3. *Certain* Jurassic (Lias-Oolite) Strata *of* South Dorset; *and their* Correlation. By S. S. Buckman, F.G.S. (Read November 3rd, 1909.)

Contents.

I. Introduction.

The object of the present communication is to show the development and sequence of certain Jurassic strata on the Dorset coast, and to make some comparisons with strata elsewhere. The range of strata dealt with is from the top of the Middle Lias (Pliensbachian) to the lower part of the Fullers' Earth (Bathonian, Vesulian) inclusive.

The communication is laid before the Society for several reasons: it was promised many years ago; it forms a sequence to the papers on North Dorset and the Cotteswolds; it aims to give a detailed account of certain fossiliferous strata of South Dorset, to be used as a foundation for the dating of the fossils; and it offers suggestions in the matter of correlation and subdivision as a basis for the work of other investigators. With this stratigraphical paper there is also offered a palæontological paper, to describe some of the new species mentioned, and to figure some other species which are new and illustrative of strata of the same dates. That communication will be alluded to as 'the palæontological paper.'

The investigations for this paper, which will probably be my last, so far as active field-geology is concerned, were complete in the main several years ago; it was announced in 1893 as nearly ready for publication. Since then changes of residence have involved

packing of specimens, and many have not been unpacked again. As a consequence the identification of species must often be given in general terms, as they were set out in the notes: to wait until the specimens were brought together, freed of matrix, and exactly identified, would lead to indefinite postponement.

However, identification in general terms is sufficient at present, because one does not ascertain the dates of the deposit so much by the actual species, as by the general facies, in the case of Ammonites. Coarse-ribbed *Dumortieriæ*, fine-ribbed *Dumortieriæ*, Ammonites of *aalensis* pattern, Opalinoids, show the dates as well as more exact identifications; because the successive Ammonites of different genera assume certain developmental facies. Examples of how this may be a guidance will be given later. In some cases there may be difficulty, and more exact identification is necessary: especially in detailed division; for instance, there are three or four successive series of Opalinoids which are not easy to distinguish in the rough, even in a general way, but their particular features are noted in Table I (p. 55).

(*a*) Bibliography of some of the Author's similar communications.

This paper is part of a series of communications made upon similar subjects, mainly to this Society, but also to other scientific bodies, so that a list of such prior communications is desirable.

(1) 1889. 'On the Cotteswold, Midford, & Yeovil Sands, & the Division between Lias & Oolite' Quart. Journ. Geol. Soc. vol. xlv, pp. 440–73.

(2) 1890. 'On the so-called "Upper Lias" Clay of Down Cliffs' Quart. Journ. Geol. Soc. vol. xlvi, pp. 518–21.

(3) 1890. 'On the *Jurense* Zone' Journ. Northants. Nat. Hist. Soc. vol. vi, pp. 76–80.

(4) 1891. 'The Ammonite Zones of Dorset & Somerset' Rep. Brit. Assoc. (Cardiff) pp. 655–56; & Geol. Mag. dec. 3, vol. viii, pp. 502–04.

(5) 1893. 'The Bajocian of the Sherborne District; its Relation to Subjacent & Superjacent Strata' Quart. Journ. Geol. Soc. vol. xlix, pp. 479–521.

(6) 1895. 'The Bajocian of the Mid-Cotteswolds' Quart. Journ. Geol. Soc. vol. li, pp. 388–462, & pl. xiv.

(7) 1896. 'Dundry Hill: its Upper Portion, or the Beds marked as Inferior Oolite (*g* 5) in the Maps of the Geological Survey' Quart. Journ. Geol. Soc. vol. lii, pp. 669–720. (In collaboration with the late Edward Wilson.)

(8) 1897. 'Deposits of the Bajocian Age in the Northern Cotteswolds: the Cleeve Hill Plateau' Quart. Journ. Geol. Soc. vol. liii, pp. 607–29 & pl. xlvi.

(9) 1898. 'On the Grouping of some Divisions of so-called "Jurassic" Time Quart. Journ. Geol. Soc. vol. liv, pp. 442–62.

(10) 1901. 'Homœomorphy among Jurassic Brachiopoda' Proc. Cotteswold Nat. F.-C. vol. xiii, pp. 231–90 & pls. xii–xiii.

(11) 1903. 'The Toarcian of Bredon Hill, & a Comparison with Deposits elsewhere' Quart. Journ. Geol. Soc. vol. lix, pp. 445–58.

(12) 1906–7. Monogr. Inf. Ool. Amm., Suppl. (Pal. Soc.) pp. cciv–ccix.

(13) 1898. The Author (& others). 'Excursion to Bridport, &c.' Proc. Geol. Assoc. vol. xv, p. 293.

(*b*) Chronology.

In the various communications enumerated in the foregoing Bibliography, I have shown how it is possible to date the Jurassic strata with very great precision, and I have given various tables of chronology. The plan of more numerous chronological or zonal divisions has been adopted by various geologists, both in this country and on the Continent: even further refinements than I had made, though not always than I had anticipated, have been proposed and used.

The Table of Chronology, which it is proposed to employ in the present paper for dating purposes, is given below. A partly similar table has appeared already [1]; but, as modifications of nomenclature have been introduced by other workers, and are now suggested by myself, republication seems desirable. Further, opportunity is taken to add what may be described as the prominent Ammonite facies of each date, employing for the purpose terms as concisely descriptive as possible. This addition may not only be a guide for field-workers, but it may illustrate what a fine museum exhibit could be made of the stratigraphical-zoological sequence of the different Ammonite facies; because not only is such a sequence proved in the main for Europe, but there is good reason to suppose that it obtains on the other side of the Atlantic and in Japan.

Of the hemeral names tabulated here, three are new: one, *Shirbuirnia*, is due to refinement in generic nomenclature, and two, *schlœnbachi* and *Ancolioceras*, arise from greater precision in chronology; they will be discussed later.

How with opportunity for the examination of thick deposits of strata the want of great refinement in stratigraphical or chronological nomenclature makes itself felt, is shown in a recent paper by Dr. Mascke. Where I have made one division he has made nearly four.[2] A copy of his interesting table is appended (Table II, p. 56), where he compares his divisions with mine. The difference is explained by the fact that in North Germany Mascke has something over 140 feet to study, whereas in this country we have in the most favoured localities less than 5 feet, and at most localities a few inches or nothing. All the same, the possibility

[1] 'On the Grouping of some Divisions of so-called "Jurassic" Time' Quart. Journ. Geol. Soc. vol. liv (1898) table i, facing p. 450.

[2] Just as I am about to present this paper, Mr. Beeby Thompson very kindly sends me some MS. showing that he is doing the same for the Upper Lias. This matter is dealt with later (p. 85).

Hemeræ.	Distinctive Fossil.	General Ammonite Facies.
fuscæ	*Oppelia fusca* (Quenst.)	Oxynote Oppelids.
zigzag	*Zigzagiceras zigzag* (d'Orb.)	Zigzag Stepheoceratids; rounded whorled *Parkinsoniæ*; trigonal whorled *Parkinsoniæ*.
schlœnbachi	*Parkinsonia schlœnbachi*, Schlippe.	Stout-whorled, crassicostate *Parkinsoniæ*.
truellii	*Strigoceras truellii* (d'Orb.)	Compressed *Parkinsoniæ*; hollow-keeled, lineate Oppelids *(Strigoceras)*.
garantianæ	*Garantiana garantiana* (d'Orb.) ...	Evolute *Parkinsoniæ*. Ammonites with ribs opposite but well broken on periphery *(Garantiana)*.
niortensis	*Strenoceras niortense* (d'Orb.)	Bispinous Ammonites *(Strenoceras)*. Fine-ribbed craterumbilicates *(Cadomites)*. Very evolute *Parkinsoniæ*.
blagdeni[1]	*Teloceras blagdeni*	Crassornate craterumbilicates *(Teloceras)*. Stout *humphriesianum* types; spheroidal Stepheoceratids.
sauzei	*Otoites sauzei*	Compressed *humphriesianum* types *(Skirroceras)*. Auriculate, spinous spheroids *(Otoites)*. Mammillate *Sonniniæ*; alticarinate *Sonniniæ*.
Witchelliæ	*Witchellia* sp.	Septicarinati-subsulcate platygyrals *(Witchellia)*. Club-bearing spheroids & subspheroids *(Emileia)*.
Shirbuirniæ ..... (olim *Sonniniæ*)	*Shirbuirnia trigonalis*, sp. nov. ...	Trigonal whorled Sonninians *(Shirbuirnia)*. Ornatilobate, subcarinate & carinate Sonninians.
post-*discitæ*	*Oppelia* of *præradiata* type	Oppelids with convex periphery.
discitæ	*Hyperlioceras discites* (Waagen) ...	Carinatitabulate Hildoceratids. Quadrate-whorled subcrenulaticarinates *(Haploceras)*.
concavæ	*Ludwigella concava* (J. Sow.)	Concavumbilicate Hildoceratids. Dwarf Ludwigoids *(Ludwigella)*.
bradfordensis ...	*Brasilia bradfordensis* (S. Buckman).	Fine-ribbed, gradumbilicate Ludwigoids. Smooth gradumbilicates.
murchisonæ ...	*Ludwigia murchisonæ* (J. de C. Sow.)	Crassornate Ludwigoids.
Ancolioceras ...	*Ancolioceras* sp.	Carinate, rostrate Opalinoids *(Ancolioceras)*.
scissi	*Tmetoceras scissum* (Benecke)	Subcarinate, subrostrate Opalinoids *(Lioceras)*. Annular ribbed, peripherally broken, Dumortierians *(Tmetoceras)*; crassornate Hammatoceratids, *Burtonia*.
opaliniformis ...	*Cypholioceras opaliniforme*, S. Buckman.	Subcarinate rostrate Opalinoids *(Cypholioceras)*.
aalensis	*Pleydellia aalensis* (Zieten)	Jugate-ribbed Grammocerates. Paucicostate Grammocerates *(Cotteswoldia)*.
moorei	*Dumortieria moorei* (Lycett)	Fine-ribbed *Dumortieriæ*. Flexiradiate *Dumortieriæ*.
Dumortieriæ ...	*Dumortieria* spp.	Coarse-ribbed *Dumortieriæ*; multicostate & periodically constricted Dumortierians *(Catulloceras)*. Smooth Oxynotes *(Hudlestonia)*.
dispansi	*Phlyscogrammoceras dispansum* (Lycett).	Nodate Grammocerates; solid-keeled Hammatoceratids.
struckmanni	*Pseudogrammoceras struckmanni*, (Denckmann).	Hollow-carinate Grammocerates.
striatuli	*Grammoceras striatulum*	Solid-keeled (non-septicarinate) Grammocerates; non-nodate *Haugiæ*.
variabilis	*Haugia variabilis* (d'Orb.)	Parvinodate *Haugiæ*.
lilli	*Lillia lilli*	Crassinodate Haugians (*Lillia*, etc. = podagrosi). Nearly smooth *bifrons* types.
[2] *bifrontis*	*Hildoceras bifrons* (Bruguière) ...	Ribbed *bifrons* types. Fibulate Dactyloids *(Peronoceras)*.
[2] *falciferi*	*Harpoceras falciferum*	Hollow-keeled *falciferi* (*Harpoceras* s. str.), genuine sickle-bearers.
[2] *tenuicostati* ...	*Dactylioceras tenuicostatum* (Young & Bird).	Annulate Dactyloids *(Dactylioceras)*.
[2] *acuti*	*Seguenziceras acutum* (Tate)	Annulate Dactyloids (compressed).
spinati	*Paltopleuroceras spinatum*	Quadrate-whorled crenulaticarinates *(Paltopleuroceras)*.

[1] This term is used in the body of the paper; but Mascke has made further subdivision here; and his terms should be inserted to make a complete sequence, see p. 56.

[2] These terms are used in the body of the paper, but other terms are necessary. See footnote 2, p. 54.

TABLE II.—CORRELATION.

Part of Table by Dr. Erich Mascke.[1]

S. BUCKMAN.	E. MASCKE, North Germany.
Strigoceras truellii.	*Parkinsonia*-zone.
Park. garantiana.	*Garantiana*-zone.
Strenoc. niortense.	oben *Strenoc. niortense*, d'Orb. *Teloceras*-zone.
Cœloceras blagdeni.	*Stepheoceras*-zone mit *Dorsetensia complanata*, Buckm.
	Stephanoceras-zone.
	Stemmatoceras-zone mit *Witchellia edouardi*, Sow.
Sphæroc. (?) sauzei.	*Otoites*-zone. *Witchelliæ* f.
Witchelliæ sp.	*Emileia*-zone. *Witchelliæ* f.
Sonninia sp.	*Sonninia*-zone. *Witchelliæ* f.

of these divisions was noted in my Sherborne paper. On p. 501 it is said:

'Bed 5 [of Frogden], with the numerous large specimens of *Stephanoceras Banksi*...seems to be a separable, third portion of the Ironshot'; [and on p. 517:] 'I think it possible that this [division] is an horizon which has escaped notice in our own country. ..... The biological characters [of certain ammonites] suggest that they may have lived in a hemera between that of *Sauzei* and *Humphriesianum*.' (Quart. Journ. Geol. Soc. vol. xlix, 1893.)

