descriptive and theoretical geology.

In the summer of 1831, before Henslow sug-

¹ Charles Darwin Papers, Volume 5, "Geological notes made with Sedgwick," Cambridge Univ. Library.

² Originals now in the Robln Darwin Collection, on deposit in the Cambridge Univ. Library.

³ Written November 14, 1822, to Charles when the latter was only thirteen years old, Robln Darwin Collection, Cambridge Univ. Library.



MAP 1.

gested that Darwin go with Sedgwick on the North Wales tour, Darwin was already preparing for an overseas expedition.⁴ He had begun again, despite his earlier resolve, to study geology. The proposed tour into Wales would possess obvious advantages to each man. It offered Darwin an opportunity to gain first-hand experience in the company of one of the most outstanding and respected geologists in England. The fact that Shrewsbury is near Wales would also be an added convenience for Darwin. For his part, Sedgwick would appreciate having the sturdy, energetic, enthusiastic, and knowledgeable young man as a companion. The Welsh mountains are rugged, the weather is frequently atrocious, and a suitable assistant to help carry rock specimens

⁴ He had in fact already proposed the trip to Professor Henslow, and to his friends William Kirby, Marmaduke Ramsay, and Richard Dawes. See Francis Darwin, ed., *The Life and Letters of Charles Darwin* (3 v., London, Murray, 1887) 1: pp. 55 and 185.

would be welcome. Being a loquacious extrovert, Sedgwick would be glad to have along a promising young scientist to whom he could impart words of wisdom.

Sedgwick and Darwin left Shrewsbury for Wales, evidently in Sedgwick's gig, on Friday, August 5. They went to Llangollen, where they met the British Ordnance draughtsman, Robert Dawson, who gave them some geological notes.⁵ The next day they went north toward St. Asaph and Abergelle. In his notes Darwin used the pronoun "we" until the two travelers arrived at St. Asaph on Monday, August 8. On that day, while going to Abergelle and on to Conway, Darwin began to use the pronoun "I." Generally, Sedgwick's field notes (now kept at the Sedgwick Museum in Cambridge) are detailed for

⁵ Copies of Dawson's early nineteenth-century topographical maps of North Wales are in the Sedgwick Museum, Cambridge University.

every day of the tour.⁶ However, there are no entries in his field notebooks for the region from Abergele to Conway. Thus, on Monday, August 8, Sedgwick probably went alone in his gig to Conway while sending Darwin on the first of several traverses the latter was to make by himself. Between Sedgwick's departure, and their subsequent meeting at Conway on Tuesday, August 9, Darwin must have walked no less than twenty, and perhaps as many as thirty miles. The notes of the two men again correspond closely from Conway to Penmaenmawr, to Aber, and on to the great Penrhyn slate quarries at Bethesda, where they arrived on Thursday, August 11. Unfortunately Darwin's notes are not dated after Monday, August 8. Therefore, his itinerary from this date on must be deduced. Contributing to the difficulty of reconstructing the itinerary, Sedgwick's notes mention Darwin's name only once, after the two had separated, and then apparently in reference to one of the letters sent to him by Darwin. But this is not surprising, since Sedgwick's notes are very impersonal; he rarely referred to himself, or to others.

Sedgwick's first letter to Darwin was written Sunday, September 4. It was in answer to one from Darwin, and in it Sedgwick recounted his itinerary from Sunday, August 21 to September 4. From the sense of Sedgwick's letter we assume that Darwin already knew of Sedgwick's activities through August 20. The two men must therefore have met on that day, or perhaps there was an exchange of letters now lost. On Thursday, August 11, Sedgwick had gone from the Penrhyn quarry to Bangor and on to Menai Bridge. From Friday the twelfth until Saturday the twentieth, he went throughout Anglesey, checking on the geology reported previously by Henslow,⁷ taking time off on Saturday and Sunday, August 13 and 14, for a side trip over to Dublin. Because Sedgwick did not mention the Anglesey trip in his letter of September 4, we must assume that Darwin already knew about it. Possibly the two men met, perhaps at Caernarvon, when Sedgwick returned on the twentieth, and they exchanged notes on their interim activities. At any rate, Sedgwick expected Darwin to

have returned to his home by September 4, for his first letter was addressed to Shrewsbury. Where Darwin was between August 12 and 20 is unknown; no dated notes of his are extant for this period.

Darwin's geological notes, after describing the Penrhyn Quarry, continue at Cwm Idwal, a tributary valley several miles up the Nant Ffrancon River from Bethesda. From Cwm Idwal he went to Capel Curig where he began a twenty-seven-mile compass traverse south-southwest across the rugged Snowdonian and Merioneth mountains to Barmouth. In his autobiography Darwin said, "At Capel Curig I left Sedgwick and went in a straight line by compass and map across the mountains to Barmouth, never following any track unless it coincided with my course."⁸ Darwin wrote his autobiography at the age of sixty seven years. His memory was essentially correct, although according to his own notes he did stray somewhat from a straight compass line, but probably only to investigate a particular peak or outcrop, returning then to his traverse. Since Sedgwick's notes do not mention Capel Curig at the appropriate date, it seems more likely that the two men separated either at Caernarvon or Bethesda.

The available evidence suggests, therefore, that Darwin was with Sedgwick for no more than about one week. We may assume that that week was an eventful one. Sedgwick was effusive and opinionated, and at times he could be pontifical. Even before they left Shrewsbury, he lectured Darwin about drawing conclusions from hearsay and from isolated facts. Darwin had commented on the paleontological significance of a tropical shell which had been found by a workman in a gravel pit near Shrewsbury. The tone of Sedgwick's two letters to Darwin suggests that Sedgwick took his authoritarian role seriously; he patronizingly advised Darwin on a number of points. A character of Sedgwick's life style was a tendency toward dogmatic adherence to principle, a trait which sometimes led to acrimonious disputes even with friends. That he was, nevertheless, capable of compromise and eventual accommodation to new ideas, is illustrated by his public renunciation, when middle aged, of Wernerism and then the Deluge theory. And it was Sedgwick's resolute adherence to rules of morality, and his courage in the discharge of duty, that made him an admirable choice for university

⁶ See Sedgwick's Journals, No. XXI, August, 1831, and No. XXII (1831), No. II, August 30 to September 15, 1831, Sedgwick Museum, Cambridge University. The Museum also possesses typed copies of the Journals transcribed by Professor Owen T. Jones.

⁷ John S. Henslow, "Geological Description of Anglesea," *Trans. Camb. Phil. Soc.* 1 (1822): pp. 339-452.

⁸ Francis Darwin, 1: p. 5R.

proctor, a position which required disciplining and even expelling students. At this time in Darwin's life, however, such traits may have been somewhat less than admirable, for Darwin would still have been in a student-professor relation with the older man.

For whatever reason, Darwin left Sedgwick no later than August 20, the latter continuing the tour until at least October 7, and returning to Cambridge by October 18. When Darwin reached Barmouth he met his friend Henry Porter Lowe (fellow member of the Glutton Club). Lowe's brother Robert, later Viscount Sherbrooke, recalling the occasion a number of years later, said,

[Darwin] carried with him, in addition to his other burdens, a hammer of 14 lbs. weight. I remember he was full of modesty, and was always lamenting his bad memory for languages and inability to quote. I am proud to remember that though quite ignorant of physical science, I saw a something in him which marked him out as superior to anyone I ever met; the proof which I gave of this was somewhat canine in its nature, I followed him. I walked twenty-two miles with him when he went away, a thing which I never did for anyone else before or since.⁹

Lowe's remarks give some clue that a conflict of personality might have existed between Sedgwick and Darwin. Sedgwick was given to expounding metaphysical and moral subjects, and he enjoyed quoting at length from Walter Scott, Milton, Cowley, Dryden, and others. Darwin's inability to reciprocate in kind and undoubted lack of interest must have made him uneasy. We can well imagine that Darwin appreciated being off by himself on the traverses. Jameson's Wernism was enough; to be exposed a second time to a domineering, religiously oriented geologist would have been too much.

Whatever personality or metaphysical conflicts may have emerged during the tour, Sedgwick's professional influence on Darwin must have been significant. Sedgwick's note-keeping habits were excellent, Darwin's at this time seem erratic; for example, some notes are dated, others are not. Sedgwick's methods of extensive and thorough collecting and cataloging of specimens must have impressed Darwin. To have had this sort of field experience just before beginning the *Beagle* voyage would have been invaluable. We must

assume also that Darwin's competence as a geologist improved under Sedgwick's tutelage, both from field instruction and from their correspondence. Sedgwick's letters to Darwin are full of geological information. Certainly the feelings between the two men could not have been entirely estranged, for Darwin did write at least two letters to Sedgwick at this time, and Sedgwick's answers are lengthy and cordial. Darwin obviously had made a favorable impression on Sedgwick, for the latter not only wrote the friendly and informative letters, he promised to nominate Darwin for a fellowship in the Geological Society at the next meeting—a promise he failed to honor.

