W. D. Conway
With the author's kind regards

NOTES ON RECENT NOTICES OF THE GEOLOGY AND PALÆONTOLOGY OF DEVONSHIRE.

PART I.

BY WM. PENGELLY, F.R.S., F.G.S.

(Read at Teignmouth, July, 1874.)

[*Reprinted from the Transactions of the Devonshire Association for the Advancement of Science, Literature, and Art. 1874.*]

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A SLIGHT experience suffices to show how very difficult it is to keep errors out of printed matter; and when it is remembered that, to say nothing of imperfections in the original manuscript, such matter has to pass through the hands of transcribers and compositors, who, though conscientious and anxious to be correct, lay no claim to infallibility, the fact, instead of causing any surprise, should teach us the great lesson that *verification is necessary*. Indeed, were it not that it might perhaps be open to the charge of cynical affectation, it might be prudent to inscribe "With a grain of salt" on the title-page of every book in our libraries.

As it seems desirable that our members should record and correct in our *Transactions*, from time to time, such errors respecting our own county as they have detected in the course of their reading, I have, in this communication, brought together a few Notes on Recent Notices of the Geology and Palæontology of Devonshire.

The following are the topics "noticed" in these "Notes:"—

1st. The Devonian Rocks of Mudstone and Slapton, South Devon.

2nd. Fossil Fish in the Devonian Rocks of Devonshire.

3rd. Devonian Trilobites of Devon and Cornwall.

4th. The Source of the White Clays of Bovey Heathfield, Devon.

5th. The Granite Boulder of Saunton, Barnstaple Bay.

6th. Brixham Cavern.

7th. Kent's Cavern.

8th. The Submerged Forests of Torbay.

I. THE DEVONIAN ROCKS OF MUDSTONE AND SLAPTON, SOUTH DEVON.

The Rev. W. S. Symonds's "Records of the Rocks" contains the following passages respecting the older rocks of South Devon, on which a few remarks seem called for:—

"Here [Mudstone Bay, immediately west of Berry Head] he [the geologist] will see a series of Silurian-looking shales faulted against the Plymouth and Middle Devonian Limestones. Mr. Pengelly has found remains of fish in these faulted rocks. . . . . These rocks cross the river Dart, and run by Cornworthy westward in an anticlinal axis. I think that if well examined they would yield fossils, but hitherto hardly any have been found.*

Again, "The slates of Slapton Sands, between Dartmouth and Start Point, are middle Devonian, and of a green colour. . . . . I am not aware that they have yielded any fossils."†

The points in the passages just quoted, which would fasten on the attention of the geologist acquainted with the district are:—1st. The alleged occurrence of a fault at Mudstone Bay. 2nd. The very small number of fossils said to have been yielded by the beds supposed to be faulted. 3rd. The question of the occurrence of fossils in the Slapton slates.

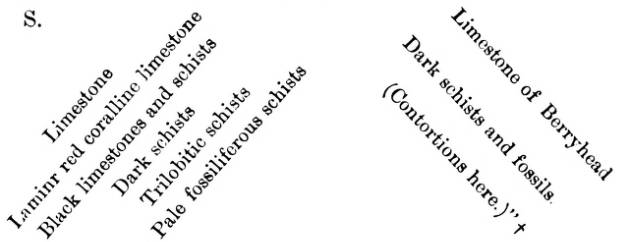
1st. Having accompanied Mr. Symonds to Mudstone Bay in 1868, I was not unprepared for his statement that there is a fault there, inasmuch as he expressed and maintained that opinion on the spot. Nevertheless, I was surprised to hear the statement at the time, and nothing has since occurred to diminish that feeling. The phenomena which the fine cliff section presents were interpreted in the following manner by Messrs. Sedgwick and Murchison, in their paper "On the Physical Structure of Devonshire, and on the Subdivisions and Geological Relations of its older stratified Deposits, &c.," read to the Geological Society of London, June 14th, 1837‡: "The great limestone at the south end of Torbay, after exhibiting a number of contortions, and spreading out into a succession of mural precipices at Berry Head, is finally (at Mudstone Sands) bent into a great arch which brings up the lower calcareous slates on which it rests, and causes the southern flap of the great limestone saddle to dip under the slate formation which is expanded towards the south along the shores of Start Bay. The same order of

* "Records of the Rocks." By the Rev. W. S. Symonds, F.G S., London, 1872, p. 281.
† Ibid, p. 295.
‡ "Trans. Geol. Soc." Lond., 2nd series, vol. v. part iii. pp. 633-687.

superposition is also indicated at Galmpton Creek on the eastern shore of the Dart, as well as at intermediate spots along the southern boundary of the limestone."*

The same view is expressed by the authors, at p. 669, in the description of their "Section from Berry Head to Start Point," Pl. li., fig. 6.

The following passage from his *Palæozoic Fossils of Cornwall, Devon, &c.*, shows that Professor Phillips interpreted the Mudstone Section in exactly the same way:—"*Mudstone Bay*—Here, between the promontories of Berryhead and Sharkham Point, an anticlinal axis (its steepest dip being north, under Berryhead) brings to view the schistose rocks below the limestone. The horns of the bay being limestone, the hollow is schist. The series of strata is nearly thus:—



Precisely the same opinion is given by Dr. Harvey B. Holl, in his paper "On the Older Rocks of South Devon and East Cornwall,"‡ read to the Geological Society of London, April 22, 1868, in which the following passage occurs:—

"The great mass of limestone of Berry Head, which stretches inland to Walton [? Waddeton], and of which the Yalberton and Stoke Gabriel limestones are but detached portions, forms an arch, which is depressed in its central portions between Walton and Fishcombe Point: while its southern margin is thrown over an anticlinal axis at Mudstone Sands, and is seen at Sharkham Point and [Higher] Brixham, dipping under the higher beds on the south."§

I fully concur in the opinions just quoted, that there is an anticlinal axis, but not a fault, at Mudstone Bay.

2nd. It may be doubted whether any rocks in South Devon, with the exception, perhaps, of the limestones quarried near Newton, have been more thoroughly and frequently examined, during the last forty years, than those very beds at Mudstone

* Op. cit., p. 652.

† "Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and West Somerset." By John Phillips, F.R.S., F.G.S, &c., 1841, p. 203.

‡ "Quart. Journ. Geol. Soc." Lond., vol. xxiv. pp. 400-454.

§ Op. cit., p. 431.

Bay; and that the labour has not gone unrewarded every local collection of fossils will show. In the beds under notice, Corals are by no means rare; Crinoideal remains, including those of *Cyathocrinus pinnatus*, Goldf., are abundant; *Retepora repisteria*, Gold = *Gorgonia ripistera*, is occasionally met with; Brachiopoda, now and then, are detected, including *Athyris concentrica*, V. Buch, in my collection, identified and figured by Mr. Davidson;* and the beds are famous for their Devonian Cephalopoda, of which *Cyrtoceras bdellalites*, Phill., and a remarkable nautiloid shell have attracted much attention. Somewhat recently, moreover, as Mr. Symonds remarks, the remains formerly known as the "Polperro Sponges" have been met with in the same beds—a fact which I placed on record in 1861.† In 1868 these so called sponges were identified, by Mr. Symonds himself, as the remains of fish, and Mr. E. Ray Lankester read to the Geological Society of London, June 17, 1866, a paper in which he announced that the same fossils had been found in the Lower Devonian slates of Mudstone Bay by the late Lieut. Wyatt Edgell also.‡

As stated by Messrs. Sedgwick and Murchison in the passage quoted above, these Lower Devonian slates extend from Mudstone Bay to Galmpton Creek, on the left bank of the Dart; and here too they are fossiliferous, for in June 1861, I found many small Brachiopods projecting in places from the edges of the layers of slate, and amongst them Mr. Davidson identified *Athyris concentrica*.§

If Dr. H. B. Holl has correctly regarded the slates near Black Hall on the Avon in South Devon as the westerly prolongation of the Mudstone beds,‖ and of this I have no doubt, there is a third locality in which they have yielded fossils, and in considerable numbers. The late Mr. J. Cornish, on whose property the Black Hall slates occur, made a collection of fossils from them; and was so good as to accompany me to the quarry, and to supplement the specimens I found with several from his own cabinet. My collection contains from this locality the Trilobite *Phacops latifrons*, Bronn;¶ the Brachiopods, *Strophomena rhomboidalis*, Wahl; *Streptorhynchus crenistria*, Phill; *Leptæna interstrialis*, Phill; and *Chonetes hardrensis*, Phill;** and numerous Cri-

* See "British Fossil Brachiopoda." By Thomas Davidson, F.R.S., F.G.S., &c., (Pal. Soc.) vol. iii. p. 16, Pl. iii., figs. 13, 14.

† See "The Geoglogist," 1861, p. 310.

‡ See "Quart. Journ. Geol. Soc. Lond.," 1868, vol. xxiv., pp. 546-7.

§ Op. cit. p. 16. ‖ Op. cit. Table i., pp. 432-3.

¶ See "A Monograph on British Trilobites." By J. W. Salter, A.L.S., F.G.S. (Pal. Soc.) Part i. p. 20. ** See Davidson, Op. cit. pp. 76, 85, and 94.

noideal stems, some of them of great length and otherwise of interest.

3rd. By "the slates of Slapton Sands between Dartmouth and the Start," spoken of by Mr. Symonds, I understand the entire series of Devonian beds from Dartmouth harbour to the commencement of the Metamorphic Schists, some distance north of the Start Point. Mr. W. Vicary, F.G.S., and I have examined these rocks with some care, but with very slender additions to our collections of fossils. Nevertheless we did find, in October 1864, a few remnants of encrinites near Torcross, at the southern end of Slapton Sands; and on the same day, a small number of corals at the point of land dividing Bee Sands and Hall Sands, still further south. In 1866 also, we found, at a spot known as Finister or Finisterre, on the left of the road between Bee Sands and the village of Beeston, unmistakable, though imperfect, remains of Brachiopoda in a quarry of quartzite, strikingly resembling some of the constituents of the famous Pebble-bed near Budleigh Salterton. The best specimens were sent to Mr. Davidson, who pronounced them too imperfect for specific identification.

There can be no doubt that these Upper Devonian beds, lying between Dartmouth Harbour and the Metamorphic Schists are prolonged westward to Bigbury Bay, where they are by no means destitute of fossils, though a careful examination of them has not been rewarded with any specimens of much interest.

II. FOSSIL FISH IN THE DEVONIAN ROCKS OF DEVONSHIRE.

There is in my collection a fine scale of the *Devonian*, = *Old Red Sandstone*, fish, *Phyllolepis concentricus*, Ag., which has been mentioned by Mr. Etheridge, Mr. Beete Jukes, and Dr. H. Holl in the following passages:—

The first says, "The 113 described species [of fish] in the three recognised divisions of the Old Red Sandstone of England, Wales, Scotland, and Ireland, until lately had no known or well authenticated representative in the British marine Devonians. We now know of three species:—*Phyllolepis concentricus* from the Lower Devonian slates of Cornwall," &c.,* and as authority for the statement he refers to a paper by me.

