

THOMAS BONNEY

CHARLES LYELL AND
MODERN GEOLOGY

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PREFACE

The life of Charles Lyell is singularly free from "moving accidents by flood and field." Though he travelled much, he never, so far as can be ascertained, was in danger of life or limb, of brigand or beast. At home his career was not hampered by serious difficulties or blocked by formidable obstacles; not a few circumstances were distinctly favourable to success. Thus his biography cannot offer the reader either the excitement of adventure, or the interest of an unwearied struggle with adverse conditions. But for all that, as it seems to me, it can teach a lesson of no little value. Lyell, while still a young man, determined that he would endeavour to put geology – then only beginning to rank as a science – on a more sound and philosophical basis. To accomplish this purpose, he spared no labour, grudged no expenditure, shrank from no fatigue. For years he was training himself by observation and travel; he was studiously aiming at precision of thought and expression, till "The Principles of Geology" had been completed and published. But even then,

though he might have counted his work done, he spared no pains to make it better, and went on at the task of improvement till the close of his long life.

My chief aim, in writing this little volume, has been to bring out this lesson as strongly and as clearly as possible. I have striven to show how Charles Lyell studied, how he worked, how he accumulated observations, how each journey had its definite purposes. Accordingly, I have often given his words in preference to any phrases of my own, and have quoted freely from his letters, diaries, and books, because I wished to show exactly how things presented themselves to his eyes, and how ideas were maturing in his mind. Regarded in this light, Lyell's life becomes an apologue, setting forth the beneficial results of concentrating the whole energy on one definite object, and the moral grandeur of a calm, judicial, truth-seeking spirit.

In writing the following pages I have, of course, mainly drawn upon the "Life, Letters, and Journals," edited by Mrs. Lyell; but I have also made use of his books, especially the "Principles of Geology," and the two tours in North America. I am under occasional obligations to the excellent life, contributed by Professor G. A. J. Cole to the "Dictionary of National Biography," and have to thank my friend Professor J. W. Judd for some important details which he had learnt through his intimacy with the veteran geologist. He also kindly lent the engraving (executed in America from a daguerreotype) which has been copied for the frontispiece of this volume.

T. G. BONNEY.

CHAPTER I.

CHILDHOOD AND SCHOOLDAYS

Caledonia, stern and wild, may be called "meet nurse" of geologists as well as of poets. Among the most remarkable of the former is Charles Lyell, who was born in Forfarshire on November 14th, 1797, at Kinnordy, the family mansion. His father, who also bore the name of Charles,¹ was both a lover of natural history and a man of high culture. He took an interest at one time in entomology, but abandoned this for botany, devoting himself more especially to the study of the cryptogams. Of these he discovered several new species, besides some other plants previously unknown in the British flora, and he contributed the article on Lichens to Smith's "English Botany." More than one species was named after him, as well as a genus of mosses, *Lyellia*, which is chiefly found in the Himalayas. Later in his life, science, on the whole, was supplanted by literature, and he became engrossed in the study of the works of Dante, of some of whose poems² he published translations and notes. Thus the geologist and author is an instance of "hereditary genius."

¹ Born 1767, died 1849 (also son of a Charles Lyell); educated at St. Andrew's and at St. Peter's College, Cambridge, where he proceeded to the degree of B.A. in 1791 and M.A. in 1794.

² In 1835, the *Canzoniere*, including the *Vita Nuova and Convito*; a second edition was published in 1842; in 1845 a translation of the Lyrical Poems of Dante.

Charles was the eldest of a family of ten – three sons and seven daughters, all of whom grew up. Their mother was English, the daughter of Thomas Smith, of Maker Hall in Yorkshire, "a woman of strong sense and tender anxiety for her children's welfare." "The front of heaven," as Lyell has written in a fragment of autobiography, was not "full of fiery shapes at his nativity," but the season was so exceptionally warm that his mother's bedroom-window was kept open all the night – an appropriate birth-omen for the geologist, who had a firmer faith than some of his successors in the value of work in the open air. He has put on record only two characteristics of his infancy, and as these can hardly be personal recollections, we may assume them to have been sufficiently marked to impress others. One if not both was wholly physical. He was very late in cutting his teeth, not a single one having appeared in the first twelvemonth, and the hardness of his infant gums caused an old wife to prognosticate that he would be edentulous. Also, his lungs were so vigorous and so habitually exercised that he was pronounced "the loudest and most indefatigable squaller of all the brats of Angus."

The geologist who so emphatically affirmed the necessity of travel, early became an unconscious practiser of his own precept. When he was three months old his parents went from Kinnordy to Inveraray, whence they journeyed to the south of England, as far as Ilfracombe. From this place they removed to Weymouth and thence to Southampton. More than a year must have been

thus spent, for their second child – also a son – was born at the last-named town. Mr. Lyell, the father, now took a lease of Bartley Lodge, on the New Forest – some half-dozen miles west of Southampton, where the family lived for twenty-eight years. His mother and sisters also left Kinnordy, and rented a house in Southampton. Their frequent excursions to Bartley Lodge, as Lyell observes, were always welcome to the children, for they never came empty-handed.

Kinnordy, however, was visited from time to time in the summer, and on one of these occasions, when Charles was in his fifth year, some of the family had a narrow escape. They were about a stage and a half from Edinburgh; the parents and the two boys in one carriage; two nursemaids, the cook, and the two youngest children, sisters, in a chaise behind. The horses of this took fright on a narrow part of the road and upset the carriage over a very steep slope. Fortunately all escaped unhurt, except one of the maids, whose arm was cut by the splintered glass. The parents ran to the rescue. "Meanwhile, Tom and I were left in the carriage. We thought it fine pastime, and I am accused of having prompted Tom to assist in plundering the pockets of the carriage of all the buns and other eatables, which we demolished with great speed for fear of interruption."³ This adventure, however, was not quite his earliest reminiscence; for that was learning the alphabet when he was about three years old.

Charles was kept at home till he had nearly completed his

³ Life, Letters, and Journals, vol. i. p. 3.

eighth year, when he was sent with his brother Tom to a boarding-school at Ringwood. The master was the Rev. R. S. Davies; the lads were some fifty in number, the Lyells being about the youngest. They seem, however, not to have been ill-treated, though their companions were rather a rough lot, and they were petted by the schoolmaster's daughter. The most sensational incident of his stay at Ringwood was a miniature "town and gown" row, a set fight between the lads of the place and of the school, from which, however, the Lyells were excluded as too young to share in the joys and the perils of war. But the fray was brought to a rather premature conclusion by the joint intervention of foreign powers – the masters of the school and the tradesmen of the town. In those days smuggling was rife on the south coast, and acting the part of revenue officers and contrabandists was a favourite school game; doubtless the more popular because it afforded a legitimate pretext for something like a fight. The fear of a French invasion also kept this part of England on the *qui vive*, and Lyell well remembered the excitement caused by a false alarm that the enemy had landed. He further recollected the mingled joy and sorrow which were caused by the victory of Trafalgar and the death of Nelson.

The brothers remained at Ringwood only for about two years, for neither the society nor the instruction could be called first-class; and they were sent, after a rather long holiday at home, to another school of about the same size, but much higher character, in Salisbury. The master, Dr. Radcliffe, an Oxford man, was a

good classical scholar, and his pupils came from the best families in that part of England. In one respect, the young Lyells found it a change for the worse. At Ringwood they had an ample playground, close to which was the Avon, gliding clear and cool to the sea, a delightful place for a bathe. In a few minutes' walk from the town they were among pleasant lanes; in a short time they could reach the border of the New Forest. But at Salisbury the school was in the heart of the town, its playground a small yard surrounded by walls, and, as he says, "we only walked out twice or three times in a week, when it did not rain, and were obliged to keep in ranks along the endless streets and dusty roads of the suburbs of a city. It seemed a kind of prison by comparison, especially to me, accustomed to liberty in such a wild place as the New Forest." One can sympathise with his feelings, for a procession of schoolboys, walking two and two along the streets of a town, is a dreary spectacle.

But an occasional holiday brought some comfort, for then they were sent on a longer excursion. The favourite one was to the curious earthworks of Old Sarum, then in its glory as a "rotten borough," one alehouse, with its tea-gardens attached, sending two members to Parliament. On these excursions more liberty seems to have been permitted. The boys broke up the large flints that lay all about the ground, to find in them cavities lined with chalcedony or drusy crystals of quartz. But the chief interest centred around a mysterious excavation in the earthwork, "a deep, long subterranean tunnel, said to have been used by the

garrison to get water from a river in the plain below." To this all new-comers were taken to listen to the tale of its enormous depth and subterranean pool. Then, when duly overawed, they felt their hats fly off their heads and saw them rolling out of sight down the tunnel. An interval followed of blank dismay, embittered, no doubt, by dismal anticipations of what would probably happen when they got back to the school-house. Then one of the older boys volunteered to act the sybil and lead the way to the nether world. Of course they "regained their felt and felt what they regained" – literally, for the hole was dark enough, though we may set down the "many hundred yards" (which Lyell says that he descended before he recovered his lost hat) as an instance of the permanent effect of a boyish illusion on even a scientific mind.