It is important to remember in analyzing the philosophies of these intellectual giants, that one was middle-aged, already professionally established, and highly respected by his colleagues. The other, although young, and however disparaging he may have been about his own memory and linguistic abilities, was not overly modest in his feelings of personal worth and mental aptitude; he had tested his mind against many of the best, at Cambridge, at Edinburgh, at Shrewsbury, and at his Uncle Josiah Wedgwood's home, Maer Hall. He knew he was the equal of most.

A comparison of Darwin and Sedgwick's field notes and letters reveals a marked contrast in their scientific philosophies. Sedgwick's notes are mainly descriptive and in the best tradition of inductive science; they are almost entirely restricted to geological "facts." Darwin's notes are not only descriptive, but deductive and speculative. He introduces hypotheses, queries, and personal anecdotes. He draws empirical generalizations, and relates broad areas of one discipline to another, one example being the observation that the character of the vegetation depends on rock types. His insight into principles of ecology are remarkable; very likely they can be attributed substantially to the influence of that master teacher, Professor Henslow.

The differences in the scientific outlook of the two men bear out the lesson of the tropical shell story. Sedgwick was by this time very cautious in theorizing. He had only recently publicly recanted two geological theories which he had previously widely supported. It was the custom of the day among most older scientists to praise and to pursue inductive science; the controversies between Neptunists, Plutonists, Catastrophists, and Uniformitarians were still a part of the contemporary scene, though less bitter than a few years

⁹ A. Patches Martin, *Life and Letters of the Right Honourable Robert Lowe, Viscount Sherbrooke, G.C.B., D.C.L. etc.* (2 v., London, Longmans, Green, 1893) 1: pp. 19-20.

earlier. Sedgwick's permanent contributions to the geological sciences are of course not insignificant. The accuracy of his work has withstood the test of more than a century and a half. His indefatigable energy, incredible reserves of physical strength, even in his later years, his exceptional intellectual powers, combined with firm religious faith and devotion to set goals, make him a rare figure in the history of geology. His unfortunate outbursts against such old friends, as for example Murchison and Darwin, are typical expressions of his moral outrage at supposed evil. His vanity, if in fact it was overbearing for Darwin, would now be understood, for when already middle-aged, he climbed those soggy, sphagnum-covered Cambrian Mountains, day after day, week on end, carrying a great iron hammer and a heavy leather collecting bag full of rocks.

Speculation about thoughts and discussions which Sedgwick and Darwin may have had on the subject of evolution must be based on meager circumstantial evidence. Sedgwick was never sympathetic to the idea of transmutation of species. From the few comments which the two men made about fossils in their notes and letters, and from comments made by Sedgwick a year and a half earlier at the Geological Society, we can assume that he would have expressed strong feelings against the theory during the tour. Having been reprimanded once for drawing unwarranted conclusions about fossils, Darwin, in his notes, even when the opportunity arose, ignored the subject. In his autobiography written many years afterwards, Darwin spoke with appreciation of having been taught by Sedgwick "that science consists in grouping facts so that general laws or conclusions may be drawn from them."²² Thus it becomes understandable that when a rhinoceros tooth was found in a cave near Cefn, neither Sedgwick nor Darwin commented in their notes about its paleontological significance.²³ If Darwin mentioned the incident in his letters to Sedgwick, the latter ignored it in his answers. Certainly Darwin would have been surprised enough at finding a rhinoceros fossil in North Wales to have commented on it, had the Shropshire shell episode

not repressed his normal curiosity. All through Sedgwick's notes and letters there is less attention paid to fossils than might have been expected, especially in view of the impact of William (Strata) Smith's new system of classifying rock formations, a system in which fossils played an important role. Only the previous January, Sedgwick as president of the Geological Society had awarded the Wollaston Medal to Smith. Sedgwick's anti-evolutionary attitudes were well expressed in his 1830 presidential address to the Geological Society. He said, "We constantly find [fossils] passing into each other [in a series of formations in contact with each other]." He concluded, nevertheless, that the doctrine of transmutation of species "is opposed by all the facts of any value."²⁴

Although Sedgwick remained to his dying day steadfast in his opposition to evolution, he attempted nevertheless in April, 1834, to bring about the abolition of the religious test for the diploma at Cambridge University. He could say, on the one hand, "If [Cambridge] once be considered as a mere school for the Church Establishment her endowments will be thought out of all reasonable dimensions, and before many years are over we may see our noble edifices beginning to crumble about our ears." On the other hand he could say that the laws of nature "teach us to see the finger of God in all things animate and inanimate."²⁵ Darwin, although not totally intimidated by the ebullient personality of the older man, would certainly have had the maturity and good judgment not to provoke him deliberately by pointing out the inconsistency in his reasoning, with regard both to the meaning of fossils, and to diplomas.

The literary style of Darwin's notes compares favorably with his *Beagle Diary*²⁶ and his *Journal of Researches*,²⁷ being a mixture of technical data, personal anecdotes, esthetic wonderment, penetrating inquiries, analogical musings, speculative deductions, and empirical generalizations.

²² Adam Sedgwick, "Anniversary Address of the President, The Geological Society of London, 19 February 1830," *Proc. Geol. Soc. London* 1 (1834): p. 205.

²³ John Willis Clark and Thomas McKenny Hughes, *The Life and Letters of the Reverend Adam Sedgwick* (2 v., Cambridge Univ. Press, 1899) 1: pp. 425 and 403.

²⁴ Nora Barlow, ed., *Charles Darwin's Diary of the Voyage of H.M.S. "Beagle"* (Cambridge Univ. Press, 1934).

²⁵ Charles Darwin, *Journal of Researches into the Geology and Natural History of the Various Countries visited by H.M.S. Beagle* (London, Colburn, 1839).

²⁶ Francis Darwin, 1: p. 57.

²⁷ In Darwin's notes, the fossil is referred to as "rhinoceros bones"; in Sedgwick's notes it is referred to as a "rhinoceros tooth." Darwin's notes, entered as an interlinear insertion, credit Sedgwick with the discovery. Probably the fossil was a jawbone with an embedded tooth. Unfortunately the fossil is not now preserved in the Sedgwick Museum.

He frequently treated geology, ecology, and geography as one science. His notes, had he made the effort, could easily have been rewritten into a publishable article.

The question arises, what specific clues are there in Darwin's notes to his religious beliefs and his metaphysics? Did he lean toward catastrophism? uniformitarianism? transmutation of species? Some passages do appear to imply catastrophic rather than uniformitarian views. For example he used the expressions: "where the strata have been much disturbed," (p. 7) "great valleys were . . . stretched," (p. 9), and "line of violence" (p. 17). The attempt to explain the shape of valleys by assuming that they had been "stretched," is a theory which Darwin attributed to Sedgwick. Thus although in his notes and letters Sedgwick maintained an essentially pure inductive stance, it is evident that in his private discussions with Darwin, he did indulge in speculation. The stretching idea philosophically conforms to similar statements Sedgwick made in his 1830 Geological Society Presidential Address:

Now every great irregular elevation of land . . . must have produced, not merely a rush of the retiring waters of the sea, but a destruction of equilibrium among the waters of inland drainage. Effects like these must have been followed by changes in the channels of rivers, by the bursting of lakes, by great detachments, and in short by all the great phenomena of denudation.¹⁴

He went on to say that some valleys are formed by causes "of disruption, marking the direction of cracks and fissures produced by great upheaving forces."

That Darwin gave as little credence to the idea of catastrophism as he did both here and in his *Beagle Diary*, is an indication of his independent and advanced thinking, particularly in view of his exposure to Jameson and Sedgwick. The fact that during the *Beagle* voyage it was Henslow, and not Sedgwick, with whom Darwin corresponded so voluminously, and to whom he entrusted his vast collection of specimens for safe keeping further suggests that Darwin and Sedgwick were metaphysically and temperamentally "incompatible."

