APRIL 9, 1851.

The following communications were read:—

1. *On the BASEMENT BEDS of the INFERIOR OOLITE in GLOUCESTERSHIRE.* By the Rev. P. B. BRODIE, M.A., F.G.S.

THE lower strata of the Inferior Oolite, near Cheltenham, and in other parts of Gloucestershire, present some features of novelty and interest, which I now proceed to lay before the Society; and this will form a conclusion to my previous paper on the superior Divisions of this Formation*. The bed immediately below the “shelly freestone” has been correctly termed Pisolite or Pea-grit in the ‘Geology of Cheltenham†,’ and is there described as being “made up of small flat concretions from a quarter to half an inch in diameter, which give it the appearance of a nummulitic rock.” At Leckhampton Hill it admits of the following subdivisions:—

	Feet.
A.—Rubbly, coarse, pisolitic Oolite, the flat concretions rather large; in places much broken up, though some large blocks occur at intervals; prevailing colours yellow and brown. It contains some Corals and several species of <i>Echinodermata</i> , among which <i>Pygaster semisulcatus</i> , Phill. (<i>Clypeus ornatus</i> , Buckman) and <i>Hyboclypeus agariciformis</i> , Forbes, are characteristic	11
B.—Hard, whitish, compact Oolite, called “Weatherstone” by the workmen; the flat concretions somewhat smaller than the above. It is a good useful stone, and stands the frost. Many beautiful Corals are scattered over the surface of the blocks.....	8
C.—Coarse, concretionary, ferruginous Pisolite, with very large grains; a loose rubbly bed, like No. 1; Shells and Corals numerous; passing into a hard rough Oolite, less pisolitic in its structure than any of the above; varying in colour, brown and yellow predominating; fragments of <i>Trichites</i> , <i>Terebratula simplex</i> ‡, <i>T. plicata</i> , <i>T. tetrahedra</i> , <i>Trigonia</i> , <i>Pectines</i> , <i>Amphidesma</i> , and other fossils abundant, and occasionally claws of Crabs§.....	19
Total.....	38

* Quart. Journ. Geol. Soc. vol. vi. p. 239 *et seq.*

A description of the new species of shells in the “shelly freestone” is given in Mr. Lycett’s valuable paper in the Annals of Natural History, vol. vi. No. 36, for December 1850.

I scarcely did justice to my friend Professor Buckman in my late communication upon the “shelly freestone,” for I inadvertently omitted to state that he had previously remarked the identity of some of the *Testacea* with Great Oolite species, although the number referred to was at that time very small (see Geology of Cheltenham, p. 31).

† Outline of the Geology of the Neighbourhood of Cheltenham, by R. I. Murchison, 2nd edit. Augmented and revised by James Buckman and H. E. Strickland. 8vo. 1845, pp. 26 and 31.

‡ *Terebratula plicata* and *T. simplex* are most prevalent in the Pisolite, and do not occur below it; the latter is often of large size.

§ A new form of the minute Brachiopod, *Thecidea*, occurs in the Pisolite, which Mr. Davidson considers to be a variety of *Th. triangularis*, D’Orb. and Dav.; the latter is frequently found attached to Corals in the Oolite-marl. Several other new species of shells have been discovered in the Pisolite (especially by my friend Dr. Wright), but they are at present unnamed.

The same characters are presented by the Pisolite at Cleeve on the north-east, and at Crickley on the south, where it admits of the same subdivisions and contains identical fossils, although its average thickness is probably rather more*. South of Birdlip and along the more south-western range of the Cotswolds, the Pisolite disappears, but its absence is more than compensated for by the increased thickness of the Ammonitiferous oolite and inferior sands, the latter of which at Wotton-under-Edge are estimated by Mr. Lycett to be about 40 feet thick, and near Minchinhampton to average from 35 to 40 feet; while up the Chalford valley they are reduced (he says) to less than half that amount, and they probably thin out northwards where they are succeeded by the Pisolite. The next strata between the sands and the Pisolite, which constitute the lowest of the Inferior Oolite round Cheltenham, have not been previously noticed, or have been erroneously classed with the Pisolite, to which they obviously do not belong; one portion being especially interesting as forming a *bone-bed*, although of limited extent and thickness.