But the restrictions of Salisbury made the liberty of the New Forest yet more dear. Bartley was an ideal home for boys. It was surrounded by meadows and park-like timber. A two-mile walk brought the lads to Rufus Stone, and on the wilder parts of the Forest. There they could ramble over undulating moors, covered with heath and fern, diversified by marshy tracts, sweet with bog-myrtle, or by patches of furze, golden in season with flowers; or they could wander beneath the shadows of its great woods of oak and beech, over the rustling leaves, among the flickering lights and shadows, winding here and there among tufts of holly scrub, always led on by the hope of some novelty – a rare insect fluttering by, a lizard or a snake gliding into the fern, strange birds circling in the air, a pheasant or even a woodcock springing

up almost under the feet. The rabbits scampered to their holes among the furze; a fox now and again stole silently away to cover, or a stag – for the deer had not yet been destroyed – was espied among the tall brake. Those, too, it must be remembered, were the days when boys got their holidays in the prime of the summer, at the season of haymaking and of ripe strawberries. They were not kept stewing in hot school-rooms all through July, until the flowers are nearly over and the bright green of the foliage is dulled, until the romance of the summer's youth has given place to the dulness of its middle age. In these days it is our pleasure to do the right thing in the wrong place – a truly national characteristic. We all – young and old – toil through the heat and the long days, and take holiday when the autumn is drawing nigh and Nature writes "Ichabod" on the beauty of the waning year.

At Salisbury, Lyell had two new experiences – the sorrows of the Latin Grammar and the joys of a bolster-fight. But his health was not good; a severe attack of measles in the first year was followed in the second by a general "breakdown," with symptoms of weakness of the lungs. So he was taken home for three months to recruit. This was at first a welcome change from the restrictions of Salisbury; but, as his lessons necessarily were light, he began to mope for want of occupation; for, as he says, "I was always most exceedingly miserable if unemployed, though I had an excessive aversion to work unless forced to it." So he began to collect insects – a pursuit which, as he remarks, exactly suited him, for it was rather desultory, gave employment to both mind

and body, and gratified the "collecting" instinct, which is strong in most boys. He began with the lepidoptera, but before long took an interest in other insects, especially the aquatic. Fortunately his father had been for a time a collector, and possessed some good books on entomology, from the pictures in which Charles named his captures. This was, of course, an unscientific method, but it taught him to recognise the species and to know their habits. There are few better localities for lepidoptera, as every collector knows, than the New Forest, and some of the schoolboy's "finds" afterwards proved welcome to so well known an entomologist as Curtis. But when Charles returned to school he had to lay aside, for a season, the new hobby; for in those days a schoolboy's interest in natural history did not extend beyond birds'-nesting, and his little world was not less, perhaps even more frank and demonstrative than now, in its criticism of any innovation or peculiarity on the part of one of its members.

The school at Salisbury appears to have been a preparatory one, so before very long another had to be sought. Mr. Lyell wished to send his two boys to Winchester, but found to his disappointment that there would not be a vacancy for a couple of years; so after instructing them at home for six months, he contented himself with the Grammar School at Midhurst, in Sussex, at the head of which was one Dr. Bayley, formerly an under-master at Winchester. Charles, now in his thirteenth year, found this, at first, a great change. The school contained about seventy boys, big as well as little, and its general system

resembled that of one of the great public schools. He remarks of this period of his life: "Whatever some may say or sing of the happy recollections of their schooldays, I believe the generality, if they told the truth, would not like to have them over again, or would consider them as less happy than those which follow." He was not the kind of boy to find the life of a public school very congenial. Evidently he was a quietly-disposed lad, caring more for a country ramble than for games; perhaps a little old-fashioned in his ways; not pugnacious, but preferring a quiet life to the trouble of self-assertion. So, in his second half-year, when he was left to shift entirely for himself, his life was "not a happy one," for a good deal of the primeval savage lingers in the boys of a civilised race. It required, as he said, a good deal to work him up to the point of defending his independence; thus he was deemed incapable of resistance and was plagued accordingly. But at last he turned upon a tormentor, and a fight was the result. It was of Homeric proportions, for it lasted two days, during five or six hours on each, the combatants being pretty evenly matched; for though Lyell's adversary was rather the smaller and weaker, he knew better how to use his fists. Strength at the end prevailed over science, though both parties were about equally damaged. The vanquished pugilist was put to bed, being sorely bruised in the visible parts. Lyell, whose hurts were mostly hidden, made light of them, by the advice of friends, but he owns that he ached in every bone for a week, and was black and blue all over his body. Still he had not fought in vain, for, though the combat won

him little honour, it delivered him from sundry tormentors.

The educational system of the school stimulated his ambition to rise in the classes. "By this feeling," he says, "much of my natural antipathy to work, and extreme absence of mind, was conquered in a great measure, and I acquired habits of attention which, however, were very painful to me, and only sustained when I had an object in view." There was an annual speech-day, and Charles, on the first occasion, obtained a prize for his performance. "Every year afterwards," he continues, "I received invariably a prize for speaking, until high enough to carry off the prizes for Latin and English original composition. My inventive talents were not quick, but to have any is so rare a qualification that it is sure to obtain a boy at our great schools (and afterwards as an author) some distinction." Evidently he gave proofs of originality beyond his fellows; since he won a prize for English verse, though he had written in the metre of the "Lady of the Lake" instead of the ordinary ten-syllabic rhyme. On another occasion he commemorated, in his weekly Latin copy, the destruction of the rats in a neighbouring pond, writing in mock heroics, after the style of Homer's battle of the frogs and mice.

The school, like all other collections of boys, had its epidemic hobbies. The game of draughts, coupled unfortunately with gambling on a small scale, was followed by chess, and that by music. To each of these Charles was more or less a victim, and his progress up the school was not thereby accelerated.

Birds'-nesting also had a turn in its season. His love for natural history made him so keen in this pursuit that he became an expert climber of trees. But his schooldays on the whole were uneventful, and he went to Oxford at a rather early age, his brother Tom having already left Midhurst in order to enter the Navy.

CHAPTER II.

UNDERGRADUATE DAYS

Lyell matriculated at Exeter College, and appears to have begun residence in January, 1816 – that is, soon after completing his eighteenth year. At Oxford, though not a "hard reader," he was evidently far from idle, and wrote for some of the University prizes, though without success. Several of his letters to his father have been preserved. In these he talks about his studies, mathematical and classical; criticises Coleridge's "Christabel," and praises Kirke White's poetry; describes the fritillaries blossoming in the Christchurch meadows, and refers occasionally to political matters. The letters are well expressed, and indicate a thoughtful and observant mind. While yet a schoolboy he had stumbled upon a copy of Bakewell's "Geology" in his father's library, which had so far awakened his interest that in the earlier part of his residence at Oxford he attended a course of Professor Buckland's lectures, and took careful notes. The new study is briefly mentioned in a letter, dated July 20th, 1817. This is written from Yarmouth, where he is visiting Mr. Dawson Turner, the well-known antiquarian and botanist. He states that, on his way through London, he went to see the elephant at Exeter Change, Bullock's Museum, and Francillon's collection of insects. At Norwich also he saw more insects, the

cathedral, and some chalk pits, in which he found an "immense number of belemnites, echinites, and bivalves." He was also greatly interested by the fossils in Dr. Arnold's collection at Yarmouth, particularly by the "alcyonia" found in flints.⁴ A few days later he again dwells on geology, and speculates shrewdly on the formation of the lowland around Yarmouth and the ancient course of the river. In one paragraph a germ of the future "Principles" may be detected. It runs thus:

"Dr. Arnold and I examined yesterday the pit which is dug out for the foundation of the Nelson monument, and found that the first bed of shingle is eight feet down. Now this was the last stratum brought by the sea; all since was driven up by wind and kept there by the 'Rest-harrow' and other plants. It is mere sand. Therefore, thirty-five years ago the Deens were nearly as low as the last stratum left by the sea; and as the wind would naturally have begun adding from the very first, it is clear that within fifty years the sea flowed over that part. This, even Mr. T. allows, is a strong argument in favour of the recency of the changes. Dr. Arnold surprised me by telling me that he thought that the Straits of Dover were formerly joined, and that the great current and tides of the North Sea being held back, the sea flowed higher over these parts than now. If he had thought a little more he would have found no necessity for all this, for all those towns on this eastern coast, which have no river god to stand their friend, have necessarily been losing

⁴ Probably they were fossil sponges.

in the same proportion as Yarmouth gains – viz. Cromer, Pakefield, Dunwich, Aldborough, etc., etc. With Dunwich I believe it is *Fuit Ilium*."⁵

Evidently Lyell by this time had become deeply interested in geology, for his journal contains several notes made on the road from London to Kinnordy, and records, during his stay there, not only the capture of insects, but also visits to quarries, and the discovery of crystallised sulphate of barytes at Kirriemuir and elsewhere.

Towards the end of his first long vacation he travelled, in company with two friends of his own age, from Forfarshire across by Loch Tay, Tyndrum, and Loch Awe, to the western coast at Oban, whence they visited Staffa and Iona. With the caves in the former island he was greatly impressed; and he noted the columns of basalt, which, he said, were "pentagonal" in form, quite different from the "four-square" jointing of the red granite at the south-west end of Mull. With the ruins of Iona he was a little disappointed, for he wrote in his diary that "they are but poor after all." The wonders of Fingal's Cave appealed to his poetical as well as to his geological instincts, for in October, after his return to Oxford, he sent to his father some stanzas on this subject which are not without a certain merit. But the covering letter was mostly devoted to geology.