Mr. Jukes's statement is as follows:—"Hearing from

* "On the Physical Structure of West Somerset and North Devon, and on the Palæontological Value of the Devonian Fossils." By Robert Etheridge, Esq., F.G.S., F.R.S.E. Quart. Journ. Geol. Soc. of London, vol. xxiii. p. 677. 1867.

Professor Huxley that he had just received from Mr. Pengelly a specimen of *Pteraspis* of a larger size than any species previously known; I wrote to Mr. Pengelly for information respecting its locality. He informs me that it was procured at Old Mills, Looe, Cornwall. . . . . The *Phyllolepis concentricus* and the other fish previously found by Mr. Pengelly were from the same beds."*

According to Dr. Holl, "In the cliff between Meadfoot sands and the Thatcher rock [Torbay] two fine scales of *Phyllolepis concentricus*, Ag., have been found by Mr. Pengelly, and are now in his collection."†

From the foregoing passages, the reader would probably feel safe in concluding that *two* scales of the fish had been found by me, and that I had *subsequently* found a specimen of *Pteraspis*; but he would of necessity be puzzled about the locality, it being the shore of Torbay according to Dr. Holl, and Cornwall according to Messrs. Etheridge and Jukes—the latter, indeed, specifying "Old Mills, Looe," as the exact spot.

In truth, however, only *one* scale was found, and that several years after the specimen of *Pteraspis* was met with. The locality, as stated by Dr. Holl, was the northern shore of Torbay, between Meadfoot beach and the Thatcher rock, at the base of the cliff, almost immediately under the house known as Kilmorie. To be perfectly correct, it may be as well to add that the scale was found, not by me, but by my son in my presence. For the History of the Discovery of Fossil Fish in the Devonian Rocks of Devon and Cornwall, see Trans. Devon. Assoc. vol. ii. pp. 423–442. 1868.

III. DEVONIAN TRILOBITES OF DEVON AND CORNWALL.

Sir Charles Lyell has greatly enriched his "Student's Elements of Geology" by adding, in the second edition, published early in the present year (1874), a diagrammatic "Table of British Fossils, illustrative of the successive Appearance and Development in Time of the different Orders of Animals and Plants," drawn up by Mr. Etheridge, F.R.S., F.G.S., of the Geological Survey. According to the table the

* "Notes on Parts of South Devon and Cornwall with Remarks on the True Relations of the Old Red Sandstone to the Devonian Formation. By J. Beete Jukes, M.A., F.R.S. Read before the Royal Geological Society of Ireland, November 13, 1867," p. 42.

† "On the Older Rocks of South Devon and East Cornwall. By Harvey B. Holl, M.D., F.G.S." Quart. Journ. Geol. Soc. of London, vol. xxiv. pp. 428-9. 1868.

"Group" *Trilobita* includes 14 British Families, all dating from pre-Devonian times, to which 10 of them are restricted.

The remaining 4 appear among British Devonian fossils: the *Calymenidæ*, extending apparently not beyond the very lowest Devonian beds; the *Harpedidæ* and *Bronteidæ*, reaching Middle Devonian times; and the *Proteidæ*, passing through to the Carboniferous period.*

The late Mr. Salter, in his monograph on "British Trilobites,"† which he unfortunately did not live to finish, also divides the "Group" into 14 "Families." When collecting materials for his work, he had access to the principal collections of the Devonian fossils of Devon and Cornwall, in addition to the national collection in Jermyn Street, London, including those of Messrs. Champernowne, Hall, Lee, Valpy, Vicary, and myself, and named all the Trilobites he found in them. I have thus been enabled, with the aid of my brother collectors, to include in the following table a few particulars not found in the parts of the Monograph which have been printed:

* Op. cit. pp. 630-2.

† "A Monograph of British Trilobites." By J. W. Salter, A.L.S., F.G.S. Four Parts only have appeared. They were printed by the Palæontographical Society in 1864, 1865, 1866, and 1867.

TABLE showing the Families, Genera, and Species of the Devonian Trilobites of Devonshire and Cornwall, as determined by the late Mr. J. W. Salter, A.L.S., F.G.S., with their Localities and Horizons, and the Collections in which they are lodged.

FAMILIES.	GENERA & SPECIES.	LOCALITIES.	HORIZONS.			REFERENCES.	COLLECTIONS.
			L.	M.	U.		
Phacopidæ.	*Phacops granulatus*, Münster.	Braunton, Croyde, Pilton, South Petherwin, Wolborough.	*	*	·	18, Pl. i. figs. 1-4.	Hall, Jermyn St., Pengelly,
	P. latifrons, Bronn.	Barton, Black Hall, Braunton, Brushford, Croyde. Goodleigh, Hope's Nose, Lummaton, Pilton, Roseland Vale, Wolborough, Yeolm Bridge.	*	*	*	18-20, Pl. i. figs. 9-16.	Hall, Jermyn St., Lee, Pengelly, Vicary.
	P. lævis, Münster.	Knowl Hill.	?	?	?	16-7, Pl. i. figs. 5-7.	Pengelly, Vicary.
	P cryptophthalmus, Emmerich.	Newton Bushell.	·	*	·	17, Pl. i. fig. 8.	Jermyn St.
	P. punctatus, Steininger ?	Torquay, Great Tressell.	·	?	*	59-60, Pl. i. figs. 17-19.	Jermyn St., Pengelly.
Cheiruridæ.	*Cheirurus articulatus*, Münster?	Lummaton.	·	*	·	61-3, Pl. vi. figs. 7-8.	Jermyn St., Lee, Pengelly, Vicary
Cyphaspidæ.	*Cyphaspis*, sp., Salter.	Lummaton.	·	*	·	Not figured.	Pengelly
Harpedidæ.	*Harpes macrocephalus*, Goldfuss.	Lummaton.	·	*	·	Not figured.	Pengelly
Bronteidæ.	*Bronteus flabellifer*, Goldfuss.	Lummaton, Wolborough.	·	*	·	Not figured.	Champernowne, Hall, Pengelly, Vicary.
Calymenidæ.	*Homalonotus elongatus*, Salter.	Meadfoot.	·	·	*	122-3, Pl. x. figs. 1, 2.	Hall.
Proetidæ.	*Proetus*, sp., Salter.	Lummaton.	·	*	·	Not figured.	Pengelly.
	Phillipsia anticipator, Salter.	Chircombe Bridge.	·	*	·	Not figured.	Pengelly.
	P. brogniartii, Salter.		·	*	·	Not figured.	Vicary.
	P. pengellyi, Salter.	Chircombe Bridge.	·	*	·	Not figured.	Pengelly.

It appears from the first two columns that the known Devonian trilobites of Devon and Cornwall belong to 7 families, 8 genera, and 14 species. In short, exactly one half of the British families are represented in the Devonian fauna.

It may be well perhaps to give a brief description of the localities named in the third column.

Barton, a village about three miles northward from Torquay harbour, contains Middle Devonian limestone.

Black Hall is about six miles south-west from Totnes, and has fossiliferous slates near it, probably of Lower Devonian age.

Braunton is a village about five miles north-west from Barnstaple. The beds are Upper Devonian.

Brushford is a village about one mile and a half south of Dulverton, and three and a half north-west of Bampton. The beds are Upper Devonian.

Chircombe Bridge crosses the River Lemon, in the Bradley Valley, about one mile and a half west from Newton Abbot. There are several Middle Devonian limestone quarries near it. The trilobites, all of the genus *Phillipsia*, are found in that known as Ivy-Green quarry, on the right bank of, and adjacent to, the river.

Croyde Bay is an inlet on the northern shore of Barnstaple Bay. The beds are of Upper Devonian age.

Goodleigh is a village about three miles east of Barnstaple. The beds are Upper Devonian.

Great Tressel quarry is in the parish of St. Keyne, about two miles south-south-west from Liskeard. The deposits are Lower Devonian.

Hope's Nose is the northern horn of Torbay. The fossiliferous beds are Middle Devonian limestone.

Knowl Hill, in the parish of Highweek, may be termed a suburb of Newton Bushell. The hill consists mainly of trap, and has a volcanic ash on its flanks, in which the trilobite *Phacops lævis* occurs. The exact horizon of this ash is difficult of determination, as scarcely any other fossil occurs there, and it is not known with certainty that the trilobite has any other British locality. Mr. Salter supposed the ash to be of Upper Devonian age, but does not appear to have stated on what evidence he came to this conclusion.

Lummaton limestone quarry is very near that at Barton, already described. The beds are Middle Devonian.

Meadfoot Bay, a portion of Torbay, is adjacent to Torquay, and lies between it and Hope's Nose. The fossils occur in gritty Lower Devonian slates.

For "Newton Bushell" may be understood any of the Middle Devonian limestone quarries near it.

South Petherwin, or, more correctly, Landlake Upper Devonian limestone quarries are about two miles south-west from Launceston.

The parish of Pilton, adjacent to Barnstaple, contains several Upper Devonian localities, including Frankmarsh, Bradiford, and Top Orchard quarries.

Roseland Vale quarry, about a mile and a half south-east of Liskeard, is worked in Lower Devonian beds.

By "Torquay" may probably be understood any fossiliferous locality near it. Fossils so labelled may be of either Middle or Lower Devonian age.

Wolborough limestone quarry, on the left of and adjacent to the road from Newton Abbot to Totnes, about a mile from the former, and very near the parish church, is famous for the great number and variety of fossils it yielded to the researches of Mr. Godwin-Austen.* Mr. Salter supposed this mass of limestone to be of Upper Devonian age, but there can be little or no doubt that it is Middle Devonian.

Yeolm Bridge, about one mile and a half north-north-west from Launceston, is an Upper Devonian locality.

Under the heading of "Horizons," L., M., U., denote Lower, Middle, and Upper Devonian respectively, and the asterisk indicates that the fossil named on the same horizontal line has been found in the "horizon" stated at the head of the column in which it stands. It is obvious that the Middle Devonian beds are richest in Trilobites, as they are in fossils generally.

The column headed "References" is intended to set forth in what part of his Monograph Mr. Salter described and figured the several species. The entry "Not figured" simply signifies that the species was not figured in the Monograph, and is not intended to intimate whether or not it has been figured elsewhere.

The "Collections" mentioned in the last column are, in addition to that in Jermyn Street, those of Messrs. A. Champernowne, M.A., F.G.S., Dartington Hall, Totnes; T. M. Hall, F.G.S., Pilton Parsonage, Barnstaple; J. E. Lee, F.G.S., F.S.A., Villa Syracusa, Torquay; W. Vicary, F.G.S., The Priory, Colleton Crescent, Exeter; and my own, Lamorna, Torquay.