Darwin's notes provide good evidence of his geological competence at this time. We can assume that while he accompanied Sedgwick his notes reflect the professor's direct influence. But

Darwin was alone from Cwm Idwal to Capel Curig and from there to Barmouth. The notes he made during this latter half of the tour fill eight of the twenty pages. We have in effect a "controlled experiment" in which the only variable affecting what Darwin records in his notes is the presence or the absence of Sedgwick. On the whole, the calibre of the notes, throughout, reflects Darwin's thorough knowledge of geology.

From his previously broad experience both in Britain and on the Continent, Sedgwick had developed a system for attacking a new area: first he made a preliminary survey, getting the lay of the land, noting general topography, strike and dip, and establishing a base line of main rock types. Then he made traverses, during which detailed observations were made. Data collected during the traverses were next compiled, and profile sections finally drawn, showing anticlines, synclines, unconformities, rock layers, etc. Unlike some geologists (Murchison, for example) he did not concentrate on a single formation and follow its stratigraphic relations exclusively. In extremely complicated regions, such as North Wales, Sedgwick eventually sorted out the numerous irregularities and arrived at accurate descriptions of the principal features. That Darwin was to use the same procedures with similar success in his South American studies undoubtedly resulted from his having been an apt student under Sedgwick.

Darwin's knowledge of different kinds of rocks and minerals, and of technical geological terminology, is evident in his notes. His insight into geological processes is illustrated by his inquiries about Cwm Idwal and Moel Siabod. He wondered whether the large mass of basalt at the rim of the Cwm Idwal cirque was part of an inverted cone. The columnar nature of the basalt must surely have reminded him of similar structures at Salisbury Craig, at Edinburgh, where he had rejected Jameson's Wernerism. The basalt at the top of Cwm Idwal is part of Twll Du, or Devil's Kitchen. It is a great lava flow which subsequently folded along with its contiguous sedimentary layers into a syncline. When viewed from a distance the syncline is conspicuous. Neither Sedgwick nor Darwin appears to have had the proper perspective to have seen the syncline; however, Darwin did detect slate dipping beneath the basalt. His suggestion that the structure is an inverted cone is curious, for such an arrangement would tend to support the Wernerian view

¹⁴ Sedgwick, *Proc. Geol. Soc. London* 1 (1834): pp. 191-192.

of veins being filled from above. But if he mentioned this point in his letters to Sedgwick, the latter did not comment on it in his answers.

Darwin's description of Moel Siabod was detailed and accurate. Here, however, in contrast to Twll Du, he found slate superimposed over trap. Puzzled by such a vertical sequence, he wrote to Sedgwick asking for an explanation of the origin of these rocks. In his answer of September 4, Sedgwick seemed quite unconcerned about the geological history of Moel Siabod, stating that he did not see any difficulty in understanding its structure, and in fact disagreeing with Darwin on the superpositional arrangement of the slate and trap, insisting that the trap was over the slate. Both men were in fact correct, for there is, on the western slope, a wedge of slate embedded within a crystalline, columnar, thick sill comprising the greater portion of the crest of the mountain. The two men undoubtedly had seen different parts of the slate wedge, Darwin approaching from an easterly direction.

One conspicuous feature of Moel Siabod is a cleft in the face of the mountain as viewed from the east. Darwin referred to it as a "valley of separation." In his field notebook, although not mentioning the cleft, Sedgwick described the structure as a "fine junction (nearly perpendicular)." It is in fact the eroded contact zone between the trap and the slate. Although both Darwin and Sedgwick recognized the indurated character of the rock, neither seemingly appreciated the intrusive nature of the trap.

The notes which Darwin made during the traverse from Moel Siabod to Barmouth are less detailed. The entire transect from Capel Curig to Barmouth is about twenty-seven miles in length. Darwin probably walked it in one day, or at most two. Near Blaenau Ffestiniog, he described the geology of the Moelwyn peaks and of the Carreg y Fran, two sites which, in an east-west direction, are about five miles apart. As the line between Capel Curig and Barmouth is almost due north and south, he obviously strayed from his compass line. His description of the geology all along the way corresponds remarkably well with that of the British Ordnance Horizontal Sections of 1880,³⁷ good evidence of his

professional competence. One example of his insight into geological structures is his comment about the distinction between cleavage and dip in slate, a concept many geologists of the day had not yet grasped. Sedgwick was first to recognize the distinction, and he can obviously be credited with having taught Darwin the phenomenon.³⁸

The great Merioneth anticline between Maentwrog, Harlech, Barmouth, and Dolgellau is now called the Harlech Dome. It is mostly Cambrian sediments. The southern end of Darwin's traverse was across this dome. His description of its rocks is therefore the first in any detail to have been done of this region. Of special historical interest is the fact that of the formations in North Wales which were classified by Sedgwick as Cambrian, including most of Denbighshire, Flintshire, Caernarvonshire, and Merioneth, only the Harlech Dome and a narrow strip in Caernarvonshire, are now considered Cambrian. It was Sedgwick's protégé and erstwhile friend, Roderick Murchison, whose works led to the reclassification of the majority of the formations of North Wales into Silurian and Ordovician rocks. Sedgwick could not agree with Murchison's divisions, and a bitter estrangement resulted between the two geologists, lasting from 1852 for more than twenty years. As a suitable memorial testifying to Darwin's priority in describing the Harlech system, it might now appropriately be called "Darwin's Dome!"

It is obvious from Sedgwick's letters to Darwin that Darwin had written to the professor expressing perplexity about several things. Thus a method of acquiring scientific information which Darwin used so successfully throughout his career, seems already to be established, viz., sending letters of inquiry to colleagues and specialists, requesting information about particular issues. Sedgwick, like most to whom Darwin wrote, obliged by giving in a thorough and cordial manner the information desired, as best he could. In Sedgwick's case, too often the only written record of his researches was his letters, for the pressures of his administrative and teaching duties at Cambridge often interfered with preparing papers for publication.

Sedgwick began his first letter to Darwin (that of September 4) by blaming a "stupid red nose waiter" for not promptly bringing him Darwin's letter. In an 1875 letter to Professor Hughes, of Cambridge, Darwin related another instance dur-

³⁷ A. C. Ramsay, "Horizontal Section Maps 28, 31, and 37, 6"mi." (Geological Survey of England and Wales, 1880). See also A. C. Ramsay, *Memories of the Geological Survey of Great Britain and Map of the Museum of Practical Geology* (3 v., 2nd ed., 1881) 3: pp. 128-129.

³⁸ Clark and Hughes, 1: p. 306.

ing the tour of Sedgwick's anger at a waiter for supposed wrong doing.¹⁹ The latter incident nearly resulted in the two men retracing their footsteps for a mile or two in order to reprimand "that damned scoundrel." Without Darwin's intercession, Sedgwick would have had his way. We can easily imagine that such displays of temper by Sedgwick made the normally calm and good-natured Darwin ill at ease.

Between the time Sedgwick wrote his letters of September 4 and September 18, Darwin had accepted FitzRoy's offer. In his second letter Sedgwick congratulated Darwin on the appointment, and, in response to a request, recommended to Darwin several books to take along on the *Beagle*. The first of the authors he listed was Daubeny. Daubeny's book, *A Description of Active and Extinct Volcanoes*,²⁰ is a good example of the state of confusion in which many geologists found themselves at that time; Hutton is quoted in the preface, Sedgwick is praised for his Wernerian views, the universal Deluge theory is given support, and Werner is condemned for his basalt theory. The second author recommended by Sedgwick was D'Aubuisson. The first edition of D'Aubuisson's *An Account of the Basalts of Saxony* had been published in 1803,²¹ and in it the author took a Wernerian stand. The book was translated into English by P. Neill, a Neptunist, who added a preface, and had it published in Edinburgh in 1814.²² A copy of the latter edition is in Darwin's library,²³ which, for the most part, is now kept at Cambridge University Library. We may assume that before leaving on the *Beagle* voyage Darwin did in fact obtain the book. Although praising D'Aubuisson, Sedgwick said the book was full of "Wernerian nonsense." D'Aubuisson's later edition, published after he renounced Wernerian, was not available in English.²⁴ Thus if Darwin had any firm convictions

about which geological theory to accept, it was not because of Sedgwick's suggestions, which at this point seem at best ambivalent.

The third book which Sedgwick recommended, somewhat condescendingly, was one of Bakewell's. Sedgwick said it was "not a bad book (for a beginning)." Bakewell, in both his geology and mineralogy books, published in 1813²⁵ and 1819²⁶ respectively, was essentially Huttonian in his views about basalt. There is no record that Darwin obtained either of these books. Certainly Darwin would have agreed with Bakewell in the latter's severe criticism of both Werner and Jameson. Had Sedgwick's endorsement of Bakewell been stronger, perhaps Darwin would have obtained copies. It had been Bakewell's books which originally interested Charles Lyell in geology. Possibly Darwin had in fact already read them in the extensive Maer Hall library of his Uncle Josiah Wedgwood, where he had spent many hours in his youth. This would logically explain his antagonism toward Neptunism when a medical school student at Edinburgh.