The next year, 1818, marked an important step in his education as a geologist, for he accompanied his father, mother,

⁵ Life, Letters, and Journals, vol. i. p. 43.

and two eldest sisters on a Continental tour. Starting early in June, they drove in a ramshackle carriage, which frequently broke down, from Calais to Paris, along much the same route as the railway now takes; they visited the sights of the capital, not forgetting either the artistic treasures of the Louvre or the collections of the Jardin des Plantes, particularly the fossils of the "Paris basin." Thence they journeyed by Fontainebleau and Auxerre to Dôle, and he makes careful and shrewd notes on the geology, for the carriage travelling of those days, though slow, was not without its advantages – and in crossing the Jura he observes the nodular flints in a limestone, and the contrast between these mountains and the Grampians of his native land. As they descended the well-known road which leads down to Gex in Switzerland, they had the good fortune to obtain a splendid view of Mont Blanc and the Alps. From Geneva, where he notes the "most peculiar deep blue colour of the Rhone," they visited Chamouni by the usual route. At this time the principal glaciers were advancing rather rapidly. The Glacier des Bossons, he remarks, "has trodden down the tallest pines with as much ease as an elephant could the herbage of a meadow. Some trunks are still seen projecting from the rock of ice, all the heads being embodied in this mass, which shoots out at the top into tall pyramids and pinnacles of ice, of beautiful shapes and a very pure white... It has been pressed on not only through the forest, but over some cultivated fields, which are utterly lost."⁶

⁶ Life, Letters, and Journals, vol. i. p. 69.

At Chamouni, Lyell made the most of his time, for in three days he walked up to the Col de Balme, climbed the Brévent, and made his first glacier expedition, to the well-known oasis among the great fields of snow and ice which is called the Jardin. Everywhere he notes the flowers, which at that season were in full beauty; and the insects, capturing "no less than seven specimens of that rare insect, *Papilio Apollo*."⁷ He feels all the surprise and all the delight which thrills the entomologist from the British Isles when he first sets foot on the slopes of the higher Alps, and sees in abundance the rarities of his own country, besides not a few new species. But Lyell does not neglect the rocks and minerals, or the red snow, or the wonders of the ice world. Chamouni, we are told, was then "perfectly inundated with English," for fifty arrived in one day. The previous year they had numbered one thousand out of a total of fourteen hundred visitors. Since then, times and the village have changed.

Returning to Geneva, the party travelled by Lausanne and Neuchâtel to Bâle, and then followed the picturesque route along the river, by the tumultuous rapids of Laufenburg and the grand falls of the Rhine, to Schaffhausen, whence they turned off to Zurich. Here he writes of the principal inn that it "partook more than any of a fault too common in Switzerland. They have their stables and cow-houses under the same roof, and the unavoidable consequences may be conceived, till they can fall in with a man

⁷ Now generally called *Parnassius Apollo*; but very likely he captured more than one species of the genus.

as able – as 'Hercules to cleanse a stable.'"

From Zurich they crossed the Albis to Zug. The other members of the party went direct to Lucerne, but Lyell turned aside to visit the spot where twelve years previously an enormous mass of pudding-stone had come crashing down from the Rossberg, had destroyed the village of Goldau, and had converted a great tract of fertile land into a wilderness of broken rock. He diagnosed correctly the cause of the catastrophe, and then ascended the Rigi. Here he spent a flea-bitten night at the Kulm Hotel, but was rewarded by a fine sunset and a yet finer sunrise.

At Lucerne he rejoined his relatives, and they drove together over the Brünig Pass to Meyringen. From this place they made an excursion to the Giessbach Falls, and saw the Alpbach in flood after a downpour of rain. This, like some other Alpine streams, becomes at such times a raging mass of liquid mud and shattered slate, and Lyell carefully notes the action of the torrent under these novel circumstances, and its increased power of transport. Parting from his relatives at the Handeck Falls, he walked up the valley of the Aar to the Grimsel Hospice, where he passed the night, and the next morning crossed over into the valley of the Rhone to the foot of its glacier, and then walked back again to Meyringen. He remarks that on the way to the Hospice "we passed some extraordinary large bare planks of granite rock above our track, the appearance of which I could not account for." This is not surprising, for he had not yet learnt to read the

"handwriting on the wall" of a vanished glacier. Its interpretation was not to come for another twenty years, when these would be recognised as perhaps the finest examples of ice-worn rocks in Switzerland. Lyell was evidently a good pedestrian; for the very next day he walked from Meyringen over the two Scheideggs to Lauterbrunnen, ultimately joining his relatives at Thun, from which town they went on to Berne, where they were so fortunate as to see, from the well-known terrace, the snowy peaks of the Oberland in all the beauty of the sunset glow.

Then they journeyed over the pleasant uplands to Vevay, and so by the shore of the Lake of Geneva and the plain of the Rhone valley to Martigny, turning aside to visit the salt mines near Bex. They reached Martigny a little more than seven weeks after the lake, formed in the valley of the Dranse by the forward movement of the Giétroz Glacier, had burst its icy barrier, and they saw everywhere the ruins left by the rush of the flood. The road as they approached Martigny was even then, in some places, under water; in others it was completely buried beneath sand. The lower storey of the hotel had been filled with mud and débris, which was still piled up to the courtyard. Lyell went up the valley of the Dranse to the scene of the catastrophe, and wrote in his journal an interesting description of both the effects of the flood and the remnants of the ice-barrier. Before returning to Martigny he also walked up to the Hospice on the Great St. Bernard, and then the whole party crossed by the Simplon Pass into Italy, following the accustomed route and visiting the usual sights till

they arrived at Milan.

The next stage on their tour – and this must have been in those days a little tedious – brought them to Venice. The Campanile Lyell does not greatly admire, and of St. Mark's he says rather oddly, "The form is very cheerful and gay"; but on the whole he is much impressed with the buildings of Venice, and especially with the pictures. On their return they went to Bologna, and then crossed the Apennines to Florence. Everywhere little touches in the diary indicate a mind exceptionally observant – such as notes on the first firefly, the fields of millet, the festooned vines seen on the plain, or the peculiar sandy zone on the northern slopes of the hills. He also mentions that shortly after crossing the frontier of Tuscany they passed near Coviliajo, "a volcanic fire" which proceeded from a neighbouring mountain.⁸ This they intended to visit on their return. But at Florence the diary ends abruptly, for the note-book which contained the rest of it was unfortunately lost.

We have given this summary of Lyell's journal in some detail, but even thus it barely suffices to convey an adequate idea of the cultured tastes, wide interests, and habits of close and accurate observation disclosed by its pages. It shows, better perhaps than any other documents, the mental development of the future author of the "Principles of Geology." Few things, as

⁸ Probably it was a bituminous shale which had become ignited, as was the case at Ringstead Bay, Dorset, with the Kimeridge clay. The same often happens with the "banks" of coal-pits.

he journeys, escape his notice; he describes facts carefully and speculates but little. As he wanders among the Alpine peaks, he makes no reference to convulsions of the earth's crust; as he views the ruin wrought by the Dranse, he says naught of deluges.

The travellers got back to England in September, and at the end of the Long Vacation Lyell returned to Oxford. There he remained till December, 1819, when he proceeded to the degree of Bachelor of Arts, obtaining a second class in Classical Honours. Considering that he had never been a "hard reader," and that he appears to have spent much of his "longs" in travel – a practice which, though good for general education, counts for little in the schools – the position indicates that he possessed rather exceptional abilities and a good amount of scholarship. Though Oxford had been unable to bestow upon him a systematic training in science, she had given a definite bias to his inclination, and had fostered and cultivated a taste for literature which in the future brought forth a rich fruitage.

CHAPTER III.

THE GROWTH OF A PURPOSE

Shortly after he had donned the bachelor's hood Lyell came to London, was entered at Lincoln's Inn, and studied law in the office of a special pleader. Science was not forsaken, for in March, 1819, he was elected a Fellow of the Geological Society, and about the same time joined the Linnean Society. Before very long his legal studies were interrupted. His eyes became so weak that a complete rest was prescribed; accordingly, in the autumn of 1820, he accompanied his father on a journey to Rome. During this but little was done in geology, for the travellers spent almost all their time in towns.

On his return, so far as can be inferred from the few letters which have been published, Lyell continued to work at geology, and at Christmas, 1821, was seeking in vain for freshwater fossils in the neighbourhood of Bartley. In the spring of 1822 he investigated the Sussex coast from Hastings to Dungeness, and studied the effects of the sea at Winchelsea and Rye. In the early summer of 1823 he visited the Isle of Wight, and in a letter to Dr. Mantell suggested that the "blue marl"⁹ in Compton Chine is identical with that at Folkestone, and compared the underlying

⁹ Now recognised as gault. The identification named above was soon found to be correct.

strata with those in Sussex, clearing up some confusions, into which earlier observers had fallen, about the Wealden and Lower Greensand. He was now evidently beginning to get a firm grip on the subject – a thing far from easy in days when so little had been ascertained – and this year he read his first papers to the Geological Society – one, in January, written in conjunction with Dr. Mantell, "On the Limestone and Clay of the Ironsand in Sussex"; the other in June, "On the Sections presented by Some Forfarshire Rivers." Also, on February 7th, he was elected one of the secretaries of that Society, an office which he retained till 1826. This is a pretty clear proof that he had begun to make his mark among geologists, and was well esteemed by the leaders of the science.

No sooner had he returned from the Isle of Wight than he started for Paris, going direct from London to Calais, in the *Earl of Liverpool* steam packet, "in 11 hours! 120 miles! engines 80 horse-power for 240 tons." In the last letter written to his father before quitting England he refers to our neighbours across the Channel in the following terms: "My opinion of the French people is that they are much too corrupt for a free government and much too enlightened for a despotic one." That was written full seventy years ago; perhaps even now, were he alive, he would not be disposed to withdraw the words.