		Feet. In.
2. Ammonite and Belemnite Bed.	D.—Immediately below C. of the Pisolite is a ferruginous Oolite, made up of small, brown, oval, shining grains like small seeds, cemented together by a sort of calcareous paste of a yellow and brown colour. It is characterized by <i>Belemnites</i> and <i>Ostrea</i> ...	3 0
	E.—Yellow sand without fossils	0 1½
	F.—Hard, dark grey, approaching to brown, shelly, crystalline limestone containing <i>Belemnites</i> , some <i>Ammonites</i> , <i>Pectines</i> (<i>P. lens</i>), <i>Terebratulæ</i> (especially <i>T. bidens</i>), <i>Lima</i> , <i>Amphidesma</i> , <i>Gervillia</i> , and <i>Serpulæ</i> . Bones, Scales, Coprolites, and Teeth of Fish are dispersed throughout the mass, and may be most readily distinguished on the surface, intermixed with the same brown oval grains as in D. higher up. The Limestone has been bored into by <i>Lithodomi</i> , and the cavities are often filled up with fragments of bones, &c. At its junction with the sand, E. above, it is of a yellow colour, and it passes into a yellow, ferruginous, pure, sandy, micaceous stone, with fewer oval particles, full of <i>Belemnites</i> , <i>Ammonites</i> , <i>Pectines</i> , and numerous fragments of Bones, Scales, and Coprolites. On the whole, <i>Belemnites</i> are more abundant than <i>Ammonites</i> at Leckhampton	1 0
	3. { Brick-coloured and dark yellow sandy marl, with broken Shells, chiefly Pectens, and small spines of <i>Cidaris</i>	0 3
	4.—Blue micaceous shale (Upper Lias).	

At this particular spot†, the junction of the Oolite and Lias is well exposed; but, with the exception of Crickley Hill, this is the only locality along the whole line of the outer escarpment of the Cotswolds where it may be observed, owing to the quantity of debris and rubble which covers the slopes of these hills. Hence it is almost impossible to trace these lowest beds with any degree of accuracy, although it is evident that throughout the whole of the line, from Cleeve to Wotton

* The Pisolite extends, in all probability, in a north-easterly direction towards Winchcomb. The Oolite marl occurs there and at Chipping Campden, on the north-eastern extremity of Gloucestershire, with the usual characteristic fossils. At the latter place, my friend Mr. Gavey informs me that the freestone rests immediately upon the Lias; so that the Pisolite is entirely wanting. At present, however, our information of the Oolitic series in that district is very scanty, but I trust his zeal will soon remedy this deficiency.

† The junction of the Oolite and Lias is seen in a corner of the lowest quarry where sand is obtained, looking towards the north-west.

and Dundry, the "Ammonite and Belemnite bed" *underlies* the Pisolite, or *overlies* the sands, and is a very constant and well-marked member of the series. At Cleve I detected just above the Upper Lias, some loose fragments of a hard, brown, sandy stone, with Shells, Bones, and Coprolites, which no doubt is present *in situ*, if it could be clearly ascertained. At Crickley the Pisolite, on the southern escarpment, reposes on a grey, bluish-brown, gritty stone, three or four feet thick, passing into a hard, grey, ferruginous rock, one foot thick. Fragments of Bones, Scales, Coprolites, and Teeth of *Hybodus* are very abundant, especially in the upper part; the shining, oolitic, oval grains are not so constant, but there are numerous *Belemnites*, *Ammonites*, *Pectines*, *Terebratulæ* (*T. bidens*, Phill.), large *Pholadomya*, *Spondylus* (*Hinnites*), &c. From the mass of debris the section is difficult to make out, but it is evidently a continuation of the same stratum at Leckhampton before described; the lithological differences are comparatively slight (the limestone, No. 2, F., being less clearly defined), and the zoological agreement nearly perfect. A roadside escarpment on Frocester Hill, facing the Severn, towards Coaley, presents the following section in descending order:—