A single example will suffice by way of explanation:— We learn from the table that the Devonian Trilobite, *Phacops*

* See "Memoirs of the Geological Survey of Great Britain," &c., vol. i., 1846, p. 88.

latifrons, has been found at Barton, Black Hall, Braunton, Brushford, Croyde, Goodleigh, Hope's Nose, Pilton, Roseland Vale, Wolborough, and Yeolm Bridge; that it occurs in Lower, Middle, and Upper Devonian beds; that Mr. Salter described it on pages 18, 19, 20 of his Monograph on "British Trilobites," published by the Palæontographical Society, and figured it in plate i. figures 9, 10, 11, 12, 13, 14, 15, and 16 of the same work; and that specimens of the fossil, found in one or more of the foregoing localities, are in the collections of the Geological Survey, Jermyn Street; Mr. Hall, Pilton; Mr. Pengelly, Torquay; and Mr. Vicary, Exeter.

IV. THE SOURCE OF THE WHITE CLAYS OF BOVEY HEATHFIELD, DEVON.

In a paper "On the Sources of the Materials composing the White Clays of the Lower Tertiaries," by George Maw, Esq., F.G.S., F.L.S., &c., read to the Geological Society of London, June 19, 1867,* the author says "Messrs. Pengelly and Heer, at p. 9 of their Memoir 'On the Lignite formation of Bovey Tracey,' . . . . make reference to the probable derivation of the deposit from the degradation of the Dartmoor granite. This inference seems to be due more to the geographical proximity of the granite to the clays of the Lignite formation than to any more certain evidence.

"The present areal outline of the deposit, and the surface-contour of the country, may perhaps give the Lignite-formation a more local aspect than it really possesses; and the occurrence of beds of similar physical character and age, far removed from the source of granite materials, would seem to throw doubt on the suggested local origin from the granite of Dartmoor.

. . . . . .

"At the time of the white Tertiary clays the chalk must have more completely covered the older formations than at present, and shrouded them from being sources of supply for the Tertiary deposits; and the geographical distribution of the white Tertiary clays, which are either superimposed on, or in close proximity to the chalk, suggests a derivation from it rather than from the granite rocks."

. . . . . .

Another point to be noticed is, that Kaolin (the result of the decomposition of felspar) is perfectly implastic, a feature opposed to the character of the white Tertiary clays, the

* Quart. Journ. Geol. Soc. vol. 23, pp. 387-394. 1867.

chemical composition of which favours a derivation from the chalk rather than from the decomposition of the felspar of granite."*

In a previous paragraph the author says, "In testing the state of division of the Bovey Tracey . . . . clays, I found that, after mixing them with water to the consistency of cream, and passing them through fine silk lawn, containing 10,000 perforations to the square inch, no appreciable quantity of coarse matter remained behind from most of the examples, not even to the weight of a grain out of several pounds of clay."†

On entering on the consideration of the paragraphs just quoted, it is but fair to my colleague, the Rev. Professor Heer, to state that the passage in "The Lignite Formation of Bovey Tracey," referred to by Mr. Maw, occurs in the geological portion of the Memoir, for which I alone am responsible, Dr. Heer having undertaken the botanical portion only. Having shown, in the Bovey Memoir, that in the three sections taken in the "Coal Pit" and described in detail, certain beds "thin out" or entirely disappear eastward, whilst others become gradually thinner in the same direction, that is, as the sections are prolonged from Dartmoor, it is remarked, in the passage alluded to by Mr. Maw, that "This attenuation, like the thinning out of the beds previously mentioned, ... is probably an indication, were one needed, that the detrital layers were formed at the expense of the Dartmoor granite."‡

The first fact which presents itself is that whilst Mr. Maw spoke of "White Clays," I was speaking of clays which were "rather light, light drab, buff, lead-colour, light lead-colour, dark lead-colour, brown, blue, very dark blue, very dark, or approaching to black," but none of them *white*. There *are* beautifully white clays on the Heathfield; but instead of being Tertiary they are of more modern age, overlie unconformably the Tertiary series, and are not the beds I was describing or referring to.

Again, Mr. Maw was speaking of clays having a commercial value, whilst those I had under notice are incapable of being utilized.

Further, though there is no doubt that "the geographical proximity of the granite" was not without influence in lead-

* Op. cit. pp. 392-3. † Ibid, 388.

‡ See "The Lignite Formation of Bovey Tracey, Devonshire." By William Pengelly, F.R.S., F.G.S., &c., and the Rev. Oswald Heer, Doctor of Philosophy, &c., London, 1863, p. 9. See also Phil. Trans., part ii. 1862, p. 1027.

ing to the conclusion that the clays were derived from the degradation of the Dartmoor rocks, it was by no means the only, or the most important evidence. Indeed, the very passage in question calls attention to the attenuation and "thinning out" of beds in an easterly direction, as indicating a granitic derivation.

In each of the Coal Pit sections there were two great divisions of Miocene beds; the upper, from the 2nd to the 27th bed inclusive, made up of lignite, clay, and sand, whilst the lower consisted of lignite and clay only. The following descriptions of some of the beds in the first section, near the western end of the pit, are copied from the "Bovey Lignite Formation," and are calculated to throw light on the origin of both the sand and clay.

"3rd Bed; 6 feet 3 inches in thickness. Sand.—Quartzose, with a ferruginous clay at the base."

"8th Bed; 5 inches in thickness. Clay.—Dark . . . . Graduates into sand at the base."

"10th Bed; 2 feet in thickness. Clay.—Tough, light lead-colour. Contains lenticular patches of sand."

"11th Bed; 8 inches thick. Sand . . . . in some cases cemented into a coarse grit or very fine conglomerate;" [the materials being quartzose without trace of flint].

"14th Bed; 2 feet 9 inches in thickness. Clay.—Sandy and brittle."

"27th Bed; 11 feet 1 inch in thickness. Sand.—Quartzose. Very coarse in the uppermost part [where angular and sub-angular fragments of crystals of felspar were prevalent], but becomes gradually finer towards the base. Contains somewhat large lenticular patches of clay."

"28th Bed; 5 feet 9 inches in thickness. Clay. Light colour. Near the top it is somewhat sandy." *

To the foregoing may be added the description of a bed in the second "Pit" section, 460 feet eastward from the first:—

"4th Bed; 10 feet 5 inches in thickness. Clay.—In some parts sandy. †

From the descriptions just quoted it will be seen—

1st. That the Sands, and notably the 27th bed, consisted of materials such as, amongst the rocks of the district, granite alone could supply, mixed with such as granite could but chalk could not furnish; but without a trace of such as could have been derived from chalk.

2nd. That the felspar crystals occurring so plentifully in the 27th Bed, show conclusively that during the period of

* "The Lignite Formation," pp. 4, 5. † Ibid, p. 7.

the Bovey Lignite formation, the chalk did not, as Mr. Maw supposes, shroud the Dartmoor granite from being a source of supply for the Tertiary deposits.

3rd. That the clays, sometimes distributed throughout the mass of the sand, and at others taking the form of lenticular patches in it, are, at least, as indicative of a granitic as of a calcareous origin; and, in all probability, were, like the sands in which they occurred, derived from the granite.

4th. That it was unnecessary to resort to such experiments as those adopted by Mr. Maw to detect the presence of coarse matter in the clays, for sand was so obviously distributed through their general mass in some of the beds as to entitle them to the epithet of "sandy," whilst others graduated into sand, and some contained it in the form of lenticular patches.

Whilst most readily acknowledging the intimate acquaintance with clays which Mr. Maw necessarily possesses, it seems a sufficient reply to his statement, "that Kaolin, the result of the decomposition of felspar, is perfectly implastic," to remark that the St. Austell clays, artificially prepared from disintegrated granite, are largely used in the manufacture of china and the fine kinds of earthenware, where "perfect implasticity" would scarcely be a recommendation. Whether the clays lying between the beds of lignite in the Bovey Coal Pit are or are not plastic, I am not prepared to state.

In short, whilst abstaining from the expression of any opinion respecting the derivation of the *white clays* to which Mr. Maw calls attention, but of which I was not writing, my opinion that the detrital layers in the Pit on Bovey Heathfield were formed at the expense of the Dartmoor granite, remains unchanged and unshaken.

Before dismissing the Bovey deposits, it may be as well to call attention to the following brief notices of them in Rev. W. S. Symonds's "Record of the Rocks":—

"It [the clay at Fremington, near Barnstaple, North Devon] may be a glacial till like that of Bovey Tracey, which there covers the Middle Tertiary Lignite, and which afforded Arctic plants such as Betula nana and Salix herbacea, to the researches of Mr. Pengelly." *

"Close to the village [of Bovey Tracey] is a Pottery in which the upper clay, which consists principally of decomposed granite, is used while the baking of the pottery is carried on by means of the coal or lignite." †

"It is not uninteresting to note that Mr. Divett's pottery

* Op. cit. p. 278. † Ibid, p. 287.

[at Bovey Tracey] should be fabricated of glacial clays, and baked with the brown coal that underlies it."*

Mr. Symonds states the total thickness of the two Bovey formations to be "66 feet." †

The foregoing passages may be said to contain statements respecting the following topics, all requiring notice:—

1st. The plants found in the Clays covering the Lignite.

2nd. The Clay used in making the Bovey pottery.

3rd. The Coal used in baking the pottery.

4th. The aggregate thickness of the Bovey formations.

1st. The Arctic plants found in the White Clay overlying unconformably the Lignite series, were identified by Professor Heer as *Betula nana*, Linn.; *Salix cinerea*, Linn.; and *S. repens* (?), Linn.‡ *Salix herbacea* was not found, as the author supposes. It may be as well to add that this error is of very little moment, the climatal indications being much the same as those of the species which really occurred. It may be also stated that Professor Heer now considers that the leaves which he doubtfully referred to *Salix repens* really belong to *S. myrtilloides*, Wild., at present a native of Sweden. Mr. Alfred Nathorst, of Lund, in Sweden, on whose authority the foregoing correction is made, visited Bovey Tracey in 1872, and found leaves of *Betula nana* very common, at depths varying in different localities from 1 to 10 feet, and with them seeds and catkins of the same species. They were deposited with leaves of *Salix cinerea* and several others of the same genus not yet specifically determined, remains of *Carices*, a *Potamogeton* or Pondweed, and leaves of *Arctostaphylos uva-ursi*, Adan., or the Red Bearberry (= *Arbutus uva-ursi*, Linn.)§; the last being, according to Smith, a native of stony, barren, alpine heaths in the North of England, and in Scotland and Ireland.‖

2nd. There is no doubt that, as Mr. Symonds states, the upper or "glacial" clay is used at the Bovey Pottery, but a very small amount only is obtained from this source. Clays of other localities, and perhaps of other eras, are chiefly used.

3rd. The statement that at Bovey the baking of the pottery is carried on by means of the lignite, though perhaps correct

* Ibid, p. 290. † Ibid, p. 267.

‡ See "The Lignite Formation of Bovey Tracey, Devonshire," pp. 26 and 62–4.

