XIX.—On the Freshwater Strata of Hordwell Cliff, Beacon Cliff, and Barton Cliff, Hampshire.

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IN the last volume of the Transactions of the Geological Society, there is a description of the strata in the cliffs between Lymington and Muddiford near Christchurch ; and, in a section accompanying the Memoir, the extent of the different formations exhibited in this line of coast is laid down. Large collections of the fossils of these cliffs have been made since the days of Brander, who published an account of them in 1766 ; and many have paid hasty visits to the spot, for the purpose chiefly of procuring fossil shells. But it was reserved for Mr. Webster to discover and first make known, in 1822, the existence of a distinct freshwater formation on the Hampshire coast, corresponding with the lower freshwater formation in the Isle of Wight. I have examined these freshwater strata in minute detail, their order of superposition, and their organic contents, with a view of furnishing data to geologists, for comparing these beds with those of the opposite coast of the Isle of Wight ; and also to decide the question, on which doubts were entertained by the author of the Memoir above mentioned, whether the upper marine formation occupies any portion of Hordwell Cliff.

In determining the names of the shells, I am indebted to the kindness of Mr. James Sowerby ; without whose assistance in examining specimens of the marls brought from these cliffs, several of the organic remains would have been entirely overlooked.

The following is a list of the beds in the order of their superposition as they are seen rising from beneath each other with a gentle inclination to the east, as we proceed from the eastern extremity of Hordwell Cliff towards Barton Cliff. Their extent and position will be easily seen by referring to the annexed sketch. (See Pl. XXX. No. 2.)

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1. Diluvial gravel composed of broken chalk flints with occasional layers of sand and marl, varying in height from 5 to 50 feet.
2. Fine white sand, sometimes containing in the lower part layers of light green marl frequently stained with iron, from 3 to 12 feet.
3. Green marls, which may be thus divided, beginning with the upper beds :—
 - a. Greenish unctuous marl without shells, varying from 1 to 3 feet.
 - b. Dark leaden-coloured greenish clay. Contains bituminized wood and numerous seeds or capsules of plants (figured Pl. XII. Geol. Trans. Part 1. vol. 1. 2nd series); and the following shells. *Unio Solandri* (Min. Con. tab. 517.). This shell is abundant, but in a very fragile state. The nacre of the shell is well preserved; sometimes, but rarely, it is found perfect with its brown covering. *Helix lenta* (Brander) in great abundance. *Melania*, in the lower part of the bed, in a very perfect state, a shell not yet described in any publication. The thickness of this bed, which is well seen at the Mine Way, is about one foot and a half.
 - c. Green marl, with the same seeds as above; also containing *unio Solandri*, *helix lenta*, and *melaniæ* in abundance, and fragments of another conical shell (perhaps part of the spire of a *lymnæa*?). The green marls containing *melaniæ* are found in the ruins of the cliff between the Mine Way and Hordwell-End-Lane, in large fallen masses; and the bed to which they belong will appear to be often repeated, unless great caution is used.
 - d. Marl of a beautiful bright green colour, characterized by *melanopsis carinata* (Min. Con. tab. 523. fig. 1.); containing also *helix lenta* and *planorbis lens* (Min. Con. tab. 140. fig. 4.); also fragments of *lymnæa fusiformis* (Min. Con. tab. 169. fig. 2, 3.).
 - e. Arenaceous-argillaceous marl dividing into laminæ, occasioned in some degree by exceedingly minute fragments of *unio Solandri* disposed in parallel layers, and resembling mica. The position of this sandy bed is not easily ascertained in the above group, in consequence of the ruined state of the cliffs. *Unio Solandri* occurs in this bed unbroken, and the seeds noted in 3. b.; also numerous valves of a small cypris of a yellow colour, in layers, as the cypris occurs in the Weald clay. Thickness of c. d. e. about 12 feet. Total thickness of No. 3. about 16 feet.
4. Sands and clays, which may be thus divided :—
 - a. Greenish brown sand, 8 inches.
 - b. Brown laminated clay, and bituminous dark clay with lignite, one foot and a half thick.
 - c. Marls of various shades of green, 12 feet.
 - d. Bright green marl; in the lower part, *mya gregarea* (Min. Con. tab. 363.) in great numbers and very perfect, lying on their sides parallel to the planes of stratification: this bed is about one foot and a half thick. Thickness of No. 4, about 15 feet.
5. a. Calcareous marl, sometimes slightly indurated, consisting of aggregated shells, *planorbis rotundatus* (Brard.), and *lymnæa longiscata* (Min. Con. tab. 343.), in a very fragile state and generally broken. A small species of *lymnæa* (*columellaris* Sow. Min. Con. tab. 528. fig. 2.), occurs, rarely; also *L. fusiformis*. In some parts, as about 200 yards East of Hordwell-Lane-End, where it first rises, this bed contains *gyrogonites* (*chara Medicago*) in abundance. Although this bed is only from six to eight inches thick, it is very conspicuous from its light colour and the black bed of carbonaceous matter immediately below it.

