

carrier must there be above the plane of permanent saturation of the Chalk, but most of our chalk-streams flow at the level of permanent saturation. This plane is not horizontal, the rivers flowing at the bottom of the valleys being at its lowest point, while on each side of the rivers the plane forms an incline towards the higher ground of from about 12 to 24 feet to the mile, varying in different years and at different times of the year. If in this valley the inclination of the surface of the ground did not exceed the inclination of the surface of the underground reservoir, the saturated chalk, the water would flow over the surface at the same time that it was flowing beneath the surface, but much more rapidly, for there is a resistance in the chalk, provided there is no channel or fissure, and it is this resistance, the amount of which is determined by the rapidity with which the chalk can absorb and part with water, which causes the plane of saturation to be inclined from the horizontal.

Water will always try to find its level, but, in the chalk, although always trying to do so, it scarcely ever succeeds, there being, in wet weather at least, a constant accession from above. Thus by the accession of water by percolation from above, and the abstraction by springs, or wells, or by outlet into rivers below, an equilibrium in the plane of saturation is maintained which is represented in this neighbourhood by an angle of at least 12 feet to the mile.

After walking a short distance across the fields the party separated at Battler's Green, some walking to Radlett Station, and others driving to Watford.

EXCURSION TO SOUTH DEVON.

JULY 21ST, AND FIVE FOLLOWING DAYS.

Directors : ARTHUR CHAMPERNOWNE, Esq., M.A., F.G.S.; WILLIAM PENGELLY, Esq., F.R.S., F.G.S.; and RICHARD NICHOLLS WORTH, Esq., F.G.S.

(*Report by* R. N. WORTH, F.G.S., *and* A. CHAMPERNOWNE, F.G.S.)

The district chosen as the scene of the long excursion of 1884 is one of peculiar interest to the geologist. The greater part of South Devon is occupied by rocks of the Devonian system, as generally recognised, and nowhere can the Devonian limestones be studied to better advantage than at Plymouth and Torquay. On the north of the area is the wild granitic expanse of Dartmoor,

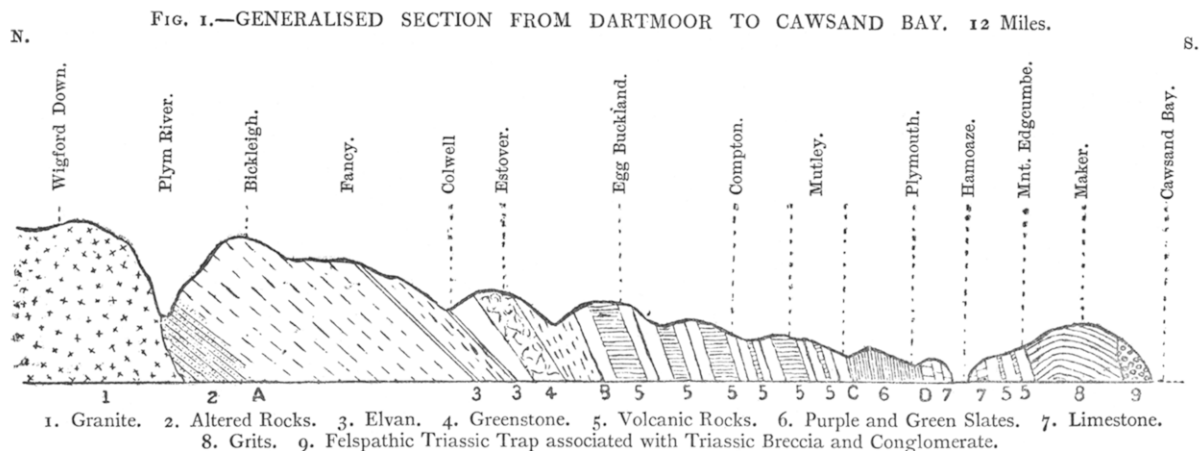
flanked by the rocks of the great Carboniferous trough of Central Devon. On the extreme south lies the Bolt-Head promontory, consisting chiefly of metamorphosed schists which have been variously assigned, and are now suggested as Archæan. The Triassic rocks of the west extend in mass to Torbay, and re-appear as small outliers within the district, at Thurlestone and Cawsand. Associated with the various systems are igneous rocks of singular scientific importance, chief among them the series of which the volcanic peak of Brent Tor forms the most notable feature. The Dartmoor granite is skirted by a belt of altered rocks of a widely varied and highly interesting character; and is intersected by numerous elvan courses and lodes. The recent geology of the area, moreover, is made specially noteworthy by the occurrence of raised beaches, submerged forests, and bone-caves—the latter including the caverns of Oreston, the first that were made the subject of scientific enquiry, and those famous factors in the solution of the question of the antiquity of man—Kent's Hole, and the Brixham Windmill Hill Cave.

Few districts therefore present such attractions to the visiting geologist as South Devon, nor is it at all necessary to enter upon the discussion of the much-vexed "Devonian question" to make a brief excursion in the "far and fair West," alike interesting and instructive. Plymouth was selected as the head-quarters for the week; and the programme was so mapped out as to embrace as many special points as possible—Dartmoor and its borders, however, having chief attention. At Plymouth and its vicinity, the members of the Association were joined by several members of the Plymouth Institution, and at Torquay by members of the Torquay Natural History Society, two provincial scientific associations which have done much to elucidate the problems of the local geology, almost from the very dawn of the science.