§ See a paper entitled "Om den Arktiska Vegetationens est bredning öfver Europa novr om Alperna under istiden." Af Alfred Nathorst. Stockholm, 1873, p. 17.

‖ See "English Botany." By Sir James Edward Smith, M.D., F.R.S., P.L.S., 3rd ed. 1851, vol. iv. p. 5.

enough during an early stage of the undertaking, has long ceased to be so. Ordinary "sea-borne" coal has for many years been used to at least a considerable extent; and in 1859, when the lignite in one of the old pit tunnels took fire and rendered it necessary to discontinue the excavation, in order that, by allowing the water to accumulate, the fire might be extinguished, it was, of course, the only fuel employed; and since that time no use has been made of the lignite at the pottery.*"

4th. The two formations—"Glacial" and Miocene—have at the Bovey coal-pit an aggregate thickness of 125 feet, of which no more than 7·5 feet belongs to the more recent series;† but good evidence was obtained in 1860–1 that the lignite or miocene series alone has a total thickness of 218 feet.‡ Mr. Symonds probably took the figures of the second Pit section, which was carried to a depth of 66 feet 10 inches only.§

V. THE GRANITE BOULDER OF SAUNTON, BARNSTAPLE BAY.

The Rev. W. S. Symonds, in his "Records of the Rocks," says, "The Rev. D. Williams, in his paper 'On the Croyde Raised Beach,' describes a large block of granite which was resting directly on the fundamental slates, and covered and imbedded by the base of the beach. It is a true erratic boulder, but comes only from Lundy Island to the westward."‖

Whilst agreeing with the author that the block "is a true erratic boulder," I am not prepared to accept his unqualified statement that it "comes only from Lundy Island." It is true that Lundy is mainly composed of granite, and is nearer than any other mass of that rock to the spot where the boulder now lies; but these are the only facts in favour of the hypothesis, against which there are two formidable objections.

1st. There is no reason to suppose Lundy capable of furnishing such a block. Mr. T. M. Hall, F.G.S., who has carefully studied the geology of the Islet, and has been so good as to write me on the subject, says, "The main body of rock on Lundy differs in every respect from that which forms the Saunton boulder, but I have seen some altered granite, adjoining one of the numerous dykes on the eastern side of the Island, which very nearly approximates it in colour and texture. Where the dykes occur, there peat and ferns generally cover the rock; but as far as I know there is no vein capable of producing a block of such magnitude."

* "The Lignite Formation," pp. xvi. xvii. † Ibid, pp. 5, 6.
‡ Ibid, p. 14. § Ibid, p 7. ‖ Op. cit p. 276.

2nd. I have shown elsewhere* that, come whence it may, the block must have been ice-borne; and that though it is impossible that the spot it now occupies could have been higher than at present above the level of mean tide, there is nothing to show that it was not lower. The ice-buoy to bring it from Lundy must therefore have been of the nature of a berg, which it is at least difficult to believe so small a spot could have furnished. Should it be suggested that the Islet may have been larger when the boulder was transported than it is at present, it may be safely replied that, respect being had to the relative levels of land and sea at that time and at present, to the very bold coast which Lundy presents, and to the great depth of water close to it, there is little or no probability that the difference of area was noteworthy.

In short, I am satisfied that Lundy could neither have furnished the boulder nor the ice-buoy to float it.

VI. BRIXHAM CAVERN.

In the third edition of his *Physical Geology and Geography of Great Britain*, Professor Ramsay gives a list of the mammals whose remains were found in Brixham Cavern in 1858–9, and places *Rhinoceros leptorhinus*, but not *R. tichorhinus*, amongst them.† He states that the list was taken from a well-known paper by Mr. Boyd Dawkins in the *Journal of the Geological Society of London, for 1869* (vol. xxv., p. 194). On turning to the Journal, a clear and elaborate table presents itself, having, on the same horizontal line with "R. leptorhinus *Ow.*" and in the same vertical column with "Brixham Cave," an asterisk justifying Ramsay's statement. On page 200 of the same journal, Mr. Boyd Dawkins says, "I have to thank Mr. George Busk, F.R.S., for a perfect list of species from this [Brixham] Cave." As Mr. Busk had been entrusted by the Brixham Cave Committee with the identification of the remains found in the Cavern, it is clear that Mr. Boyd Dawkins got his information from head quarters, and there *seems* every reason for accepting it as perfectly trustworthy. Nevertheless, "a grain of salt" is never a thing to be treated with indifference. In 1870, Mr. Busk read to the Geological Society of London a paper "On the Species of Rhinoceros whose remains were found in a Fissure Cavern at Oreston in 1816." This paper, printed in the Journal of the Society for 1870 (vol. xxvi.), contains the following passage:—"The Oreston collection . . .

* See Trans. Devon. Assoc., vol. vi. pp. 211-22, 1873.

† See "Physical Geology and Geography of Great Britain," by A. C. Ramsay, LL.D., F.R.S., third edition, 1872, p. 186-7.

acquires very great interest, not only as adding another to the as yet scanty instances of the occurrence of that species [*Rhinoceros leptorhinus*] anywhere in Britain, but more especially as affording the only recorded example of its discovery in a cavern of any kind—a fact the more remarkable, perhaps, since *no vestige of its remains has occurred in the Brixham Cave.*"*

It is not enough therefore to be sure that we read Professor Ramsay correctly, not enough to find that he quoted Mr. Dawkins accurately; so long as there is yet another step in the process of verification by all means let it be taken. On going to Mr. Busk, it proves that there is a mistake somewhere; there should have been no asterisk opposite "Rh. leptorhinus" and under "Brixham Cave." Its place is opposite *Rh. tichorhinus.*

But let us recur to Mr. Busk's paper. It states, it will be remembered, that with the exception of Oreston, there is no recorded instance of the occurrence of *Rhinoceros leptorhinus* in a cavern of any kind. Yet, whilst this is still ringing in our ears, Mr. Boyd Dawkins's table ascribes this very species to no fewer than eleven British Caves—Coygau Cave in Caermarthenshire, Cefn Cavern in Denbighshire, Durdham Down near Bristol, Kirkdale Cavern in Yorkshire, Wokey Hole in Somersetshire, and Bacon's Hall, Crawley Rock, Crow Hole, Long Hole, Minchin Hole, and Raven's Cliff, all in Gower in South Wales. The table is followed by a long list of authorities, to which it would be delightful to proceed in pursuit of further game, were it not beyond our present limits.

There can be no doubt that this apparent conflict between the two eminent authors originated in the printing office, through a misplacement of the asterisks in Mr. Boyd Dawkins's table, and much to his annoyance, of course.

Be this as it may, the error is by no means of slight importance, inasmuch as the climatal indications of the two species of Rhinoceros are believed to differ greatly.

Mention having been made above of the Oreston Caverns, it may be as well to state that the word which the Rev. W. S. Symonds, no doubt, wrote "Oreston," when speaking of the Caverns "a little east of Plymouth," in his "Records of the Rocks," has unfortunately been printed "Preston." The error has crept in no fewer than five times.† Though he places the "Irish Elk" in the Oreston list, I am not aware of any authority for doing so.

The late Dr. Falconer identified amongst the remains found

* Op. cit. p. 456. † See pp. 296-7, and "Index" p. 430.

in Brixham Cavern, a fragment of the cranium, including the entire maxilla and all the teeth but one, of *Lagomys spelæus*, Owen = Cave Pika = Tailless Hare. Professor Prestwich mentions it at least four times in his "Report on the Exploration of Brixham Cave," presented to the Royal Society of London, and printed by that body in the Phil. Trans.* Twice he uses the names "*Lagomys spelæus*" and "Lemming" jointly—the former as the scientific name and the latter as the popular one,—and once he employs the latter only. In short he seems to treat *Lagomys* as a Lemming.

I was much surprised at the fact on reading the Report, but concluded that possibly some discoveries of which I had not heard had rendered it necessary to remove Lagomys from the Hares and place it among the Voles.

No 153 of the "Proceedings of the Royal Society," which has just reached me (July 1874), contains a "Note on the alleged Existence of Remains of a Lemming in Cave deposits in England," by Professor Owen, C.B., F.R.S., who, after quoting as his text the passages just alluded to in Professor Prestwich's Report, states that no fossil evidence of a Lemming had come to his knowledge when in 1846 he published his "British Fossil Mammals and Birds;" that he has since obtained such evidence from a deposit of brick-earth near Salisbury associated with *Elephas primigenius;* that the Lemmings belong to the family of Voles (*Arvicolidæ*), not of Hares (*Leporidæ*); that the fossil from Brixham appears from the figures to be rightly referred to *Lagomys* and to the species he had determined and named in 1846, from a specimen submitted to him by Dr. Buckland, which had been found by the Rev. Mr. MacEnery, in Kent's Hole, Torquay; that it is evidently a tailless Hare, not a Lemming; that the first evidence of *Lagomys spelæus* had led him to remark that "it unquestionably attested the former existence in England of a species of rodent, whose genus is not only unrepresented in the present day in our British fauna, but has long ceased to exist in any part of the Continent of Europe;"† and that the Lemmings still disturb by their multitudinous migratory swarms, the husbandmen of Scandinavia.‡

VII. KENT'S CAVERN, TORQUAY.

In a paper entitled "Observations on the Rate at which Stalagmite is being accumulated in the Ingleborough Cave,"

* See Phil. Trans. vol. clxiii. part ii. 1873, pp. 556, 560.
† See "British Fossil Mammals," &c., p. 215.
‡ Op. cit. pp. 364-5.

by W. Boyd Dawkins, F.R.S., F.G.S.,* the author states, on what appears to be most satisfactory evidence, that the apex of a boss of stalagmite, known as the *Jockey's Cap*, in that cave, rising from the crystalline pavement to a height of 2·5 feet, was found, by careful measurement, on March 13th, 1873, to be 87 inches from the roof, whilst, when measured by Mr. James Farrer, on October 30th, 1845, it was 95·25 inches from it; so that the upward growth has been 8·25 inches in 27·37 years, giving an average vertical growth of ·3 inch per year.

On the strength of this fact, the author remarks that "all the stalagmites and stalactites in the Ingleborough Cave may not date further back than the time of Edward III. if the Jockey cap be taken as a measure of the rate of deposition." "It is evident," he continues, "from this instance of rapid accumulation, that the value of a layer of stalagmite, in fixing the high antiquity of deposits below it is comparatively little. The layers, for instance, in Kent's Hole, which are generally believed to have demanded a considerable lapse of time, may possibly have been formed at the rate of a quarter of an inch per annum."

It is but fair to state that Mr. Dawkins admits that "it is very possible that the Jockey Cap may be the result, not of the continuous, but of the intermittent drip of water containing a variable quantity of carbonate of lime, and that, therefore, the present rate of growth is not a measure of its past or future condition;" but it may be doubted whether in his reasoning he has been sufficiently influenced by his own admission.