Thus the sequence expected in our thin beds was:

Niortensis,
Banksi,
Humphriesiani
inter *Humphriesiani-Sauzei,*
Sauzei;

and this is the stratal sequence which Dr. Mascke has been able to prove in the thick deposits of North Germany. It has not seemed necessary to adopt his divisions in the present paper, because the deposits of those dates are so indistinct in South Dorset; but any future investigator in the Sherborne District should find them very useful.

[1] 'Die *Stephanoceras*-Verwandten in den Coronatenschichten von Nord-Deutschland' Inaugural-Dissertation, Göttingen, 1907, p. 16.

II. Description of the Strata.

(*a*) Chideock.

There is a very interesting and fairly continuous section from the top of Chideock Quarry Hill to the cliffs by the seaside. The sequence on the hill is difficult to follow, because there are only shallow workings and most of these are closed; so, in my former paper, the extent of the beds on the Chideock Quarry Hill was understated, owing to the difficulty of seeing junctions properly.[1] The same cause may affect the section now tabulated; but more details have been obtained, and the method of dating the beds is more exact and elaborate than was in use at that time.

In the same paper was given a section of part of Down Cliffs—the cliffs to the south of Chideock on the sea-coast. Here there was an omission. It was noted in the paper (p. 519) that there was no evidence of the *dispansum*, *striatulum*, and *variabilis* beds, and it was stated that they ought to come in at the base of the Blue Clay, there numbered Bed 9, or at the top of the Junction Bed, there numbered Bed 10. Subsequent discovery verified that surmise; for, in certain places, at the top of the Junction Bed there is a thin layer (2 inches) of a light-coloured stone containing ammonites of the *Grammoceras-striatulum*[2] series. But in many places, even where the Junction Bed is investigated *in situ* in the cliffs, this layer is absent. However, it has also been found in the fields on the west side of Chideock Quarry Hill. Then, in a road-cutting at Symondsbury, there was found further evidence of deposit of this date—a specimen of *Haugia fascigera* encrusted with irony matter.

At about the same time that I had noted the occurrence of *Grammoceras-striatulum* forms near Chideock, the late Mr. J. F. Walker had made the same discovery near Bridport, where he quotes '*Am. (Harpoceras) striatulum*' and '*Am. (Grammoceras) thouarcense*'.[3] He had, however, announced a further discovery—that of *Ammonites germa*[*i*]*ni*, d'Orbigny, in a higher layer.[4] With his usual kindness he gave me examples; and, though I have not seen the rocks *in situ* myself, I consider that *Am. germaini* indicates the presence of some portion of the *dispansum* zone: at any rate, a layer lower than the Blue Clay of Down Cliffs. This layer has not been found in the coast-sections.

The top bed of Chideock Quarry Hill consists of several feet of blue clay of the Fullers' Earth. Below this are some 14 feet of limestones—actual limestones which can be burnt for lime. No evidence was found of the upper or *zigzag* layer, and nothing was seen of any evidence for the lower or *truellii* layer; hence it is presumed that all these limestones belong to the intervening layer which may

[1] 'On the so-called "Upper Lias" Clay of Down Cliffs' Quart. Journ. Geol. Soc. vol. xlvi (1890) p. 519.

[2] To find the author's name, etc., of Ammonites thus mentioned, consult Index, 'Monogr. Inf. Ool. Amm.' (Palæont. Soc.) 1907.

[3] Geol. Mag. dec. 3, vol. ix (1892) pp. 440, 442.

[4] *Ibid.* p. 442.

be dated as hemera *schlœnbachi*: the section of Burton Bradstock (p. 72) will show what this means.

Below these limestones are red earthy stone-beds, much iron-shot, the grains becoming coarser and coarser in the lower part. Rather more than 6 feet of these was noted, and their fossil evidence in part is abundant. A few inches of the top yield Ammonites indicative of the *sauzei* zone; and about 2 feet down there is evidence of the fauna of the *Witchellicæ* hemera. The date of the lower part is not certain: the only evidence was an Ammonite which could be said to be a coronate, and either *Emileia* or a *Stepheoceras*-like form; its condition did not allow of any more exact determination, but it suggests hemera *Shirbuirniæ* (*Sonniniæ*). Below this there seems to be a break in the sequence—nothing of *discitæ* or *concavi* date was noted,[1] though the discovery is possible. The next bed seen is what the quarrymen call the Wild Bed, with its planed-off top, by which they say it can be recognized all over the hill. In some places the top of the Wild Bed shows pockets containing Ammonites of the *Brasilia-bradfordensis* style, in a matrix different from that of the Wild Bed proper. The Wild Bed itself is remarkable for the number of finely preserved examples of the *Ludwigia-murchisonæ* style, many of which from this locality have been figured in my Monograph.

At the bottom of the Wild Bed, attached, is a different matrix containing a big Lytoceratoid, near to *Pachylytoceras aalenianum*.[2] The *Lytoceras wrighti* cited in the former paper[3] is, perhaps, this species, for *L. wrighti* strictly defined is a noticeable fossil of the strata of *aalensis* hemera, a good bit lower down.

This basal part of the Wild Bed it is desirable to date as something earlier than *murchisonæ* hemera and later than *scissi*: it may be dated as *Ancolioceras* hemera; and it will be discussed later.

Below the Wild Bed is the first bed of the Bridport Sands—a hard sandy limestone—the *scissum* bed—with *Tmetoceras scissum* and *Lioceras*, that is, the true *opalinum* group (see Burton Bradstock section, p. 74). Below is marl and stone with badly preserved Opalinoids. Some 6 feet lower is found a noticeable little globose *Rhynchonella* in some abundance (*Rhynchonella pentaptycta*, sp. nov., see the palæontological paper, p. 103).

Associated with it are fine-ribbed Ammonites of *Canavarina-steinmanni* type. About 2 feet lower are many Ammonites of the *aalensis* pattern (for instance, *Canavarina*, *Cotteswoldia*, etc.), on the whole coarser in the character of their ornament than those above: they are good, but difficult to extract. For about 25 feet down there are more or less indications of Ammonites of the *aalensis* pattern. Then there is a break of some 15 feet, which

[1] *Sonninia dominans*, 'Monogr. Inf. Ool. Amm.' p. 324, from Chideock would indicate the presence of *discitæ* deposit. A little to the east, at Mappercombe near Powerstock, evidence of *discitæ* deposit was found by the roadside:—*Terebratula eudesiana*, *Rhynchonella forbesi*, and a Sonninian.

[2] Quart. Journ. Geol. Soc. vol. lxi (1905) pl. xv, figs. 3 & 4.

[3] *Ibid.* vol. xlvi (1890) p. 519, Bed 4.

gave no result, and then was found a block with many specimens of fine-ribbed *Dumortieriæ*, indicative of *moorei* hemera.

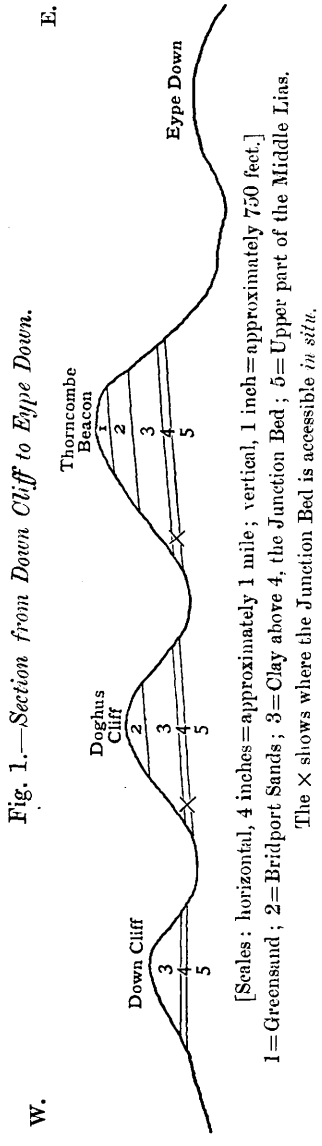


Fig. 1.—*Section from Down Cliff to Eype Down.*

[Scales: horizontal, 4 inches = approximately 1 mile; vertical, 1 inch = approximately 750 feet.]
1 = Greensand; 2 = Bridport Sands; 3 = Clay above 4, the Junction Bed; 5 = Upper part of the Middle Lias.
The × shows where the Junction Bed is accessible *in situ*.

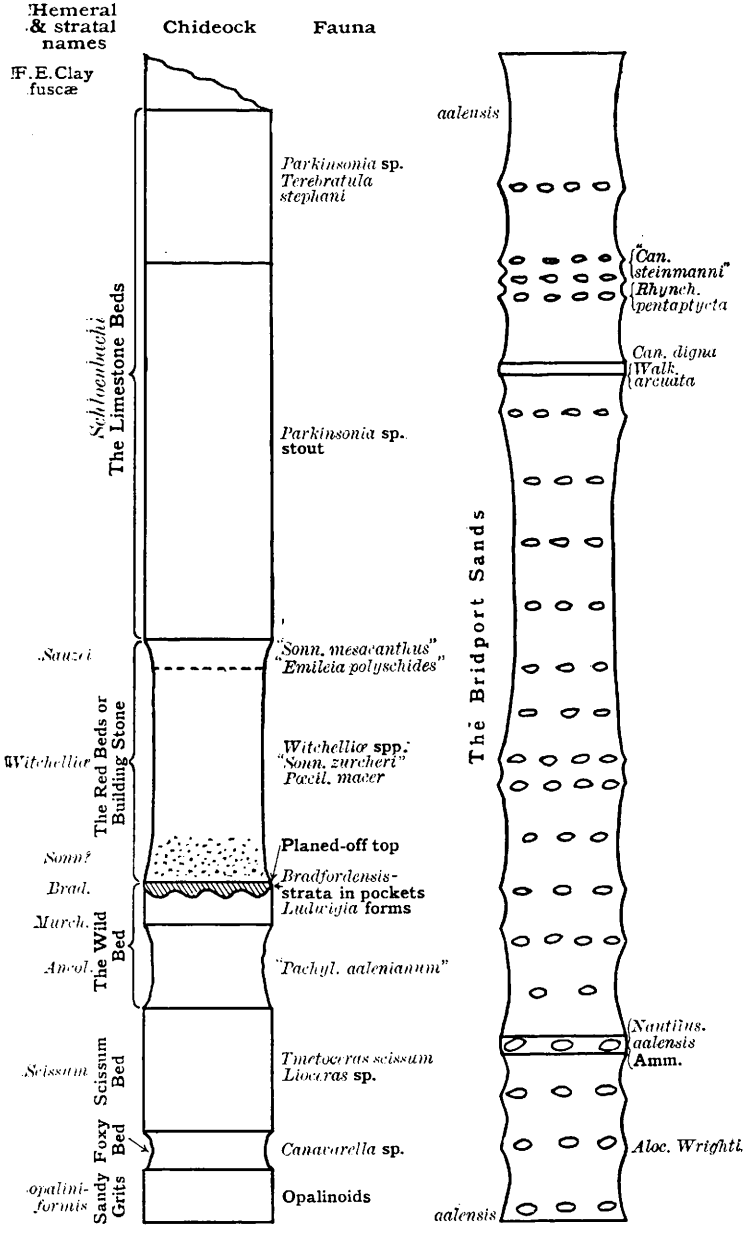
The important point about this part of the section is that there are more than 40 feet of strata deposited during the hemeræ *aalensis* and *moorei*. In the Cotteswolds the amount of deposit during these dates was only a few inches—so insignificant that separation of the distinctive deposits is not easy. Here there is no doubt about the sequence; and, further, change even in the character of the Ammonites of the *aalensis* pattern (*Canavarina*) can be noted: the finer-ribbed forms are later than the coarser-ribbed, as is right in a catagenetic series.

Below the *moorei* bed is a series of yellow sands and sandstones, made out roughly by the level to be about 100 feet thick, down to the spring of water in the road near the top of the hill east of Chideock. This water is held up by the clay-bed which forms the top of Down Cliffs.

The beds have now to be studied on the sea-coast. Here, between Seatown and Eype, are four prominences of the cliffs with hollows between: fig. 1 represents a rough sketch of them. Some local informants stated that the prominences are called from west to east as shown in the appended sketch; others that the term Down Cliffs covered the two prominences west of Thorncombe Beacon. The former is the most suitable for distinctive purposes. Down Cliff is not capped by Bridport Sands, but Doghus Cliff is the first one from Seatown which is so capped. Thorncombe Beacon shows Bridport Sands capped by Greensand; while Eype Down is below the Junction Bed.