Monday.—The business of the meeting commenced on Monday evening, when the Director of the Plymouth district conducted the members of the Association, as soon after their arrival in Plymouth as circumstances permitted, to the famous Hoe, and from that point of vantage called their attention to the leading features of the geology of the country commanded. The summit of the Hoe, he explained, was nearly the central point of the most important development in the Plymouth area of the limestones of South Devon, commonly classed as Middle Devonian. Below, to the north, lay

a mass of shales and slates, in which he recognised three successive divisions—one associated with lodes and elvans; a second largely mixed with interbedded lava and ash beds; and a third composed of more compact slates, purple and green in colour. (Fig. 1). At several points the slates graduated up into the limestones through calcareous shales; but at others there was a band of trap rock in close proximity to the limestone, which occasionally produced alterations in its character. The limestone itself formed a ridge about half-a-mile in width, the upper surface of which had a wall-like or terraced character—a platform of denudation—which was not peculiar, however, to the calcareous beds of Plymouth. Several features in the occurrence of the limestone pointed back to its origin as a fringing coral-reef, and its organic remains were largely disposed, not so much in horizons as in areas—corals, bivalves and univalves having their own associations. Though the limestone band was composed of the hardest rocks in the locality, it was broken through at several points, as where it was passed by the Tamar and the Plym, and at Stonehouse Creek, Mill Bay, and Sutton Pool. These openings, though mainly worn and eroded by subsequent causes, originated, he believed, in the operation of forces which had greatly disturbed the strata to the south. The depth of the river-channels within the limestone was remarkable. At Laira Bridge the bed of the rock was 80ft. below high-water mark; but immediately adjacent to the Hoe there was a depth of over 160ft; in fact, it was precisely within the limits of the limestone that the greatest depths in the harbour and its branches were to be found.

As the main characteristic of the rocks directly north of the limestone was slate, so that of the rocks immediately to the south was sandstone. The twin elevations of Staddon and Maker Heights, east and west of Plymouth Sound respectively, were composed of red and grey Devonian sandstones and grits, which the Director was inclined to correlate with those of Pickwell Down in North Devon. Associated with them were some patches of highly fossiliferous shales. These southern grits and their connected slates were much contorted and disturbed; in fact, Professor Phillips had called the contortions at Staddon “amazing,” and Professor Jukes, while giving up their solution as hopeless in the time at his disposal, suggested that possibly these apparently overlying rocks might be really underlying, and brought up by an anticlinal accompanied by inversion and contortion. This view the Director did not accept.



The rocks from the moor to the sea generally dip southward at angles increasing from the granite; northerly dips are few, but there are frequent repetitions which can only be worked out satisfactorily by very detailed mapping.

A to B, Buckland and Bickleigh beds. The lowest group of the Plymouth series, gray and drab slates with lodes and elvans, probably to be correlated with the Combe Martin of North Devon.

B to C, Weston and Compton beds. Slates with interbedded volcanic matters in great variety—lavas and ashes and slaggy rocks, often graduating into the shales. There is unquestionably much repetition here, and Mr. Rutley's suggested identification of the volcanic rocks with those of Brent Tor seems highly probable.

C to D, Mutley beds—frequent repetitions.

The limestone rocks contain bone caves. The lava and ash beds at Mount Edgcumbe are associated as in B to C with shales; and the grits, which seem to correspond with the Pickwell Down sandstones, are much disturbed by some cause near at hand.

The existence of granitic rocks in the Channel area have been shown by Mr. A. Roope Hunt, F.G.S.; and the Eddystone Reef is a typical gneiss; while there is evidence that the Shovel Reef in Plymouth Sound is in part gneissic also.

The displacements of the rocks on the west of the Sound were partially caused by the occurrence of a mass of intrusive Triassic trap, which was associated with a patch of Triassic breccia and conglomerate, the most westerly outlier of the Trias in the country. The contortions on the east of the Sound were, however, more marked, and accompanied by what seemed traces of metamorphism. This was possibly to be connected with the fact that the Channel contained a large submarine area of granitic or granitoid rocks. The Eddystone reef, the lighthouse crowning which was seen on the horizon, was a mass of gneiss and allied rocks, and there was some evidence that these rocks extended into Plymouth Sound, and formed part of the Shovel Reef, on which the Breakwater was built.

Turning to more recent geographical phenomena, the Director pointed out the limestone quarries at Oreston, where, in 1816, the first bone-cave which was made the subject of scientific enquiry was found. Fissures on the Hoe had also proved ossiferous. Besides this they had, contiguous to the Hoe, at Sandycove, in Millbay, the remains of a submarine forest, and on the Hoe itself was one of the finest examples of a raised beach in the country. By a fortunate coincidence, after having been hidden for some 40 years, the beach had again been exposed within the past few weeks. At the finest section there were 18 distinct beds of sand and pebbles, between the bouldered rock-masses which lay immediately above the limestone shelf on which the beach rested and the head of surface soil. The beach had been confounded with a totally distinct set of deposits on the top of the Hoe, and at other points on the limestone plateau. Huge cavities or pockets in the limestone were filled with sand and clay and water-worn stones, and it was assumed that these alluvia and the beach were identical. One suggestion was that they were both "Northern Drift." No geologist, however, who had ever examined the two could confound them. The summit and fissure beds were distinctly alluvial, the high-level deposit of an ancient river. Their character, moreover, was well marked. The clay occurred in patches, mingled with veins and beds of sand. The pebbles ranged from a very small size up to a dozen pounds in weight. They were chiefly quartzose, some schorlaceous, a few granitic or granitoid, some of a dark hard hornblendic or altered slate. An occasional pebble of trap or basalt, and a few flints (Greensand?) also occurred.

The raised beach possessed no single one of these characteristics.

There was no clay, the sand was of a totally distinct nature and origin, and the pebbles, instead of having been derived from a distance, were wholly composed of the rocks at present exposed on the shores of the Sound. The most remarkable feature was that limestone *débris* was scarce, and that the material had evidently come from the westward. The Triassic trap of Cawsand was, as a rule, the rock most largely represented; while one boulder of a least two hundred-weights came from a Devonian trap exposure at Drake's Island. All this pointed to a very different contour of the Sound at the raised beach period than that which would *prima facie* have been anticipated.