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- b.* Black carbonaceous clay with lignite, from one to five inches. Thickness of No. 5. about 1 foot.
6. *a.* Green unctuous marls without shells, four feet. In some places, as near Long-Mead-End, this marl hardens into green stony concretions, which, when exposed, acquire a ferruginous colour, and are seen projecting from the cliff or strewed along the beach.
- b.* Green arenaceous marl, in some parts passing into a pure white siliceous sand. The two shells which occur in great abundance in this stratum are *mya plana* (Min. Con. tab. 76. fig. 2.) and a species of *potamides*. Besides these are found *melanopsis brevis*, two species of *cyclas*, a *neritina*, fragments of *helix lenta* (Brander), a small cylindrical *serpula*, and also shining lozenge-shaped scales of fish? *Gyrogonites* also (*chara Medicaginula*) abound in some of the sandy portions of this stratum in Beacon Cliff. This bed is about two feet and a half thick.
- c.* Beds of pure white sand and argillaceous sand. These are characterized by a layer of sand filled with a *potamides* like *P. margaritaceus* (Min. Con. tab. 339. fig. 4.), accompanied by *mya plana*; the latter in a very perfect state with both valves. Hardened blocks of this sand lie on the beach, containing the *potamides* in abundance. A species of *mytilus* also occurs (*M. Brardii*, Min. Con. tab. 532. fig. 2.), and one from hence has a small *serpula* attached, which is cylindrical, with two ridges. These beds are from 8 to 10 feet in thickness. *Melania conica* (Min. Con. vol. 6, p. 60.) (*bulimus conicus* Brard.) is also abundant with the above. Total thickness of No. 6. about 15 feet.
7. *a.* Light green marl, containing *mya subangulata* and a *planorbis*, 3 feet thick.
- b.* Dark arenaceous bed, sometimes argillaceous. In this are found *helix* or *paludina lenta* (Min. Con. tab. 31. fig. 3.), *mya subangulata**, *melanopsis brevis* (Min. Con. tab. 523. fig. 2.), a small *planorbis*, a new species of *ancylus*, *A. elegans* (Min. Con. tab. 533.); with many minute shells, apparently the young of some of the preceding: also small smooth shining black capsules, of a plant nearly spherical, hollow, lined with a membrane, the integument composed of minute cells. 2 feet thick.
- c.* Light green marl with a layer of bluish sandstone, 4 feet.
- d.* Carbonaceous clay and lignite, 6 inches.
- e.* Light green marl, 2 feet.
- f.* Carbonaceous black clay, 6 inches.
- g.* Sandy loam, 3 feet.
- h.* Reddish brown clay, 3 feet.
- i.* Light green loam; in lower part univalves (*helix lenta*?) and *gyrogonites* (*chara Medicaginula*), 7 feet. Total thickness of No. 7, about 22 feet.
8. *a.* Green marl; bivalves in the upper part, 5 feet.
- b.* Coal-black carbonaceous clay and lignite, 6 inches.
- c.* Black mould resembling bog-earth, 6 inches.
- d.* Ferruginous clay. In this is a species of *cyclas*, the same as one of those noted in 6 *b.*, fragments of a *mytilus* resembling *crenatus*, *mya subangulata*, and fragments of an univalve, 6 inches.

* Mr. J. Sowerby considers it not improbable that this shell may be the young state of *mya plana*.

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- e. Light bluish gray marl with vegetable impressions, 1 foot.
 - f. Black carbonaceous clay and lignite, 6 inches.
 - g. Green clay, 1 foot. Total thickness of No. 8. about 9 feet.
9. White siliceous sand, without shells, rises near Long-Mead-End and extends through Beacon and Barton Cliffs to the middle of Highcliff.

Besides the organic remains above enumerated, scales of tortoises have been found by some collectors*. They occurred either in the group of strata No. 3, or in that termed No. 4, of the above section. Gyrogonites also have been found in abundance in the same part of the cliff, though I did not observe them myself. In No. 3, the seed-vessel called by M. Brongniart *carpolithes thalictroides*† has been procured. In No. 4, teeth of a crocodile or some saurian animal, and lozenge-shaped scales of fish?

On reviewing the strata described in the above section, and their contents, the following observations occur.