Sedgwick's weakness in paleontology is shown by his inability to propose books on fossils. He did however advise Darwin to consult W. Lonsdale at the Geological Society, and to study the Society's collections. He also suggested that Darwin repay the Society with specimens, a request that Darwin more than fulfilled by the incredibly rich collections sent back to England.

Another recommendation of Sedgwick was Humboldt's *Personal Narrative*, a book Darwin had already read "and reread."²⁷ The copy Darwin took with him on the *Beagle* was presented and inscribed by Professor Henslow. Sedgwick and Darwin obviously agreed that Humboldt would "at least show the right spirit with which a man should set to work." The indomitable energy with which Sedgwick and Darwin scaled the great mountain ranges of the world, and with which each made enormous contributions to science, proves how well they emulated the illustrious Humboldt.

¹⁹ Robert Bakewell, *An Introduction to Geology, Illustrative of the General Structure of the Earth, etc.* (London, Harding, 1813).

²⁰ Robert Bakewell, *An Introduction to Mineralogy: Comprising the Natural History and Characters of Minerals; and a Description of Rocks, etc.* (London, Longman, etc., 1819).

²¹ Alexander Humboldt and Aimé Bonpland, *Personal Narrative of Travels to the Equinoctial Regions of the New Continent during the years 1799 to 1804*, transl. by H. Williams (7 v., London, Longman, etc., 1814-1829).

¹⁹ *Ibid.*, pp. 380-381.

²⁰ Charles Daubeny, *A Description of Active and Extinct Volcanoes; with Remarks on their Origin, their Chemical Phenomena, and the Character of their Products* (London, Phillips, 1826).

²¹ J. F. D'Aubuisson, "Sur les basaltes de la Saxe," *Annal. de Chimie* 46 (1803): pp. 170-190, 225-250.

²² J. F. D'Aubuisson, *An Account of the Basalts of Saxony, with Observations on the Origin of Basalts in General*, transl. with notes, by P. Neill (Edinburgh, Longman, etc., 1814).

²³ H. W. Rutherford, *Catalogue of the Library of Charles Darwin now in the Botany School, Cambridge* (Cambridge Univ. Press, 1908).

²⁴ J. F. D'Aubuisson, *Traité de Géognosie* (2 v., Strasbourg, 1819).

The last publication Sedgwick suggested was a "small paper printed by the Geological Society containing directions for travellers," presumably *Geological Inquiries*, 1808.²⁸ Sedgwick described the paper as a "mere hornbook [i.e., a child's primer], hardly worth your looking at." There is no evidence that Darwin obtained the pamphlet, which is nevertheless an excellent treatise outlining in twenty pages a series of questions designed to give geologists important clues for observation. It directs the attention of the observer, for example, not only to ordinary rocks and minerals and their *in situ* relations, but to specific details which if detected ought to lead either to plutonic or neptunistic conclusions. Paragraph ten, "Concerning Veins," inquires, for example, about the thickness of veins at different depths, about whether veins terminate in a wedge, and if so toward the top or bottom; about the interruption of veins by faults; about metamorphosis of intruded rock at contact zones, and whether veins can be traced to beds of like materials. Paragraph eleven urges the observer to note similarities of fossils to living forms, and to look for traces of the existence of man. When we compare this set of directions with the comprehensive geological essay Darwin himself wrote in 1848 for the British Admiralty at the suggestion of Professor Sedgwick,²⁹ we can perhaps appreciate Sedgwick's "hornbook" comment.

In his second letter (September 18), Sedgwick sketched a section diagramming the profile along a transect from west of Mynydd Mawr near Caernarvon eastwardly to near Pfestiniog. His labeled sketch shows peaks, valleys, passes, and strata. The distance along the traverse is about seventeen miles. From these data it is evident that Sedgwick's accomplishments that summer were extensive indeed. He did however make one small error in the letter, obviously an oversight. Near the left (westerly) end he drew the peak of Mynydd Mawr as if it were a syncline. In the text of his letter he calls the mountain a "great anticlinal line." An almost identical profile section is published in Clark and Hughes, *Life and Letters of Sedgwick*³⁰ reproduced from one Sedg-

wick had sketched in a letter sent to Murchison dated July 23, 1832. The published version extends the line farther eastwardly and westwardly, its total length being nearly thirty miles. Thus the section he drew in the letter to Darwin would have historical priority. In the Murchison letter Myndd Mawr is shown to be porphyry surrounded by synclinally dipping layers. Smith and George in their 1961 *Geology of North Wales* indicate that the mountain is microgranite.³¹ In his Darwin letter Sedgwick commented that the site marked "X" represents the place "where the two systems of elevation interfere with each other." This is between Nricht Mountain and the Pass of Aberglaslyn. Thus Sedgwick at his first inspection made a notable discovery, viz., the juncture of three great tectonic systems, Snowdonia, Arenig, and the Hartek Dome. The eastward extension of Sedgwick's traverse passes through the Moelwyn and Carreg y Fran peaks following exactly the five-mile detour Darwin had made earlier on his Capel Curig to Barmouth traverse. We can surmise that Sedgwick had asked Darwin to make this side jaunt.

It would be helpful to know the content of Darwin's two letters to Sedgwick. They might contain some clue that explains why Darwin seemingly abruptly left Sedgwick and North Wales. In his autobiography Darwin said he returned to Shrewsbury in order not to miss the beginning of the hunting season. But the opportunity to establish himself professionally in geology was certainly promising. Sedgwick must have been favorably impressed with Darwin's ability, for he had given him several challenging assignments. To have expected Darwin to travel alone over so much rugged territory, making geological notes, and to have no plans for a future meeting to share experiences, is strange. Perhaps the best conclusion is that the two were in fact already ill at ease with each other, at this time in the respective careers, and by mutual consent agreed to discontinue their joint expedition.

Because Darwin had had the good fortune to be with the master geologist, if only for a short period, he could feel confident that his geological training, and his physical stamina were sufficient for the difficult tasks ahead. And as luck would have it, he would for the third time be thrown

²⁸ *Geological Inquiries* (Geological Society of London, W. Phillips, 1808).

²⁹ Charles Darwin, "Geology," in *A Manual of Scientific Enquiry: Prepared for the use of Her Majesty's Navy: and adapted for travellers in general*, ed. by John F. W. Herschel (London, Murray, 1849).

³⁰ Clark and Hughes, 1: pp. 394-395, and 2: pp. 518-523.

³¹ Bernard Smith and T. Neville George, *British Regional Geology North Wales* (London, Institute of Geological Sciences, Geological Survey and Museum, 1961).

in, in an intimate way, with a strong personality. Captain Robert FitzRoy was in his religious beliefs more fanatic, in his temperament more explosive, and in egotism more selfrighteous, than Jameson and Sedgwick. That Darwin had the psychological strength to endure five years with FitzRoy can at least partially be attributed to his exposure to Sedgwick. The North Wales tour was therefore for many reasons an invaluable experience for Darwin. In a letter from Rio de Janeiro to Henslow, May 18, 1832, Darwin said, "Tell Professor Sedgwick he does not know how much I am indebted to him for the Welsh Expedition; it has given me an interest in Geology which I would not give up for any consideration. I do not think I ever spent a more delightful three weeks than pounding the North-west Mountains."²²

In order to complete the transcription of Darwin's and Sedgwick's writings I have needed the assistance of a number of individuals. Although in 1831 Darwin wrote more legibly than in later years, the many Welsh names in his notes could not have been accurately read without expert help. For that reason in the summer of 1972 my wife Wilma and I retraced the Sedgwick-Darwin tour in North Wales. We consulted with many of the local inhabitants about the notes. In every instance we were met with the kindest hospitality, and the assistance, freely given, was always courteous, generous, and invaluable. There was unfortunately in one or two instances not complete agreement on the meaning, or even the spelling, of some words. One word about which there were different opinions is "Llan—." Some of our informants insisted it means "township," others "church." To settle the issue, I wrote to Professor M. Richards, Department of Welsh, University College of North Wales, Bangor. He replied that both are correct; however, in place names, "Llan" stands for "church," and it is generally followed either by a saint's name or a place name. An equally perplexing issue has been Darwin's spelling of certain words beginning "Llan—." In his script his capital "L" in some instances is almost indistinguishable from his capital "S." But generally there is a fairly consistent difference between the two. In my opinion he wrote, for example, "Slanelidan," not "Llanelidan," and "Slanfair," not "Llanfair." The double "Ll" is of course correct. Some scholars who are expert in reading Darwin's handwriting

insist that he would not have written "Sl—" since he was brought up in Shrewsbury, near Wales, had previously traveled many times in Wales, and would have known better. Further evidence to me that Darwin, at the beginning of the tour, did in fact spell these Welsh words with an "Sl" is in his spelling of other words beginning "Ll" such as "Llyn," and words beginning "sl" such as "slate," in both instances of which his spelling is obviously correct. My explanation for Darwin's misspelling at this point is that he was, during the first few days of the tour, under the influence of Professor Sedgwick. He would have demurred to the domineering professor, endeavoring to please him. Sedgwick always considered himself a linguistic expert. He did have facility in learning foreign languages; he took pleasure in instructing others in pronouncing Welsh words, etc., and he enjoyed making a play on words. It would have been entirely in character for him to have told Darwin that Llangollen was pronounced as if it were spelled "Slangollen."