The raised beach, so fortunately recovered to sight, having been inspected with much interest, forming quite an unexpected treat to the bulk of the company, the party proceeded by boat to Deadman's-Bay quarry, which had been chosen by the Director as illustrative of the Cattedown limestone quarries, not only because it was the nearest of the series, but because of the peculiarities of stratification which it presented, some of the beds being approximately horizontal and others nearly vertical, as opposed to the usual southerly dip, and others again being faulted, while the crest of the quarry showed the shallow Cattedown synclinal to great advantage. By way of illustrating the character of the alluvial deposits described in connection with the Hoe, and the absolute dissimilarity between them and the raised beach, the Director called attention to a great fissure or pocket, the side of which had been opened out in some of the older workings, and identified some of the pebbles dug out as belonging to rocks of the Dartmoor border series. The President called the special attention of the younger members of the party to the beautiful illustrations of stratification presented; and the weathered corals with which the older portions of the quarry abound were much admired.

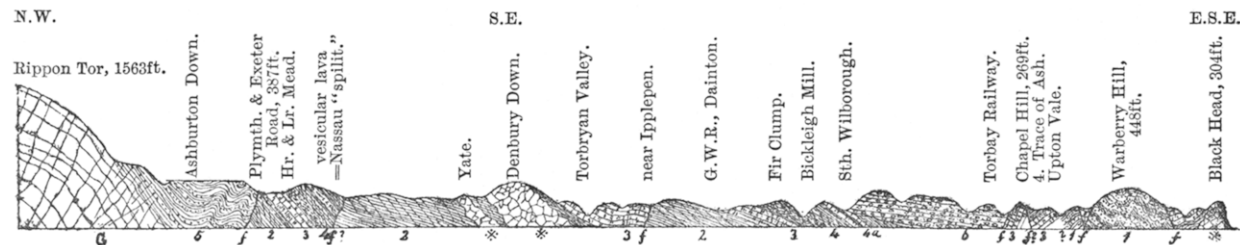
The evening was wound up in the Museum of the Plymouth Institution, the Council of which had invited the members of the Association to a *conversazione*. The President of the Institution (D. Slater, Esq., M.A.) gave the visitors a very hearty welcome, expressing the hope that they would be so pleased with their visit that before long they would come again. The Plymouth Institution had been founded more than 70 years, for the promotion of science, literature, and art; and 30 years since the Devon and Cornwall Natural History Society was incorporated with it, as it was thought the objects of both Societies could better be attained

by amalgamation. The numbers had never reached so high a figure as the Association roll, yet they had always had some members enthusiastically devoted to the study of geology. He really envied his friends the pleasure they would enjoy if favoured with fine weather, and he hoped the excursion would prove successful in every respect ; and that the united labour of all would tend to the furtherance of their great object—the extension of geological knowledge.

The President (Dr. Hicks), in thanking the Institution for its hearty welcome, said : “ It is one of the pleasantest features of our excursions that we are universally welcomed, a fact which shows the universality of the appreciation of science. We have come down here entirely to learn, to get information concerning this neighbourhood. Many of us know little of the geology of the neighbourhood except from books. We have come also to admire the beautiful scenery of the county. Of course the duty of the geologist is to unravel the history of the past from the features of the country he sees around him. The attempt to do this in Devonshire has been made on many occasions before, but there is yet much to learn, and I hope that an institution like this will be the means of stirring up many young men who will add to science fresh victories, to join Mr. Worth in pursuing this study locally. Mr. Webb has handed to me a specimen of the rock upon which the Eddystone Lighthouse stands. That rock is Archæan, and shows that we are right in supposing that out by the Eddystone and nearer the shore in your Sound, there are remains of the Archæan continent, which was the first formation of the globe we live in. One cannot wish anything better than that some of your members should take up such studies as these. Every movement that takes place in the earth is a kind of history. You may unravel the history of your own country, but how many countries are there whose histories are, as it were, under our feet. These are the foundations on which we stand, and we must, with your assistance, unravel in this way the history of this portion of Europe. I feel sure that before we leave this county we shall learn very much indeed from your eminent Devonshire geologists. Without the assistance of their local knowledge it would be impossible for us to do much, and the men who have local knowledge and love for the science, and who pursue it for its own sake, are the men we look to as guides this week, for the instruction we hope to receive, and for the information we hope to carry away.”

FIG. 2.—SECTION FROM RIPPON TOR, DARTMOOR, THROUGH DENBURY DOWN TO THE BLACK HEAD, TORQUAY.

About fifteen miles. Vertical scale exaggerated.



- | | | | |
|----------------|---|--|---|
| Upper Devonian | { | 6. Triassic breccio-conglomerates. | 3. Middle Devonian limestone (Stringocephalus beds). |
| | | 5. Culm series; shales, sandstones, and black cherts.† | 2. Clay-slates, locally purple and green, fossils rare, no grits. |
| | | 4A. Bands of red limestone and shales.‡ | 1. Lower Devonian; tough grauwacke grits and sandy schistose beds (fossils of "Spiriferen-sandstein," notably <i>Homalonoti</i> and <i>Pleurodictyum</i>). |
| | | 4. Diabase tuffs, schalstein, &c., with nodular shale and coarse slate.* | |
- * Eruptive rocks. G, Granite. f, Faults.

† Group 5 rests unconformably on 3 and 4 within a mile north of the middle of the section.

‡ On the same horizon as the Ramsleigh reef-limestone (calcaires de Frasnes).

* Equivalent to Sandberger's "Diabas-gesteine der Mittleren und oberen Gruppe."

The Museum, which has been recently built, is a very fine room ; and contains a large and good local geological collection. Among the more notable features are some of the original specimens by which the Rev. R. Hennah established the fossiliferous character of the lime rocks of Plymouth, and a fine suite of Carboniferous fossils from North Devon, presented many years ago by General Harding. All the bone caves of Devon have contributed to the collection—from the discoveries of Whidby at Oreston ; Northmore and McEnergy at Kent's Hole ; Moore at the Hoe, and Bellamy at Yealmpton, to the more modern results of investigation by Mr. Spence Bate at Stonehouse, and the Director's own discoveries at Stonehouse and Pomphlet.