But waiving all this, and assuming that the upward growth of the Jockey Cap, that is its approach to the roof, has been uniform, the following questions present themselves:—

1st. Is the accumulation of stalagmite equally rapid in all caverns?

2nd, If not, why must the rate of accumulation in Ingleborough Cave be taken as the measure for other caverns?

3rd. Has there been an undue tendency to trust to the thickness of the Kent's Hole stalagmites in fixing the antiquity of deposits below it?

1st. It is probably doubtful whether useful observations on the rate at which stalagmite accumulates have been made in many caverns; the well known Cheddar cavern, however, furnishes information as trustworthy and as significant as

* See "Proceedings of the Philosophical Society of Manchester," March 18, 1873, pp. 83-6.

that obtained from Ingleborough. When the late Mr. George Cox, in 1838, discovered that cavern he noted the case of a stalactite and stalagmite which had approached so near to one another that a single drop of water suspended from the point of the former just touched that of the latter. When this fell off, its place was taken by a second drop, which as completely filled the interspace; and this has gone on ever since without bringing the points perceptibly nearer. In short, to use the words of Mr. J. Streatfield Cox, the present proprietor of the Cavern, who has been so good as to write me on the subject, "In 35 years there has been no appreciable growth in any of the formations."

2nd. Should it be remarked that there may be in other parts of Cheddar Cave examples of perceptible or even comparatively rapid increase, it may be replied that, though this may perhaps be true, it cannot be admitted without admitting also that it is probably as true that in other parts of Ingleborough Cave there may be rates of increase very slow as compared with that of the Jockey Cap, and that it is unsafe to use the rate at which stalagmite accumulates in one branch of a cavern to measure the time represented by the stalagmite in any other branch of the same cavern; and that, consequently, even if it has been uniform, the rate of the growth of the Jockey Cap of Ingleborough Cave cannot be applied as a chronometer in the case of any other cavern. Speaking for myself, and after an experience in numerous caverns and extending over very nearly 30 years, I may say that it appears to be just as reasonable to use for the same purpose the rate at which veritable jockey caps, birds' nests, wigs, stuffed rats, &c. are encrusted with carbonate of lime in the "dropping well" at Knaresborough.

3rd. Mr. Boyd Dawkins tells us that the layers of stalagmite in Kent's Hole may have been formed at the rate of a quarter of an inch in a century. Let us assume that this is a fact, and see whither it will lead us. I have found teeth of the Cave Bear, Cave Hyæna, the Mammoth, and the tichorhine Rhinoceros so very little below the surface of the stalagmite in Kent's Cavern, that more than an inch and half, at most, of calcareous matter had not accumulated there since they were lodged where they were met with, whilst below them was a floor of the same material a foot, and sometimes much more, in thickness; and the situation was such as to place it beyond all doubt or question that they had not been dislodged from an older deposit and re-inhumed. Taking the suggested chronometer of a quarter of an inch for

a year, we arrive at the startling but inevitable conclusion that *Rhinoceros tichorhinus* and his contemporaries were living in the Torquay district about six years ago.

Again, there is in a branch of the Cavern sometimes called the "Cave of Inscriptions," a vast boss of stalagmite having on one of its sides an inscription partially sealed up with a film of stalagmite not more than ·05 inch thick. At the rate of a quarter of an inch per year this must have been cut something less than three months ago (= ·05 ÷ ·25 = ·2 year). Unfortunately for this conclusion, however, the inscription was observed in 1825 by the late Rev. J. MacEnery, who described it in the following words:—"The letters are glazed over and partly effaced."* Hence it is obviously at least 49 years old. Indeed, it is certainly much older, inasmuch as the description just quoted clearly shows that it had not then been recently cut. The inscription itself—"Robert Hedges of Ireland Feb. 20, 1688,"—claims to be 186 years old, and the fact that, though the drip is still certainly at work on it, MacEnery's description, given very nearly half a century ago, is still perfectly apposite, shows that this claim is too well founded to be resisted.

Enough has perhaps been said to show that the application of the Ingleborough rate to the Kent's Hole facts leads to utterly untenable and, indeed, absurd conclusions. It must be unnecessary to say that Mr. Boyd Dawkins simply meant, not that the layers of stalagmite in Kent's Hole were actually or probably formed at the rate of a quarter of an inch per annum, but that if there were no facts to the contrary, their formation may have gone on at that rapid rate.

In Kent's Cavern there are two Stalagmites, about the relative ages of which there is not the least uncertainty. The least ancient, which, as already stated, was cœval with the tichorhine Rhinoceros and his extinct contemporaries, is of granular texture, and was formed on, and subsequent to the introduction of, the mechanical deposit known as the *Cave-earth*. The more ancient Stalagmite lies below this Cave-earth, and was not only formed, but in many places broken up by some natural agency, before the deposition of the Cave-earth commenced. It is commonly much thicker than the other and differs from it in having a very crystalline texture. Beneath it and of still higher antiquity is another and distinct mechanical deposit termed *Breccia*, in which undoubted evidences of contemporary man have been found.

The Granular, or less ancient, Stalagmite is of less variable

* See Trans. Devon. Assoc., vol. iii., p. 275.

thickness, being in some places upwards of five feet, in others not more than a mere film, whilst in certain areas there is none. It has been observed that where this floor is very thick the drip of water from the roof is at present unusually copious, where it is thin there is but little drip, and where there is none the Cavern is at all times quite dry. Again, where a large stalactite depends from the roof, betokening a point where the calcareous water has access, there is vertically beneath it a boss of stalagmite rising from a floor of the same substance; and where the more ancient, the Crystalline, floor of Stalagmite occurs *in situ* vertically below, there is on it also another such boss. These facts have been observed and recorded, not only by the British Association Committee at present exploring the Cavern,* but also by Mr. MacEnery who first made it famous. "The floor of the Bear's den," he says, "was studded with pyramidal mounds of spar [stalagmite] supporting corresponding pendants from the roof. . . . . An irregular crust [of stalagmite] overspread the floor. . . . . This crust was about a foot thick, and was based on a shallow bed of indurated rubble. . . . . On clearing a considerable space of which, points of concealed cones were observed to protrude upwards into this rubbly bed, and as we advanced, what we had hitherto imagined to be the rocky bottom, discovered itself to be a second plate of stalagmite. It is curious that the cones of this lower crust were seated precisely under those of the upper, denoting [that] they were successively deposited from the same tubes above . . . . but the lowermost set exceeded by double the thickness of the upper, and the depth of the stalagmite plate around was in the same proportion."†

From the foregoing facts it may be safely inferred that through the entire period of the Cavern history, so far as it is known, the channels which have introduced the calcareous water have remained the same in all known cases, and that at least the relative rates of the accumulation of stalagmite in the different branches of the Cavern have not altered.

The inscription mentioned above is far from being the only one, nor is it the oldest in Kent's Cavern. There are several of the 17th century, and so far as is at present known the most ancient of the entire series bears the date of 1604. One branch, which prior to 1868 was extremely difficult of access, is so crowded with them as to have received the name of *The Crypt of Dates*. In a review of "Lyell's 'Antiquity of Man,'"

* See British Association Report, 1871, p. 13.

† See Trans. Devon. Association, vol. iii., p. 306, also figure p. 311.

in "Nature," October 2, 1873, Mr. A. R. Wallace, speaking of the Kent's Cavern stalagmites and the inscriptions in the Crypt of Dates, says, "It has been remarked that the varying thicknesses of the stalagmitic floor, from 16 in. to 5 ft. and upwards, closely correspond to the present amount of drip in various parts of the cave. . . . . But names cut into this stalagmite more than two centuries ago are still legible, showing that, in a spot where the drip is now very copious, and where the stalagmite is 12 ft. thick, not more than about one-eighth of an inch, or say one-hundredth of a foot, has been deposited in that length of time. This gives a foot in 20,000 years, or 5 ft. in 100,000 years. . . . . But below this again there is another and much older layer of stalagmite. . . . . This older stalagmite is very thick, and is much more crystalline than the upper one, so that it was probably formed at a slower rate. . . . . A fair estimate will therefore give us, say 100,000 years for the upper stalagmite, and about 250,000 for the deeper layer of much greater thickness, and of more crystalline texture."*

For the data on which his calculations and reasoning are based, Mr. Wallace refers to the British Association Report, 1869, p. 196, for which I am responsible. The following is the paragraph to which he alludes:—"In looking at these dates [in "The Crypt of Dates"], it seems impossible to abstain from reflecting on the facts that they are cut on the upper surface of a mass of stalagmite upwards of 12 feet thick, in a locality where the drip is unusually copious; and that two and a half centuries have failed to percipitate an amount of calcareous matter sufficient to obliterate incisions which at first were probably not more than an eighth of an inch in depth."

In the passage quoted from Mr. Wallace two things are obvious:—(*a*) That he has taken the rate of deposition at the rate of the eighth of an inch in 200 years, whereas my statement is that 250 years "have failed to precipitate an amount of calcareous matter sufficient to obliterate incisions which at first were probably not more than an eighth of an inch in depth;" not that an eighth of an inch had been deposited in 250 years. In fact, my estimate is, and always has been, that on no date known to me in the Cavern has there been deposited more than ·05 inch.

(*b*) Mr. Wallace supposes that the stalagmite 12 feet thick is entirely of the older, the crystalline, variety; and that in addition to this there is a thickness of 5 feet of the less

* Op. cit., p. 463.

ancient, the granular, stalagmite; making for the two thicknesses a total of 17 feet; which, at the rate of ·01 foot in 200 years, would give the total of 350,000 years at which he arrives for the formation of the two stalagmites alone. Instead of this, however, as is shown by the context of the passage in the Report of 1869, the two stalagmites lie one immediately on the other, without any Cave earth between them, in the Crypt of Dates, and the total thickness of the two taken together is about 12·5 feet; not 17 feet.

In short, Mr. Wallace has made two errors calculated to partially, but not entirely, neutralize each other;—he has taken too high a rate of deposition which of itself would lead to too small an amount of time, and too great a total thickness, which, so far as it goes, has the contrary effect. Taking the correct data, that of the Report of 1869, we have 12 feet of stalagmite, formed, let it be assumed from the dates on its upper surface, at the rate of ·05 inch in 250 years, and thereby arrive at the conclusion that the accumulation of the whole required 720,000 years.

Without intending to apply the Kent's Hole chronometer to Cheddar Cave, it may not be uninteresting to remark that the rate of accumulation in the former cavern serves to diminish the surprise with which we learn that the stalactitic and stalagmitic points of the latter have not appreciably come nearer to one another in 35 years; for at the Kent's Hole rate of ·05 inch in 250 years, the actual approach of the points in 35 years would be no more than ·007 inch (·05 ÷ 250 × 35 = ·007);—a quantity too small to be perceptible by the naked eye.