1st. No portion of the upper marine formation exists anywhere in this part of the Hampshire coast. The uppermost beds of the series in Hordwell Cliff, so far from indicating a passage into the upper marine formation, contain organic remains, both animal and vegetable, exclusively belonging to freshwater genera. The shells referred to by Mr. Webster as cerithia, occurring in fallen blocks along the shore, belong to the genus *Potamides* of Brongniart, and the stratum in which they abound occupies a middle place in the series. *Cerithium* is a marine genus; but the *potamides*, of which some species still exist in a recent state, inhabit rivers, or at least the mouths of rivers‡.

2ndly. The extent of the freshwater formation is somewhat greater than had been supposed, as it is continued in Barton Cliff to nearly opposite the village of Barton. The lower beds of the series there exposed contain in parts gyrogonites and freshwater shells.

3rdly. The fine white siliceous sand of Beacon and Barton Cliffs must, till some reason be shown to the contrary, be referred to the freshwater formation: for it will be seen by the above description, that two beds of a similar fine white sand occur associated with the freshwater strata in Hordwell Cliff. It is therefore clear, that when this series was deposited, all the circumstances existed which were required for the formation of such sand; whereas nothing similar is found connected with the London clay in any part of England. The lower freshwater formation must thus be considered as extending throughout Barton Cliff to about the middle of High Cliff.

* The entire shell and bones of a tortoise have lately been found in the lower freshwater formation near Thorness Bay, in the Isle of Wight.

† Cuv. Oss. Foss. tom. ii. edit. 2de. Pl. XI. f. 5.

‡ Cuv. Règne Anim. tom. ii. p. 438.

4thly. The strata of Hordwell Cliff correspond with those on the opposite side of the Solent, particularly with the lower freshwater beds between Yarmouth and Gurnet Point : where, as Professor Sedgwick observes*, they lose the appearance of an indurated calcareous marl, and are not unfrequently of a bright green colour, and preserve their continuity for a great extent. "In a part of the coast between Yarmouth and Hampstead Cliff," he adds, "the beds are brought out from one under another in a long succession. The whole formation is subdivided by almost innumerable layers of fossil shells, which follow the planes of stratification. The beautiful preservation even of the minutest characters both of the bivalves and of the univalves, and still more the arrangement in distinct families, afford a proof not short of demonstration that the whole system has originated in a tranquil deposition." Professor Sedgwick's description is equally applicable to the strata on the Hampshire coast; and the genera of shells enumerated by him are the same, as far as they go, with those which I have mentioned. Although no doubt can be entertained that the strata of Hordwell Cliff belong exclusively to what has been termed in the Isle of Wight the Lower Freshwater Formation, yet it may be a question whether the organic remains are not of a mixed nature, some few examples presenting themselves of shells belonging to marine genera. Thus a small mytilus occurs in two of the beds, and, in two instances, a small serpula; the latter shell was found also by Professor Sedgwick in Hampstead Cliff† in the Isle of Wight. But although these latter testacea may have required salt-water, they may very probably have inhabited the estuary of a river within the influence of the tides; for the whole assemblage of organic remains is so precisely similar to that which characterizes recent freshwater deposits, and there are so many proofs of tranquil deposition, that we cannot suppose them to have been all washed by the violence of floods into the sea.

The plentiful exuviae of the cypris‡, as well as the gyrogonites§, are positive indications of the freshwater origin of this formation. The small number of genera and species to which the shells are referrible, though the

* Ann. of Phil. for 1823, vol. iii. p. 347.

† Sowerby Min. Con. No. 91, description of Tab. 527.

‡ Lamarck observes in his work "*Animaux sans Vertèbres*," that these microscopic entomostraca change their skin and shell at the same time. They inhabit the fresh and stagnant waters of marshes and ditches, and swim swiftly. Vol. v. p. 124.

§ These fossil seed-vessels have been found by some collectors in Hordwell Cliff in great abundance, in some of the fine white sands. The fine sand of the Thames, used for covering the floors of kitchens in London, is often filled in a similar manner with the seed-vessels of recent Charæ. The integument is so tough that the spiral ridges on the surface retain their sharpness as in their fossil analogues, uneffaced by the attrition of the sand.

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individuals are in great abundance, is a circumstance characteristic of recent freshwater deposits : whereas shells, whenever they occur plentifully in ancient marine formations, belong to a variety of distinct species ; and, from what we know of the living testacea of our seas, we may conclude that this is the case in submarine strata now in the act of forming. The almost entire absence, amid such a multitude of organic remains, of decided marine productions, is, when coupled with the other circumstances, a strong negative fact. Upon the whole, there are sound geological reasons, both in this and in other instances, for extending the term *Freshwater Formations* to deposits which may have been formed at the mouths of rivers, and for no longer restricting it to such as have originated in inland lakes.

No. 1. SECTION of the Coast from Muddiford, Hants. to Studland Bay, Dorset.

No. 2. SECTION of the Lower Freshwater Strata, in Hordwell, Beacon, and Barton Cliffs, Hants.