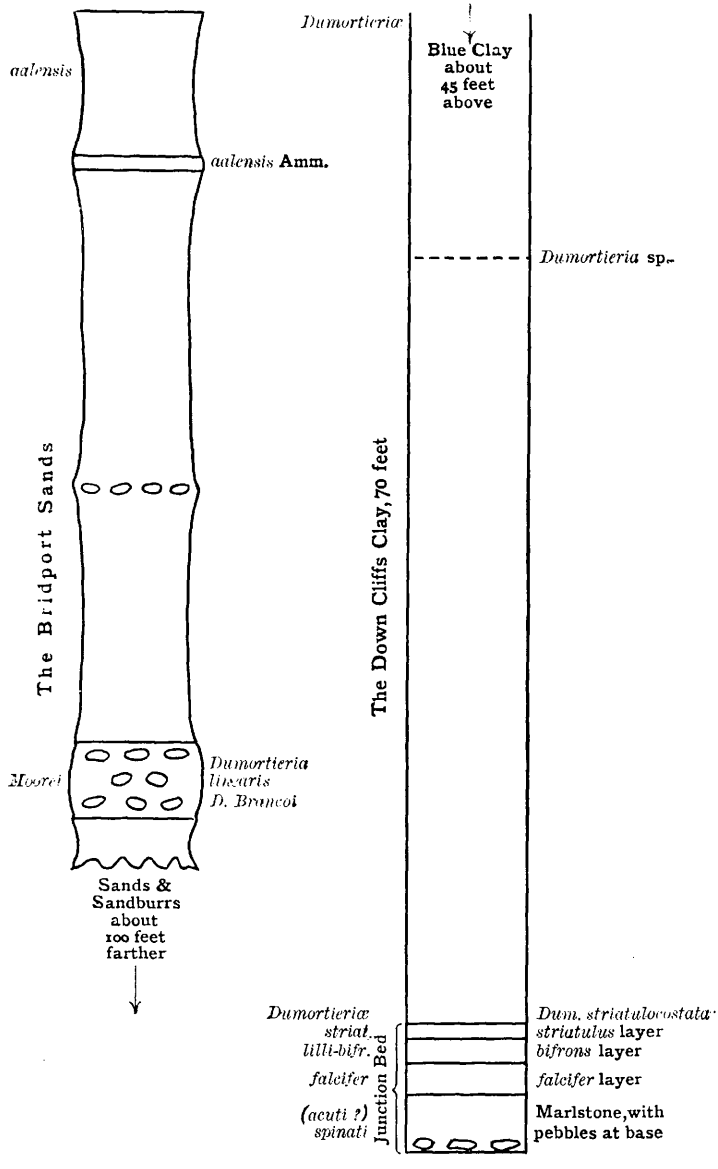
It may be noted that the cliffs are very fairly accessible even for ladies, with a little practice, though they look formidable.

Fig. 2.—*Vertical section of Chideock*



Scale. 1 inch = 5 feet. 1 : 60
10 millimetres = 2 feet.

Quarry Hill and the coast.



Scale. 1 inch = 5 feet. 1 : 60
10 millimetres = 2 feet.

In the Blue Clay of Doghus[1] Cliff below the Bridport Sands, species of *Dumortieria* were obtained at 12, 40, 50 feet down and right on top of the Junction Bed.[2] The names were noted many years ago, and the specimens were fragmentary; but a reference to my Monograph on Inf. Oolite Ammonites (Palæont. Soc.) pt. v (1890) will indicate the approximate forms. The really important point is that they are more or less coarse-ribbed *Dumortieriæ*, and that the 70 feet of blue clay can be dated as belonging to the hemera *Dumortieriæ*: it is of later date than the Midford Sands of Bath, and still later than the Cotteswold Sands of Gloucestershire, yet it is earlier than the Bridport Sands of Dorset.

Inland, in the lane-cutting from Symondsbury leading up to Chideock Quarry Hill, this blue clay is not found on the top of the representative of the Junction Bed: it has either passed laterally into yellow sands, or it is absent.

The Junction Bed lies below the clay. In its more complete form it consists of five different layers of matrix, which occur in regular order and can be easily separated one from another by the chisel. The strata are those of *striatulus*, a *bifrons* bed, a *falcifer* bed, and two layers of marlstone down to *spinatus*: so that this bed of about $2\frac{1}{2}$ feet at the best, represents the lower part of the Toarcian joined to Upper Pliensbachian. However, it is seldom complete—the top, or the bottom, or a middle layer will be wanting. The characters and contents of this bed demand separate treatment later.

The following is a detailed section of Chideock Quarry Hill and the cliffs (see also fig. 2, pp. 60–61):—

SECTION I.—CHIDEOCK QUARRY HILL AND THE COAST.[3]

		Thickness in feet	*inches.*		
fuscæ	(1) Blue clay, capping the limestone .			10–12	0
	(2) 'The Limestone Beds.'[4]				
schlœnbachi ...	(*a*) Grey crystalline limestone, with bands of clayey marl in the lower part. *Parkinsonia* sp., stout form; *Terebratula stephani*	4	0		
	(*b*) Similar limestone. *Parkinsoniæ* same as those in 2nd Bed of Burton Bradstock	0	6		
	(*c*) Earthy parting	0	2		
	(*d*) Greyish limestone.....	1	3		
	(*e*) Grey crystalline limestone, the lower part in massive blocks, about	8	0		
				13	11

[1] Doghus is the name of the cliff and of the farm in the valley behind it. The name is printed as pronounced. A Yorkshireman might think that the name referred to the sandburrs in the cliff which he would call 'doggers.' A south countryman, with as little reason, supposes it to be a corruption of 'doghouse'; but a Welshman might perhaps have more right to claim the name as a corruption of a Celtic term.

[2] See also Quart. Journ. Geol. Soc. vol. xlvi (1890) p. 519.

[3] It is sometimes called Chideock Hill, but this term is given by the natives to the hill up the road to the west. Quarry (Qwor) Hill is the native term for this eminence on the east.

[4] Quarrymen's term. 'These are the only beds of stone fit for lime, the other stone, if burnt, will not slake.'—Quarrymen's information.

		Thickness in feet	inches.
	(3) 'The Red Beds or the Building-Stone.' (Quarrymen's terms.)		
sauzei, *Witchelliæ*.	(*a*) Dark brown, fairly ironshot, sandy, easily worked stone ..... about In the upper few inches alticarinate *Sonniniæ* of the *S. mesacanthus* type, and large *Emileia* cf. *polyschides*, Waagen. About 2 feet down, *Sonniniæ* of the *S.-zurcheri* type, *Sonninia buckmani*, Haug, *Poecilomorphus macer*, numerous *Witchelliæ*, *Stepheoceras*, *Otoites* cf. *contracta* (Sow.).	6	0
	(*b*) Brown ironstone with coarse grains, more irony than bed above.	0	4
Sonniniæ or *discitæ* (?)	Bluish-brown, coarsely ironshot oolite; more coarsely grained than bed above. *Stepheoceras* or *Emileia*.	0	3
	(4) 'The Wild Bed.'		
bradfordensis...	(*a*) Ironshot sandy stone, with Ammonites of the *Ludwigia-gradata* type, often in a perished condition, found in irregular hollows of (*b*). *Cosmogyria subtabulata*, *Apedogyria platychora*, *A. subcornuta*.[1]		
murchisonæ ...	(*b*) Light yellow, finely ironshot stone, sometimes bluish yellow. *Zeilleria anglica* (Oppel) at base. *Welschia obtusiformis*, *Crickia reflua*, *Hyattia pustulifera*, *H. wilsoni*, *Apedogyria patellaria*, *Strophogyria cosmia*, *Kiliania armipotens*, *K. laciniosa*, *Pseudographoceras literatum* (see Monograph)	1	0
Ancolioceras ...	(*c*) Light yellow, softer and less ironshot than above. Large Lytoceratid, cf. *Pachylytoceras aaleniaanum* ..... about	2	0
scissi	(5) Grey sandy limestone. *Tmetoceras scissum* and *Liocerata*	3	0
opaliniformis.	(6 *a*) Brown ironshot, marly stone, with Opalinoid Ammonites, cf. *Canavarella*.. ..... 1 0		
	(*b*) Sandstone with Opalinoid Ammonites, cf. *Walkeria subglabra*, *Rhynchonella stephensi* (*cynocephala*) ... 1 8		
	(*c*) Sands and sandburrs. *Rhynchonella* of *cynocephala* pattern, Opalinoid Ammonites 3 8		
		6	4

[1] See Monograph. These Ammonites were entered as 'from base of red beds'; but it was afterwards found that this particular red bed was in hollows of the Wild Bed.

		Thickness in feet	inches.	feet	inches.
aalensis	(7 *a*) Sand and sandburrs. Fine-ribbed *aalensis*-like Ammonites (the *Canavarina-steinmanni* pattern)... *Rhynchonella pentaptycta*, sp. nov. at about 2 to 2½ feet down.	2	9		
	(*b*) Yellow sands	1	0		
	(*c*) Sand-rock, with coarse-ribbed *aalensis*-like Ammonites (*Canavarina digna*; *Walkeria arcuata*, *W.* cf. *lotharingica*)	0	4		
	(*d*) Sands and sandburrs. Fragment of large *Nautilus*, and coarse-ribbed Ammonites of *aalensis* pattern at the base	17	0		
	(*e*) Sands and sandburrs. *Alocolytoceras wrighti* at the base	2	4		
	(*f*) Sands and sandburrs, fragments of Ammonites of *aalensis* pattern at the base.....	6	3		
				29	8
moorei	(8) Sands and sandburrs: in the lower 2 feet striate *Dumortieriæ* of the *D. moorei* pattern (for instance, *D. linearis*) and of the *D. subundulata* series (for instance, *D. brancoi*) occur			17	0
moorei and *Dumortieriæ*.	(9 *a*) Sands and sandburrs, down to spring by roadside, ... about			100	0
	Sea-coast cliffs:—				
	(*b*) The blue clay of Down Cliffs. At 12 feet down *Dumortieria* cf. *striatulocostata*, *D.* cf. *radians*, *D.* cf. *pseudoradiosa*; at 40 feet down fragments of *Dumortieria*; at 50 feet *D.* cf. *costula*; and at the base *D.* cf. *striatulocostata*			70	0
	(10) Junction Bed, generalized:—				
	(*a*) Irony scale.				
striatuli	(*b*) Yellowish-grey, earthy, slightly ironshot stone, with a somewhat soapy feel. *Grammoceras striatulum* and allied forms.....	0	2		
lilli (?).....	(*c*) Grey earthy stone. *Hildoceratа* of the *bifrons* type (angustumbilicate forms), some much eroded and iron-covered, some quite sharp. A small specimen of the Podagrosi (*Lillia-Haugia* series) occurs; it has large ribs, cf. *Lillia* or *Denckmannia*	0	2		
bifrontis	Yellowish-pink earthy stone, with derived lumps of pink stone. '*Hildoceras bifrons*' small, eroded, iron-coated. Lower down pink (*d*) stone predominant, '*H. bifrons*' larger and less iron-coated; *Harpoceratа* derived (in irony nodules)	0	6		
	(*e*) Irony scale.				
	(*f*) Pink stone with red streaks.....	0	2		
	(*g*) Yellowish-pink stone	0	4		

		Thickness in feet	inches.	
falciferi	(*h*) Attached to yellowish-blue, somewhat sandy stone. *Harpoceras falciferum* and *H.* cf. *strangwaysi*.	0	8	
acuti or *tenuicostati* (?) (*serrata*-bed)	(*i*) Marlstone brown, finely ironshot. In two beds. In the upper bed: *Rhynchonella serrata*; large, hollow-keeled Harpoceratoid Ammonites and *Thysanoceras*.			
spinati..... (*Rh. media* bed).	(*j*) In the lower bed *Rhynchonella media* (that is, the rotund *tetrahedra* form), *Rh. acuta*, *Spiriferina*.	1	3	
	(The thickness of the Junction Bed is thus 3 feet 3 inches, but it is never found complete; about 2 feet, with beds missing, is the rule.)			3 3

Having come so far down the cliff in detail, it may not be uninteresting to reproduce, with modern interpretations, the section published by E. C. H. Day, which embraces the whole of it (see fig. 3, p. 66).