		Feet. In.	
1.	Freestone (base of), the top beds shelly and flaggy, like the "shelly freestone" at Leckhampton, the lower part generally softer, coarser, and gritty; here and there traversed by hard shelly layers; the surface of the blocks often covered with broken stems of a new species of <i>Pentacrinites</i> , plates of <i>Cidaris</i> , and small water-worn Corals. It is used for building purposes, and is remarkable for its dazzling whiteness. These constitute the lowest beds of the freestone and are about 40 feet thick, the thickest portion forming the summit of the hill, and being on the whole quite as thick as at Leckhampton, which with some slight mineralogical difference it clearly represents	40	0
	2. Fine-grained gritty stone of a light brown colour, resembling the "Trigonia-grit," loaded with <i>Pholadomya</i> , <i>Trichites</i> , <i>Modiola plicata</i> , Sow., <i>Serpula socialis</i> , Goldf., and frond of a Fern, a rare fossil in the Inferior Oolite of Gloucestershire.....	3 or	4
	3.—Hard, yellow Oolite with few fossils	5	0
	D.—Coarse Oolite, of a brown and yellow tint, made up of oval oolitic particles; full of <i>Belemnites</i> *, <i>Ammonites</i> (<i>A. discoides</i> , D'Orbigny, <i>A. excavatus</i> , Sow., <i>A. Parkinsoni</i> , var. Sow.), large <i>Nautili</i> , <i>Modiola plicata</i> , Sow., <i>Astarte</i> , and numerous other shells. <i>Terebratula bidens</i> , Phill., occurs in layers at the top.....	4	0
	F.—Loose rubbly bed, with irregular nodules of a hard micaceous stone; the surface covered with <i>Serpulae</i> , and occasionally bored into by a lithodomous Mollusk as the equivalent limestone at Leckhampton (see No. 2. F.); passing into a hard coarse Oolite, similar to D. above described, yielding <i>Belemnites</i> , <i>Ammonites</i> , and carbonized Wood. It becomes sandy at the base. I could detect no remains of Fish in any part, but it is evident that this entire band is identical with No. 2. at Leckhampton and Crickley, with which it agrees in most particulars	0	7
4. Ammonite and Belemnite Bed.	Yellow micaceous sand; depth uncertain, but it must be of considerable thickness, probably 30 or 40 feet. Dip slight, to the south-east. The Lias is not well exposed in this section, although it is visible near the turnpike at the bottom of the hill, on the road to Frocester.		
	5.		

* The greater number of the *Belemnites* and *Ammonites* from this division in the Cotswolds are unnamed.

In my former paper in the Quarterly Geological Journal, the group below the Pisolite was named the "Ammonite and Belemnite bed*," for the preponderance of these shells, independent of any other characters, distinguishes it from all others in the series. On the whole, these genera are comparatively rare in any of the superior divisions, and occur in greater or less profusion in the equivalent strata at Painswick, Beacon Hill, Haresfield, Frocester, Wotton-under-Edge, and Dundry. In all cases it may be also identified by the presence of the small shining oolitic grains, cemented by a brown or white calcareous paste. The remains of Fish appear to be merely local, for I have not observed them in any of the localities above-mentioned. With the exception of a few large Palatal teeth in the Pisolite, any traces of Fish are seldom met with in the Inferior Oolite of Gloucestershire, and their abundance in the present instance is a remarkable exception to the general rule. The bones, scales, coprolites, and teeth are very minute, rolled, and fragmentary, but in sufficient numbers to form a kind of *Bone-bed*, and probably belong to more than one species of Fish, and I have only noticed one which could be ascribed to Saurians. Teeth are not common; the few which have been discovered were pronounced by Sir P. Egerton to belong to a species of *Hybodus*. The great profusion of certain genera of Cephalopods, such as *Ammonites*, *Nautili*, and *Belemnites*, indicates a deep sea, which evidently became shallower during the deposition of the shelly freestone, and even in some degree before the Pisolite; an inference which may be drawn from the presence of *Lithodomi*. The evidence afforded by the occurrence of a boring Mollusk is that of partial elevation and repose; but, as *Ammonites* and *Belemnites* are again found a little higher up, there must have been another local subsidence; *after* which, and *before* the formation of the freestone, the sea would seem to have been getting gradually shallower; for the general character both of the Pisolite and freestone points to an ocean of less depth than that in which the Ammonite-bed† was deposited.