4th. There can be little or no doubt that most of his readers would understand from Mr. Boyd Dawkins's words that there had been too great a tendency to trust to the thickness of the Kent's Hole stalagmite in forming an estimate of the antiquity of the Cave men; and I shall be agreeably surprised if they are not thus quoted in many future discussions on the subject. Be this as it may, it should be added in justice to myself, that I have always abstained from, and cautioned others against, insisting that the thickness of the stalagmite is a perfectly trustworthy chronometer;* nevertheless, it seems fair to ask those who deny that it is of any value to state the basis of their denial; and I fully concur with Mr. Wallace, that though the estimate arrived at in a solitary case may in itself be loose and untrustworthy, "such estimates, if sufficiently multiplied,

* See "The Ancient Cave-Men of Devonshire," *Chambers's Miscellany*, p. 16, 1872.

are of great value, since they help to form a definite idea of what kind of periods we are dealing with, and furnish us with a series of hypotheses to be corrected or supported by further observation, and will at last enable us to arrive at the antiquity of man within certain possible limits of error."*

The question of the antiquity of the Cave men rests, not on geological evidence merely, but also on palæontological, climatological, archæological, and geographical considerations; and if the conclusions to which the latter concur to lead us harmonize better with a slow than with a rapid accumulation of stalagmite,—that is with a rate which has certainly obtained for several hundreds of years—than with a rate of which there is no evidence whatever, it is surely more philosophical to adopt the hypothesis of slow accumulation.

But waiving all this, and supposing it to be true that the actual and clearly ascertained rate during the last 250 years is not only too small, but, on the average, 100 times below the truth, the result would be that the Kent's Cavern stalagmites represent, not 720,000, but 7,200 years. Are those who object to the larger estimate prepared to accept the smaller? They must bear in mind that unmistakable evidences of human existence have presented themselves in the Breccia which the Crystalline, that is the more ancient, Stalagmite covers, and which is therefore older still; and that, after all, the total result would give the antiquity, not of man, but of the earliest known traces of man in Devonshire. It is of no service to attempt a concealment of the fact, that the real contention at present is, not whether man has occupied *Devonshire* during 70,000 or 700,000 years, or any still greater number; but whether the old belief that he first appeared on the *Earth* some 6,000 years ago is to be retained or abandoned.

Mr. Wallace's speculations, mentioned above, appear to have elicited several letters on "Stalagmitic Deposits." One from Mr. John Curry, which appeared in "Nature" of December 18th, 1873, contains the following statement:—"Some thirty years ago I procured a piece of lime deposit from a lead mine at Boltsburn, in the county of Durham; it measured about 18 in. in length, 10 in breadth, and fully ·75 inch thick; it was compact and crystalline, and showed distinct facets of crystals on its surface, over which the water was running. I had indisputable evidence that the deposits had taken place in fifteen years. The water, from which it was produced,

* "Nature," October 2, 1873, pp. 463-4.

issued from an adit in the Little limestone, which is about 9ft. thick. After leaving the adit, the water ran down the perpendicular side of a rise, for some fathoms, on to some rock *débris* which was lying on the bottom of a hopper, whence it proceeded from the upper part of the hopper mouth, then perpendicularly down over two narrowish wood deals, which were set on edge, and put across the mouth of the hopper to retain the worked materials. It was from off these deals that I obtained the specimen above described. On its back side the forms of the deals were well defined; on the front one the crystals were best developed, where the stream was most active.

"In accordance with the above rate of increase of deposit, namely ·75in. in fifteen years, 5in. would require 100 years, 4ft. 2in. 1,000 years, and 41ft. 8in. 10,000 years. The data given to arrive at these results may be relied on as being accurate. In the case now related, the rate of increase of deposit was likely to continue tolerably uniform; as the surface water could have no appreciable influence in augmenting or lessening the flow from the adit."*

Being carefully observed and clearly described, Mr. Curry's facts are valuable and interesting; but his concluding paragraph shows distinctly that they are of no service in the chronological valuation of the Kent's Cavern Stalagmites. In the Boltsburn lead mine the work was continuous; in Kent's Hole it was intermittent. In the Torquay Cavern it was solely performed by the immediate rainfall, whilst in the Boltsburn mine "the surface water," we are told, "could have no appreciable influence in augmenting or lessening the flow from the adit:" in other words, the volume of water constantly flowing is so great that the rainfall of the district is comparatively nothing, and may be utterly left out of the data. The conformation of the hill containing Kent's Hole renders it certain that the only water entering the Cavern is the rain which falls on the hill itself, and the only source of stalagmitic matter is the limestone shell of the Cavern; but nothing is stated, probably nothing is known, as to the extent of country contributing the water issuing from the Boltsburn mine, or how many subterranean streamlets are contributories to the stream finding its outlet at the adit.

Mr. Curry has been so good as to inform me that there is no rain gauge at Boltsburn; that the nearest is that at Allen-

* "Nature," vol. ix. pp. 122-3. See also "The Geological Magazine" for April, 1874, New Series, Decade ii. vol. i. p. 191, where the letter has been reprinted.

heads in Northumberland, about five miles distant in a north-westerly direction, at which the rainfall, he thinks, will closely approximate that at Boltsburn; that Allenheads is 1,369 feet above the sea and Boltsburn 1,100 feet; that there is much moorland in the vicinity of each place, and a good deal of peat in the high parts of the moor.

Mr. Symons's "British Rainfall" shows that for the nine years ending with December 31st, 1872, the rainfall at Allenheads averaged 51·80 inches per annum, whilst at Torquay the average was 37·65 inches; the two numbers being as 138 : 100; and yet this heavy rainfall may be neglected, as it can have no appreciable influence on the permanent flow of water.

Mr. W. Bruce Clarke, writing to the same paper, states that he visited about ten years ago, a cavern near Brixton, commonly known as "Poole's Hole" and observed some stalagmite, probably $\frac{1}{8}$ inch in the back [? thickness], had become deposited upon the gas-pipes, which were used to light the cave and had been laid down six months before.* This rate considerably exceeds that mentioned by Mr. Curry, but, unfortunately, no information is given respecting the conditions under which the deposit took place.

Mr. Thomas K. Callard appears to have written about the same time, and to the same journal, expressing the belief that the Kent's Cavern rate of deposit was not uniform; "for when the thick forest (the habitat of the animals whose bones are found in the cave) left an accumulation of decayed vegetation on the soil, we had the natural laboratory where the rain would find the carbonic acid, to act as a solvent upon the calcareous earth, and as this acidulous liquid percolated through the soil and dripped into the cave, we have the origin of the stalagmite, but, as by the axe of man, the forest decreased, in that proportion the chemicals lessened, and as a consequence the deposit diminished. Besides the diminution of the solvent, every year that the operation was going on the material that composed the stalagmite must have been decreasing in the superjacent soil, so that the bicarbonate of lime which now takes two centuries to cover one eighth of an inch [really one twentieth as stated above], might have been, in days gone by, the work of much shorter time."†

It is obvious that Mr. Callard makes the following assumptions:—

1st. That the Cavern hill was formerly clothed with a thick forest.

* "Nature," vol. ix. p. 171, January 1, 1874. † Ibid.

2nd. That a thick forest is peculiarly productive of carbonic acid.

3rd. That the amount of carbonic acid being the same, the Cavern hill was formerly more capable of yielding stalagmitic material than it is at present.

1st. It must be admitted on all hands that we have no means of ascertaining what was the condition of the hill in the early times to which the Cavern points, but according to the author of "A Guide to all the Watering Places," published in 1803, Kent's Hole was at that time in a coppice, and the opening was almost hid in bushes.* Such, also, was its condition when I first visited it in 1834, and such it remained until the house that now crowns its summit was erected a very few years ago. The thickness of the ancient forest of Devonshire could produce no effect in Kent's Hole unless the Cavern hill bore its full share of such forests, or unless the configuration of the adjacent district was so very unlike that which at present obtains as to send a large part of the water draining it into the Cavern. The latter hypothesis, however, would probably of itself take us farther into antiquity than the present slow rate at which additions are made to the stalagmite.

2nd. If the trees it bore in earlier times were larger than those which formed the coppice just mentioned, it is certain that they must have been correspondingly fewer; and, had we no further data, it might be doubted whether on an area fully stocked more carbon would be fixed by large old trees than by small young ones. Fortunately, however, this problem received the attention of the eminent Liebig, who gives the following statement on it:—

"Fertile land produces carbon in the form of wood, hay, grain, and other kinds of growth, the masses of which differ in a remarkable degree.

"2650 lbs. of firs, pines, beeches, &c., grow annually as wood upon one Hessian acre of forest-land with an average soil. The same superficies yields 2500 lbs of hay.

"A similar surface of corn-land gives . . . . 800 lbs. of rye, and 1780 lbs. of straw,—in all 2580 lbs.

"One hundred parts of dry fir-wood contains 38 parts of carbon; therefore 2650 lbs. contain 1007 lbs. of carbon.

"One hundred parts of hay, dried in air, contain 40·73 parts carbon. Accordingly, 2500 lbs. of hay contain 1018 lbs. of carbon.

. . . . . .

* Op. cit. p. 357. See also "Trans. Devon Asso." vol. ii. p. 474.

"One hundred parts of straw, dried in air, contain 38 per cent. of carbon; therefore, 1780 lbs. of straw contain 676 lbs. of carbon. One hundred parts of corn contain 43 parts of carbon; 800 lbs. must therefore contain 344 lbs.—in all 1020 lbs. of carbon."*

The amounts of carbon from the same area—1007, 1018, and 1020 lbs.—though not identical, are so nearly so, as to justify Liebig in remarking that "it must be concluded from these incontestable facts, that equal surfaces of cultivated land of an average fertility are capable of producing equal quantities of carbon;" they suffice also to neutralize the objection urged by Mr. Callard.

3rd. Though it must be admitted that the hill is necessarily somewhat smaller at present than it was prior to the commencement of the stalagmitic formations, the diminution cannot be considerable; for, judging from the mean thickness of the stalagmite into which the limestone has been converted, and making ample allowance for insoluble matter, it cannot be supposed that the vertical loss has amounted to five feet.

But waiving this; since a given volume of water, at a given temperature and pressure, can absorb but a definite and limited quantity of carbonic acid, which in its turn can dissolve but a limited quantity of carbonate of lime, it may be believed that the existing limestone roof of the Cavern, from 30 to 50 feet in thickness, and the walls of still greater volume, are amply sufficient to give the solvent the opportunity of doing all the work of which it is capable.

The "Popular Science Review" for January 1874, No. 50, contains an article on the fourth edition of Sir C. Lyell's "Geological Evidence of the Antiquity of Man," &c., in which the following passages occur:—

"[Sir C. Lyell] has completely recast the chapter on Kent's Hole and the Brixham Cavern, and has added a considerable mass of novel evidence regarding the former. This part of his work is of considerable importance, for the vast researches of Mr. Pengelly and his fellow labourers, Mr. Falconer and Mr. Prestwich,—assisted by grants from that wonderfully generous lady Baroness Burdett Coutts and the Royal Society, and carried on as they were for a considerable number of years —have only lately been brought to a conclusion." †

* "Chemistry in its Applications to Agriculture and Physiology." By Justus Liebig, M.D., PH.D., F.R.S., M.R.I.A. Edited by Lyon Playfair, PH.D., F.G.S., and W. Gregory, M.D., F.R.S.E., 4th ed. 1847, pp. 11, 12.