At Paris he was well received by Cuvier, Humboldt, and other men of science, attended lectures at the Jardin du Roi, and saw a good deal of society. His letters home often contain

interesting references to matters political and social – such as, for example, the following remarks which he heard from the mouth of Humboldt: "You cannot conceive how striking and ludicrous a feature it is in Parisian society at present that every other man one meets is either minister or ex-minister. So frequent have been the changes. The instant a new ministry is formed, a body of sappers and miners is organised. They work industriously night and day. At last the ministers find that they are supplanted by the very arts by which a few months ago they raised themselves to power."¹⁰ Lyell more than once expresses a regret, which, indeed, was generally felt in scientific circles, that Cuvier had lost caste by "dabbling so much with the dirty pool of politics"; and himself works away at geology, studying the fossils of the Paris basin in the museums, and visiting the most noted sections in order to add to his own collection and observe the relations of the strata.

He returned to England towards the end of September, and no doubt spent the next few months in working at geology as far as his eyes, which were becoming stronger, permitted. The summer of 1824 was devoted to geological expeditions. In the earlier part he took Mons. Constant Prévost, one of the leaders of geology in France, to the west of England. Their special purpose was to examine the Jurassic rocks, but they extended their tour as far as Cornwall. Afterwards Lyell went to Scotland, where he was joined by Professor Buckland; and the two friends,

¹⁰ Life, Letters, and Journals, vol. i. p. 127. Some sentences (for the sake of brevity) are omitted from the quotation.

after spending a few days in Ross-shire, went to Brora, and then returned from Inverness by the Caledonian canal. This gave them the opportunity of examining the famous "parallel roads" of Glenroy, which were the more interesting because they had already seen something of the kind near Cowl, in Ross-shire. Afterwards they went up Glen Spean and crossed the mountains to Blair Athol, visiting the noted locality in Glen Tilt, where Hutton made his famous discovery of veins of granite intrusive in the schists of that valley, and then they made their way to Edinburgh. Here much work was done, both among collections and in the field, and it was lightened – as might be expected in a place so hospitable – by social pleasures and friendly converse with some of the leading literary and scientific men.

Four years of comparative rest and frequent change of scene had produced such an improvement in the condition of his eyes that he was able to resume his study of the law, and was called to the Bar in 1825. For two years he went on the Western Circuit, having chambers in the Temple and getting a little business. But, as his correspondence shows, geology still held the first place in his affections,¹¹ and papers were read to the Society from time to time. Among them one of the most important, though it was not printed in their journal, described a dyke of serpentine which cut through the Old Red Sandstone on the Kinnordy estate.¹²

¹¹ He was also elected a Fellow of the Royal Society in 1826.

¹² It appeared in the *Edin. Journ. Sci.*, iii. (1825) p. 112, being his first actual publication. Its importance consisted in proving that serpentine was, or rather had

But, as is shown by a letter to his sister, written in the month of November, he had not lost his interest in entomology. At that time the collectors of insects in Scotland were very few in number, and the English lepidopterists welcomed the specimens which Lyell and his sister had caught in Forfarshire. The family had left Bartley Lodge in the earlier part of the year and had settled in the old home at Kinnordy. About this time also Lyell began to contribute to the *Quarterly Review*, writing articles on educational and scientific topics. This led to a friendship with Lockhart, who became editor at the end of 1825, and gave him an introduction to Sir Walter Scott. A Christmas visit to Cambridge introduced him to the social life of that university.

In the spring of 1827 his ideas as to his future work appear to have begun to assume a definite form. To Dr. Mantell¹³ he writes that he has been reading Lamarck, and is not convinced by that author's theories of the development of species, "which would prove that men may have come from the ourang-outang," though he makes this admission: "After all, what changes a species may really undergo! How impossible will it be to distinguish and lay down a line, beyond which some of the so-called extinct species have never passed into recent ones!" The next sentence is significant: "That the earth is quite as old as he [Lamarck]

been, an igneous rock. If proper attention had been paid to it, fewer mistaken statements and hypotheses would have attained the dignity of appearing in print.

¹³ Dr. Gideon A. Mantell, a surgeon by profession, at that time resident in Lewes, who made valuable contributions to the geology of South-East England, and was also distinguished for his popular lectures and books. He died in 1852.

supposes has long been my creed, and I will try before six months are over to convert the readers of the *Quarterly* to that heterodox opinion."¹⁴ A few lines further on come some sentences which indicate that the leading idea of the "Principles" was even then floating in his mind. "I am going to write in confirmation of ancient causes having been the same as modern, and to show that those plants and animals, which we know are becoming preserved now, are the same as were formerly." Hence, he proceeds to argue, it is not safe to infer that because the remains of certain classes of plants or animals are not found in particular strata, the creatures themselves did not then exist. "You see the drift of my argument," he continues; "*ergo*, mammalia existed when the oolite and coal, etc., were formed."¹⁵ The first of these quotations strikes the keynote of modern geology as opposed to the older notions of the science; what follows suggests a caution, to which Darwin afterwards drew more particular attention, though he turned the weapon against Lyell himself, viz. "the imperfection of the geological record."

A letter to his father, also written in the month of April, shows that, while he has an immediate purpose of opening fire on MacCulloch,¹⁶ who had bitterly attacked in the *Westminster*

¹⁴ Probably referring to an article on Scrope's "Geology of Central France," in which he shows that he fully accepted the Huttonian doctrine of interpreting the geology of past ages by reference to the causes still at work. It appeared in the *Quarterly Review*, Oct. 1827, vol. xxxvi. p. 437.

¹⁵ Life, Letters, and Journals, vol. i. p. 169.

¹⁶ Dr. John MacCulloch, author (among other works) of the "Highlands and Western

Review Scrope's book upon Volcanoes, he has "come to the conclusion that something of a more scientific character is wanted, for which the pages of a periodical are not fitted." He might, he says, write an elementary book, like Mrs. Marcet's "Conversations on Chemistry," but something on a much larger scale evidently is floating on his mind. In this letter also he discusses his prospects with his father, who apparently had suggested that he should cease from going on circuit; and argues that he gains time by appearing to be engaged in a profession, for "friends have no mercy on the man who is supposed to have some leisure time, and heap upon him all kinds of unremunerative duties." Lyell was not devoid of Scotch shrewdness, and doubtless early learnt that when it is all work and no pay men see your merits through a magnifying glass, but when it comes to the question of a reward, they shift the instrument to your defects.

Gradually the plan of the future book assumed a more definite shape in his mind, as we can see from a letter to Dr. Mantell early in 1828. About this time also Murchison, with whom he was planning a long visit to Auvergne,¹⁷ appears among his correspondents. Herschel¹⁸ tells him how he and Faraday had

Isles of Scotland." He was an excellent geologist on the mineralogical side, but had little sympathy with palæontology or with the views to which Lyell inclined. He died in 1835.

¹⁷ This district had been already explored by Mr. G. P. Scrope, the first edition of whose classic work, "The Volcanoes of Central France," was published in 1826.

¹⁸ Sir John F. W. Herschel, the second of the illustrious astronomers of that name.

melted in a furnace "granite into a slag-like lava"; Hooker¹⁹ begs him to notice the connection between plants and soils as he travels; his father urges him to take his clerk with him to act as amanuensis and save his eyes, which might be affected by the glare of the sun, and to help him generally in collecting specimens and carrying the barometers. Early in the month of May he started for Paris, where he met Mr. and Mrs. Murchison, and the party left for Clermont Ferrand in a "light open carriage, with post horses." As far as Moulins the roads were bad, but as they receded from Paris and approached the mountains "the roads and the rates of posting improved, so that we averaged nine miles an hour, and the change of horses [was] almost as quick as in England. The politeness of the people has much delighted us, and they are so intelligent that we get much geology from them." Clermont Ferrand became their headquarters for some time, and Lyell's letters to his father are full of notes on the geology of the district, one of the most interesting in Europe. The great plateau which rises on the western side of the broad valley of the Allier is studded with cones and craters – some so fresh that one might imagine their last eruptions to have happened during the decline of the Roman empire;²⁰ others in almost every stage of

¹⁹ Sir W. J. Hooker.

²⁰ Certain passages in a letter of Sidonius Apollinaris, Bishop of Clermont, dated about 460 A.D., and in the works of Alcimus Avitus, Archbishop of Vienne, about half a century later, have been interpreted as referring to volcanic eruptions somewhere in Auvergne. This, however, is disputed by many authorities. (See *Geological Magazine*, 1865, p. 241.)

dissection by the scalpels of nature. Streams of lava, still rough and clinkery, have poured themselves over the plateau and have run down the valleys till they have reached the plain of the Allier, while huge fragments of flows far larger and more ancient have been carved by the action of rain and rivers into natural bastions, and now may be seen resting upon stratified marls, crowded with freshwater shells and other organisms, – the remnants of deposits accumulated in great lakes, which had been already drained in ages long before man appeared on the earth.

The two geologists worked hard, for who could be idle in such a country as this? They often began at six in the morning and rested not till evening, though the summers are hot in Auvergne, and this one was exceptionally so. Lyell writes home, "I never did so much real geology in so many days." Mrs. Murchison also was "very diligent, sketching, labelling specimens, and making out shells, in which last she is a valuable assistant." Sometimes they went farther afield, visiting Pontgibaud and the gorge of the Sioul, where they found a section previously unnoticed, which gave them a clear proof that a lava-stream had dammed up the course of a river by flowing down into its valley, and had converted the part above into a lake. This again had been drained as the river had carved for itself a new channel, partly in the basalt, partly in the underlying gneiss. Here, then, was a clear proof that a river could cut out a path for itself, and that forces still in operation were sufficient, given time enough, to sculpture the features of the earth's crust. Notwithstanding the hard work,

the outdoor life suited Lyell, who writes that his "eyes were never in such condition before." Murchison, too, was generally in good health, but would have been better, according to his companion, if he had been a little more abstemious at table and a worse customer to the druggist.