(*b*) Burton Bradstock.[1]

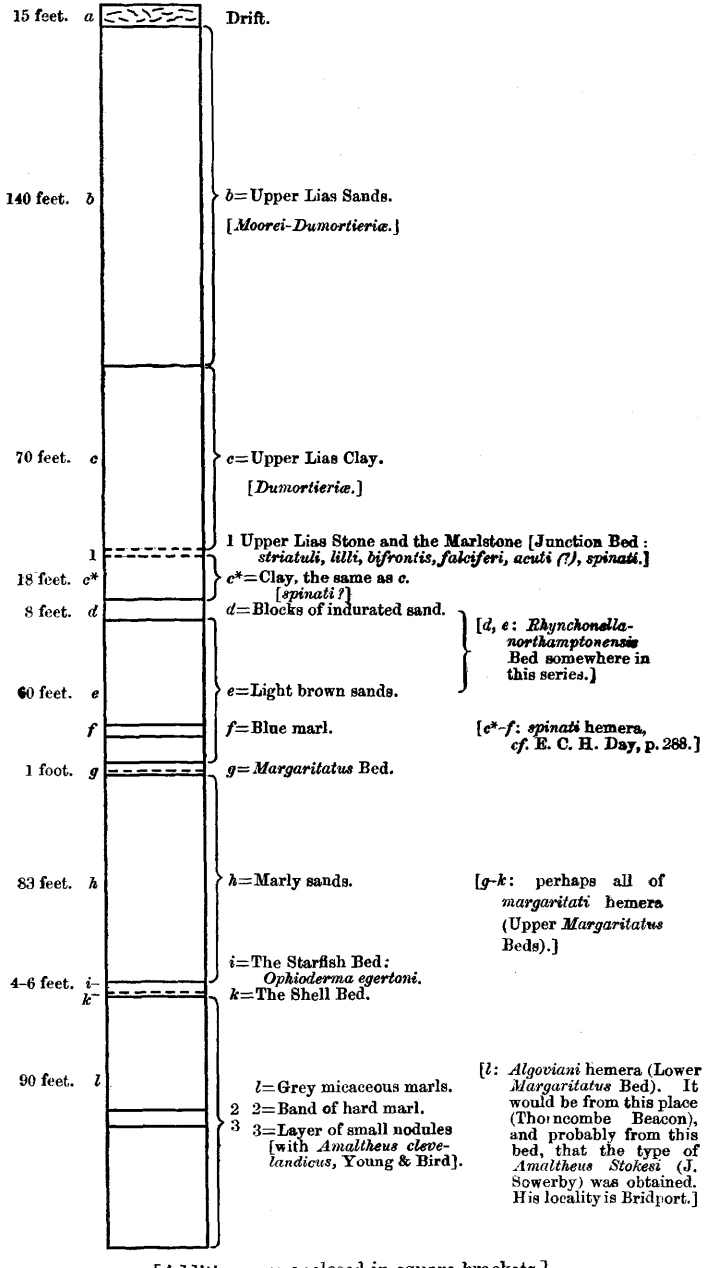
Eastward along the coast the cliffs east of West Bay up to Burton Bradstock afford fine sections of Bridport Sands, capped in places with Inferior Oolite: the latter, especially at Burton Bradstock noted for its abundant fauna, can also be studied in quarries about the village. The details of the stone beds—the Inferior Oolite—differ greatly in a short distance; and therefore only a generalized account of the succession is necessary.

The Fullers' Earth Clay rests on a bed known to the workmen as The Scroff—a thin irony layer yielding *Oppelia fusca* and allied species. Like the *striatulus* layer on the top of the Junction Bed, it is often missing.

The *zigzag* bed comes below the Scroff—it is confined to about the top 6 inches of what the workmen call the 1st Bed, and is recognizable by its bluish colour. The rest of this bed is a different matrix: it is somewhat deficient in fossils; but lithically and faunally it seems to be the continuation of the bed below, which the workmen call the 2nd Bed. Its yellowish colour, with earthy partings, and its stout forms of often poorly preserved *Parkinsoniæ* distinguish it. This 2nd Bed and the lower part of the first, containing a fauna distinct from that of the *zigzag* bed above or the *truellii* bed below, may be dated as hemera of *Parkinsonia schlœnbachi*, Schlippe. The 3rd Bed of the workmen contains two

[1] For other accounts of the strata of this locality, the reader is referred to W. H. Hudleston, 'Monogr. Brit. Jurass. Gasteropoda' (Palæont. Soc.), 1887, pt. i, p. 31; H. B. Woodward, 'Jurassic Rocks of Britain: vol. iv—The Lower Oolitic Rocks of England' Mem. Geol. Surv. 1894, pp. 55 *et seqq.*; also S. S. Buckman, Quart. Journ. Geol. Soc. vol. xlv (1889) p. 451, and Proc. Geol. Assoc. vol. xv (1898) p. 296.

Fig. 3.—*Vertical section of the Middle and Upper Lias at Down Cliffs and Thorncombe Beacon; adapted, with additions, from E. C. H. Day, Quart. Journ. Geol. Soc. vol. xix (1863) p. 285.*



[Additions are enclosed in square brackets.]

distinct beds for the geologist. The upper or *Terebratula* Bed may be recognized by its whitish colour, the masses of *Terebratula* '*sphæroidalis*,' and the excellent preservation of its numerous bluish-coloured *Parkinsoniæ*: this is the *truellii* zone. At the base are some few inches of an ironshot layer, the *Astarte* Bed, so called from the abundance of *Astarte* (now *Crassinella*) *obliqua*; though the species, or something very similar, also occurs in the bed above.

This *Astarte* Bed, or ironshot marly bed, contains fine specimens of *Garantiana*, of *Parkinsonia rarecostata*, and of forms intermediate between that and *P. parkinsoni*. It is Hudleston's P.1, and can be dated exactly as *Garantiana* Beds. It is of the age of the Rubbly Beds and Building-Stone of Sherborne in North Dorset.[1]

Below the *Astarte* Bed is a massive bed, known to the workmen as the 4th Bed, or the Red Bed. It is so massive that, even with the help of a quarryman wielding a sledge-hammer, little impression can be made on the very large blocks lying on the sea-shore. For this reason, and because it is not richly fossiliferous like the other beds, it has not been possible to obtain information as to the exact sequence of fossils in the bed. All the available evidence points to the bed being a conglomerate, containing the fossils of various dates mixed in more or less confusion. The latest date, indicated by a *Perisphinctes*, is the *niortensis* hemera: hence it may be surmised that the deposition of the bed, or of the greater part of it, was finished in that hemera; but right at the top are found Stepheoccrata of the *blagdeni* and *sauzei* hemeræ, with a matrix agreeing more with the middle part of the bed.

In the bottom 9 inches of the bed are large limonitic concretions, sometimes measuring as much as 4 inches in length by about 3 inches across. They are arranged roughly in two layers, and are known to the workmen by the expressive name of Snuff-boxes. These snuff-boxes are also found about 3 miles to the north, inland, in quarries near the high road about 2 miles east of Bridport.

The matrix associated with the snuff-boxes at Burton is coarsely ironshot, different in character from the rest of the bed above. From the workmen and from scattered blocks have been obtained specimens showing somewhat this character of matrix—*Witchelliæ* and alticarinate *Sonniniæ* of the *S. propinquans* type—species of the *Witchelliæ* and *sauzei* hemeræ.

The conclusions that may be drawn concerning the date or dates of the deposition of the Red Bed—including the snuff-box layers—are:—that the bed was begun in the *Witchelliæ* or *sauzei* hemera, was continued during the *blagdeni* hemera, and was much disturbed, broken up, and greatly re-arranged during the *niortensis* hemera.

This Red Bed affords a good instance of the difference between zones and hemeræ. It cannot be said to belong to any definite zone or zones: rather is it a mix-up of several zones; but it is

[1] Quart. Journ. Geol. Soc. vol. xlix (1893) p. 507.

possible to say that species known to have existed during the various dates *Witchelliæ* to *niortensis* hemeræ are found in this bed.

The bed below is another example of the same phenomenon—it is a yellow marly conglomerate of very irregular thickness—generally no more than a couple of inches; and it is cemented on to a sandstone-bed below, though portions of it are sometimes found striking to the base of inverted blocks of the snuff-box bed.

This 'Yellow Conglomerate Bed,' as it may be called, is really no more than a parting between the snuff-box bed and the sandstone (*scissum*) bed. But it contains a rich assemblage of mostly small fossils of many different dates. Its latest fossils are of the date of *discitæ* hemera; and so it may be supposed that the bed was formed during that date, deriving materials from the destruction of earlier deposits.

The characteristic fossils of the *discitæ* hemera are carinatitabulate Hildoceratids of the *Reynesella*, *Darellia*, etc. pattern[1]; small gastropoda characteristic of the *discitæ* bed of Bradford Abbas; Belemnites of the *blainvillei* type, and so forth. Indications of *concavi* hemera are various small *Ludwigellæ*. Fragments of fine-ribbed gradumbilicate Hildoceratids indicate derivation from strata of *bradfordensis* date; while such a species as *Cirrus nodosus* points to strata of *murchisonæ*, or perhaps earlier, *Ancolioceras* hemera. Then there are derived fragments of the *scissum* bed included.

Below the Yellow Conglomerate Bed is the *scissum* bed—a sandstone, or sandy limestone, of a bluish-grey colour. This bed yielded the series of *Liocerata* described in my Monogr. Suppl. pp. xxxvi *et seqq.* It also furnished *Tmetoceras scissum* (from which it takes its name) and *Tm. circulare*, besides yielding species of a rather remarkable series of Hammatoceratidæ. For these a new generic name *Burtonia* is proposed[2]; and they are remarkable for their likeness to what used to be known in a wide sense as *Ammonites murchisonæ obtusus*; the likeness has not improbably led to confusion in regard to zonal identification; at any rate it would be desirable to be sceptical about any records of *A. murchisonæ* from Burton or the neighbourhood to the north.

Below the *scissum* bed is a brown marly layer, whence has come *Zeilleria* (or *Ornithella*) *oppeli*.[3] In it, too, are various more or less poorly preserved Opalinoid Ammonites, differing from the *Liocerata* in having a much larger umbilicus in proportion to their tenuity. They are near to *Canavarella sceleta*[4]; but that species, though its horizon is not exactly known, probably came from the sand-rock immediately below.

This sand-rock yields poorly preserved Opalinoids, of the *Walkeria-subglabra* pattern; but the collection of identifiable specimens *in situ* is difficult.

[1] 'Monogr. Inf. Ool. Amm.' Suppl. (1906–07) pp. cv *et seqq.*
[2] See the palæontological paper, p. 97.
[3] Quart. Journ. Geol. Soc. vol. lii (1896) p. 702.
[4] Monogr. Inf. Ool. Amm.' Suppl. (1906–07) p. cxxix & pl. xxii, figs. 19–21.

Some 6½ feet below the top of the *scissum* bed are found sand-burrs and sand-rock, yielding Ammonites of the *aalensis* pattern; they are good but not very easy to extract, and the sandy matrix is removable with difficulty.

Scattered blocks yielding Ammonites of the *aalensis* pattern may be presumed to belong to this horizon: they have yielded *Canavarina*, *Walkeria*, *Cotteswoldia*, and various examples of *Alocolytoceras wrighti*: one, which broke up while a workman was extracting it, was 20 inches in diameter; there is also a *Nautilus* near to *N. multiseptatus*, Foord & Crick.[1]

It may be presumed that it was from this horizon that *Canavarina digna* (Monogr. p. cxlii) and *Walkeria burtonensis* (p. cxxxix) were obtained, while possibly *W. delicata* (p. cxl) and *Canavarina steinmanni* (p. cxlii) were just a few inches higher, by analogy with Chideock.

In a little knoll north of Freshwater, the name for the place where the River Bredy enters the sea, west of Burton, there is a section in sands—a few feet. It gave evidence for *aalensis* beds at the top, and for *moorei* beds some few feet lower down; but the condition of the Ammonites allowed merely of a general determination of their facies.

The *Catulloceras dumortieri*[2] was from a fallen block: it can only be said that it belongs to a group indicative of an earlier date than *moorei* hemera. The lower part of the sands in the cliff, where they are accessible, seems to be particularly barren: so far as Ammonites are concerned, nothing can be recorded; there are Belemnites.

The thickness of Bridport Sands shown in the Burton cliffs would somewhat exceed 100 feet, and at intervals of every few feet there are lines of sandburrs, or sometimes more continuous sand-rock (see fig. 4, p. 70). As the sands (or sand-rock) become blue in the lower layers, which are exposed occasionally after exceptional tides, it may be presumed that these sands rest upon a blue clay like that at Down Cliffs.

The White Bed or *Nautilus* Bed.—In the foregoing account of the strata of Burton the bed which is of special interest, because it is a new discovery, has not been mentioned, for the reason that it is not found in the main cliff, nor in any of the quarries. It only occurs in a more or less tumbled condition in the bank at the beach opposite the villas, where the roadway comes to the shore (see fig. 4, p. 70). It is particularly exposed on the sort of pathway leading from the road to the beach, and just to the right hand as one reaches the beach.

The place where this bed is exposed is in the line of fault, a downthrow to the east of 200 feet or more, which has brought Bradford Clay and Forest Marble (Bathonian) of the East Cliff of

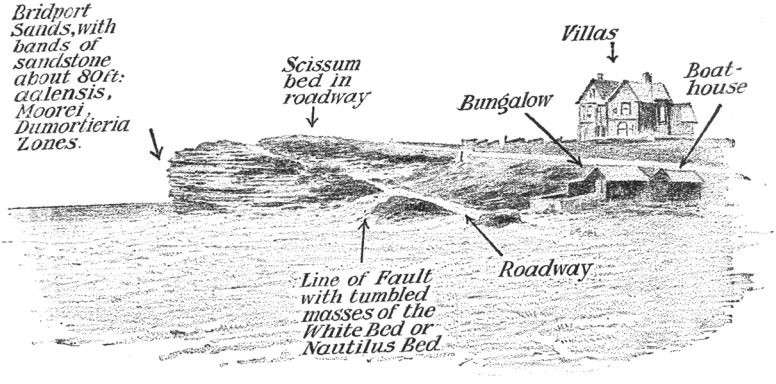
[1] The specimen is now in the Museum of Practical Geology, Jermyn Street.