† Op. cit. pp. 62-3.

Again, "There is a deal of important evidence cited in regard to the exploration of Kent's Cavern, and some important remarks are made on the subject of the teeth of Machairodus. Mr. Pengelly is opposed to Mr. Boyd Dawkins as to the position of this animal. The latter is inclined to place it in a lower deposit than Mr. Pengelly. That, however, will not much affect the importance of the discovery of its teeth. Besides, Mr. Pengelly's idea that the teeth are not mineralized as the bear's bones are, does not appear to us a very formidable objection. For he must remember that the layers of the enamel do not normally contain more than two per cent. of animal matter, and that the dentine contains vastly less than the ordinary bones of a bear. Still, however, his objection is worthy of attention."*

The former passage, being not unlikely to allow the reader to get confused, appears to call for a definite statement respecting the exploration of the two famous caverns named in it.

The researches in which I had the pleasure of co-operating with the late Dr. Falconer and Mr. Prestwich, were those carried on in the Windmill Hill Cavern, at Brixham, commencing in July 1858, and closing, so far as the actual excavation was concerned, at Midsummer 1859. A Report on the results obtained was presented to the Royal Society in 1872, and published in the "Philosophical Transactions" for 1873.† The funds were obtained from the following sources:—The Royal Society of London, £200; The Baroness Burdett-Coutts, £50; Sir J. Kay Shuttleworth, £5; and R. Arthington, Esq., £5.

The Kent's Cavern researches have been carried on entirely at the expense of the British Association, and by a Committee of that body. The Committee was first appointed in 1864, when it consisted of Sir C. Lyell, Bart. (Chairman), Professor Phillips, Sir J. Lubbock, Bart., Mr. J. Evans, Mr. E. Vivian (Treasurer), and Mr. Pengelly (Hon. Secretary); Mr. G. Busk was added in 1866; Mr. W. Boyd Dawkins, in 1868; Mr. W. Ayshford Sanford, in 1869; and Mr. J. E. Lee, in 1873. The work was commenced on 28th March 1865, has been continued without intermission to the present time, and is still in progress. The Association has already spent on it the sum of £1,400, in annual grants varying from £100 to £200.

With regard to the Kent's Hole Machairodus (*M. latidens*, Owen), I have stated elsewhere that Messrs. Boyd Dawkins

* Op. cit. p. 65. † Vol. ii. Part ii. pp. 471-572.

and Ayshford Sanford had suggested a higher antiquity for the species than that which I had assigned to it, and have done my utmost to state fully and fairly the grounds on which their suggestion rested, as well as those which led me to decline its acceptance.* It is therefore unnecessary to do more than to recapitulate them here.

There are in Kent's Cavern two mechanical deposits, differing greatly in age, containing remains of extinct mammals. One of them, certainly the more ancient, and known as the Breccia, has, up to the present time, yielded remains of Bears only; whilst the other, or less ancient, termed the Cave Earth, was replete with a great variety of the ordinary Cave Mammals, amongst which the Cavern hyæna (*Hyæna spelæa*, Gold.) was by far the most prevalent species. His presence was attested by his bones and teeth, by his coprolites, by bones broken after a pattern known to be characteristic of the genus, and by his teeth-marks on bones which he had gnawed; but no trace of any of these evidences of him occurred in the more ancient deposit. The remains of Machairodus found in the Cavern are but scanty, and consist of seven teeth only—five canines met with by the late Rev. J. MacEnery, in January 1826, one incisor, by the same explorer subsequently, and one incisor by the British Association Committee in July 1872. It is admitted on all hands that they were all actually found in the Cave-earth, or less ancient deposit, commingled with remains of species undoubtedly characteristic of it. Nevertheless, Messrs. Dawkins and Sanford, impressed with the fact that, whatever its own era may be, its zoological affinities are undoubtedly Pliocene, and with the further fact that bones and teeth of bear have in some cases been dislodged from the Breccia, or more ancient deposit, and re-inhumed in the Cave-earth, or less ancient accumulation, have suggested that possibly, and, indeed, probably, the Machairodus teeth have undergone a similar dislodgment and redeposition; that, in short, the species belonged to the fauna of the Breccia, but not to that of the Cave-earth.

The following are the facts which appear to me to be fatal to this hypothesis:—

1st. In some places animal remains formed fully 50 per cent. of the entire mass of the Breccia, yet not a trace of Machairodus was found amongst them,—a fact nothing short of wonderful if the teeth under discussion were derived from it.

* See "Trans. Devon. Assoc." vol. v. pp. 165-79; or "Quart. Journ. Science," vol. ii. N.S. pp. 204-23.

2nd. The remains of the Breccia were more highly mineralized than those of the Cave-earth, and the teeth of Machairodus had the mineral condition characteristic of the less ancient deposit, but not that of the more ancient. It will be remembered that the Popular Science reviewer reminds me that in teeth "the layers of the enamel do not normally contain more than two per cent. of animal matter, and that the dentine contains vastly less than the ordinary bones of bear." To this it is only necessary to reply that the teeth of Machairodus were compared, not with the *ordinary bones*, but with the *teeth*, of bear. Indeed, the opinion that certain teeth and bones of bear found in the Cave-earth had been derived from the Breccia is based solely, but no doubt securely, on the fact that they were highly mineralized; that they were identical, in short, in this respect, with the remains met with in the undisturbed Breccia, and differed from those usually found in the Cave-earth. In other words, mineral condition was the only test by which bones and teeth of *Ursus spelæus* derived from the older deposit and redeposited in the less ancient, could be distinguished from those of the same species primarily lodged in the latter.

3rd. It is admitted by all that the canines of Machairodus have teeth-marks on their fangs,—a character which does not occur on any tooth or bone found in the undisturbed Breccia or known to be dislodged from it; a character, moreover, which in all probability establishes the contemporaneity of Machairodus and the bone-eating *Hyæna spelæa*, and thus makes the former a member of the Cave-earth fauna to which the latter exclusively belonged.

4th. The delicate denticulations which, as is well known, characterize the teeth of Machairodus, are beautifully preserved in all the Cavern specimens,—a fact not calculated to excite surprise if they were found where they were primarily entombed, but by no means harmonizing with the hypothesis of dislodgement, transportation, and redeposition.

The Rev. A. G. L'Estrange's "From the Thames to the Tamar,"* contains the following passage on Kent's Cavern:—

[Kent's Cavern] "is said to be upwards of 600 feet in length, and has many branches and ramifications. The entrance is wild and wooded, such as it probably was when, at some indefinitely distant period, it was the abode of the wild animals whose bones are now embedded in the rock. There are three distinct floors in the cavern; in the first and latest

* "From the Thames to the Tamar; A Summer on the South Coast." By the Rev. A. G. L'Estrange. London, 1873.

are Saxon beads, and bones of foxes and badgers; in the next those of lions, elks, wolves, hyænas, elephants, and rhinoceroses; in the third and lowest those of bears, which, from the size of their bones, must have been of the most formidable proportions. There is also a nondescript animal found, something between a lion and a bear. Mr. Evans states that some remains of tigers have been found here—a rare discovery. Some branches of the cavern seem to have been favourite resorts for particular kinds of animals; on one side lived the elephants, on the other the wolves. Explorations have been long carried on here. Before the year 1846 the cave was open to the public, and the tradesmen of the town were in the habit of breaking the stalactites and carrying off the bones. From the year 1831, a Mr. MacEnery, a Roman Catholic priest, greatly exerted himself in investigating the locality, and made some valuable discoveries. After 1846 it was closed, and came successively into the possession of the Torquay Natural History Society and of the British Association; the latter are still continuing the excavations. Our guide, who was one of the workers, told us that each inch of the formation represented 10,000 years, showing how much his scientific occupation had enlarged his views! There is no very satisfactory theory with regard to these caves, of which there are several on this coast. . . . We can only surmise that the carnivorous animals dragged their prey after them, and then, dying themselves, made way for a new race of depredators. Flint knives are found intermingled with the bones of extinct animals, and it is evident that at some periods the cave was inhabited by men, little superior, perhaps, to these beasts of prey. The fauna points to a great alteration in the climate, and to a very wild state of the country, probably to the time when woods grew and mammoths ranged over what is now Torbay, and when this island was connected with the continent."*

Though Mr. L'Estrange does not pretend that his is a scientific work, it would be to be regretted if the numerous topographical, historical, and archæological statements which occupy so great a portion of its 341 octavo pages were found to be untrustworthy, leading the reader into error instead of supplying him with interesting information. Without venturing to give any opinion respecting its value on other topics, it may be safely stated that its description of Kent's Cavern and its contents is by no means accurate.

Though geologists have no right to object to the statement

* Op. cit. pp. 313-4.

that in the Cavern the "bones of the wild animals are now entombed *in the rock*," seeing that they apply the term "rock" to *all substances which occupy definite spaces in the earth's crust and exhibit a certain order of arrangement, whether they be soft or stony*,* there can be little doubt that the statement would lead unscientific readers, those in fact for whom the book was intended, to the conclusion that the mammalian remains were emtombed, not in loose mud or loam, but in coherent masses of *rock* in the popular acceptation of the term.

With regard to the number of "floors" in the Cavern; instead of "three," they should be stated to be "five"—*three* of mechanical origin separated from one another by *two* chemical deposits; the first, or uppermost, or latest, being the *Black Mould;* the second, *Granular Stalagmite;* the third, *Cave-Earth;* the fourth, *Crystalline Stalagmite;* and the fifth, or lowest, or earliest yet known, *Breccia*. It is usual, however, to apply the name "floor" to the two stalagmites only. But waiving this, and assuming that the three mechanical accumulations, those in which the osseous remains are chiefly found, were alone alluded to by the author, it is true that a very few beads, all of amber, were found in the first "floor," or black mould, but it may be doubted whether the author is justified in terming them *Saxon beads*, or referring them to Saxon times or people.

"Bones of foxes and badger" were undoubtedly found in this "first floor," but it is equally true that they were met with also in the Cave-earth—the third of the five deposits, or what the author probably termed the "second floor."

The "nondescript animal . . . . something between a lion and bear," mentioned by Mr. L'Estrange, was, of occurs, the famous *Machairodus latidens*, Owen; but when he asserts that "Mr. Evans states that some remains of tigers have been found in the cavern," there can be no doubt that he has misunderstood the author he refers to. Mr. Evans, after giving a tabular list of the principal species of animals found in the Cavern, remarks "To this may be added the *Machairodus latidens*, or sabre-toothed tiger, of which one incisor and five canines were discovered . . . . . by Mr. MacEnery.† There is no other passage to which allusion can have been made; but Mr. L'Estrange, misled by the word tiger, has failed to detect in the great sabre-toothed felis, his "nondescript animal . . . something between a lion and bear."