From Clermont Ferrand the travellers moved on to the Cantal, where they investigated the lacustrine deposits beneath the lava-streams all around Aurillac. These deposits exhibited on a grand scale the phenomena which Lyell had already observed on a small one in the marls of the loch at Kinnordy. Thence they went on through the Ardèche and examined the "pet volcanoes of the Vivarais," as they had been termed by Scrope. The Murchisons now began to suffer from the heat, for it was the middle of July. Nevertheless, they still pushed on southwards, and after visiting the old towns of Gard and the Bouches du Rhône, went along the Riviera to Nice, having been delayed for a time at Fréjus, where Murchison had a sharp attack of malarious fever. It was an exceptionally dry summer, and the town in consequence was malodorous; so after a short halt, they moved on to Milan and at last arrived at Padua, working at geology as they went along, and constantly accumulating new facts. From Padua they visited Monte Bolca, noted for its fossil fish, the Vicentin, with its sheets of basalt, and the Euganean Hills, where the "volcanic phenomena [were] just Auvergne over again." Then the travellers parted, the Murchisons turning northward to the Tyrol, while Lyell continued on his journey southward to Naples and Sicily.

Some four months had now been spent, almost without interruption, in hard work and the daily questioning of Nature. The results had surpassed even Lyell's anticipations; they had thrown light upon the geological phenomena of the remote past, and cleared up many difficulties which, hitherto, had impeded the path of the investigators. On the coast of the Maritime Alps Lyell had found huge beds of conglomerate, parted one from another by laminated shales full of fossils, most of which were identical with creatures still living in the Mediterranean. These masses attained a thickness of 800 feet, and were displayed in the sides of a valley fifteen miles in length. They supplied a case parallel with that of the conglomerates and sandstones of Angus, and indicated that no extraordinary conditions – no deluges or earth shatterings – had been needed in order to form them. If the torrents from the Maritime Alps, as they plunged into the Mediterranean, could build up these masses of stratified pebbles, why not appeal to the same agency in Scotland, though the mountains from which they flowed, and the sheet of water into which they plunged, have alike vanished? The great flows of basalt – some fresh and intact, some only giant fragments of yet vaster masses – the broken cones of scoria, and the rounded hills of trachyte in Auvergne, had supplied him with links between existing volcanoes and the huge masses of trap with which Scotland had made him familiar; while these basalt flows – modern in a geological sense, but carved and furrowed by the streams which still were flowing in their gorges – showed

that rain and rivers were most potent, if not exclusive, agents in the excavation of valleys. "The whole tour," thus he wrote to his father, "has been rich, as I had anticipated (and in a manner which Murchison had not), in those analogies between existing nature and the effects of causes in remote eras which it will be the great object of my work to point out. I scarcely despair now, so much do these evidences of modern action increase upon us as we go south (towards the more recent volcanic seat of action) of *proving* the positive identity of the causes now operating with those of former times."²¹

One important result of this journey was a conjoint paper on the excavation of valleys in Auvergne, which was written before the friends parted, and was read at the Geological Society in the later part of the year. Lyell writes thus to one of his sisters from Rome, on his return thither, in the following January²²: —

"My letters from geological friends are very satisfactory as to the unusual interest excited in the Geological Society by our paper on the excavation of valleys in Auvergne. Seventy persons present the second evening, and a warm debate. Buckland and Greenough furious, *contra* Scrope, Sedgwick, and Warburton supporting us. These were the first two nights in our new *magnificent* apartments at Somerset House." He adds, "Longman has paid down 500 *guineas* to Mr. Ure, of Dublin, for a popular work on geology, just coming out. It is to prove the Hebrew

²¹ Life, Letters, and Journals, vol. i. p. 199.

²² Life, Letters, and Journals, vol. i. p. 238.

cosmogony, and that we ought all to be burnt in Smithfield."

On the way to Naples, Lyell made several halts: at Parma, Bologna, Florence, Siena, Viterbo, and Rome; visiting local geologists, studying their collections of fossil shells, keeping his eye more especially on the relations which the species exhibited with the fauna still existing in the Mediterranean, and losing no opportunity of examining the ancient volcanic vents and the crater lakes, which form in places such remarkable features in the landscape. "The shells in the travertine," he writes, "are all real species living in Italy, so you perceive that the volcanoes had thrown out their ash, pumice, etc., and these had become covered with lakes, and then the valleys had been hollowed out, all before Rome was built, 2,500 years and more ago."

On reaching Naples, he climbed Vesuvius, and saw for the first time the lava-streams and piles of scoria of a volcano still active; while the wonderful sections of the old crater of Somma furnished a link between the living present and the remote past – between Italy and Auvergne. He visited Ischia, where another delightful surprise awaited him, for on its old volcano, Monte Epomeo, he found, at a height of 2,000 feet above the sea, marine shells which belonged "to the same class as those in the lower regions of Ischia." They were contained in a mass of clay, and were quite unaltered. This was a great discovery, for the existence of these fossils "had not been dreamt of," and it showed that the land had been elevated to this extent without any appreciable change in the fauna inhabiting the Mediterranean.

Except for this, the island was "an admirable illustration of Mont Dore." He made an excursion also to the Temples of Pæstum, wonderful from the weird beauty of their ruins, on the flat plain between the Apennines and the sea, but with interest geological as well as archæological, because of the blocks of rough travertine with which their columns are built. These he studied, and he visited the quarries from which they were hewn. His letters frequently contain interesting references to the tyranny of the Government, "the inquisitorial suppression of all cultivation of science, whether moral or physical," the idle, happy-go-lucky habits of the common people, the prevalent mendicancy, universal dishonesty, and general corruption. One instance may be worth quoting – it indicates the material with which "United Italy " has had to deal. He wanted to pre-pay the postage of a letter to England. The head waiter at his hotel had said to him, "'Mind, if it is to England you only pay fifteen grains' (sous). I thought the hint a trait of character, as they are all suspicious of one another. The clerk demanded twenty-five. I remonstrated, but he insisted, and, as he was dressed and had the manners of a gentleman, I paid. When I found on my return that I had been cozened, I asked the head waiter, with some indignation, 'Is it possible that the Government officers are all knaves?' 'Sono Napolitani, Signor; la sua eccellenza mi scusera, ma io sono Romano!'"²³ The old proverb, what is bred in the bone will out in the flesh, still holds good; but we may doubt whether

²³ Life, Letters, and Journals, vol. i. p. 215.

the standard of virtue is quite so high as the speaker intimated in certain other provinces which Piedmont has acquired at the price of the cradle of the royal house and some of the best blood of the nation.

At Naples, Lyell was detained longer than he had expected, waiting for a Government steamer. "There was," he says, "no other way of going, for the pirates of Tripoli have taken so many Neapolitan vessels that no one who has not a fancy to see Africa will venture." But he arrived in Sicily before the end of November, and succeeded in reaching the summit of Etna on the first of December. He was only just in time, for the next day bad weather set in, snow fell heavily, and the summit of the mountain became practically inaccessible for the winter. But as it was, he was able to examine carefully another active volcano, the phenomena of which corresponded with those of Vesuvius, though on a grander scale. From Nicolosi, where he was delayed a day or two by the weather, Lyell went along the Catanian plain to Syracuse and southward to the extreme point of the island, Cape Passaro. From this headland he followed the coast westward as far as Girgenti, and then struck across the island in an easterly direction till he came within about a day's journey of Catania, and then he turned off in a north-westerly direction through the island to Palermo. In this zigzag journey, which occupied about five weeks, he succeeded in obtaining a good general knowledge of the geology of the eastern part of the island; he examined many sections and collected many fossils,

thus obtaining material for an accurate classification of the little-known deposits of the Sicilian lowland, and in addition he lost no opportunity of studying the relations of the volcanic masses, wherever they occurred, to the sedimentary strata. As his letters show, bad roads, poor fare, and miserable accommodation made the journey anything but one of pleasure; but its results, as he wrote to Murchison, "exceeded his warmest expectations in the way of modern analogies."

By December 10th he was once more back in the Bay of Naples. As he returned through Rome he availed himself of the opportunity of examining the travertines of Tivoli, which, as he remarked, presented more analogies with those of Sicily than of Auvergne, and welcomed the news that the bones of an elephant had been found in an alluvial deposit which lay beneath the lava of an extinct Tuscan volcano. His notes also prove that he was beginning to see his way to the classification of the extensive deposits of sand and marl in Italy and Sicily, which were subsequently recognised as belonging to the Pliocene era.

Early in February Lyell reached Geneva on his homeward journey, after crossing the Mont Cenis, and by the 19th was back in Paris among his geological friends, "pumping them," as he says, and being well pumped in return. Some of them, he finds, "have come by most opposite routes to the same conclusions as myself, and we have felt mutually confirmed in our views, although the new opinions must bring about an amazing overthrow in the systems which we were carefully taught

ten years ago." The accurate knowledge of Deshayes, one of the most eminent conchologists of that day, was especially helpful in bringing his field work in Italy and Sicily into clear and definite order, and he obtained from him a promise of tables of more than 2,000 species of Tertiary shells, from which (he writes to his sister Caroline, who shared his entomological tastes) "I will build up a system on data never before obtained, by comparing the contents of the present with more ancient seas, and the latter with each other."²⁴

By the end of February he is back in London and at the Geological Society, defending his views on the constancy of Nature's operations – views which seemed rank heresy to the older school, who sought to solve every difficulty by a convulsion, and were fettered in their interpretation of the records of geology by supposed theological necessities. In April Lyell writes thus to Dr. Mantel²⁵: —

"A splendid meeting [at the Geological Society] last night, Sedgwick in the chair. Conybeare's paper on Valley of the Thames, directed against Messrs. Lyell and Murchison's former paper, was read in part. Buckland present to defend the 'Diluvialists,' as Conybeare styles his sect; and us he terms 'Fluvialists.' Greenough assisted us by making an ultra speech on the importance of modern causes... Murchison and I fought stoutly, and Buckland was

²⁴ Life, Letters, and Journals, vol. i. p. 252.