[2] 'Monogr. Inf. Ool. Amm.' p. 277 & pl. xxxix, figs. 6–9.

Burton to a level with the Bridport Sands (Toarcian) of the West Cliff. It is singular, however, that the white bed with its attached sandstone was found alone—not associated with other Inferior Oolite beds, although the *scissum* bed crops out in the road above (see fig. 4), near the top of the hill.

The characters of the White Bed are:—That it is a conglomerate

Fig. 4.—*View of the cliff-exposure at Burton Bradstock.*



of various sorts of white, and sometimes brownish, matrix; there is a fine-grained white matrix looking like a lithographic stone, and very similar to the White Jura of Würtemberg, or the *diphya*-kalk of Tyrol—it has a smooth soapy feeling: there is a less fine-grained white matrix which feels rough, and seems to be somewhat sandy. These two sorts of stone are in fragments irregularly compacted together, sometimes in larger masses, sometimes more or less in layers; and with them occurs some brownish stone. Of this bed there would seem to be some 3 or 4 feet; and attached, presumably to the base,[1] is a layer of about 1½ to 2 feet of a brown sandy rock.

As to the position of this bed or beds,—in the Red Bed, about the middle, there is a small amount of a brown sandy matrix. In the upper part of the Red Bed there are pieces of rock similar to the less fine-grained stone enclosed in the redder matrix; but there is no trace of the rock resembling lithographic stone in any other exposures than this one at the roadway.

The evidence from fossils is poor. The help of a man with a sledge-hammer was obtained, and the blocks on the beach were broken. The yield was several specimens of a *Nautilus*,[2] a *Rhynchonella* like *Rh. parvula*, a *Garantiana* (difficult to identify on account of condition), and a piece of a *Garantiana* sp. nov. with

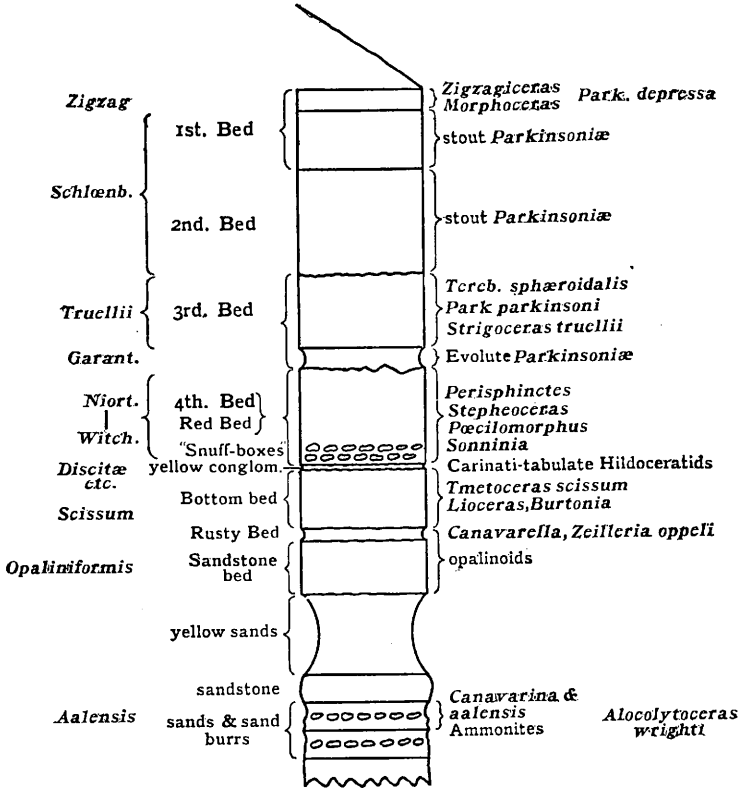
[1] The tumbled condition prevents any opinion as to top or bottom.

[2] Probably new. It is something like *Nautilus rotundus*, Crick, has a rapidly increasing whorl, a small (almost closed) umbilicus, and a periphery becoming flattened.

a latesulcate periphery, known as a species from the *niortensis* beds of Louse Hill near Sherborne.

This evidence then, although not satisfactory, would date the deposit as *niortensis*, or as late *niortensis* early *Garantianæ* hemera: it would make the deposit of the same date as the upper part of the Red Bed, and earlier than the *Astarte* Bed; but how it happens

Fig. 5.—*Vertical section of the beds exposed at Burton Bradstock.* *(See pp. 72 et seqq.)*



Scale: 1 inch = 5 feet.
5 millimetres = 1 foot.

that so distinct a deposit should have been formed at the same time as the Red Bed at this one place, and not at the others, is certainly a puzzle. There is one section a quarter of a mile north (Larkfield Quarry), another section a quarter of a mile north-west (road-cutting to Burton village), and the cliff-section a quarter to half a mile westward of this exposure of the White Bed; and yet in these short distances there is practically no sign of any deposit of a thick white bed of the character of the one that has just been described.

SECTION II.—BURTON BRADSTOCK.

[The section is generalized: it is based mainly on information obtained from the blocks under the cliff: but there is some variation in the thicknesses of these from different parts. Information as to fossil contents is also embodied from other places, the cliff between West Bay and Freshwater, Larkfield Quarry, the road-cutting, the quarry north of Bredy River, and even from the walls. The lithic differences of the beds are so distinctive and are so soon recognized, that fossils from isolated blocks can be placed without difficulty. The quarrymen know them quite well.]

		Thickness in feet	inches.
fuscæ	Lower Fullers' Earth Clay. At Larkfield Quarry, Burton Bradstock, many Belemnites can be obtained from this. At Eype Cliff it has produced *Oppelia fusca* and *Perisphinctes.*		
	The Scroff. At the base of the clay and at the very top of the stone-beds there is a brown, more or less indurated marl, sometimes considerably iron-stained. It is 3 to 4 inches thick, and contains *Oppelia fusca* and *Perisphinctes.* Canaliculate Belemnites of the *B.-parallelus* type and *Zigzagiceras* cf. *subprocerum* are in it, partly attached to the bed below.		
zigzag	(1) The 1st Bed.—The top 6 inches of this bed (Hudleston's P. 3) are a somewhat hard, bluish, earthy limestone. *Zigzagiceras zigzag, Z. subprocerum,* and others; *Morphoceras polymorphum, M. pseudoanceps; Parkinsoniæ* of the *P. depressa* and *P.-lævis* type; *Oppelia* sp.; *Collyrites ovalis*	0	6
schlœnbachi...	(2*a*) Rest of bed bluish yellow to yellowish, fossils sparingly found; but there are *Parkinsoniæ* like those of the bed below	2 1	
	(2*b*) The 2nd Bed.—Mostly a yellowish limestone with much brown, earthy matter, the Ammonites often in rotten condition. *Parkinsoniæ* which have squared inflated whorls, coarse ribs, and conspicuous peripheral interruption like *P. schlœnbachi,* Schlippe; *Terebratula phillipsi, T. sphæroidalis, Rhynchonella parvula, Acanthothyris spinosa, A. panacanthina, Aulacothyris carinata; Collyrites ringens, C. ovalis, Holectypus hemisphæricus, Stomechinus bigranularis*	2 6	4 7
truellii	(3) The 3rd Bed of the quarrymen, with their Shell Bed at the base. To be divided:—Main part *Terebratula* Bed or *truellii* bed. Fairly hard grey limestone, softer towards the		

		Thickness in feet	inches.
	bottom, sometimes almost white with greenish grains. Masses of rather small *Terebratula sphæroidalis* just above the bottom. Large *Parkinsonia dorsetensis*, *P. parkinsoni*, etc., in excellent condition, *Strigoceras truellii*, *Nautilus* spp., and *Crassinella* [*Astarte*] *obliqua*. These are the most noticeable fossils. Others are: *Morphoceras dimorphum*, *M. defrancii*, *Cadomoceras cadomense*, *Cadomites daubenyi* (Gemm.); *Polyplectites* spp. var., *Lissoceras psilodiscum* (Schlœnb.), *L. monachum* (Gemm.); *Acanthothyris panacanthina*	1	10
Garantianæ...	(4) At base of 3rd Bed is the Shell Bed or *Astarte* Bed, Hudleston's P.1 in part—a soft brownish ironshot. Contains numerous *Crassinella obliqua* and flat evolute *Parkinsoniæ*, *Perisphinctes* of the *P.-martinsi* type; *Ancyloceras*; *Garantiana* spp.; occasional *T.* '*sphæroidalis.*' Derived fossils like *Stepheoceras umbilicus*	0	4
niortensis, ... *blagdeni*, *sauzei*, *Witchelliæ*.	(5) The 4th Bed, or Pink Bed, or Red Bed of the quarrymen. A hard, fine-grained, ironshot, somewhat crystalline limestone, particularly massive. The top is very irregular, and portions of the shell-bed lie in hollows. The fossils represent various dates: they are mostly derived, and covered with limonitic layers. In the lower 9 inches there is more coarse ironshot, irregular; it is coarser towards the bottom. Mixed with it are large limonitic concretions called by the workmen snuff-boxes, with much-bored pieces of *Myoconcha*, *Ctenostreon*, etc., and bits of stone as nuclei. Fossils of the Red Bed, at the top, were *Perisphinctes* sp., of *niortensis* date; *Stepheoceras umbilicus*, of *blagdeni* date; *Skirroceras* cf. *macrum*, *sauzei* date	2	10
	Other species from this bed are:— *Blagdeni* date: *Pœcilomorphus cycloides*. *Sauzei* date: *Stepheoceras freycineti*, *St. bayleanum*, *Sonninia* cf. *patella*; *Acanthothyris paucispina*. *Witchelliæ* date: *Witchellia* sp. There is a rare, but very characteristic, rather large *Terebratula burtonensis*, sp. nov. (see the palæontological paper, p. 99), which is probably of *sauzei* date.		

			Thickness in feet	inches.
discitæ, *concavi*, *bradfordensis*, *murchisonæ*.	(6)	Yellow Conglomerate Bed.—A thin yellowish marl, containing in irony coatings and often worn condition small fossils of various dates: those of *discitæ* date perhaps most numerous. The bed may generally be seen attached to upturned masses of the Pink Bed.....		
		Discitæ date: Carinatitabulate Hildoceratidæ, *Toxolioceras incisum*, *Braunsina elegantula*; *Haplopleuroceras subspinatum*; *Belemnites blainvillei*; *Nautilus bradfordensis*, *N. exiguus*; *Cœlastarte excavata*.		
		Concavi date: *Ludwigella*.		
		Bradfordensis date: Broken fragments of *Brasilia-bradfordensis* pattern.		
		Murchisonæ (or *Ancolioceras*) date: *Cirrus nodosus*, *Onustus*.		
		Scissi date: *Burtonia* sp., and rock-fragments derived from the		
scissi	(7)	*Scissum* bed. Grey sand-rock with *Tmetoceras scissum*, *Tm. circulare*; *Lioceras* spp. var. See 'Monogr. Inf. Ool. Amm.' Suppl. *Burtonia*; and large *Lima* of the *etheridgi* type	1	6
scissi-opaliniformis.	(8 *a*)	Foxy Bed, Rusty Bed, ironstained sandy marl. *Canavarella* spp.; small Hammatoceratids, *Zeilleria oppeli*, *Rhynchonella stephensi*	0	2
opaliniformis...	(*b*)	Brown sands and sandburrs, with Opalinoid Ammonites in poor condition	1	6
	(*c*)	Sands	2	0
aalensis	(9 *a*)	Sandstone 0 8		
	(*b*)	Sands with Ammonites of the *aalensis* pattern in occasional sandburrs 0 10	1	6
	(*c*)	Sand and sandburrs continued downwards.		

NOTE:—The sands are known to the natives as 'Fox-mould.' There is a notice in Burton village about the removal of fox-mould and sand, where 'sand' presumably means a sharp grit for building-purposes.

III. COMPARISON OF THE STRATA.

(*a*) Comparison of the Sections at Burton and Chideock.

Working upwards, from the bottom of the sands to the top of the *scissum* bed, the strata of these two localities seem to be the counterpart one of another, so far as the evidence goes. After the *scissum* bed, changes begin—due to penecontemporaneous erosions. The Wild Bed of Chideock (*Ancolioceras* to *bradfordensis*) is not represented by deposit at Burton; the *discitæ* bed of Burton has not been definitely found at Chideock. The Red Bed

of Burton and the Red Beds or Building-Stone of Chideock are only partly on the same horizon, while they differ in lithic character very considerably. The beds yielding fossils of *Witchelliæ* and *sauzei* date are well developed at Chideock, and are rich in specimens; they are poorly developed at Burton. At Chideock, however, there are no strata yielding species of *blagdeni-niortensis* dates. The *Astarte* Bed (*Garantianæ*) is not found at Chideock. In regard to the Top Beds, neither the *truellii* bed nor the *zigzag* bed have been noted at Chideock, where the mass of limestone seems to belong to the position of the 2nd Bed and the lower part of the 1st Bed of Burton (*schlœnbachi*).