The suggestions of the many individuals who have answered my inquiries have, wherever possible, been incorporated into the transcriptions which follow. References to the map, the figures, and the footnotes, should make easier an understanding of the text of Darwin's notes and Sedgwick's letters. The photographs of North Wales, except for figure 7, were taken by myself.

In the transcriptions, page numbers of the notes and letters are enclosed in square brackets. Enclosures in angular brackets are crossed out in the original manuscript; enclosures in double parentheses are interlinear insertions. The "L" in the transcription of Darwin's notes referring to strata represents his symbol denoting angle of dip or of cleavage. Original spelling, punctuation, and abbreviations have been preserved.

DARWIN'S NOTES

Llangollen²³—Ruthvin²⁴

Saturday 6th *Vale of Crucis*. The bank facing the abbey consists of Clay slate, which breaks out at regular intervals, striking NW, by N, dipping 25° to the NE by N. At different parts of the road observed beds of diluvium, very like

²³ Llangollen, "The Church among hazel trees," or "Township of Colten, a legendary giant and ancient Saint."

²⁴ Darwin at first spells Ruthin, "Ruthvin," then "Ruthen," and later, after arriving the next day at Ruthin (Welsh, *Rhudd*, "red"), he spells it correctly.

²² Francis Darwin, 1: pp. 237-238.

Shrops, only no sand; also boulders of trap. Beyond V. of Crucis, on the road to Ruthvin the Limestone is seen having a grand escarpment to the West: The contrast between this & the more regular slope of the Clay Slate gives great grandeur to the views. The Greywacke generally covered by Gorse, Heath & Fern; the limestone either bare or the verdure very green. About mile & 1/4 before the road passes Dafarn Dowarch,³⁵ ((going to Ruthven)) quarry of (Limestone) Clay slate (A)³⁶ containing organic remains, a sort of flattened Pecten, & about 4 miles before this the slate is quarried, although it is of an inferior quality. [2] About 1/2 mile beyond Dafarn, a black bituminous Limestone, organic remains, veined quartz, in parts reddish, in one part strata exactly arched, the line N by E. 1/2 mile further, a tortuous valley.³⁷ through Clay Slate, generally dipping to E.

About mile from Ruthvin, beds of Sandstone.

Notes from Mr. Dawson³⁸ of the Limestone in Vale of Clwyd.

(1) W. bank 1/2 mile S by W of Slanganhafal³⁹ dip 40° W. Not again seen for 5 miles up the valley.

(2) Graigwilt⁴⁰ a large mass in the parish of Slanfair⁴¹

³⁵ *Dafarn Dwyrych*, "Tavern of turf." The tavern is now a private residence. On Walker's map, it is spelled "Dafarn Dowarch"; on John Evans's map it is "Tafarn Dowyrych." In his field notebooks, Sedgwick mentions Walker, Evans, and Greenough. Their maps would be: J. and A. Walker, *Map of North Wales* (dedicated to the Marquis of Anglesey; London and Liverpool, 5 mi./1 3/8" no date); John Evans, *Map of the Six Counties of North Wales* (inscribed to Sir Watkin Williams-Wynn, 1 mi./2 cm; June 1, 1795); G. B. Greenough, *A Geological Map of England and Wales* (London, Longman, etc. Geological Society, 6 mi/1", November 1, 1819).

³⁶ Darwin does not indicate to what "(A)" refers, nor the "(B)," on page 5 of his notes.

³⁷ Gordon Sherratt and Sara Pugh-Jones, of Llangollen, believe this to be the valley of Nanty Garth.

³⁸ Robert Dawson, 1776-1860, ordnance draughtsman.

³⁹ *Llangynhafal*, "The Church of Cynhafal." On Evans's map it is spelled "Llanganhafal."

⁴⁰ *J-Graig-wyilt* "wild rock," a quarry 1/2 mile north of Pentre-celn (according to Mr. J. A. Jones, retired postmaster, and his wife, life-long residents of Pentre-celn). In his field notes, Sedgwick adds the marginal notation, "South end of this mass is at Craigelech; it strikes N 3/4 a mi."

⁴¹ *Llanfair*, "The Church of Mary."

(3) Above Pentre Caehelyn⁴² dip 20° W then turn round by Tynyllan Fair⁴³

(4) Y Graig,⁴⁴ dip N. 17° (1 mile NE of Slaneilidan)⁴⁵

(5) Then turns round to the N & seen on [3] the Corwen road about 1/2 mi f Slaneilidan church, then a regular escarp.: ranging N & passing 1/2 mi W. of Ruthvin.

Ruthen: takes its name from the new red Sandstone on which it is built. The soil is red for some miles about the town, & the whole plain may be considered of that formation, only in most places covered up by diluvium, 1/2 a mile to the west of the town a quarry of it is worked. The rock is spotted with brown, like the stone at Cardeston,⁴⁶ overlying Magnesium conglomerate, it is very irregularly stratified: but the rock on which the castle is built, is in nearly horizontal seams. Just above where this quarry is we find Limestone dipping E 15° N L. 9°, fine grained, with petrifications [4] Under this, there are some beds of Old red Sandstone. Striking the same way as the overlying Limestone but dipping at greater angle. A little further is more clearly visible in a water course.

Aug 7. Ruthin to Denbigh. For the greatest part of the way you have the Limestone about 1/2 a mile to your left. When you come about 3 & 1/2 miles to Denbigh pass through the new red. *Denbigh Castle* is built on the Limestone, from which point the Limestone ranges away to the N. with few points West.

Aug. 8th. We were told that road from Denbigh to St Asaph⁴⁷ passes through new red Sandstone, we followed the escarpment of the [5] Limestone to the West of the road. About 1 & 1/4 from Denbigh N few points W dip NE by E. L. 17 containing Sulph: Barytes Product⁴⁸ (B).

At *Henllan*,⁴⁹ rock almost composed of Pro-

⁴² Mr. and Mrs. Jones informed me that the hamlet was formerly known as *Pentre Caehelyn*, "Village of Helen's fields." Only on John Evans's 1795 map is it spelled "Caehelyn." Modern maps list it as *Pentre Celn*.

⁴³ *Tyn-Llanfair*, "The house near Llanfair," is 1/4 mile S.W. of *Pentre Celn*.

⁴⁴ *Graig-afwy-tywt*, "Rock of the Wing-Gap."

⁴⁵ *Llanelidan*, "The Church of Elidan."

⁴⁶ *Cardeston*, five miles west of Shrewsbury.

⁴⁷ *St. Asaph, Llanobwy*, "The Church by the River Elyw."

⁴⁸ A Carboniferous brachiopod.

⁴⁹ *Henllan*, "Old Church."

ducti & Madreporae.⁵⁰ Dip NE 1/2 N Half mile NW of Henllam Grey Wacke dipping N by E.

At *Cefn*,⁵¹ grand escarpment, rock with Caverns, wooded, river winding at bottom, giving very much the same character to Scenery as in Derbyshire the strata dip N 25° E. ((P. Sedgwick (found) saw that [illegible] in the mud in a cavern. Rhinoceros bones)⁵² [fig. 1.]

(The) For about 3 miles before St *Asaph*, the plain has same appearance as about Denbigh, & doubtless it is owing to the New Red Sandstone formation. The view from St *Asaph*, very fine, the vale Clwyd bounded on each side by long chain of greenwacke [6] that to the North, being the most perfect. The valley indeed may



FIG. 1. Caverns at Plas-yn-Cefn where Sedgwick and Darwin found rhinoceros fossils.