Tuesday.—The following day was devoted to Totnes and Dartington, the geological director for the day being Mr. A. Champernowne, F.G.S. Leaving Plymouth by train at 8.35 a.m. a halt was made at Totnes, where the visitors were welcomed by various members of the Corporation, to inspect the antiquities of that notable old town, under the guidance of Messrs T. C. Kellock and Edward Windeatt. The castle, church, walls, and gates, the remains of the Priory, the ancient Guildhall, and last, not least, the quaint piazzas—which, if at some distance, never fail to recall Chester to those who are familiar with the “rows”—each and all lent their quota of interest.

From Totnes the party walked to Dartington Hall, the seat of the Director, a distance of two miles. The earliest records of Dartington relate to the time of Edward the Confessor, for from Domesday Book we learn that “Alwin held it in his time.” At the actual time of the Domesday Survey (1086) we have “William de Falaise holds Dertrintone, Cockington, Rattrew, and other manors. . . .” Shortly after this Robert, son of Martin de Turonibus (de Tours), Lord of Ceamois, in Wales, and of Combe Martin and Martinhoe in North Devon, became possessed of this and the other lands formerly held by William de Falaise in this county, and the place remained in this line eight descents.

In the 19th year of King Edward II., William, Lord Martin, who was a Parliamentary Baron, was holding Dartington, and on his death, without issue, it devolved to James, Lord Audelegh, his nephew, who afterwards became famed in the battle of Poitiers, and what share in the victory the Black Prince attributed to his valour is quaintly told in Prince's ‘Worthies of Devon,’ p. 14.

Dartington was not long in the Audeleghs' hands, and on the death of James, Lord Audelegh, without issue male, escheated to the Crown. Lysons, referring to the Patent Rolls, mentions that in 1385 King Richard II. "granted it with other manors to Robert de Vere, till he should have conquered Ireland and kept it in peace." This was probably a mere temporary holding, for we know that subsequently the King granted it to his half-brother, John Holland, Earl of Huntingdon and Duke of Exeter, who built the great hall, kitchen, and dependent buildings. The central boss of the hall porch carries the cognizance of Richard II., the rose of York with the white hart couchant. The hall, in the Early Perpendicular style, measures 69ft. by 37ft., and about 50ft. in height. The roof was taken down in 1805.

On the death of John, second Duke of Exeter (13 Edw. IV., 1473), the lands escheated to the Crown, and Margaret, Countess of Richmond, had a grant of it for life in 1487. The land continued in the Crown until one Ailworth, of London, bought it, and exchanged ("as I have heard" says Sir William Pole in his 'History of Devonshire,' p. 296) for the Abbey site of Polsloe, near Exeter, with Sir Arthur Champernon, the younger son of Sir Philip Champernon, of Modbury, who made it the place of his dwelling. A monument in the old church tower, bearing date 1578, is to his memory. Since that time Dartington has continued in this family.

This place is situated on a varied group of the Devonian system which clearly succeeds the Middle Devonian limestone in ascending order, and the principal rock exposures in this depressed and faulted district were shown and explained by the Director as well as the time and difficult stratigraphy would permit. (See figs. 3 and 4.)

But it may be well, before describing the route to say a few words on the country extending eastwards, and slightly exceeding the area studied. A key to this broken bit of country is found in the fact that the slates which on the Dart about North wood and Staverton are seen to dip under the limestone, again reach the surface at Bunker's Hill, north-east of Totnes, forming a low dome-shaped elevation, from which, on three-quarters of its circumference, the limestones have a quâquâversal dip. The south-western continuation appears to be interrupted by the down-thrown upper beds. Dr. Holl ('Quart. Journ. Geol. Soc.,' 1868, p. 430) recognised the fact that "all the slaty rocks between the

FIG. 3.—GEOLOGICAL SKETCH-MAP (11 SQ. M.) NEAR TOTNES.

(From a Drawing by A. CHAMPERNOWNE, F.G.S.)



Scale—1 inch to a mile.

- } Alluvium.
- } Terraces (more or less distinct) with older Dart gravels.
- { Berry Park and Upper Dartington slaty shales, succeeded by purple grits farther eastwards.
- { Middle Devonian limestone; and subordinate layers both above and below.
- } All the slaty rocks below the Dartington limestone.
- } Contemporaneous igneous rocks of all kinds.
- } Eruptive igneous rocks (dolerite, &c.).
- } Mostly faults, a few doubtful boundaries.

The queries (?) indicate some doubt as to which of the slaty masses the beds belong.

A. B. Line of accompanying section (fig. 4.)

1. Totnes. 2. Totnes Station. 3. Dartington Hall. 4. Little Hempston.
5. Staverton. 6. Church. 7. Belleigh. 8. Berry Pomeroy.

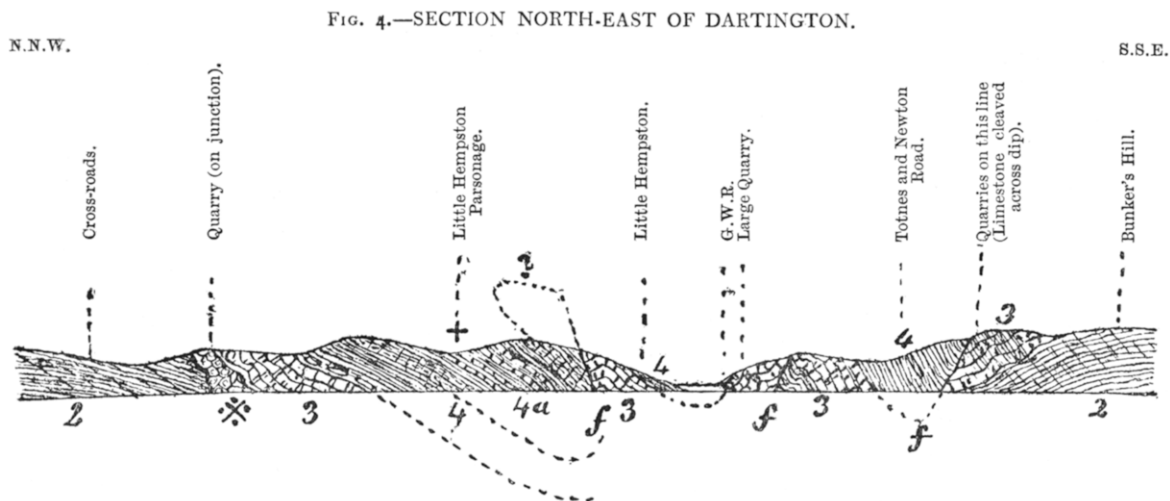
Buckyatt limestone and Gatcombe House," in other words the Dartington and Little Hempston trough, "are above the limestones," but in the following paragraph he expressed great doubts as to the slates between Bunker's Hill and Berry Pomeroy. As to the latter the writer has not experienced this difficulty, notwithstanding some conflicting evidence from cleavage alluded to by Dr. Holl. They are below the limestones, as the section (Fig. 4) shows.