(*b*) Other South Dorset Sections.

The general type of the Burton Bradstock Inferior Oolite will be found reproduced with variation of detail in quarries inland, bordering the main road from Bridport to Dorchester. One of these quarries, Vetney (or Vinney) Cross, shows the *Astarte* Bed thicker, and an excellent repository of well-preserved fossils. Farther inland, around Beaminster, the 'Top Beds' are found resting on deposits of different dates—on those of *concavi*, or *bradfordensis*, or *murchisonæ*, according to the quarry. At Broad Windsor the Top Beds rest on strata of *murchisonæ* date in the road-cutting, where the sequence into the sands might be profitably investigated with regard to modern divisions: old notes are not sufficiently detailed.

The Grange quarry at Broad Windsor has produced a remarkable series of fossils, mostly from the *zigzag* and *schlœnbachi* horizons; but the strata of *truellii* date are to be seen.

Between Broad Windsor and Beaminster, however, is a locality which shows a very much more complete sequence than any other in South Dorset, so far as Bajocian-Aalenian beds are concerned. It is Stoke Knap, and deserves some notice.

(*c*) Whaddon Hill, or Stoke Knap.

About 6 miles north of Bridport, and about 7 miles to the northward of Down Cliff, is the locality marked on the Ordnance Survey map as Stoke Knap, known to the natives as Whaddon Hill. It is about midway between Beaminster and Broad Windsor, and is of interest for the development of strata of *bradfordensis* to *discitæ* hemera, which yield a profusion of specimens in excellent condition. The bed in which they occur is known as the Building-Stone; and some years ago, when I was visiting the locality, the workmen took off the bed for me layer by layer, so that it was possible to collect each species *in situ*, and note the change of fauna in one bed.

Mr. H. B. Woodward, F.R.S., has published a section of Stoke Knap.[1] Though it is not detailed enough for my purpose, and he has not numbered his beds, it may usefully be compared with the workmen's divisions and with my dating system.

[1] 'Jurassic Rocks of Britain: vol. iv—The Lower Oolitic Rocks of England' Mem. Geol. Surv. 1894, p. 63.

SECTION III.—STOKE KNAP.

Hemeræ.	H. B. Woodward. Numbers supplied.	Workmen's Terms. Fossils inserted. (S. S. B.)	Thickness in feet	inches.
		'Clay.'		
schlœnbachi	1	'Ragstone'	7	0
	2	[*Terebratula stephani, Collyrites ringens, Parkinsonia.*]		
	3	'Best Limestone'	4	2
Shirbuirniæ	4	'Roadstone'	1	4
		[Top planed off and covered with oysters. *Sonninia* cf. *adicra* (Waagen). *S.* cf. *fissilobata* (Waagen).]		
		'Waste'	0	5
		[Clay, limestone, and marl in three beds, irregular.]		
post-*discitæ*, *discitæ*, *concavi*, *bradfordensis*, *murchisonæ*, *Ancolioceras* (pars)	5	'Building-Stone.'		
		[See p. 77 for details.]		
		'Bottom Bed.'		
		[To which some Building-Stone may be attached. *Ludwigia lævigata*, *Ancolioceras substriatum.*]		

			Thickness. (H. B. W.)
Ancolioceras (pars) and *scissi* (?).	6	[The Sandy Grits with Brachiopod Beds in the middle. Not economically worked.] (S. S. B.)	4 to 5
	7	.....	about 8
scissi-opaliniformis .	8	.....	10 to 14
	9	.....	6 to 8
	10	.....	2 to $2\frac{1}{2}$
	11	.....	about 3

The Beds 6–11 (Woodward) may, for distinction's sake, be called the Sandy Grits, with Brachiopod Beds (8 & 10) in the middle. The chief Brachiopods are—*Terebratula whaddonensis* [='*T. infra-oolithica*'], *Zeilleria whaddonensis*, *Aulacothyris* '*blakei*,' and *Rhynchonella stephensi* (see the palæontological paper, pp. 101 *et seqq.*). Of Ammonites which have been recorded from these Sandy Grits, without precise horizon, are—*Lioceras uncinatum* and *Canavarella belophora* (type): there are many Ammonites in poor condition.

These Sandy Grits are later than *aalensis* hemera, so far as my collecting goes. They may be dated approximately as *Ancolioceras-scissi-opaliniformis*; but they have not been studied sufficiently for present detailed work. The ferruginous clayey seam [9] of Woodward suggests correlation with the Rusty Bed of Burton Bradstock; possibly then the Brachiopod Beds (8 & 10) are a thickened development of the Rusty Bed, and should really be dated as pre-*scissi*–post-*opaliniformis*.

SECTION III *a*.—STOKE KNAP BUILDING-STONE (detailed).

(In square brackets are names of species known to be from the Building-Stone, but their exact layer was not ascertained: it is here suggested.)

		Thickness in feet	*inches.*
post-*discitæ*...	1st Bed.—Top bed of Building-Stone. Brown ironshot limestone. *Stepheoceras*, and *Oppelia* of the *præradiata* pattern[1]	0	4
	2nd Bed.—Bluish-grey ironshot limestone. No fossils except at the bottom, where there were impressions of those in the bed below	0	5
discitæ	3rd Bed.—Yellowish ironshot limestone with (on top) numerous carinatitabulate Hildoceratids. *Darellina dorsetensis, Reynesella piodes, Lopadoceras arcuatum, L. euides*; *Rhynchonella forbesi, Terebratula eudesi*; *Stepheoceras*. *Graphoceras* sp. at the bottom	0	7
	[*Sonninia inæqua, S. lævigata*; *Depaoceras fallax, Platygraphoceras latum, Pl. apertum, Reynesia laxa, Œdania lepta, Reynesella juncta, R. inops, Lopadoceras furcatum, Darellia polita, Dissoroceras subornatum, Stokeia marmorea.*]		
	4th Bed.—Greyish-yellow, hard, ironshot limestone; the iron grains being numerous, and of fair size. *Megalytoceras confusum, Graphoceras* spp.	0	5
concavi	5th Bed.—Similar to 4, but harder. *Graphoceras* spp. *Ludwigella casta*	0	7
	[*Ludwigella concava, L. tenuis, Lucya marginata, Graphoceras v-scriptum.*]		
bradfordensis .	6th Bed.—Similar ironshot. Ammonites of *Brasilia-bradfordensis* pattern, *Graphoceras* sp.; *Rhynchonella ringens*; *Ludwigella arcuata, L. carinata, Pseudographoceras limatum*	0	6
	Then there is attached to the top of the bottom bed, which is whitish limestone, some of this ironshot bed with *Brasilia* spp.	0	6
	[*Wiltshireia gigantea, Brasilina tutcheri, Ludwigella flexilis, L. rugosa, L. nodata, Vacekia stephensi, Zurcheria pugnax, Welschia rustica, Apedogyria platychora.*]		
		3	4

(*d*) South and North Dorset.

Since the present communication is supplementary to that on the 'Bajocian of the Sherborne District' and in part to that 'On the Cotteswold, Midford, & Yeovil Sands,' it may be desirable to show the comparison of the strata on the Dorset Coast with those found in North Dorset; and it will be interesting to see how the chronological arrangement introduced for the North Dorset strata several years ago can be followed out in those of the coast.

Table III, facing p. 78, shows the comparison: some illustrative remarks are also appended.

[1] *Sonninia densicostata* (Monogr. p. 376), labelled 'Beaminster,' was probably from Stoke Knap from the 1st or 2nd Bed; its character is of later pattern than that of the *discitæ* species. Going from Stoke Knap to Beaminster, in each quarry more and more of the Building-Stone is found to be denuded and removed until it quite disappears; so Stoke Knap is the likely place.

IV. Remarks on Hemeral Terms.

Schlœnbachi.—This term was suggested by me in some MS. notes to a paper by Munier-Chalmas [1] whence it was inadvertently copied by Mr. Richardson.[2] It is a term for dating the strata which had been hitherto called inter-*truellii-zigzag*.[3]

Whereas at the top of the 'Top Beds' of Burton Bradstock there is a distinct Ammonite fauna, *Zigzagiceras* spp., *Morphoceras* spp., and *Parkinsoniæ* of the *depressa* type with rounded whorls, and of the *P. lævis* (Quenstedt) pattern with involute trigonal whorls; and in the lower part of the 'Top Beds' there is a fauna with *Strigoceras truellii*, and *Parkinsoniæ* of the *P.-parkinsoni* type with flattened whorls: there is in the 2nd Bed of Burton Bradstock and in the lower part of the 1st Bed a series of *Parkinsoniæ* different in character from those above or below—they are massive forms with stout, somewhat squared whorls.

Thus, on the evidence of Burton and other Dorset localities, there is need to recognize a date of deposition later than *truellii* and earlier than *zigzag* hemera. But Mr. Richardson's investigations in Somerset have shown that this refinement was most necessary; for between strata of *zigzag* date (there basal Fullers' Earth) and strata of *truellii* date (Upper Coral Bed) he finds three noticeable deposits—Rubbly Beds, *Anabacia* Limestones, and Doulting Stone (*loc. cit.*); and, as regards the Cotteswolds, he would put the *Clypeus* Grit (sometimes over 30 feet thick) as belonging to this date.[4]

Shirbuirniæ.—The deposit of this date was formerly known as hemera *Sonniniæ*, but a generic rearrangement of the numerous forms of *Sonninia* will have to be undertaken. The true *Sonniniæ*, the platyleptogyral, angustumbilicate, alticarinate species of the *Sonninia-propinquans* type, are found only in a deposit of *sauzei* date.

The type-species of the genus *Shirbuirnia* will be described in the palæontological paper (pp. 92 *et seqq.*).

The deposit of *Shirbuirniæ* hemera is noticeable, because it is of the date of the celebrated deposits of Gingen (Würtemberg), the Ammonites from which were described by Dr. W. Waagen.

In this country a deposit of *Shirbuirniæ* date is only found in perfection at one quarry, Sandford Lane near Sherborne (Dorset), where it forms the bottom part of the fossil-bed. Here it has produced an extraordinary abundance of remarkable Ammonites, most of which are new: they have waited over 40 years to be figured and described. And in this country the channels for palæontological publication are becoming more and more unable to keep pace with the new discoveries of geologists.

[1] C. R. Soc. Géol. France, 1892, no. 14, pp. 164–67.
[2] Proc. Cotteswold Nat. F.-C. vol. xvi, pt. 2 (1908) p. 188.
[3] L. Richardson, Quart. Journ. Geol. Soc. vol. lxiii (1907) p. 423.
[4] Proc. Cotteswold Nat. F.-C. vol. xvi, pt. 2 (1908) p. 187.

This Sandford Lane bed was only worked once, for economic purposes, about 1875. It was opened up again specially for the purpose of the paper on the 'Bajocian of the Sherborne District'.[1] It is evident that the collecting that can have been done from this deposit must be a mere scratch of the surface; yet the results are remarkable, and the beautiful preservation of the Ammonites is extraordinary.

At a few other localities evidence of a deposit of *Shirbuirnia* date can be detected by a few ill-preserved Ammonites: for instance, at Dundry (Somerset), and in the Gryphite Grit of the Cotteswolds; but, for all practical purposes, the quarry of Sandford Lane is the one place in the kingdom, known at present, where the deposit could be studied, and that place has been closed these 40 years.

Ancolioceras.—The finding of Opalinoid Ammonites in the base of the *murchisonæ* bed has before now led to the supposition that there was a certain mixture of forms of *murchisonæ* and *opalinum* (*scissum*) zones. The explanation would appear to be that what has been regarded as the base of *murchisonæ* is really of an earlier date.

At Chideock Quarry Hill the lower part of the Wild Bed is of different matrix from the upper part: it yields a Lytoceratoid, but does not furnish any Ammonites of the *murchisonæ* pattern. In the neighbourhood of Beaminster, strata at the base of *murchisonæ* yield *Ancolioceras cariniferum* and similar forms; but they were not associated with Ammonites of the *murchisonæ* types. Around Crewkerne (Somerset) there are several species more or less allied to *Ancolioceras costatum*, and they seem to be somewhat peculiar to that district ('Monogr. Inf. Ool. Amm.' Suppl. 1899, p. xlix).

At Misterton, which is near Crewkerne, the strata hitherto regarded as early *murchisonæ* yield Lytoceratoids of the style of *Pachylytoceras aalenianum*. At Chideock the bed yielding the Lytoceratoid is in position above the *scissum* bed and below the *murchisonæ* bed; and is distinct from both by its matrix. Presumably then the Misterton strata are on the same horizon.

At Chideock in the *murchisonæ* part of the Wild Bed is a characteristic brachiopod, *Zeilleria* [*Waldheimia*] *anglica*. This is a noticeable species, which may be followed a long way.