⁵⁰ A coral.

⁵¹ *Plas-yn-Cefn*, "Hall in the backlands." On the River Elwy.

⁵² According to Sedgwick's field notebook, it was a rhinoceros tooth. (In a marginal note he said, "just opposite . . . lived Catherine of Berain [Berain?] who had 9 husbands. . . .")



FIG. 2. Limestone cliffs at Abergele beneath which "cold and excellent [artesian] spring break out."

be said to be bounded on the South by the Limestone which on this side is much more developed: We were struck the whole way from Langollen to this place by the almost entire absence of turf pits.⁵³ St *Asaph* to *Abergele*,⁵⁴ by Bettys,⁵⁵ at the point where the road to Bettys divides from that to Abergele, a shaft was sunk for lead ore in the Limestone, which contained sulph. Barytes & . . .⁵⁶ A little further on road to Bettys, I crossed a great bed of diluvium chiefly consisting of Clay slate, & under [7] this the Limestone ranges. But there is no very apparent escarpment for some miles: The scenery along this road very uninteresting & the soil poor, a little SW of Abergele, first saw an escarpment, the rock was striking W & E. Dip to N. L. 30, higher on hill, same strike but L. 20. It was in such points as these where the strata have been much disturbed, that I observed the greatest number of bits of Sandstone, but in no place could I find it in Situ. Beyond Abergele, I found Limestone, dipping at usual L, about 150 feet above the level of (the sea) ((a brooke)). A Valley running through the escarpment showed this low section. From several observations I am sure, the Sandstone does [8] not crop out anywhere near Abergele. The very red colour of the soil under the escarpment, I attribute entirely to the very ferruginous clay seams, in the rock

⁵³ A legend of the land is that if a person built a turf house beginning after dark, and had smoke rising from the chimney by daybreak, he was the rightful owner.

⁵⁴ *Abergele*, "Estuary of the River Gele."

⁵⁵ *Bettys*, "Beaticus," according to certain legends meant "beadhouse," where pilgrims stayed before going to a nearby monastery. *Fw-Rhau*, "in the moor."

⁵⁶ Darwin's dots.



FIG. 3. Great Ormes Head.

itself, & not to the supposed sandstone beneath it. Abegele. Very cold & excellent springs break out about the town; this I should think was owing to the strata being broken, as might be expected from this great dip; & the water coming down from the mountains between the strata would be forced upwards.²⁷ In the upper



FIG. 4. Penmaenmawr, great promontory quarried for granite.

²⁷ Some houses in Abergele are still supplied by artesian flows.

beds of broken limestone observed a white powder like Chalk, covering the fragments: it is called Rock milk, & seems to be sort of Stalactite, without water of crystallization.—[9] The general dip here was N by W, about L. 10. This escarpment is very remarkable from its great valleys, some 1/2 mile broad & one near Colwyn 2 miles broad. In one near Abegele, there were a great number of rounded Sandstone pebbles & some few conglomerates. About 2 w of Abegele very fine escarpment. The limestone fine grained. Dip N I. 9°. The escarpment facing the South, was most remarkably covered with wild flowers, & the rock coated with Lichens. From Colwyn to L Ormes head, broad valley the bottom with bed of Clay slate diluvium about 40 feet thick. P. Sedgwick supposes these great valleys were caused by the rocks being stretched & the fact of there not being Limestone pebbles in the diluvium, seems to countenance this. [10] where the road ((to Bangor))²⁸ passes (through) ((by)) the Limestone again. You see it reposing on the Grey wacke. The Grey Wacke hills appear to be almost characterised in contradiction, with those of Limestone, by the quantity of Furze growing on them. The space which separates, during most of its course, the Lime from Grewwacke hills is divided into a system of two valleys, or rather one great valley with a bank running up the centre, at Abegele 1/4 mile from town a pit of Sand. Most likely Alluvium, alternations of sand & fine gravel.—

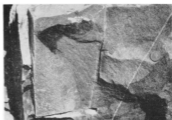


FIG. 5. Penmaenmawr "greenstone" (microgranite) which "chinks" beneath the hammer.

²⁸ First plaited walls of the original chapel were made of wattles, called "bangor," to keep out wolves and sinners.

a hill lying S by W of Conway⁵⁵ the top part very craggy consisting of quartzose greenstone, sometime porphyritic with crystals of quartz & feldspar [11] with a prismatic cleavage. on the NW side of hill. within 20 yrd of this trap, there is an indurated rotten slate, with cleavage striking NE by E. also a hard quartzose conglomerate. On the top of Penmaen Mawr,⁵⁶ a greenstone which chinks very much & runs N by W. at the (bottom) ((lower part)) of this hill like the former there is an altered Clay slate. at the bottom rock very like Grey Wacke. The coloured seams in the rock P. Sedgwick remarks generally indicate the strata. Through this rock there often runs (masses) veins of quartz & hornblende, & at about 2 miles to the NW. of the great Slate quarry contains a good deal of arsenical copper, which is worked somewhere near the Quarry.⁵⁷ Four observations on the road (over mountain from Aber⁵⁸ to Slate Quarry, the dip of [12] these altered slates was SE by E. Great Slate quarry 200 yd deep (16) 12 workings 16 yd each thick.⁵⁹ The rock is divided into cleavages, joints & dip. Cleavage is NE 1/2 E L. 80. The joints slip from S, & hang to the



FIG. 6. Veins of quartz near Penmaenmawr.

⁵⁵ Sedgwick went to Penmaenmawr, southwest of Conway, on Tuesday, August 9, and from there to Llan-santffraid about three miles southeast of Conway. (Conway—Conwy, "the river amongst reeds.")

⁵⁶ *Pruscaenawor*, "a promontory."

⁵⁷ On Wednesday Sedgwick returned to Penmaenmawr, and then went to Aber, about five miles southwest.

⁵⁸ "Estuary," or "stream."

⁵⁹ Thursday, August 11. Sedgwick's description in his field notes of the great slate quarry of Penrhyn is essentially the same as Darwin's.



FIG. 7. Great slate quarry of Penrhyn at Bethesda. From *British Regional Geology, North Wales*, 1961: p. 24. Crown Copyright Geological Survey photograph. Reproduced by permission of the Controller, Her Britannic Majesty's Stationery Office.

North.⁶⁰ The dip very obscure SE 50°. Some hard chloritic quartzose veins run through the quarry & accompany the slate to Llanberis.⁶¹ There veins contain Carb. of Lim, Quartz, Chlorite, Talc, Molybdene There are 2 principal ones. (1) has same range & L as cleavage of slate & is (including the altered slate) 2 yd thick; (2) runs N 3 W & is 7 yd thick, 4 yd being altered slate. The vein has an appearance like this⁶² the contracted parts abounding with quartz. The miners give the following names to the slates of different quality. 1: Queens, Dutchesses, Countesses, Ladies, & halves.⁶³ (? is this owing to their cracked character). Sedgwick says there are same names in Cumberland.

[13] *Cwm Idwal*⁶⁴ consists in a circle of steep

⁶⁰ When slate is loosened by blasting, it breaks along lines of cleavage, and "slips" into the quarry if the angle of dip is down away from the cliff; if the dip of the cleavage angles down into the side of the cliff, as it would on the opposite side of the quarry, the broken fragments remaining next to the face of the cliff tend to be caught by the upward protruding "hook" made by the split joints, and remain "hanging" there. Sedgwick has a sketch in his notebook illustrating these principles.

⁶¹ *Llanberis*, "The Church of Peris." On Greenough's map, Llanberis could easily be read "Llanberis."

⁶² Darwin drew a figure like links of sausage.

⁶³ The slates vary in dimensions, viz., Queens—24-26" long; Princess—24 × 14"; Dutchess—24 × 12"; Countess—20", and Ladies—16". "Halves" are 1/2 or 1/3 times the regular width.

⁶⁴ *Cwm Idwal*, "Idwal's Valley."



FIG. 8. Slate quarry workers. (1) Splitting slabs, (2) measuring and trimming slabs, and (3) apprentice. Sketched by the Welsh artist, historian, and linguist, Mr. Elfed Thomas, of Nant Peris.

rocks surrounding the Llyn,⁹⁹ they generally consist of an altered slate, which is very tough, of a light green colour, sometime passing into a very compact conglomerate, occasionally having an amygdaloid ((owing to organic remains?)) appearance; the parts which are weathered, become converted into a very rotten slate. The general cleavage is E by N & S by W dipping to the W 2 N.¹⁰⁰ Many of the planes of cleavage are covered with quartz containing fibres of Titanium. This rock in many parts has a tendency to split into prismatic forms, & chinks under the hammer. In general appearance it resembles a basalt. But



FIG. 9. Glacial grooves at Cwm Idwal; not noticed by Sedgwick or Darwin.