The Berry Pomeroy limestone thus thrown off on the east of Bunker's Hill is overlain by the Berry Park slates, the equivalent of the upper Dartington beds (*Streptorhynchus umbraculum*, Schloth., being common as a cast), and these in turn are surmounted by a series of purple and grey grits and slates, which form the highest ground between the Dart and Torbay, viz., Westerland Beacon on the north, and Windmill Hill on the south of the Paignton Trias, which thus lies in a hollow. The grits are the same as those of Staddon Heights and Mount Edgecumbe in Plymouth Sound, and doubtless also of the Pickwell Down beds in North Devon, of the Psammites Du Condroz in Belgium, and by probable inference, not perhaps the most satisfactory means, they would represent generally (both stratigraphically and lithologically) parts of the Upper Old Red Sandstone.

To return to the upper Dartington beds—the walk before luncheon was taken across the inverted side of the trough to Hillpark quarry, where some beds made up of corals were pointed out. Thence, turning north and crossing a N.W. and S.E. fault to its upcast side, an exposure of coarse volcanic tuff passing into an ashy slate was seen. The tuff is chiefly made up of slaty-looking fragments, broken and kaolinized felspar crystals and a few quartz grains. This description might pass for a grit; Mr. Rutley, however, having examined microscopic sections, has given his opinion in favour of its volcanic origin, for which in the field it would readily be put down. Some of the Nassau schalsteins come very close.

The limestone, not well exposed, was then crossed, and an eruptive rock forming the hill crowned by the old keeper's lodge was inspected. It would be premature to assign a name to this rock, which is heavy, abounds in iron pyrites, and, from the sub-translucent aspect of its felspar, was regarded by some of the party as probably less basic than many of the "greenstones" of the neighbourhood.

Thence, recrossing the above-named fault and a corner of the limestone, the escarpment of the upper group was surmounted to



N.B.—The fault west of Little Hempston is a genuine reversed fault, having under the upcast, it is exposed in the railway cutting on east bank of the Dart opposite Dartington.

the Trigonometrical station, where a good view was obtained, and the features indicating the various outcrops pointed out. The ridge was followed to the higher entrance, where the tuff beds are well exposed. A bed containing casts of *Pachypora*, *Cyathophylla*, and *Brachiopoda* was shown, the fossils proving its sedimentary origin. Towards the axis of the trough, a little above the tuff beds, there are many layers of blue limestone, which were pointed out close to the farm entrance, intercalated with slaty shale; the same appear at Little Hempston Parsonage, north-east of the Dart.

After luncheon at Dartington Hall, the next point was Pit-park quarry, in the higher beds of the Middle Devonian limestone, here much dolomitized and disintegrated. One bed, four feet thick, is remarkable for its profusion of Stromatoporoids, and has been alluded to elsewhere. ('Quart. Journ. Geol. Soc.,' 1879, p. 67).

To give an idea of the richness of this spot the following imperfect list is appended:—

Stringocephalus Burtini, Defr. (rare).

Spiriferina cristata (var. *octoplicata*), Schloth.

Cyrtina heteroclita, Dav.

Atrypa reticularis, Linn.

„ *aspera*, Schloth.

Rhynchonella primipilaris, V. Buch.

Hexacrinus (pelvic plates and stems), rare.

Cyathocrinus geometricus, Goldf. (plates), very rare.

Pachypora cervicornis, Blainv.

Alveolites suborbicularis, Lam.

„ *Battersbyi*, Edw. and Haime.

„ sp. (thin expanded form, with very oblique calices.)

Heliolites porosa, Goldf.

Cyathophyllum Dammoniense, Lonsd.

„ *obtortum*, Edw. and Haime.

Heliophyllum, sp.

Zaphrentis, sp.

Cystiphyllum vesiculosum, Goldf.

Stromatopora concentrica, Goldf.

„ sp. nov.

Pachystroma (at least four species, including *S. Dartingtonensis*), Carter.

Caunopora placenta, Lonsd.

The Brachiopoda are scarce, but the above-named forms have been identified by Dr. Davidson.

Shinner's Bridge quarry, in the lower portion, of nearly black fossiliferous limestone, had a few minutes' inspection, and then to complete the programme the eruptive rock of Yarner Beacon was visited; the soft slates which underlie the limestone being exposed midway. A small piece of fresh rock had been previously opened in an orchard. The rock may be considered a dolerite, consisting of labradorite, augite, viridite and magnetite, or ilmenite.

A break met the party at Lownard Cross, and took them to Totnes Station in time for the 6.39 train to Plymouth, the round, walking and driving, having been about seven miles.