It is a curious and interesting fact, that, in nearly every example, the large fragmentary accumulations of the remains of Fish or Saurians, commonly called "bone-beds," have taken place at the close of one formation and the commencement of another; and it is not perhaps easy to assign a reason for this coincidence, although most of these peculiar deposits are only local and not very extensive, the Lias

* When I spoke of this stratum near Cheltenham (Quart. Journ. Geol. Soc. vol. vi. p. 224, note) as being a diminished representative of its equivalent at Frocester, I referred more especially to the increased thickness of the sands beneath, which at Leckhampton are barely represented by three inches of sandy marl; the *Ammonite* and *Belemnite* bed itself being of uniform thickness, or nearly so, at both those places, but expanding considerably at Wotton and Dundry.

† Mr. J. C. Nesbitt has kindly examined some portions of this rock, and informs me, that although he has not yet had leisure to make an accurate quantitative analysis, yet, from qualitative experiments, he feels satisfied that the specimens he examined, viz. a cast of a small Ammonite and hand-specimens with many small fragments of bones, &c., from this basement-bed of the Inferior Oolite, contain between 40 and 60 per cent. of phosphate of lime;—in fact, that the whole of the specimens are highly phosphatic.

“bone-bed” being the thickest and most widely distributed. The following well-known examples will point this out:—

Bone-bed at the base of the Lower Greensand at its junction with the Wealden.

Bone-bed at the base of the Inferior Oolite at its junction with the Lias.

Bone-bed at the base of the Lias at its junction with the New Red Marl.

Bone-bed at the base of the Mountain Limestone at its junction with the Old Red Sandstone.

Bone-bed at the base of the Old Red Sandstone at its junction with the Ludlow Rock*.

If the Lias bone-bed be correctly assigned to the Trias, it would then mark the commencement of the New Red Sandstone epoch, instead of the close of the Liassic.

I am indebted to my friend Mr. Lycett for some useful information respecting the Lower Division of the Inferior Oolite in his own district, and with which indeed he is in all respects so well acquainted.

2. *On some Points of the PHYSICAL GEOGRAPHY of NORTH AMERICA in connection with its GEOLOGICAL STRUCTURE.* By SIR JOHN RICHARDSON, M.D., F.R.S.

[Communicated by Sir C. Lyell, F.G.S.]

IN the following brief communication it is my purpose to draw the attention of the Society to the remarkable connexion that exists between the river- and lake-basins of North America and the geological structure of that region.

An inspection of Arrowsmith's or any other good general map of the continent will show, that to the east of the Rocky Mountain chain the chains of great lakes or the river-valleys have either a parallelism to the Rocky Mountains, or run nearly at right angles thereto. North of the St. Lawrence basin all the greater excavations lie in a line parallel to the axis of the Rocky Mountains, and at the junction of Silurian strata with a granitic formation, while narrower valleys, occupied by the greater rivers, cross them nearly at right angles. A few explanatory observations will make this more clear.

The Rocky Mountain chain has a general course for 2500 miles, or from the 30th parallel of latitude to the Arctic Sea, of North 26° West; that is, of about North-west by North. Its peaks rise from 12,000 to 15,000 feet above the sea, but passes occur at various places at elevations of from 6000 to 8000 feet. The higher parts of the range rise abruptly, but along the eastern base of the chain there exists a belt, composed chiefly of sandstone, 150 miles wide, which has a mean inclination of thirty-six feet in the mile, in its descent from 8000 feet to 2500. From this belt to the shores of the Atlantic, a distance of about 1800 geographical miles, the descent

* See Sil. System, pp. 198–200.