²⁵ *Ibid.*

very piano. Conybeare's memoir is not strong by any means. He admits three deluges before the Noachian! and Buckland adds God knows how many *catastrophes* besides; so we have driven them out of the Mosaic record fairly."

Again, in the month of June, he writes to the same correspondent in regard to the second portion of the same paper²⁶: —

"The last discharge of Conybeare's artillery, served by the great Oxford engineer against the Fluvialists, as they are pleased to term us, drew upon them on Friday a sharp volley of musketry from all sides, and such a broadside, at the finale, from Sedgwick as was enough to sink the 'Reliquiæ Diluvianæ'²⁷ for ever, and make the second volume shy of venturing out to sea."

In a third letter, written to Dr. Fleming, he gives a similar account of the battle between the Diluvialists and Fluvialists, and concludes with these words²⁸: —

"I am preparing a general work on the younger epochs of the earth's history, which I hope to be out with next spring. I begin with Sicily, which has almost entirely risen from the sea, to the height of nearly 4,000 feet, since all the present animals existed in the Mediterranean!"

²⁶ *Ut suprà*, p. 253.

²⁷ "Reliquiæ Diluvianæ, or Observations on Organic Remains contained in Caves, Fissures, and Diluvial Gravel, and on other Geological Phenomena attesting the Action of an Universal Deluge." By Professor Buckland. 1823.

²⁸ *Ut suprà*, p. 254.

CHAPTER IV.

THE PURPOSE DEVELOPED AND ACCOMPLISHED

The summer of 1829 was spent at Kinnordy, when the quarries of Kirriemuir and the neighbouring districts were visited from time to time, the workmen being encouraged to look out for the remains of plants and the scales of fishes. Murchison, however, was again travelling on the Continent, and, in company with Sedgwick, was exploring the geological structure of the Eastern Alps and the basin of the Danube. They appear to have kept up communication with Lyell, who hears with satisfaction of the results of their work, since these cannot fail to keep Murchison sound in the Uniformitarian faith and to complete the conversion of Sedgwick.²⁹

"The latter" (Lyell writes to Dr. Fleming) "was astonished at finding what I had satisfied myself of everywhere, that in the more recent tertiary groups great masses of rock, like the different members of our secondaries, are to be found. They call the grand formation in which they have been working sub-Apennine. Vienna falls into it. I suspect it is a shade older, as the sub-Apennines are several shades older than the

²⁹ Life, Letters, and Journals, vol. i. p. 255.

Sicilian tertiaries. They have discovered an immensely thick conglomerate, 500 feet of compact marble-like limestone, a great thickness of oolite, not distinguishable from Bath oolite, an upper red sand and conglomerate, etc. etc., all members of that group zoologically sub-Apennine. This is glorious news for me... It chimes in well with making old red transition mountain limestone and coal, and as much more as we can, *one epoch*, for when Nature sets about building in one place, she makes a great batch there... All the freshwater, marine, and other groups of the Paris basin are one epoch, at the farthest not more separated than the upper and lower chalk."

A letter to the same correspondent, written nearly three weeks later, at the end of October, and after his return to London, refers to the consequences of this journey.³⁰

"Sedgwick and Murchison are just returned, the former full of magnificent views. Throws overboard all the diluvian hypothesis; is vexed he ever lost time about such a complete humbug; says he lost two years by having also started a Wernerian. He says primary rocks are not primary, but, as Hutton supposed, some igneous, some altered secondary. Mica schist in Alps lies *over* organic remains. No rock in the Alps older than lias.³¹ Much of Buckland's dashing paper

³⁰ *Ut suprà*, p. 256.

³¹ Further work has not verified some of these statements. There can be no question that a great deal of rock in the Alps is much older than even the Trias. The apparent superposition of crystalline schists to rocks with fossils is due to over-folding or over-thrust faulting — *i. e.* the schists are the older rocks. Though the Secondary rocks of

on Alps wrong. A formation (marine) found at foot of Alps, between Danube and Rhine, thicker than all the English secondaries united. Munich is in it. Its age probably between chalk and our oldest tertiaries. I have this moment received a note from C. Prévost by Murchison. He has heard with delight and surprise of their Alpine novelties, and, alluding to them and other discoveries, he says: 'Comme nous allons rire de nos vieilles idées! Comme nous allons nous moquer de nous-mêmes!' At the same time he says: 'If in your book you are too hard on us on this side the Channel, we will throw at you some of old Brongniart's "metric and peponary blocks" which float in that general and universal diluvium, and have been there "depuis le grand jour qui a séparé, d'une manière si tranchée, les temps ante-des-temps Post-Diluviens."'

A short time afterwards, in a letter addressed to Mr. Leonard Horner, Lyell declines to become a candidate for the Professorship of Geology and Mineralogy at the London University,³² which was first opened in the autumn of the previous year. Evidently he considers himself to be too fully occupied, for he writes to Dr. Mantell on December 5th that his book has taken a definite shape.³³ "I am bound hand and foot. In

the Alps have undergone, in places, some modification and mineral changes, these are very different from the metamorphism of those crystalline schists which have a stratified origin.

³² Now "University College," London, having been incorporated by Royal Charter under that title in November, 1836.

³³ *Ut suprà*, p. 258.

the press on Monday next with my work, which Murray is going to publish – 2 vols. – the title, 'Principles of Geology: being an Attempt to Explain the Former Changes of the Earth's Surface by Reference to Causes now in Operation.' The first volume will be quite finished by the end of the month. The second is, in a manner, written, but will require great recasting. I start for Iceland by the end of April, so time is precious." The process of incubation was continued throughout the winter. On February 3rd, 1830, he had corrected the press as far as the eightieth page, getting on slowly, but with satisfaction to himself. "How much more difficult it is," he remarks, "to write for general readers than for the scientific world; yet half our *savants* think that to write *popularly* would be a condescension to which they might bend if they would." He fully expects that the publication of his book will bring a hornet's nest about his head, but he has determined that, when the first volume is attacked, he will waste no money on pamphleteering, but will work on steadily at the second volume, and then, if the book is a success, at the second edition, for "controversy is interminable work." He felt now that the facts of nature were on his side, and his conclusions right in the main; so, like most strong men, he adopted the same course as did the founder of Marischal College, Aberdeen, and wrote over the door of his study, "Lat them say."

The plan of a summer tour in Iceland fell through; so did another for a long journey from St. Petersburg by Moscow to the Sea of Azof, to be followed by an examination of the Crimea and

the Great Steppe, and a return up the Danube to Vienna; but by the middle of June the first volume of the "Principles" was nearly finished; and in a letter to Scrope,³⁴ to whom advance sheets of the book had been forwarded, in order that he might review it in the *Quarterly*, Lyell explains concisely the position which he has taken in regard to cosmology and the earth's history.

"Probably there was a beginning – it is a metaphysical question, worthy a theologian – probably there will be an end. Species, as you say, have begun and ended – but the analogy is faint and distant. Perhaps it is an analogy, but all I say is, there are, as Hutton said, 'no signs of a beginning, no prospect of an end.' Herschel thought the nebulae became worlds. Davy said in his last book, 'It is always more probable that the new stars become visible, and then invisible, and pre-existed, than that they are created and extinguished.' So I think. All I ask is, that at any given period of the past, don't stop inquiry when puzzled by refuge to a beginning, which is all one with 'another state of nature,' as it appears to me. But there is no harm in your attacking me, provided you point out that it is the proof I deny, not the probability of a beginning. Mark, too, my argument, that we are called upon to say in each case, 'Which is now most probable, my ignorance of all possible effects of existing causes,' or that 'the beginning' is the cause of this puzzling phenomenon?"

In other parts of the letter he refers to his theory of the

³⁴ Life, Letters, and Journals, vol. i. pp. 269-271.

dependence of the climate of a region upon the geography, not only upon its latitude, but also upon the distribution of land and sea, and that of the coincidence of time between zoological and geographical changes in the past, as the most novel parts of the book; stating also that he has been careful to refer to all authors from whom he has borrowed, and that to Scrope himself he is under more obligation, so far as he knows, than to any other geologist. The concluding words also are interesting: —

"I conceived the idea five or six years ago, that if ever the Mosaic geology could be set down without giving offence, it would be in an historical sketch, and you must abstract mine in order to have as little to say as possible yourself. Let them feel it, and point the moral."

The last-named difficulty, to which Lyell refers in another part of this letter, was undoubtedly one of the most formidable "rocks ahead" in the path of his new book. Up to that time the progress of geology had been most seriously impeded by the supposed necessity of making its results harmonise with the Mosaic cosmogony. It was assumed as an axiom that the opening chapters of Genesis were to be understood in the strict literal sense of the words, and that to admit the possibility of misconceptions or mistakes in matters wholly beyond the cognisance of the writers, was a denial of the inspiration of Scripture, and was rank blasphemy. A large number of persons — among whom are the great mass of amateur theologians, together with some experts — are always very prone to assume the

meaning of certain fundamental terms to be exactly that which they desire, and then to proceed deductively to a conclusion as if their questionable postulates were axiomatic truths. They further assume, very commonly, that the possession of theological knowledge – scanty and superficial though it may be – enables them to dispense with any study of science, and to pronounce authoritatively on the value of evidence which they are incapable of weighing, and of conclusions which they are too ignorant to test. Being thus, in their own opinion, infallible, a freedom of expression is, for them, more than permissible, which, in most other matters, would be generally held to transgress the limits of courtesy and to trespass on those of vituperation. Lyell had perceived that little real progress could be made till geologists were free to look facts in the face and to follow their guidance to whatever conclusions these might lead, irrespective of supposed consequences; or that, in other words, questions of science must be settled by inductive reasoning from accurate observations, and not by an appeal to the opinions of the men of olden time, however great might be the sanctity of their characters or the honour due to their memories. Wisely, however, he determined to prefer an indirect to a direct method of attack, and to avoid, so far as was possible, giving needlessly any cause of offence by abruptness of statement or by intemperance of language.