Wednesday.—Torquay, also reached by railway, was the scene of the pleasant labours of the Wednesday, and very fortunate were the members in being placed under the direction of Mr. W. Pengelly, F.R.S., F.G.S., whose labours have made Torquay classical ground with the student of geology. All things considered, no one locality in Devon presents so many and such varied features of geological interest, and no one is at once so familiar with the phenomena of the district, and has so thoroughly worked out all its problems, which are neither few nor light, as Mr. Pengelly. Not merely are the Devonian limestones to be studied there to excellent advantage, but the Triassic series (it was in the "red rocks" here that the curious beekites were first found), and all the leading features of the more recent geological phenomena of the county—cavern deposits, raised beaches, and submerged forests. Mr. Pengelly had arranged his route so as to enable the visitors to see all that could possibly be seen in the time at their disposal. Starting from the Torquay railway station, the coast was skirted to Hope's Nose, the northern horn of Torquay, the chief objects of interest to be noted *en route* being the submerged forest on Torre Abbey sands, which has yielded not only relics of the mammoth, but evidence of man's contemporaneity in implements of deer horn and of flint; the place of junction of the Trias and Devonian limestone, the finest illustration of which, however, is that in Babbacombe Bay; the contortions in the limestone at Torquay; the slaty cleavage at Meadfoot; the contorted and cleaved limestone near Hope's Nose, and the raised beach on that headland, first described by the late lamented Godwin-Austen.

The visit to Kent's Hole, which was planned to succeed the stratigraphical work of the day, was, however, the most anxiously

anticipated item; and this famous cavern was never visited by a more interested party. Its recorded history, if inscriptions may be taken as a starting point, dates for some three centuries; but of how many myriads of years it has been proved to contain the record who can say? Its exploration by the British Association, under the direction as secretary of Mr. Pengelly, has made it the most famous cavern, scientifically speaking, in the whole world. It has yielded thousands upon thousands of relics of the highest interest and value in relation to the conditions of existence of early man and of now extinct mammalia, and it has given birth to a veritable library of descriptive and controversial literature. Had its original investigators, Mr. Northmore and Mr. McEnery, or, at any rate, the latter, had their minds fully receptive to the evidence it afforded, the question of the high antiquity of man would have been probably settled half a century since; but here, as at Oreston, direct evidence was either ignored or destroyed, because it conflicted with preconceived opinions; and thus it was the Windmill Hill-Cavern at Brixham, and not Kent's Hole, that led the way in establishing the contemporaneity of man with the mammoth and its associates. To be able to visit such a famous charnel and record chamber of the geological past as Kent's Cavern has proved, under the guidance of such a renowned cavern-haunter as Mr. Pengelly, who has literally spent whole years of his life in its service, and in investigating and setting forth its characteristics, was a scientific treat of no small moment; and so the members of the Association thought, especially as they were invited to follow it, as time might permit, by an inspection of the finest series of the mammalian and human industrial remains which the cavern has yielded, in the museum of the Torquay Natural History Society.

Thursday.—This morning the party again passed under the charge of the Plymouth Director, and so continued for the remainder of the excursion. The purlieus of Dartmoor were visited, with the special object of studying the bordering granitic and allied rocks and the altered Devonians skirting them. The nearest station to the Moor from Plymouth is Bickleigh; and hence the party had to make a sturdy tramp of well nigh a dozen miles across country to Dousland Barn, where the train was again available for the return journey.

On the way to Bickleigh such of the geological features of the Plym Vale as could be seen from the train were pointed out,

including the Cann Elvan ; and on alighting, before descending into the vale, a few remarks were made on the general characteristics of the Moor. Special attention was called to the plainness with which the line of junction between the granite and the slate on the face of Shaugh Hill could be traced, by their contrasted rugged and smooth surfaces. The walk to Shaugh Bridge, with its flashing rivers, ancient oaks, and towering crag of semi-columnar granite—the Dewerstone—was delightedly enjoyed. Here the real work of the day commenced. Wigford Down, on the north-west flank of which the Dewerstone rises in all its massive grandeur, projects into the Devonian area peninsular fashion, and is bordered on three sides by rocks, which display in varying degree important illustrations of contact metamorphism. The micaceous schists of Meavy and of Shaugh are brought prominently into notice in the well-known Report of the indefatigable De la Beche ; but he does not pursue the subject into its minuter details, and indicate the different gradations by which the alteration dies away as we remove from the edge of the granite ; nor does he define precisely the extent of the zone of alteration. To do more than he did was, however, impossible at the time, and under the conditions on which his work was carried on, and later geologists have enjoyed many facilities which to him were unknown. The altered rocks are now clearly traceable, from their contact with the granite as well-defined micaceous schist—in patches almost gneissic in character—through andalusite schists of varying degrees of “spottiness,” until the last indication of change is seen in a slight silkiness of texture which has still its variations and its stages. In the neighbourhood of Ivybridge the andalusite appears more in the form of chiastolite ; but chiastolite characters are less distinctly seen on this extreme western edge of the Moor ; while in some of the altered schists of Cornwood, andalusite is developed more strongly than at any other point.

The Director first led the party to an old quarry, which afforded the best available exposure of the altered rocks on their outer verge, and in which the sericitic schists were admirably represented. Thence he made a traverse up the hill to the granite, pointing out the evidence afforded of increasing metamorphism until—in actual contact with the granite—there was found highly micaceous schist passing into a compact felsitic rock of very unusual character.

A rugged walk along the hill-side, thickly strewn with weathered

granite boulders, brought the party to the little village of Shaugh. This was the only "refreshment station" on the route; and here, therefore, a welcome halt was called. From Shaugh the road was followed by the northern flank of the long ridge of Saddleborough to Cadover Bridge; some large blocks of schorlite yielding to the hammer *en route* interesting specimens of achroite and epidote. Cadover Bridge lies in the heart of a characteristic stretch of wild moorland scenery. Here the Director pointed out the obscure remains of an old "streamer's" settlement, and the line of ancient tin streaming works, traces of which abound in the valley of the Plym, was indicated. Attention was also called to the relics of an ancient hut and enclosures at Trowlesworthy, as probably the vestiges of the original "houseplace" of the old Saxon who gave to this particular "worthy," or farm, his name. Cadover was explained to mean not the "bridge over the Cad," which it was not, the river being the Plym, but "Coed worthy," the *weorthig* or farm in the wood; and "Shell Top" (1,600 ft.) had attention directed to it as the highest point in the locality.