⁹⁹ Llyn, "lake."

¹⁰⁰ Darwin means two points of the compass (i.e., 22°30') toward the north from west. He afterwards uses the same system to designate direction of dip.

what is very important it contains organic remains, both in the hard light green & the conglomerate. I found Madreporas [14] to the South of the lake. there is a very large mass of Basalt protruded out of the Slate. In shape it must be an inverted cone. as a section has the appearance of lapping over the slate. The Junction on each side is most clear. The basalt is a compact rather brittle, black rock, splitting with conchoidal fracture. The whole mass is more or less divided into 4, 5, or 6 sided pillars, & each pillar appears to be jointed, about a foot apart. A natural surface where the pillars end appears like tessellated pavement. The basalt appears to have carried with a large bed of the altered slate. At the entrance to Llyn Idwal is a quarry for Hone slates: [fig. 9.]

[15] *Moel Siahod*.¹⁰¹ May be described as consisting of three parts. I will describe the formations as seen in ascending from the Eastern end of the Capel Curig¹⁰² lakes. 1st a rock like a coarse quartzose Grey Wacke, becoming alternately Porphyritic & conglomerate, with pebbles of porphyry & a compact greenish slate; proceeding higher a Feldspathic rock with veins of quartz & Chlorite. At this point there appears a line or rather a valley of separation. it is about half way in the mountain. After this the whole northern side of mountain is composed of a blue (rock) slate; the lower part almost is made of Terebratulæ; the higher parts are more indurated, but (speaks) cavities of a rusty sub-



FIG. 10. Capel Curig lakes; Moel Siahod in background. One of hundreds of perched boulders is visible in the center foreground.

¹⁰¹ Moel Siahod; *Moel*, "bare"; *siahod*, probably from *schabbed*, "scabbed," "worthless."

¹⁰² "Chapel of Curig"; Curig, "saint."

stance appear to be remains of fossils. [16] The general cleavage is (SW & NE) ((W 3 S, E 3 N)) which is also that of the 1st part of mountain & indeed in this, there (have been) ((are signs)) Organic remains.

The 3d part of mountain or the top is of a crystalline grey coloured Trap, with its usual cleavage. this forms a precipice to the South & composes all that side of the mountain. The line of disturbance seem to have run NE-SW. At the Western end of hill, the Slate appears to overlie the Trap. The beds composing N 1 of mountain appear to Dip E 2 S, & in general looks seems of different formation to main mass of mountain.

[17] *South of Shiabod.*¹³ Trap, slate & a Feldspathic rock alternating, nearer the mountain most trap, & the more remote, the slate is most (importa.) ((abundant)). The feldspathic rock appears evidently merely slate altered. These alternations last for about 2 miles S of Shiabod. General line of violence as before SW & NE. Cleavage of slate W 2 S.

*Dolyddelan.*¹⁴ A slate quarry apparently situated between the Feldspatic altered rock, with cleavage W 1 & 1/2 S. From *this to Moelwyn*¹⁵ generally slate occasionally beds of Trap. *North-east Moelwyn.* Eastern side of it a blue slate, cleaving & line of violence SW. Dip N. Carreg y fran.¹⁶ slate NW side to the S a precipice of an hard altered compact [18] quartzose greenish rock; it occasionally splits into column like basalt, sometime become a coarse, but extremely hard



FIG. 11. "Valley of Separation," along eastern face of Moel Siabod.

¹³ Moel Siabod.

¹⁴ *Dolwyddelan*; *Dol wydd elen*, "meadow in sight of Elen," or "Helen."

¹⁵ *Moel*, "bare"; *gwyn*, "white."

¹⁶ *Carreg y Fran*, "The Crow's Rock,"

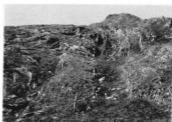


FIG. 12. Igneous "trap" toward the left; indurated slates to the right, in the "Valley of Separation," Moel Siabod.

(conglomerate) breccia, pebbles of a rock like itself. Associated with this a rock oftentimes nearly pure quartz.

*Festineog.*¹⁷ The country has the appearance of a Greywacke, so has the slate in external appearances

*Draes Ardidy.*¹⁸ to the East micaceous slate; the rocks that compose the hill through which the road passes, are of a most complicated nature, generally (Felds) porphyritic, with Quartz & sometimes Feldspar, & Pyrites base chiefly quartz, with Hornblende & mica. The rock becomes [19] either conglomerate or concretionary with quartz. The general dip W 3 N, but the formation of the valley appears to me to have altered it on the S side. The pass seems to be caused by a subsidence & crack of SE part [of] strata.



FIG. 13. Castle of Dolyddelan, along Darwin's traverse, across the moors from Moel Siabod.

¹⁷ *Ffestiniog*, "Ffestin"; masculine forename.

¹⁸ *Burick Draes Ardady*, the pass between Rhinog Fawr and Rhinog Fach, about half-way from Maestwrog to Barmouth, along Darwin's traverse.

For the hill on NE¹⁹ side would have been much loftier (if) than the other owing to the dip, if it had not been altered by some subsidence the general appearance of valley countenances this idea. At W end of valley the rock is jointed with such remarkable regularity, as to give the appearance [20] of beds dipping to S by W. But (on the) road to Barmouth crosses several alternations of micaceous slate, the porphyry & a porphyritic slate, with a vertical cleavage, running N & S, but one of the beds of porphyry has the (junct) [or joint?] apparent dip to S by W, & which if a true dip would have cut through the beds of slate which is absurd ∴ not true dip.

SEDGWICK'S LETTERS

Tremadoc Sept. 4, 1831

Dear Darwin

I left Capel Curig the day before yesterday & the stupid red nosed waiter did not shew me your letter till a few hours before I started. Otherwise I should have endeavoured to profit by your information respecting Cwm Idwal. I ought however to have seen the madrepores; for last wednesday I went from Capel Curig to Cwm Idwal and thence clambered out at the top by the side of Twll Dy²¹ a very curious chasm which I suppose you have seen. I then scaled the crests of Glider Bach & G. Fawr²² and zig-zagged down to the Inn. Your information did not however surprise me, as madrepores are quite as likely to be met with as terebratulæ,²³ which seems to occur here and there thro' the Snowdonian chain. I found terebratulæ, among the talcose slates of Foel Goch²⁴ a precipice just to the west of Cwm Idwal—I found organic remains in the slate of Moel Shabod, but did not stumble on any bed in which they abounded. At first I found specimens about the middle of the great zone of slate, & afterwards (found them) in the stone walls above the wood (by the way, stone walls are good localities for fossils and often tell us a good story wh it wd be difficult to make out without 'em). I don't understand your

¹⁹ The "N" of "NE" has been scratched out, or perhaps an "S" drawn over it.

²⁰ Twll da, "Black Hole." Also known as *Cegys Gytiroaf*, "Devil's Kitchen."

²¹ *Glyder Fach* (small) and *Glyder Fawr* (large). *Glyder*, feminine forename.

²² According to John Challinor, the "fossil would not in fact be this brachiopod genus even in the widest sense."

²³ *Y Foel Goch*, "The Red Bare Hill."

puzzle [2] about M. Shabod. Why should not the rough beds at the bottom, on the N.W. side, pass under the blue slate with shells? I don't agree with you in thinking that the mass of trap on the crest of the hill is under the slate. It appears to me decidedly to be over it. And in the great Cwm with the small lake²⁵ on the East side we see the slate under the trap. Again the trap wraps round in a horse shoe shape to the S.E. twists round bed E. side of the great Cwm, & then runs in a mass about 200 yards wide or so direct²⁶ about N. E. for a mile or two, between two great vertical masses of baked slate. E.G.,

Trap at the top of M. Shabod

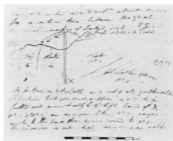


FIG. 14. Diagram drawn by Sedgwick in letter.