In deluges, the favourite resort of every "catastrophic" geologist, Lyell had long lost faith, and he laughs in one of his letters at the idea of a French geologist, that a sudden upheaval of

South America may have been the cause of the Noachian flood. To the breaks in the succession of strata, a fact upon which the catastrophists much relied, he attached comparatively little value, insisting on their more or less local character. In the records of the rocks he finds no trace of a clean sweep of living creatures or of anything like a general clearance of the earth's surface, and no corroboration of the Mosaic cosmogony. He is bent on interpreting the work of Nature in the past by the work of Nature in the present, and not by the writings of the Fathers, or even by the words of Scripture itself.

Some time in the month of June the last sheet of the "Principles" must have been sent to press; for on the 25th of that month Lyell writes from Havre on his way to Bordeaux, through part of Normandy, Brittany, and La Vendée. This journey took him, as he says, "through some of the finest countries and most detestable roads he ever saw." On this occasion he was accompanied by a Captain Cooke, a commander in the Royal Navy; a man well informed, acquainted with Spain (the end of their journey), a botanist, and not wholly ignorant of geology – in short, an excellent companion, whose only fault was being "a little too fond of lagging a day for rest," even in places where nothing is to be done. Writing from Bordeaux to a sister, Lyell expresses a hope that at Bagnères de Luchon he may hear whether his book is out.³⁵ Two passages in his letter are not without a more general

³⁵ When he left the publisher had not decided whether it should be issued at once or kept back till October.

interest. One repeats a remark made to him by D'Aubuisson, whom he describes as "a great gun of the old Wernerian school, who ... thinks the interest of the subject greatly destroyed by our new innovation, especially our having almost cut mineralogy and turned it into a zoological science."³⁶ D'Aubuisson also said, "We *Catholic* geologists flatter ourselves that we have kept clear of the mixing of things sacred and profane, but the three great Protestants, De Luc, Cuvier, and Buckland, have not done so; have they done good to science or to religion? No, but some say they have to themselves by it." The other remark is interesting in its reference to French politics, seeing that it is dated on the 9th of July, 1830. It runs thus³⁷: —

"The quiet and perfect order and calmness that reigned at Bourbon, Vendée, and Bordeaux and Toulouse during the heat of the elections, afford a noble example to us – never were people in a greater state of excitement on political grounds than the French at this moment, yet never in our country towns were Assizes conducted with more seriousness and quiet. There is no occasion to make the rabble drunk. All the voters of the little colleges are of the rank of shopkeepers at least, those of the highest are gentlemen – only 20,000 of them out of the 30 millions of

³⁶ D'Aubuisson, as time has shown, foresaw a real danger. The neglect of, if not contempt for, mineralogy, which became conspicuous between the years 1840 and 1870, or thereabouts, seriously impeded the progress of geology, at any rate in England.

³⁷ Life, Letters, and Journals, vol. i. p. 276.

French. They are too many for such jobbing as in a Scotch county, and too independent and rich to have the feelings of a mob."

Yet at the end of this month came the "three days of July"; "perfect order and calmness" were at an end; Charles X. abdicated the throne, and the Bourbons again became exiles from France.

From Toulouse Lyell and his companion journeyed by the banks of the Ariège to the picturesque old town of Foix, and from this place to Ax, a watering-place on one of the tributaries to that river, in the heart of the Pyrenees. His keen eye notes at once the difference between the scenery of this chain and that of the Alps. Apart from the different character of the vegetation – the more luxuriant flora, the extensive forests of beech and oak at elevations where in Switzerland only the pines and larches would flourish – the valleys are narrower, the mountains more precipitous – the scenery, in short, is more like that around Interlaken or in the valley of Lauterbrunnen, without the lakes of the one or the grand background of snowy peaks in the other. In the Pyrenees the inferior height and the more southern position of the chain diminishes the snowfields and curtails the glaciers, so that the torrents run with purer waters, like they do in the Alps about the birthplace of the Po.

In order to acquire a clear idea of the structure of the Pyrenees the travellers crossed from Ax to the southern side of the watershed, though they still remained on French territory; for

here, in the neighbourhood of Andorre, the frontier cuts off the heads of one or two valleys which geographically form part of Spain. Into this country they had purposed to descend, but the obstacles interposed by the reactionary jealousy of local Dogberries and the possible risks from political complications were so great, that they judged it wiser to abandon the attempt. So the travellers separated for a time, Captain Cooke, who feared the heat of the lower country, going eastwards through the curious little mountain republic of Andorre to Luchon; while Lyell, who seems to have been proof against the sun, recrossed the watershed into the valley of the Tet and descended it to Perpignan. Information obtained in this town encouraged him to go direct to Barcelona, where the Captain-General, the Conde D'Espagne, a distinguished soldier and diplomatist, gave him a courteous reception, and did everything in his power to smooth the way for a visit to Olot, a region of extinct volcanoes, which had been one of the chief ends of Lyell's journey. The expedition was successful; he did not fall among thieves, and was only annoyed by the tedious formalities and petty impertinences of the local functionaries of northern Spain; and he returned to France by a pass on the eastern side of the Canigou. He was not a little astonished, as might be expected from the remarks already quoted, when he found on arriving in that country that the reign of the Bourbons and the priests was over, the tricolor flag was hoisted on all the churches, and the royalist officials had been replaced by the nominees of the National Government.

The visit to Olot amply repaid him for the toil and trouble of the journey. An account of the district was inserted in the concluding volume of the "Principles," which was afterwards incorporated into the "Elements of Geology." The following summary is quoted from a letter to Scrope, who had suggested the visit, which was written from Luchon, where he arrived a few days after his return into France³⁸: —

"Like those of the Vivarais [the volcanoes of Catalonia] are all, both cones and craters, subsequent to the existence of the actual hills and dales, or, in other words, no alteration of previously existing levels accompanied or has followed the introduction of the volcanic matter, except such as the matter erupted necessarily occasioned. The cones, at least fourteen of them mostly with craters, stand like Monpezat, and as perfect; the currents flow down where the rivers would be if not displaced. But here, as in the Vivarais, deep sections have been cut through the lava by streams much smaller in general, and at certain points the lava is fairly cut through, and even in two or three cases the subjacent rock. Thus at Castel Follet, a great current near its termination is cut through, and eighty or ninety feet of columnar basalt laid open, resting on an old alluvium, not containing volcanic pebbles; and below that, nummulitic limestone is eroded to the depth of twenty-five feet, the river now being about thirty-five feet lower than when the lava flowed, though most of the old valley is still occupied by the lava current.

³⁸ Life, Letters, and Journals, vol. i. p. 283.

There are about fourteen or perhaps twenty points of eruption without craters. In all cases they burst through secondary limestone and sandstone, no altered rocks thrown up, as far as I could learn, not a dike exposed. A linear direction in the cones and points of eruption from north to south. Until some remains of quadrupeds are found, or other organic medals found, no guess can be made as to their geological date, unless anyone will undertake to say when the valleys of that district were excavated. As to historical dates, that is all a fudge ... I can assure you that there never was an eruption within memory of man."

At Luchon Lyell rejoined Captain Cooke, and they visited one or two interesting spots in the more western part of the Pyrenees, such as the Cirque de Gavarnie and the Brèche de Roland. The former would afford object-lessons on the erosive action of cascades; the latter would set him speculating on the causes which could have fashioned that strange portal in the limestone crest of the mountain. They descended some distance on the Spanish side of the Brèche, in order to make a more complete investigation of the structure of the chain, sleeping at a shepherd's hut and returning across the snowfields next day. It is evident that whenever there was a hope of securing any geological information or of seeing some remarkable aspect of nature, Lyell was almost insensible either to heat or to fatigue.

Towards the middle of September he had reached Bayonne, from which place another very interesting letter is despatched

to Scrope.³⁹ In this he gives suggestions for making a number of experiments in order to produce by artificial means such rock-structures as lamination, ripple-mark, and current-bedding, and describes briefly a series of observations bearing on these questions, which had been carried out both during his late journey and on other occasions. "I have," he says, "for a long time been making minute drawings of the lamination and stratification of beds, in formations of very different ages, first with a view to prove to demonstration that at every epoch the same identical causes were in operation. I was next led in Scotland to a suspicion, since confirmed, that all the minute regularities and irregularities of stratification and lamination were preserved in primary clay-slate, mica-slate, gneiss, etc., showing that they had been subjected to the same general and even accidental circumstances attending the sedimentary accumulation of secondary and fossil-bearing formations.⁴⁰ Lastly, I came to find out that all these various characters were identical with those presented by the bars, deltas, etc., of existing rivers, estuaries, etc."

Early in October Lyell is back again in Paris, to find Louis Philippe seated on the throne in the place of Charles X., and a

³⁹ Life, Letters, and Journals, vol. i. p. 296.