Of schorl rocks, granites, and elvans there is a greater variety to be found in the valley of the Plym than at any other point of the moorland. The quarries at the Dewerstone are of an average-grained grey granite of ordinary type; but veins of fine-grained and coloured granites are of common occurrence, and Trowlesworthy Tor contains the finest red granite in mass in the country, granite that can hold its own with the very finest Scotch. Trowlesworthy, too, has yielded that most beautiful of all Devonian rocks, Trowlesworthite, discovered last year by the Director. Moreover, there is much variety in the felsitic porphyries, or elvans, of the district, some of which have almost the fineness of grain and purity of colour of statuary marble, while another marked variety is a peculiar flesh colour dotted by nests of schorl. The bed of the Plym at Cadover yielded a large number of interesting petrological specimens to the researches of the members, and a brief halt there was well repaid.

From Cadover the route lay over Ringmore Down to the sequestered village of Sheepstor. On the road some abandoned china-clay pits, or "stopes," as they are locally called, were examined, to illustrate the kaolinised granite *in situ*. Crossing Ringmore, the altered rocks were seen to correspond in character with those at Shaugh; and a fine porphyritic elvan, hitherto unmapped, was discovered traversing the Devonians.

From the descent into the valley, the grand old hill of Sheepstor and its "clatter"—a confused stretch of granite blocks which tells the tale of long ages of atmospheric waste—were seen to the best advantage, under the most brilliant effects of light and shade, and Dousland Barn was reached, after what all the party declared had been quite an exhilarating and in no way a tiring walk—so invigorating was the fresh mountain air—soon enough to refresh before taking the rail on the return journey. In every respect the day proved most successful, and the arrangements made secured all that was either wished for, or hoped. Save a passing shower, the weather was delightful.

Friday.—This day was set apart for a visit to the volcanic centre of Brent Tor, Lydford being selected as the outward railway station and Mary Tavy as the homeward. A mile from Lydford junction is one of the most remarkable features of Devonian scenery, the picturesque Gorge, through which the Lyd brawls its way. The Gorge is within the grounds of Daniel Radford, Esq., who has made its inmost recesses accessible, and, with his ever-ready courtesy, he invited the Association to pay it a visit. On leaving the train, therefore, the party were conducted direct to Lydford Bridge, where they were admitted to the depths of this famous recess. Regarding this historic cleft as a fault fissure, or shake, worn into its present configuration by the action of the river, the Director showed that it did not stand alone, but was part of a network of ravines by which Lydford was so hemmed in that it could be approached from its own level on the moorland at one point only. Moreover, the Gorge, though the most beautiful and striking, was not the most prominent feature in the configuration of the locality. As to the strata, though he did not care to commit himself to a definite opinion, he saw as yet no reason to doubt the correctness of their assignment to the Carboniferous. The party were enthusiastic in their admiration of the Gorge, which was pronounced unsurpassed in its way as an example of erosive action, and the President, accepting the Director's view of the initiation of the fissure, pointed out that its present configuration was due to the cross-jointing of the rocks, which afforded points of lesser resistance, and thus allowed the water to scoop out peculiar pot-hollows, as shown, not only at its bottom, but on its sides. A more beautiful illustration he had never seen, and it alone was well worth the whole excursion. Near the Gorge the keen eye of Dr. Hicks detected a small dyke, which turned out to have been altered into a chloritic mineral.

Mr. Radford having been heartily thanked for his kindness, the start for Brent Tor was made, with a halt for refreshments immediately before commencing the stiff up-hill pull of nearly three miles from the railway level to the quaint church-crowned peak. There was, not unnaturally, a good deal of straggling, and the President and Director were the last of the party to enjoy the magnificent view from the summit. Their time had not, however, been wasted, for traces of organic remains had at last been found in the slates of the neighbourhood, and some evidence afforded that the rocks whence the Tor rises were not Carboniferous. The stone heaps of the roadside afforded some very good specimens of porcellanite, from quarries at the junction with the slates of the gabbro and allied rocks which form a belt by Smear Down, White Tor, and Cocks Tor.

Brent Tor has attracted notice from the very earliest dawn of geological science. Its peculiar peak, which, in ancient times, caused it to be selected as the site of its odd little church, and which has connected its history with myth and legend, has always given it a character of its own among Devonian heights. Sir Henry de la Beche was the first observer to form an unequivocal opinion as to its volcanic origin, for, in his Report, he remarks:—"The idea that in the vicinity of Brent Tor, a volcano had been in action, producing effects similar to those produced by active volcanoes from a similarity of causes, forcibly presents itself. That this volcano ejected ashes, which, falling into adjacent water, became interstratified with the mud, silt, and sand there depositing, seems probable. That greenstones and other solid trappean rocks constituted the lavas of that period and locality, seems also a reasonable hypothesis. Upon the whole, there seems as good evidence as could be expected, that to the north and north-west of Tavistock, ash, cinders, and liquid melted rocks were ejected, and became intermingled with mud, silt, and sand, during this geological epoch, corresponding with the phenomena exhibited in connection with volcanoes of the present day."

One of the Memoirs of the Geological Survey is devoted to the "Eruptive Rocks of Brent Tor and its Neighbourhood." In this work Mr. Frank Rutley, F.G.S., took up the record of this volcano from the petrological side, and came to some very important conclusions. Sections were cut of all the leading varieties of rock, and examined microscopically, the result being their identification as distinctly volcanic—pumice breccia, rhyolitic breccia. devitrified

rhyolite, scoriaceous lava, decomposed basalt lava, pitchstone, and various forms of basalt in different stages of alteration. Mr. Rutley likewise examined the eruptive rocks of the district generally, and identified amphibolite bordering the granite of Brazen Tor, gabbro at White Tor, Smear Ridge, and Cocks Tor, schistose ash at Kilworthy, Hurdwick, and Milton Abbot, amygdaloidal ash (schalstein) at Churlhanger, and decomposed greenstone at Greston Bridge.