* See "Lyell's Student's Manual of Geology," 1871, p. 2.

† "The Ancient Stone Implements, Weapons, and Ornaments of Great Britain. By John Evans, F.R.S., F.S.A." &c., London, 1872, p. 463.

It is difficult to imagine where he obtained the amusing piece of information that "some branches of the cavern seem to have been favourite resorts for particular kinds of animals, having on one side the elephants and on the other the wolves." In the first place, there is no reason to believe that elephants or any other of the great herbivores ever *lived* in the Cavern. Their remains were probably lodged there through the agency of hyænas, who dragged into their den portions of such animals as they found dead in its vicinity. In the second place, all branches of the Cavern in which remains of elephant have been met with, have yielded those of wolf also.* Mr. Mac Enery, unaware of the fact that the deposits he found in different branches of the Cavern belonged to two distinct eras, and contained remains representative of two faunæ, came to a somewhat similar conclusion; but his two imaginary unsocial groups were not elephants and wolves, but bears and hyænas.†

The statement that "before the year 1846 the cave was open to the public," is no doubt intended to convey the idea that it was first closed in that year. It was certainly under lock and key in 1834 when I first visited it, and it has remained so from that up to the present time. Mr. Northmore, the first who found bones in the Cavern, writing in 1832, remarks, somewhat complainingly, that in 1824 when his first visit was made, there were "no bars, no locks, no bolts, every one might enter the cave, explore if he pleased, and return according to his will and pleasure;" and he adds, "not that I blame the owner Sir Lawrence Palk (since the bones have become objects of sale), for closing the entrance."‡ Sir W. C. Trevelyan, Bart., F.G.S., one of the earliest explorers of the Cavern, has been so good as to favour me with copies of passages in letters sent him by the Rev. Dr. Buckland. In one of these, dated "Oxford, Nov. 14th, 1824," Dr. Buckland states his intention to visit Kent's Hole in the following January, "which," he says, "will be soon enough, if in the mean time Sir L. Palk walls up the cave." In a later portion of the same letter he says, "I hope Sir Lawrence's wall will be got up as speedily as possible." Sir W. C. Trevelyan says, in his letter accompanying the copies, "I had written to Sir L. Palk, recommending him to put a door to the cave, to prevent the indiscriminate and unscientific ransacking of the

* See Tables in "Reports of the British Association," 1870, pp. 19, 24, and 27; 1871, pp. 4 and 9; 1872, pp. 31, 35, and 42.

† See "Trans. Devon. Assoc." vol. iii. pp. 255-6.

‡ See "The Panorama of Torquay. . . . By Octavian Blewitt." Second Edition, 1832, p. 116; or "Trans. Devon. Assoc." vol. iii. p. 483.

contents, which were then going on, previous to Mr. MacEnery having entered on his researches. This I tell you to explain a passage in one of Dr. Buckland's letters." As we know that Mr. MacEnery began his systematic researches "at the close of 1825,"* there can be little or no doubt that the door had been put up by that time, and this receives some support from the fact that in his subsequent letters, dated May 4th, 1825, May 23rd and Dec. 16th in the same year, Dr. Buckland makes no mention of a wish to have the cavern closed. Indeed, evidence of the Cavern being closed in 1825 or the following year has recently reached me from America. Mr. William Minifie, Professor of Mathematics, Baltimore, Maryland, U.S.A., but formerly resident in Torquay, says, when writing me on the Cavern, in November, 1873, "Having had the free use of the Cavern for so many years, people were much dissatisfied at its being locked up, much grumbling against Sir Lawrence Palk was the consequence: I believe the gate was several times broken open. In the summer of 1825 or 26 a party of four of us wished to visit the Cavern. . . . . I endeavoured to get the key from Mr. George Pearce . . . . Sir Lawrence Palk's factotum, but could not find him, so we walked out in hopes to find the gate open." There can be no doubt, therefore, that in 1825 or 1826 at latest the Cavern ceased to be open to all comers, that is fully 20 years before the date given by Mr. L'Estrange.

The author is incorrect also in stating that Mr. MacEnery commenced his researches in 1831, the real date being 1825, as already stated.

It is, perhaps, impossible to say whether Mr. L'Estrange misunderstood the guide's statement respecting the chronology of the deposits, nor are there any means of ascertaining on what the statement, if made, was based. "That each inch of the formation represented 10,000 years," is an estimate greatly exceeding any which has reached me from any other quarter. For myself, I am content with the modest hypothesis of 5,000 years for each inch of the stalagmites, and am willing to suppose the mechanical deposits to have accumulated more rapidly. It must be admitted that the author had some reason for supposing that the guide's "scientific occupation had enlarged his views."

VIII. THE SUBMERGED FOREST OF TORBAY.

The Rev. W. S. Symonds has the following remarks, in his

* See "Trans. Devon. Assoc." vol. iii. p. 444.

"Records of the Rocks," respecting the *Submerged Forest of Torbay*:—"The waters of Torbay roll over the site of a submerged forest which extends seaward for a considerable distance. The remains of the Mammoth, with those of the Bos longifrons, have been found between Torquay and Torbay in forest peats. It is very doubtful, however, whether the Mammoth remains are not derived from some more ancient deposits. There is no good evidence that this animal lived up to the period of the submerged forests."*

The allusion to the Mammoth in the foregoing paragraph, is to a left lower molar, now in the Museum of the Torquay Natural History Society, and is the only relic of that animal which the Torbay forest is known to have yielded. It has been identified by Professor Owen and the late Dr. Falconer, and mentioned by several authors. The statements just quoted render it desirable to bring together, and place on record, all that is known respecting the locality in which it was found, the evidence that it belonged to the Submerged forest, and the era of the species.

1st. As conflicting statements have appeared from time to time respecting the locality in which this interesting specimen was met with, and as it is not easy to say what is meant by "between Torquay and Torbay," it may be as well to state the facts of the case, which are as follow:—Mr. C. E. Parker, of Torquay, being one day at Brixham harbour, observed the molar as it was brought ashore by some trawl fishermen, who informed him that they had dredged it up in their trawl, a little within and on the southern side of Torbay. From the situation, it must have been in fully five fathoms water; and this is confirmed by the depth required for trawl fishing. Mr. Parker at once purchased the tooth, and presented it to the Torquay Natural History Society, of which he was a member.

2nd. That it is a true Submerged forest specimen is admitted by Mr. Godwin-Austen, Dr. Falconer, and Sir Charles Lyell;† all of whom have studied it and called attention to it. It has been remarked by Dr. Falconer that "it is exceedingly fresh-looking, with a slight tinge of smut, as if it had lain in a peat-bed;"‡ and that "the surface is entirely free from any incrustation of marine Polyzoa, with which it must have got covered had it lain long at the bottom of the sea.§ To this I would add, that it has not a trace of abrasion,

* Op. cit., p. 292.

† See "Quart. Journ. Geol Soc" Lond. vol. vii. p. 131, 1851; "Nat. Hist. Rev." vol. iii. p. 68, 1863;" "Principles of Geology, 11th ed. vol. i. p. 549, 1872; and "Antiquity of Man," 4th ed. pp. 398 and 415, 1873.

‡ "Nat. Hist. Rev." vol. iii. p. 68. § Ibid.

which in all probability would not have been the case had it been a redeposited fossil. Sir C. Lyell observes that its fresh condition is "probably due to the antiseptic quality of the peat."*

3rd. It must be unnecessary to remark that the conclusion to which we have just been led, is itself a reply to the author's statement, that "there is no good evidence that this animal lived up to the period of the submerged forests;" and as such it is understood by all the authors already mentioned: Thus, Dr. Falconer says, "This [Torbay] peat-bed indicates a subsidence of the land in Devonshire, then peopled with Elephants, of a very modern date, and long subsequent to the period of the raised beach, which is so boldly developed along that part of the coast;"† and according to Sir C. Lyell, "The specimen [the Torbay molar] is interesting as serving to establish the fact that the Mammoth survived when the surface of this region had already acquired its present configuration, so far as relates to the direction and depth of the valleys in the bottom of one of which the peat alluded to . . . was found."‡

Nor is the Torbay molar a solitary "find;" for in 1849 two perfect heads of the Mammoth were found in a forest at Holyhead, of which Sir C. Lyell says, "It is not improbable that these Mammoths survived most of the lost species which were their contemporaries in what has been called the Cavern period."§

Again, and within our own county, in 1869, 1871, and 1872, Mr. P. O. Hutchinson laid before the Devonshire Association, molars of Mammoth cast up by the waves on Sidmouth beach; in 1872 he also produced an unusually large molar of the same species, found in the Sid, by a young man wading up the bed of the river in search of lampreys; and in July, 1873, he read to the same body a paper on "Submerged Forest and Mammoth Teeth at Sidmouth," when he described a series of carefully observed facts connected with a Submerged forest laid bare on Sidmouth beach, by the gales of the preceding winter, which "had never been seen before within the memory of living man," and in which were found four Mammoth's molars.‖

The foregoing well-established facts render it, at least, extremely difficult to believe that "there is no good evidence

* "Principles of Geolo-y," 11th ed. vol. i. p. 549.
† "Nat. Hist. Rev." vol. iii. p. 68.
‡ Op. cit. p. 549. § Ibid, p. 550.
‖ See "Trans. Devon. Assoc." vol. iii. p. 143, iv. p 455, v. pp 39-40, and vi. pp. 232-5.

that the Mammoth lived up to the period of the submerged forests." What may be the era of the forests themselves is a question on which it seems at present only possible to say that they are more modern than the mammoth-bearing Cave-earth of Devonshire.

It is almost amusing to find one's self contending that the Mammoth had not become extinct before the growth of the forests now submerged on our coasts, at the very time that the editors of the "Zoologist"* and of the *Standard* newspaper are calling attention to an article, by a correspondent of the *New York World*, to the effect that an escaped Russian convict, named Cheriton, has just discovered in a valley, 150 miles long and 50 miles wide, near the River Lena, from 15 to 20 living Mammoths, each about 18 feet long, 12 feet high, with tusks projecting 4 feet, and measuring from 8 to 10 feet along the curve. They were all aged, very peaceable animals, and torpid as old oxen; nevertheless one of them was seen to engage in a battle, of an hour's duration, with an aquatic Saurophidian, 38 feet long and armed with scales as well as horrible fangs, and occupying a blue lake in the valley. The battle ended in the discomfiture of the Mammoth, which could hardly limp off after the contest.† Being myself connected with the continent to which Cheriton, the Mammoths, and the Saurophidian belong, I cannot but feel hurt that a newspaper in another continent, in short an *American* paper, was selected as the medium for making known so important a discovery.

* See "The Zoologist," October 1873, pp. 3731-3.

† See "The Mammoth still living," in *The Zoologist* for October, 1873, 2nd series, vol. viii. pp. 3731-3.