⁴⁰ Subsequent experience has shown that, while the above observations are beyond all question in the case of ordinary sedimentary rocks, structures curiously resembling lamination and ripple-mark may be produced in certain gneisses and crystalline schists by other causes. Still, in many schists, they have originated in the way suggested by Lyell, and indicate that the rock formerly was deposited by water.

war party "praying night and day for the entry of the Prussians into Belgium in the hope of the French being drawn into the affair. A finer opportunity, they say, could not have happened for resuming our natural limits on the Rhine." In the midst of political changes and warlike aspirations geology, he observes, is not making much progress in Paris. Some of the naturalists have "got their heads too full of politics"; others are forced to work as literary hacks in order to live. "Books on natural history and medicine have no sale; there is a demand only for political pamphlets." So Lyell enters into an engagement with Deshayes, who, like so many others, has to live by his pen lest he should starve by science, for "a private course of fossil conchology," and for two months' work after Lyell has returned to England, to be spent in tabulating the species of Tertiary shells in his own (Deshayes') and the other great collections of Paris. "I shall thus," Lyell says, "be giving the subject a decided push by rendering the greater wealth of the French collectors available in illustrating the greater experience of the English geologists in actual observation; for here they sit still and buy shells, and work indoors, as much as we travel." He also remarks to the same correspondent (a sister): "I am nearly sure now that my grand theory of temperature will carry the day... I will treat our geologists with a theory for the newer deposits in next volume, which, although not half so original, will perhaps surprise them more."⁴¹ He was expecting, as another letter shows, to prove the

⁴¹ Life, Letters, and Journals, vol. i. p. 303.

gradual approximation of the fauna preserved in the Tertiary deposits to that which still exists, and to settle, as he hopes "for ever, the question whether species come in all at a batch or are always going out and coming in." Already he is in a position to affirm that the Tertiary formations of Sicily in all probability are more recent than the "crag" of England, for, among the sixty-three species which he had collected from the beds underlying Etna, only three were not known to be still inhabitants of the Mediterranean; and besides this, between these "crag" and the London clay a series of formations can be intercalated. In the same letter (to Scrope)⁴² he states that Deshayes has found, at St. Mihiel on the Meuse, three old needles of limestone, like those in the Isle of Wight, round which run three distinct lines of perforations, like those on the columns of the "Temple of Serapis;" these hollows being "sometimes empty, but thousands of them filled with saxicavas." This, of course, was a proof that there had been, in comparatively recent times, important changes in the level of the land and sea.

Early in November Lyell is back in London, at his chambers in Crown Office Row, Temple, to find that Scrope's review of the first volume of the "Principles" has been much admired, that the book is selling steadily, and is likely to prove "as good as an annuity"; that it has not been seriously attacked by the "Diluvialists," while it has been highly praised by the bulk of geologists. He is about to move, he writes, into chambers in

⁴² *Ut suprà*, p. 305.

Raymond Buildings, Gray's Inn, which are "very light, healthy and good, on the same staircase as Broderip." Invitations to dinner are becoming frequent, but he wisely determines to go but little into society. "All my friends," he says, "who are in practice do this all the year and every year, and I do not see why I should not be privileged, now that I have the moral certainty of earning a small but honourable independence if I labour as hard for the next ten years as during the last three. I was never in better health, rarely so good, and after so long a fallow I feel that a good crop will be yielded and that I am in good train for composition."⁴³ The second volume, he hopes, will be out in six months; this will include the history of the globe to the beginning of the Tertiary era, when the first of existing species appeared.

The next year, 1831, was an epoch marked by more than one change. To take the smallest first, he was made a deputy-lieutenant of the county of Forfar; next, in March, he was elected Professor of Geology at King's College, London, which had been recently founded by members of the Church of England as an educational counterpoise to the University of London (University College). To Lyell himself the appointment was comparatively unimportant, but it indicated that wider views on scientific questions and a more tolerant spirit were gaining ground among the higher ranks of the clergy in the Established Church. The appointment was in the hands, exclusively, of the Archbishop of Canterbury, the Bishops of London and of Llandaff, and

⁴³ Life, Letters, and Journals, vol. i. p. 313.

two "strictly orthodox doctors." Llandaff, Lyell was informed, hesitated, but Conybeare,⁴⁴ though opposed to Lyell's theories, vouched for his orthodoxy. So the prelates declared that they "considered some of my doctrines startling enough, but could not find that they were come by otherwise than in a straightforward manner, and (as I appeared to think) logically deducible from the facts; so that whether the facts were true or not, or my conclusions logical or otherwise, there was no reason to infer that I had made my theory from any hostile feeling towards revelation"⁴⁵— a conclusion, marked by a wise caution, which representatives of the Church of England would have done well to bear in mind on more than one subsequent occasion — such as, for example, when the question of the antiquity of man or that of the origin of species was raised. But supporters of the Church of England may fairly maintain that in difficult crises, especially in those connected with discoveries in science or in history, the utterances of her bishops have been generally cautious and far-seeing; displays of confident ignorance and rash denunciations are more common among the "inferior clergy." As a comment on the moderation indicated by his election, Lyell says that a friend in the United States affirms that there "he could hardly dare to approve of the doctrines even in a review, such a storm would the orthodox raise against him. So much for toleration of

⁴⁴ The Rev. W. D. Conybeare, afterwards Dean of Llandaff, an eminent geologist, rather senior to Lyell.

⁴⁵ Life, Letters, and Journals, vol. i. p. 316.

Church Establishment and No Church Establishment countries." A third event of the year – which also happened in the earlier part of it – was destined to exercise a much more lasting influence upon his life. This was his engagement to Miss Mary Horner, eldest daughter of Mr. Leonard Horner, the younger and hardly less distinguished brother of Francis Horner, who, while almost as enthusiastic a geologist as his future son-in-law, took an active interest in educational questions, and afterwards did public service as Inspector of Factories.

By the middle of June Lyell had advanced as far as page 110 in printing the second volume of the "Principles of Geology," notwithstanding interruptions, such as a visit to Cambridge, where he took an *ad eundem* degree,⁴⁶ and the presence of his father and brother, as well as of his friend Conybeare, in London, all of whom required to be lionised. The letter⁴⁷ (to Mantell) which refers to these impediments, passes abruptly from Fitton's broken arm to the giant femur of a new reptile, and incidentally mentions the discovery of a section which has since become a centre of geological controversy. "Murchison and his wife," he writes, "are gone to make a tour in Wales, where a certain Trimmer has found near Snowdon 'crag' shells at a height of

⁴⁶ It was formerly conceded by the Universities of Oxford, Cambridge, and Dublin that a Master of Arts in any one could assume, under certain conditions, the same position in the others. This carried with it some privileges, though not the suffrage and the full rights of the degree. Lyell had proceeded to the degree of M.A. at Oxford in 1821.

⁴⁷ Life, Letters, and Journals, vol. i. p. 318.

1,000 feet, which Buckland and he convey thither by the deluge." The shells are at an altitude above sea-level considerably higher than Lyell supposed. Moel Tryfaen is a massive, rather outlying hill, about five miles west of the peak of Snowdon, and at about the same distance from the nearest part of the sea-coast. Its bare summit rises gently to a scattered group of projecting crags, the highest of which is 1,401 feet above the sea. On the eastern side are extensive slate quarries, and in working these the shell beds are disclosed a short distance below the summit. They consist of well-stratified sands, with occasional gravelly beds, and contain a fair number of shells, both broken and whole, the fauna being slightly more arctic than that which still inhabits the neighbouring sea. The deposit is now recognised as more recent than the "crag" of East Anglia, for none of the species are extinct, and is assigned to some part of the so-called Glacial Epoch. It was before long regarded as an indication that, at no very remote date after North Wales had assumed or very nearly assumed its present outlines, the whole district was depressed for at least 1,380 feet, so that the sea broke over the summit crags of Moel Tryfaen. For many years this interpretation passed unquestioned; but a modern school of geologists has found it to be such an inconvenient obstacle to certain hypotheses about the former extent of land-ice, that they maintain these shells were collected from the bed of the Irish Sea (then supposed to be above water) by an ice-sheet as it was on its way from the north to invade the Principality, and were conveyed by it, with all care,

up the slopes of Moel Tryfaen, till they were finally deposited on its summit, in beds which somehow or other were stratified. One may venture to doubt whether the hypothesis of a rampant and conchologically-disposed ice-sheet would have found much more favour with the cautiously inductive mind of Lyell than that of a deluge.

Shortly after this letter, Lyell, though all the manuscript of his second volume had not yet been sent to the printers, and proof-sheets followed him, refreshed himself with a tour of four or five weeks in the volcanic district of the Eifel. Here the cones, all comparatively low, are scattered sporadically over a rolling upland which occupies the angle between the Rhine and the Moselle. The valleys for the most part are carved out of slaty rocks much of the same age as those of Devonshire; and the craters, "strange holes, each eruption having been almost invariably at some new point," are now very commonly occupied by quiet pools of water, such as Lyell had already seen in the old volcanic districts of the Papal States. Among these craters, composed sometimes of loose and light scoria, from which no lava-stream ever flowed, he found fresh evidence – as at the Rotherberg – against the diluvian hypothesis. "It is," as he writes to his friend, Dr. Fleming, "one of the ten thousand proofs of the incubus that the Mosaic deluge has been, and is, I fear, long destined to be, on our science. Now, I am fully determined to open my strongest fire against the new diluvial theory of swamping our continents by waves raised

by paroxysmal earthquakes. I can prove by reference to cones (hundreds of uninjured cones) of loose volcanic scoriæ and ashes, of various and some of great antiquity (as proved by associated organic remains), that no such general waves have swept over Europe during the Tertiary era – cones at almost every height, from near the sea, to thousands of feet above it."⁴⁸

⁴⁸ Life, Letters, and Journals, vol. i. p. 328.

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