This monograph, however, does not contain Mr. Rutley's last published views as to the stratigraphical relations of the Brent Tor volcanic series. These are to be found in a paper read before the Geological Society. Here he points out the downthrow of the existing portion of the old volcano between two faults; that by far the greater portion of the cone has been long since removed by denudation; and that a considerable portion of the downcast must also have disappeared, leaving what is by comparison a mere mole hill. The most important suggestions in this paper, however, are based upon lithological similarity between Brent Tor rocks and schistose lavas and ashes of the Saltash district. These, he suggests, may belong to the same series, from which it follows either that the Saltash rocks are wrongly classed as Devonian, or the rocks around Brent Tor as Carboniferous; but there seems no doubt whatever that the Saltash rocks are Devonian; and the Director, in explaining these points, stated that any argument based upon the volcanic rocks of the Saltash area must apply also to those of the Plymouth district, into and through which the trappean bands of the Saltash area continue.

The Tor having supplied the wallets of the collectors with characteristic examples of its various rocks, it was descended with regret, and the road taken across bleak Black Down—where bands of grit, interstratified with the slates, were detected by the President—to Wheal Friendship copper mine. The character of mining operations was here explained in such detail as time allowed, and a hunt in the “burrows” resulted in the discovery and annexation of some interesting mineral specimens. Among the rarer species was allophane; and a beautifully crystallized mineral, lining some cavities in a block of quartz, which at first rather puzzled the mineralogists, but was at length unanimously pronounced by them celestine. The visit to the mine brought the work of the day to a close, and the station was speedily reached. The walk had been long, but full of interest and pleasure, and the Director remarked that the weather was the most perfect he had ever known in that locality.

Saturday.—On this day the excursion was brought to a close with a visit to the great China-clay works at Lee Moor, near Plymouth, on the kind invitation of W. L. Martin, Esq. The party drove to the moor through a delightful country, and all that was wanted was fine weather. Having been most propitious, however, all the week, the elements were now determined on a change, and the round of the works was made in a drenching shower, cheerfully endured.

The decomposed felspar which, when washed, constitutes the China Clay of commerce, is worked at Lee Moor in a huge excavation, over 120 feet in depth, scarring the face of the hill for a considerable distance. Originally this pit was worked very shallow, and the water carrying the clay washed down from its sides to the depositing pits had to be pumped up. By driving an "adit" level from a lower point in the face of the hill, a distance of about half a mile, the depth to which the pit can be worked by gravitation has been so increased that the Lee Moor works are now the most extensive in the country. This adit, although worked on continuously night and day by three gangs (locally "cores") of men, took nine years to execute. Some of it was through exceedingly hard ground; some (and this gave the most trouble) through very loose ground. For a considerable distance it followed the line of a "flookan" or cross-course, which extends from end to end of the pit, and seems now as if it had reached a termination—if so, a very remarkable fact. In the course of driving the level several interesting minerals were found, and Mr. Martin thoughtfully had a series of these arranged for the inspection of his visitors. They included beautiful specimens of opal and jasper, an example of torbanite, and magnificent crystals and stones of tin, found at the intersections of some lodes and the cross-course. Although there are several lodes in the sett, the quantity of tin they contain is so small that Mr. Martin was perfectly astonished at the amount of work the old tanners must have done on that very spot, for what must have been very meagre results. The inspection of the pit section proved a matter of great interest, not only from the illustration of the way in which the clay was wrought by the operation of judiciously directed streams of water down the faces of the stopes, but from a scientific point of view. The various lodes were clearly seen traversing the faces of the huge excavation, with the course of the flookan, and its effect in "heaving" the lodes. One lode had been carried some distance along with the flookan before it

started on its own course again. Mr. Martin also showed the position of the best runs of clay and their peculiar relation to the lodes and cross-course. From the pit the party were conducted to a spot where the junction of the granite and the slate was to be distinctly seen. The rain was descending so heavily when the junction was reached that prudence forbade any lengthy or detailed examination, but the President was able to satisfy himself of its essential correspondence with the junctions traced on the previous Thursday—an important factor in any generalisation—though there are variations in the character of the changes at the junction itself, and the adjacent slates are more massive and ferruginous, and less andalusitic than at Shaugh. Some specimens of a very handsome black and white rock, picked up *en route*, have since turned out to be a variety of Luxullianite, with white instead of pink felspar; the first record of the occurrence of this rock in Devon.

The next point visited was the mouth of the adit, where the milk-white torrent comes rushing forth charged with the clay from the stopes, running at such a rate that it brings along stones of considerable size. Its course is soon checked, however, by a great gridiron of mica “strips,” a series of narrow channels, in which the coarse material carried settles down, with a six-fold division. Thence it flows on peacefully enough, leaving behind the mica which had been in suspension, into the depositing pits, which form a double tier immediately above the collecting tanks. The latter again communicate with the “drys” where the water is driven off from the clay—by this time a thick pasty mass—by the agency of flues passing under the shallow, tiled pans into which it has been allowed to run. When sufficiently dry, as Mr. Martin explained, it is cut into cubes, and piled under sheds, or barrelled, preparatory to being loaded into trucks which convey it along Messrs. Martins’ private tramroad to their quays at Laira Bridge. All the stages in the production of the clay were followed and explained; and Mr. Martin showed also the range of kilns (which there was no time to visit) in which the sandy refuse, or what used to be considered as such, is made into admirable fire-bricks and tiles.

Very hearty were the thanks tendered by the President, on behalf of the Association, to Mr. Martin, who, in response, said he was always glad to afford an opportunity of showing the works to those who felt an interest in them. Plymouth was reached after a wet drive about 2 p.m., and the “long excursion” of 1884 came to an end, leaving many pleasant memories behind it.