At Chideock the strata dated *Ancolioceras* are below the *anglica* horizon. At Haselbury Mr. Hudleston recorded a thickness of 2 feet 5 inches between the *anglica* horizon and the 'Base Bed'[2] (presumably *scissum*).

In my descriptions of strata of the Sherborne District[3] the *anglica* horizon is marked as O; and a lower level (P), 2 and 3 feet thick, was noted for Halfway House and Louse Hill. But the P noted for Marston Road (*op. cit.* p. 490) is apparently wholly or in part *scissum*.

[1] Quart. Journ. Geol. Soc. vol. xlix (1893) p. 479.
[2] 'Monogr. Brit. Jurass. Gasteropoda' (Palæont. Soc.) 1887, p. 41.
[3] Quart. Journ. Geol. Soc. vol. xlix (1893) p. 489.

However, in Dorset-Somerset the strata which it is suggested should be dated as *Ancolioceras* are those above *scissum* and below the *anglica* horizon.

In the Cotteswolds, there is between the Sandy Ferruginous Bed (*scissum*) and the Pea Grit (*murchisonæ*) a considerable development known as the Lower Limestone: it is suggested that this should be dated *Ancolioceras*.

Various species of Ammonites of which the horizon has been given 'near base of limestone-beds,' and the date as *murchisonæ* or doubtful between *murchisonæ* and *scissi*, are presumably more correctly to be dated as *Ancolioceras* hemera: for instance, the following species:—*Ancolioceras cariniferum*, *A. substriatum*, possibly *A. costatum*, *Geyeria fasciata*, and *G. evertens*. Investigation will probably reveal others, which in former days were recorded under the too comprehensive term *Ludwigia murchisonæ*.

Moorei, *Dumortieriæ*.—The strata of these dates make a fine showing in the cliffs of the Dorset coast as the Bridport Sands[1] and Down Cliff Clay: they attain a thickness of nearly 200 feet.[2] The Bridport Sands and the subjacent clay are represented around Yeovil in Somerset by the Yeovil Sands, which are also of considerable thickness and have yielded many species of *Dumortieriæ*, as at Yeovil Junction, Furzy Knaps near Yeovil, Bradford Abbas, etc. The Ham Hill Stone is a local development of calcareous beds of *moorei* date.

The Yeovil Sands have suffered denudation, because around Yeovil they end with the Dew (Dhu) Bed, which contains *Dumortieriæ* like those in the *moorei* bed of Chideock Quarry Hill. Somewhere between Crewkerne and Yeovil the failure of the *aalensis-scissi* beds begins.

In the neighbourhood of Ilminster, Barrington, and Shepton Beauchamp, the Yeovil Sands rest upon clay of *dispansi* date: in these places the strata of *variabilis* date are a thin development of clayey limestones very well charged with Ammonites.[3]

Around Yeovil the sands become bluish and clayey in their lower part: this may be of *dispansi* date. But the argillaceous limestones of the Upper Lias on which this blue part rests gives no certain evidence for later date than *striatulus*; the principal strata are *falcifer*, *bifrons*, *striatulus*, all thin, without *variabilis*. The same beds are found at Glastonbury Tor; there is no sign of *variabilis* forms among the fossils lying about in the fields.

The deposit of sands between Yeovil and the Mendips presents a field not yet investigated. When the Somerset & Dorset Railway was made, a cutting in the sands at Cole Station near Bruton (Somerset) yielded some fine specimens of *Hammatoceras* and Lytoceratoids. I obtained a few of these, many years afterwards, by

[1] Excepting the upper 40 feet which are *aalensis* to *scissi*. See fig. 4, p. 70, showing the Bridport Sands of Burton Bradstock.

[2] 210 feet, *teste* E. C. H. Day, possibly including the upper 40 feet.

[3] See Monogr., *Haugia-Lillia* series.

accident, from a man who had been employed as a mason on the line; and, in a collection of Ammonites sent to me for determination from Yale University, New Haven (Conn.), U.S.A., there was a fine *Hammatoceras* without further localization than England: there is no doubt that it came from Cole, on account of its condition and matrix. These Hammatocerata mark the Yeovil Sands of Cole as belonging to the *dispansi* hemera in date; but I have never had the opportunity of inspecting the deposit in this neighbourhood.

To return to the *moorei-Dumortieria* beds. In North Somerset, at Dundry, the *Dumortieria* Beds appear as a thick clay-deposit. In the Cotteswolds, they and the *moorei* beds are found as a thin deposit of ironshot marl or marly stone, in the middle of the so-called 'Cephalopod Bed'; but they are not recorded in the Cotteswolds north of Haresfield. There is some indication of the beds at Bredon Hill,[1] but in the rest of the Lias outcrop they are not known until they are met with as '[the Yellow and] Grey Sands below the Dogger' of the Yorkshire Coast.[2]

The 'Grey Sands' are also divided as the *Lingula* Bed, and the *Serpula* Bed above it.[3]

Hudlestonia sinon (Mon. Amm. p. 227) is from the Grey Sands. *H. affinis* (*ibid.* p. 229) was sent as from the 'Yellow and Grey Sands'; but presumably it is from the Grey Sands: these species indicate *Dumortieria* date. *Dumortieria munieri* (Mon. pl. xxxvii, figs. 14 & 15), evidently from Blea Wyke (Yorkshire), ought to be from the same beds. On this evidence the 'Grey, but not the Yellow, Sands' are of *Dumortieria* date; but whether it is the *Lingula* Bed or the *Serpula* Bed, or both, that are of this date is uncertain.

The identification of Ammonites quoted from these beds cannot be trusted, unfortunately. A specimen in the Museum of Practical Geology (Jermyn Street), 4423, labelled '*Am. aalensis* var. *Moorei*, bottom bed,' cited by Mr. C. Fox Strangways[4] and by Mr. R. H. Rastall[5] as from the *Serpula* Bed, is really an unidentifiable fragment of a body-whorl $1\frac{1}{2}$ inches long. It shows remains of a small distinct carina, which makes its agreement with any *aalensis* form (Fam. Hildoceratidæ) or any *moorei* form (Fam. Polymorphidæ) almost impossible. It shows a Hildoceratid radial line, agreeing with fig. 155, Monogr. Suppl. p. clxvii, which happens to be *Phlyseogrammoceras orbignyi*, a species sent to me by Hudleston from the *striatulus* beds (Mon. p. 188) but suggestive of *dispansum* date. This, therefore, should not occur above the *Lingula* Bed (*Dumortieria*) except by derivation; the evidence of a fragment like this, even if determined with some certainty, is not of any value.

Since the above was written, Mr. L. Richardson has shown me specimens of Ammonites collected by him 4 feet from the top of the *Lingula* Bed: they are *Hudlestonia* sp. (*affinis* form) and

[1] Quart. Journ. Geol. Soc. vol. lix (1903) p. 447.
[2] 'Monogr. Inf. Ool. Amm.' (Palæont. Soc.) p. 168.
[3] W. H. Hudleston, Proc. Geol. Assoc. vol. iii (1874) p. 296.
[4] 'Jurassic Rocks of Yorkshire' vol. i, Mem. Geol. Surv. 1892, p. 153.
[5] Quart. Journ. Geol. Soc. vol. lxi (1905) p. 444.

Phlyseogrammoceras cf. *dispansum*. They date the *Lingula* Bed as *Dumortieriæ-dispansi* hemera, and make it exactly contemporaneous with the middle part of the Gloucestershire Cephalopod Bed, and with the lower 100 feet of the Yeovil Sands near Yeovil.

Striatuli-spinati (The Junction Bed).—There are two situations in which the Junction Bed of the coast can be studied *in situ*: in the cliffs and on the beach in the fallen blocks. In the cliffs is the best place to find the *striatulus* layer; and, after scraping away some of the overlying clay, portions of this layer can be detached with a chisel, and then broken up for examination. One of the best places for this purpose is on the west side of Doghus Cliffs; but curiously enough, even in the cliffs, the *striatulus* layer is often missing. It is always missing, so far as my knowledge goes, from the Junction Bed at Thorncombe Beacon, and it is rarely found in the blocks on the shore: small portions of it may sometimes be found loose on the shore.

For general examination of the Junction Bed, the shore is the best place; but, as the blocks are often upside down, care is required in collecting. A heavy hammer and good chisels are also necessary.

The complete series of the Junction Bed is seldom, perhaps never found. While the *striatulus* layer, if it be met with, is only found under Down and Doghus Cliffs, the basal Marlstone layer is not present until one is well under Thorncombe Beacon. Even then the upper layer of Marlstone—Day's *Pleurotomaria* Bed[1] presumably—is often absent.

Sometimes the greenish rock—the *falciferum* layer—is absent; sometimes it is 10 inches thick, at other times 3 inches. The most persistent rock is the pink rock—the *bifrons* layer; there seems to be no failure of this. Its colour reminds one of the colour of *bifrons*-yielding beds of the Toarcian of Lombardy. The pink bed is generally separated from the *falciferum* layer by an ironstone band 1 to 2 inches thick.

With a little practice it is quite easy to distinguish the different layers when they are lying detached from blocks: roughly there are—the white (*striatulus*), the pink (*bifrons*), the greenish (*falciferum*), and the brown (Marlstone).

J. F. Blake's suggestion that the Junction Bed was an aggregate deposit formed at one time by the sweepings of various zones[2] fails to meet the facts of the case: there are not only the layers of distinct matrices, but they contain their distinctive fossils, in definite sequence. It is true that there has been erosion and redeposition nearly all the time: thus the Marlstone is conglomeratic, and contains sometimes Blue Lias pebbles (? *algoviani*, or lower); the *bifrons* bed sometimes holds broken and worn specimens of *Harpoceratæ*, which really belong to the bed below; while the

[1] Quart. Journ. Geol. Soc. vol. xix (1863) p. 284.
[2] 'Excursion to Bridport, &c.' Proc. Geol. Assoc. vol. xv (1898) p. 295.

specimens that properly belong to the *bifrons* bed are often worn, iron-coated, and deposited on edge.[1]

The *striatulus* layer appears to be quite a regular deposit; but then there is a big gap between the *striatulus* layer and the *bifrons* bed—a time during which about 250 feet of strata were laid down in the Cotteswolds.

With regard to Day's *Pleurotomaria* Bed—the top layer of the Marlstone[2]—I do not feel certain of having met with it, unless it be the *serrata* bed mentioned above (p. 65). But, considering how often certain beds are locally missing from the Junction Bed, it is quite possible that it may be a layer just above the *serrata* bed, only developed occasionally. In the Jermyn Street Museum there are the following Ammonites from Upper Lias of Chideock [=Junction Bed of Down Cliffs]—R. No. 22475, *Dactylioceras* cf. *tenuicostatum* (Young & Bird), and 22514, *Dactylioceras crassiusculosum* (Simpson). The first of these is a species from the *annulatus* zone of Yorkshire, and Martin Simpson records the second from the Jet Rock, which is higher. It may be interesting, therefore, to compare the Dorset and Yorkshire Toarcian.

V. Pre-*striatulus* Toarcian.

(*a*) Dorset and Yorkshire Coasts compared.

The difference in development is remarkable. On the Dorset coast the pre-*striatulus* Toarcian beds are packed into a seam of calcareous stone about 2 feet thick. On the Yorkshire coast, according to a useful section given by Martin Simpson,[3] they occupy nearly 200 feet. An epitome of Simpson's section and divisions of the Yorkshire Toarcian is given on p. 84 (Table IV), with the dates, according to my interpretation, at the side. Tate & Blake's rendering is also given, correlated with Simpson; the correlation is fairly obvious, except with regard to Beds 1–10, where they have a far greater thickness. Alongside is the development of the Dorset strata of the same dates.

Simpson's Division 1, by the species recorded and known to come from there, was deposited during five hemeræ—*dispansi–bifrontis*. The bulk of the strata of the division probably belong to the date of *bifrons*; but there is good evidence for the others. For *dispansi* hemera, *Phlyseogrammoceras orbignyi*, S. Buckman (Monogr. p. 188) and *Ammonites gubernator*, Simpson—a Lytoceratoid, probably *Alocolytoceras* near to *perlæve*, Denckmann. For *striatulus* date the evidence is abundant—the term '*striatulus* shales' is in use; and species of this facies are plentiful at the Peak. For *variabilis–lilli*, the latter perhaps dubious, there is evidence, in the Whitby Museum collection of types, of a rich Ammonite fauna:—*A. obliquatus*,

[1] The Red Bed and the Yellow Conglomerate Bed of Burton Bradstock would conform much more to Blake's requirements for an aggregate deposit; they are made up of sweepings from deposits of various dates.

[2] Quart. Journ. Geol. Soc. vol. xix (1863) p. 288.

[3] 'Fossils of the Yorkshire Lias' 2nd ed. (1884) pp. ix–xiv.

TABLE IV.—COMPARISON OF YORKSHIRE AND DORSET TOARCIAN.