My picture is detestable and out of all gentleman-like proportions but you must suppose 4 & 5 to be pulled out considerably to the left hand of X N¹ & N² are as in your letter; N³ ranges a mile to the S. & then comes round to N⁵ the connexion is not ideal, as you may walk [3] all the way on trap from N³ to N⁵. The slate N⁴ where in contact is as hard as a flint. I'm beginning to think that I shall not reach Barmouth this year. Therefore have the kindness to address me at Carnarvon,²⁷ which I shall for some time consider as my headquarters. Tho²⁸ I shall probably not often be there. To give you some outline of my progress I will send you a skeleton of my walk. 21st (this day fortnight) from Carnarvon to Dollodarn;²⁹ having in the

²⁵ *Llyn-y-foel*, "Lake of the barren hill."

²⁶ *Caerwarton* (*Caer-yu-Arfon*). "The Fort in Arfon."

²⁷ *Dollodarn*, "Padarn's meadow" (Padarn, an early saint).

morning heard a sermon an hour long & gone [on] a geological Sunday walk towards the S. 22d. a hardworking day along the Crown, Shoulders & ribs of Snowdon. 23d. a still harder day commencing with the slate quarries.⁸⁷ (4 hours before Breakfast, what wd your man⁸⁸ have said to that?) and then scaling Lidir Mawr,⁸⁹ & zigzagging along the Crests of the Chain to Twll Dy, & so home in the dusk (24th. weather bound the whole day (25th. Hammer my way to Capel Curig; lunch. & then hammer my way to Tinny Maes⁹⁰ making anot[her] modest collection of geological specimens.) 26th. Carnedd David, Carned Llewelyn,⁹¹ & so down the rough crags of Porphyry (we saw at a distance) down to Aber & thence back to Tinny Maes. 27. ascertain the nature of the beds below the great slate zone by two or three traverses; & end at Bangor. 28. In a great measure a day of rest E.G. drive to Aber. 29th. To Conway by the crests of the hill thence across the water to the ridges between great & Little Ormeshead Evg drive to Llanrwst. 30th. Cross the mountains on foot by the line of the *laker* to Capel Curig.; caught in a mist and deluge of rain and steer over the mountains by compass, reach the turnpike within a quarter of a mile of the road turning off to the Inn. 31. Lake Ogwen Glider Fawr & Bach,⁹² etc etc to C. Curig. 1st Sepr The crest & flanks of Moel Shabod Evening excursion to the knolls N. of the [illegible]. [4] 2d. Mountains between C. Curig and Llanrwst,⁹³ & visit some of the mines—3d. Bettws, Penmachno,⁹⁴ Maentwrog,⁹⁵ & Tremadoc, ⁹⁶ ascending one or two hills by the way. 4th. Sunday. a day of rest continual mist & rain.

My best regards to your friends at Shrewsbury.

Yours most truly

A Sedgwick

⁸⁷ Mr. Smith's Quarry by Llyn Peris (Peris, an old Roman cardinal.)

⁸⁸ To whom Sedgwick has reference has not been traced.

⁸⁹ Now Eildir Fawr.

⁹⁰ *Tyn-y-waer*, "House in the meadow." About midway between Bethesda and Cwm Idwal.

⁹¹ The cairns of Dafydd and Llewelyn, two old Welsh princes.

⁹² *Glyder Fawr* and *Glyder Fach*.

⁹³ "The Church of Rhwt."

⁹⁴ "The Head of Machno."

⁹⁵ "Stone of Twrog," old Celtic saint.

⁹⁶ *Tremadoc*, "Town of Madoc." Prince Madoc, according to Welsh tradition, sailed from Porthmadog with thirteen ships and discovered America before Columbus.

P. S. I saw no *basalt* at Lake Ogwen but a scory black pyritous variety of rock something between Lydian stone⁹⁷ & compact felspar. It differs from basalt in being extremely siliceous. Perhaps I did not see the spot you mention. I am going as soon as wind and weather permit to make traverses between this place & Carnarvon. They will take 10 days⁹⁸

Carnarvon. Sepr. 18, 1831

Dear Darwin

Before this you will have received a letter I addressed to you, some time since at Shrewsbury. It contained a statement of what I was doing & had done. I have now resolved to confine myself to this country, & if I can finish it to my satisfaction I shall be well content to turn my back on these mountains for a season. I cannot but be glad at your appointment & I truly hope it will be a source of happiness & honor to you. I really don't know what to say about books. No. 1 Daubeny. No. 2 a book on Geology. D'subission's work is one of the best tho' full of Wernerian nonsense. I don't think Bakewell's a bad book ((for a beginner))—for *fossil shells* what is to be done? Go to the Geological Society and introduce yourself to W. Lonsdale as my friend & fellow traveller & he will counsel you. Humboldt's personal narrative you will of course get. He will at least show the right spirit with wh a man [2] should set to work. There is a small paper printed by the Geol. Socy containing directions for travellers etc. Lonsdale will give you a copy; but it is a mere horn book⁹⁹ hardly worth your looking at—Study the *Geological Socys. collection* as well as you can & pay them back with specimens. I am to propose you when the meetings begin. I am in great hurry as my gig is at the door; on my way to Clynnog¹⁰⁰ from which place D. V. I hope in ten days to work my way round the great S. Western Promontory of Cardigan bay—¹⁰¹ I shall then return pack up & start for Capel Curig where I

⁹⁷ Lydian stone—black or grayish, finny slate often traversed by minute veins of quartz; may fracture in splinters or be conchoidal.

⁹⁸ Sedgwick actually arrived at Caernarvon on September 18, six days later.

⁹⁹ "The first book of children, covered with horn to keep it unsoiled." S. Johnson's Dictionary, 1755.

¹⁰⁰ Clynnog, from *Celynnog*, "holly."

¹⁰¹ Sedgwick in fact went throughout the Llyn Peninsula between Caernarvon Bay and Cardigan Bay returning to Caernarvon on October 5.

must halt again for the 3d time to make a traverse or two in the chain But this depends on the weather. Should it fairly break up I must lodge [3] The Carnarvon Chain is very *troublesome* from the number of *anticlinal lines* wh I have to follow out from hill to hill & valley to valley upways, downways, & crossways. I will try to give you a notion of our section

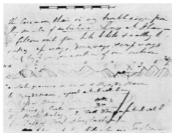


FIG. 15. Diagram drawn by Sedgwick in letter.

- slate quarries on W. side of Mynydd Mawr¹⁰²
- Mynydd Mawr, a great *anticlinal line*¹⁰³
- pass of Drws-y-Coed¹⁰⁴
- Drws-y-Coed—D¹⁰⁵—[a great anticlinal line]
- Moel Hebog¹⁰⁶

¹⁰² *Mynydd Mawr*, "mountain large."

¹⁰³ Sedgwick has in fact drawn a syncline.

¹⁰⁴ *Drws-y-Coed*, "the doze to the forest."

¹⁰⁵ *Moel Hebog*, "the bare hill of the hawk."

e. Foel Ddu¹⁰⁷ an anticlinal li—

f. Pass of Pont Aberglaslyn¹⁰⁸

g. Cnicht¹⁰⁹, k. L. hills toward Festiniog

The prevailing dip in the Snowdonian chain is S.E. with numberless great contortions; & the base of the series is near the line of the Slate quarries (a) on the west side of the Chain. The *strike* of the beds in the chain is about N.N.E. with singular uniformity till you reach the Eastern outskirts & then all is confusion. The Merioneth chains are elevated in the same direction (as far as I have seen 'em) [4] but the prevailing tilt seems to be to the N.W. I expect to find (next year!) a great central anticlinal axis in Merioneth. The place marked X in the sectn. is the place where the two systems of elevation interfere with each other. But my picture is so detestable and out of all proportion that I fear you cannot comprehend it. I consider poor Ramsay's death¹⁰⁹ a grievous loss to the whole university. God bless you & preserve your health of mind & body.

Most truly yours

A Sedgwick

I shall be happy to hear from you.

write to Carnarvon¹¹⁰

¹⁰⁷ *Foel Ddu*, "The dark hill."

¹⁰⁸ *Pont Aber glaslyn*, "The bridge of the stream from the blue lake."

¹⁰⁹ *Cnicht*, "a peak."

¹¹⁰ Darwin mentions Ramsay's death; see Francis Darwin, I: p. 54.

¹¹¹ Problems of consistent spelling of Welsh names were well expressed by John Fisher in Richard Fenton, *Tours in Wales (1804-1813)*. Edited from his MS. Journals in the Cardiff Free Library, John Fisher, ed. (London, Bedford, for the Cambrian Archeological Association, 1917). Fisher commented, p. x, "[Fenton] was by no means correct, or even consistent, in his spelling of Welsh names; but no worse than the 'official' spelling of today!"

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