Tate & Blake. 1876.		Simpson. 1884.		Dorset Coast.	
		Thickness in feet			
Zone of *A. jurensis*, p. 190.		Division 1	34		
Zone of *A. communis*, p. 182.	Beds 1–10.	Alum Shale.			
	Beds 11, 12.	Division 2	18		
	Beds 13, 14.	Division 3	18		
	Bed 15.	Division 4 — *A. 'ovatus.'*	18		
	Bed 16.	Hard Shale. Division 5 *a*	10		
Zone of *A. serpentinus*, p. 174.	Beds 1, 2.	Division 5 *b* — *A. mulgravius.*	12		
	Beds 3, 4.	Division 6 — *A. mulgravius.*	21		
	Bed 5.	Jet Rock. Division 7 — *A. exaratus.*	20		
Zone of *A. annulatus*, p. 168.		Grey Shales. Division 8 — *A. annulatus* [= *A. tenuicostatus*].	40		
		Total	194		

	inches.	
striatulum	2	Upper Lias of the Junction Bed.
lilli	2	
bifrons	10	
falciferum	8	
[1] Total	1′ 10″	

[1] The stratum at Down Cliffs which yielded *Dactylioceras* cf. *tenuicostatum* and *D. crassiusculosum* (see above, p. 83) shows that the Grey Shales and Jet Rock are represented in Dorset. Perhaps this stratum is the *Pleurotomaria* Bed, base of *falciferum* or top of Marlstone.

Young & Bird, *A. fabalis*, *A. beani*, *A. phillipsi*, *A. rudis*, Simpson, are species of the *Lillia-Haugia* series, indicative of deposits of *lilli-variabilis* dates: they are fine specimens too. There is also *Haugia patelliformis*[1] = *Ammonites obliquatus*, Simpson, *pars*, *non* Young, indicative of *variabilis* beds.

I have not yet seen the type of *Hildoceras hildense* (Young & Bird); but, from their figure, it appears to be a species of the *lilli* beds, from its likeness to my *H. semipolitum* which is so characteristic. The *Ammonites hildensis*, Simpson, is another species; it occurs in the Jet Rock, and has no likeness to Young & Bird's figure.

In Divisions 2 & 3 Simpson records no Ammonites: Tate & Blake appear to have *Ammonites bifrons* from about this level.

In Division 4 there is evidence of a deposit made during a period of time of which there is not evidence in the south—a hemera of *ovatus*. However, this is not the true *Ammonites ovatus* of Young & Bird's first edition, though it is of their second: they had a happy knack of changing names.

The Hard Shale and the Jet Rock give nearly 70 feet of deposit during the *falciferi* hemera; unless, as seems possible, this can and ought to be subdivided into an earlier and a later period.[2]

Interest now centres in the Grey Shales, or *annulatus* beds of Tate & Blake. First, the *Ammonites annulatus* is wrongly named: it is *A. tenuicostatus*, Young & Bird: with it occurs *A. semicelatus*, Simpson, and both belong to *Dactylioceras*. It is best to call this the deposit of *tenuicostati* hemera.

The point that now remains for consideration is this:—What relation does the stratum of *tenuicostatus* bear to the stratum of *Seguenziceras acutum* (Tate)—the Transition Bed of the Midlands? Is it of the same date, or earlier, or later? The question is difficult to answer, because it is impossible to trust the identifications of the *Dactylioceras* Ammonites. To answer this question, it may be advisable to consider the relationship of the Yorkshire and Midland Toarcian strata; and this, through the kindness of Mr. Beeby Thompson, I am able to do in greater detail than when the preceding paragraphs were first penned.

(*b*) Yorkshire and other Districts compared.

Since this paper was written, Mr. Thompson, in answer to certain queries which I addressed to him with regard to the correlation of the Northamptonshire and Yorkshire Upper Lias, placed in my hands some MS. of a paper just printed off by the Geologists' Association. This MS. is valuable, for it shows that Mr. Thompson, from his study of the Northamptonshire Upper Lias, finds it necessary to increase the number of zones, a process that I was contemplating for this paper from a consideration of the records of the Yorkshire strata.

[1] 'Monogr. Inf. Ool. Amm.' Suppl. pl. iii, figs. 1–3.

[2] Mr. Thompson has done this since these words were penned, see later in this page.

The following Table shows Mr. Thompson's results, summarized and compared with details of Yorkshire and Gloucestershire strata, while at the side is placed the zonal classification which appears to be necessary for future work:—

TABLE V.—COMPARISON OF TOARCIAN DEPOSITS.

Gloucestershire generalized.	Northamptonshire, from Mr. Beeby Thompson's MS., summarized.	Yorkshire, based on Simpson (& see Table IV, p. 84).	Zonal or hemeral terms.
Lilli beds, or lower part of Cotteswold Sands.	Upper *Leda-ovum* or *lilli* beds.		*lilli.*
The *bifrons* or *communis* beds.	Oyster Bed.	The lower part only of Simpson's Division 1.	
	braunianum zone. Middle *Leda-ovum* Beds.		*braunianum.*
	braunianum zone. Lower *Leda-ovum* Beds.		
	Unfossiliferous beds or *fibulatum* zone.		*fibulatum.*
	Upper Cephalopod Bed. *Communis* bed or *subcarinatum* zone.		*subcarinatum.*
		Division 2.	'*ovatum.*'
		Division 3.	
		Division 4 with *A.* '*ovatus.*'	
The *falcifer*, or *serpentinus*, or fish-and-insect beds.	Lower Ceph. Bed. *falcifer* beds.	Divisions 5 & 6. *A. mulgravius.*	*falciferum.*
	Fish-beds or *latescens* zone.	Division 7 with *A. exaratus.*	*exaratum.*
The *Leptæna* Beds.	Paper Shale.	Division 8 with *A. tenuicostatus.*	*tenuicostatum.*
acutum layer on top of Marlstone.	*acutum* zone.	? Top of Ironstone Series, if present.	*acutum.*

From the foregoing Table it will be seen that Mr. Thompson finds the greatest development (in the way of faunal change) of Upper Lias, in Northamptonshire, to be in the strata once called *bifrons* or *communis* beds. Here he makes five divisions, and names three zones—*braunianum*, *fibulatum*, *subcarinatum*. There is good reason to suppose that all these zones could be detected in Yorkshire; only that they are more obscure from paucity of sediment. But in Yorkshire Simpson's Divisions 2, 3, & 4 (some 50 feet of strata) appear to be a development not found in Northamptonshire; for this series I was proposing a zonal name, and *Ammonites* '*ovatus*' will have to do duty temporarily, though the identification is incorrect (see above, p. 85).

Below the '*ovatus*' bed of Yorkshire is the *mulgravius* bed, and below this again the Jet Rock series with *A. exaratus*, etc. It is evident from the Yorkshire strata that there are two zones, and I was preparing to name them in this paper. I find that Mr. Thompson, from his study of the Northamptonshire strata, has reached the same conclusion independently, and has named the lower zone *latescens* zone. I hesitate to adopt this: a study of Yorkshire types throws much doubt on identifications of *Ammonites latescens*, and on its horizon; while of *A. exaratus* the type is definitely known, and so too its bed.

Below the *exaratum* zone (Jet Rock) of Yorkshire is the deposit known as the 'Grey Shales', or *annulatus* zone of Tate & Blake. As the species is not *A. annulatus*, but is *A. tenuicostatus*, Young & Bird, a change of name is desirable. Below the *latescens* zone of Northamptonshire is a small deposit of paper-shale; and below the equivalent of the *exaratum* zone of Gloucestershire is the deposit called the *Leptæna* Beds, which are certainly above the *acutum* layer. The suggestion may, then, be made that the *Leptæna* Beds of Gloucestershire and the South-West of England are of about the same date as the *tenuicostatum* zone of Yorkshire, and that this zone is later in date than the *acutum* zone or Transition Bed of the Midlands. It may be admitted that this is at present only a suggestion based on stratigraphical evidence, and that the faunal evidence is mainly negative—that is to say, that the fossils of the *acutum* zone and of the *tenuicostatum* zone are different, implying that the zones are sequential, not contemporaneous. So here is a working hypothesis: to prove or disprove it further evidence is required.

(*c*) Migration of Areas of Maximum Deposit.

The migration from north to south of the area of maximum development of the Toarcian strata in England is an interesting phenomenon. It seems to be a regular progress from earliest beds in the north to latest beds in the south; but, no doubt, further knowledge will show some irregularity. Present results are given in the accompanying Table (VI, p. 88):—

TABLE VI.—MIGRATION OF AREAS OF DEVELOPMENT IN THE TOARCIAN.

	Zones.	Localities.	Approximate development. Feet.
Yeovilian.	*moorei* ..... / *Dumortieria* .	South Dorset	200
	dispansum ... / *struckmanni* .	Mid and North Somerset	100[1]
	striatulus ...	South Cotteswolds.....	240
Whitbian.	*variabilis* ... / *lilli*		
	braunianum . / *fibulatum*..... / *subcarinatum*.	Northamptonshire.....	150[2]
	ovatum..... / *falciferum* ... / *exaratum*..... / *tenuicostatum*.	Yorkshire	160
		Total.....	850

Owing to this migration of area of maximum deposit, it happens that the strata of the Toarcian in any one English locality do not exceed much over 250 feet in thickness, and are often far less ; yet the amount of work done in deposition during that time is equal to 850 feet or more.

Though the Toarcian is now divided into fourteen zones, these zones can hardly be called minute divisions, when some of them develop thicknesses of 100 or more feet each and maintain these for many miles.

Since the Toarcian thus contains so many zones, it is often necessary to speak of the earlier of these zones as distinct from the later, or *vice versa*, and as the circumlocutory phrases pre-*striatulus* Toarcian, *striatulus* and post-*striatulus* Toarcian are very awkward, it is now suggested that the former be called Whitbian and the latter Yeovilian. The Whitbian would contain the zones *tenuicostatum* to *variabilis* inclusive, all of which are more or less finely developed on the Yorkshire coast in the neighbourhood of Whitby ; while the Yeovilian would contain the zones *striatulum* to *moorei* inclusive, and certain of these are remarkably developed in the Somerset-Dorset district.

The special faunal feature of the Whitbian is the development of the Lias *planulati* (Dactylioidæ, Hyatt) which are very numerous in most of the zones; while the feature of the Yeovilian is the absence of all Dactylioidæ, but the development of Grammoceratinæ, of Hammatoceratidæ, and of *Dumortieria*.

The names would mark another distinction—the difference between the Cotteswold and other sands in date. Thus, the Cotteswold Sands being pre-striatulan would be Whitbian ; but the

[1] Estimate, data uncertain.
[2] Average thickness according to Mr. Beeby Thompson.

Yeovil Sands, the main mass of the Bridport Sands, and the Midford Sands in a strict sense, being post-striatulan would be, therefore, Yeovilian. Owing to a non-sequence in the Yeovil district, the finish of the Yeovil Sands coincides with the end of the Yeovilian, which makes the name appropriate; but, there being a due sequence in the Bridport area, the upper part of the Bridport Sands is later than Yeovilian: it is Aalenian.

VI. Summary.

(1) Descriptions are given of certain strata (Lower Bathonian to Pliensbachian) on the Dorset coast—Chideock and Burton Bradstock.

(2) Comparison is made with similar strata inland—with a summary of beds at Stoke Knap; with certain North Dorset strata; and with Toarcian beds of Yorkshire and Northamptonshire.

(3) The strata described are classified according to what may be called the multizonal or polyhemeral system—in the main, according to the scheme introduced for these strata in 1893[1]; but further divisions due to other investigators and to myself are dealt with.

(4) The strata described are arranged among thirty-six zonal (hemeral) divisions—a greater number of divisions than Oppel used in 1856 for all the Jurassic rocks, of which these beds form but a small part.

(5) The Upper Lias part of the Junction Bed of Down Cliffs, Chideock (Lower or pre-*striatulus* Toarcian), is a very condensed, imperfect epitome in 20 inches of about 180 feet of strata on the Yorkshire coast, and of very much more when allowing for gaps.

(6) Between the *bifrons* layer and the *striatulus* layer of the Junction Bed there is occasionally a 2-inch layer which is all that represents some 250 feet of deposit in the Cotteswolds—so that about 2 feet of Junction Bed was formed while a thickness of some 550 feet was being deposited elsewhere.

(7) The Upper Toarcian (*moorei-Dumortieriæ* hemeræ) makes a great showing at Burton Bradstock and Down Cliffs as the Down Cliffs Clay and Bridport Sands (*pars*), the greatest thickness of rocks of these dates in the kingdom.

(8) The sequence of *aalensis* strata above *moorei* beds is demonstrated at Chideock Quarry Hill, in the upper part of the Bridport Sands.

(9) The Inferior Oolite (Aalenian, Bajocian, Bathonian, *pars*) strata of Burton and Chideock are not counterparts of one another: they supplement each other to a certain extent; both are incomplete and much epitomized representations of thicker deposits elsewhere.

(10) Mr. Beeby Thompson's zonal scheme for the Upper Lias is considered, and a table of Upper Lias zones for future work is presented.

[For the Discussion, see p. 109.]

[1] Quart. Journ. Geol. Soc. vol. xlix, p. 481.