2. *On the Tertiary and more recent Deposits in the ISLAND OF NANTUCKET.* By M. E. DESOR and EDWARD C. CABOT.
(In a letter to Sir Charles Lyell, Pres. Geol. Soc.)

KNOWING how much you are interested in all inquiries about the drift of this country, we take the liberty to forward to you some specimens of shells which we have lately collected from the cliffs of Sancati Head, in the island of Nantucket. Allow us to accompany them with some observations upon this locality.

The cliff of Sancati, as you know, constitutes the eastern border of the island of Nantucket, rising to a height of ninety-two feet above the beach. Although covered in a great measure with the loose sand that is carried by the wind from the beach, yet there are several points where the successive layers are to be seen, as for example near the tripod: fig. 1 will give an idea of their superposition.

Fig. 1.

At the base of the cliff is found a stratum of brown, very brittle and partly sandy clay (*l*), nearly twenty feet thick. Over this rests a bed of gravel several feet thick (*k*), which is overlaid by a stratum of homogeneous white sand (*j*). On this is found a layer of very tough clay (*i*), very similar in its aspect to the plastic clay near Paris, except that it contains a great many nodules of ferruginous sand. This clay-bed is overlaid by an oyster-bank (*h*) one foot thick, intermixed and covered by large masses of *Serpula* (*g*), which are, like the oysters, in their natural position. There are besides a great many other shells scattered through this bank, all of them in a most perfect condition, although it is difficult to preserve them entire when taken out from the layer. This oyster-bank is followed by another fossiliferous stratum (*f*), in which the shells are in a different state: they bear evident traces of exposure, the valves of the bivalves being

generally isolated, and the *Balanus* disintegrated and more or less worn. There are besides no traces of dendritic (manganese) incrustations, which, as you will perceive, are very common on most shells of the oyster-bank beneath. Above this stratum of loose shells there is found a series of layers of sand and gravel, with a thickness of nearly fifty feet, in which every variety of materials may be seen, from the finest sand to the coarsest gravel. On the top of these sand layers lies a stratum of dry peat (*b*), filled with trunks and roots of trees, the remains of a peat bog that has been drained by the washing away of the cliff. Finally there is seen, covering this peat deposit, a stratum several feet thick of fine sand (*a*), which has been deposited by the wind, as is evident from its form, being everywhere bent according to the outline of the hill, and likewise from the fact that there is not a single stone to be found in it, but only such grains of sand as are capable of being transported by the wind, thus affording a striking instance of the action of wind in the formation of stratified deposits.

The strata thus enumerated seem at first horizontal, but in digging along their edges, we soon ascertained that they all dipped to the west, their inclination varying from fifteen to five degrees, the upper beds being generally less inclined than the lower ones. The inferior clay stratum, however, was found to differ considerably from the others, its dip being nearly thirty degrees to the south-west, and in some places even as much as forty degrees.

This circumstance induced us to examine this lower clay stratum more carefully. Having made out a spot where the overlying gravel bed was seen in immediate contact with the top of the clay, we could distinctly trace its unconformable deposition, the gravel being seen dying out towards the more inclined clay-stratum, as shown in the above section, fig. 1, taken on the side of a gully in the cliffs. Such differences in the inclination cannot be attributed merely to a difference in the mode of deposition. A considerable change of level must have taken place between the deposition of the clay and that of the gravel. And although no fossils have been found in this clay, yet its great resemblance to the clay of Truro in Cape Cod, which Mr. Hitchcock considers as tertiary, leads naturally to the idea that they may be contemporaneous, and probably of the same epoch as the clay of Gay Head, which you have proved to be miocene. Indeed there may be seen below the red clay of Gay Head, several layers of a brown sandy clay very similar to that of Sancati. Thus the tertiary cliffs of Gay Head should no longer be looked upon as an isolated fact, but the cliffs of Sancati may be considered as the opposite outcrop of a large tertiary basin, underlying the islands of Nantucket and Martha's Vineyard, fig. 2, and extending to the south below Long Island, and to the north as far as Truro. The edges of this basin having thus been raised, became, at the time of the deposit of the drift, a nucleus against which the tide-currents, according to the theory of Capt. Davis, deposited the mud, sand and gravel which they carried with them in their course along the eastern coast of the United States, just as they do at present. We are even in-

clined to consider the tertiary itself as deposited by the same tidal agency, being formed from the detritus of the greensand of New Jersey; a supposition which seems the more probable as it would account for the great similarity of materials between the greensand of New Jersey and the tertiary of Long Island, a similarity which is so striking, that it led even Mr. Mather to consider this tertiary as identical with the greensand.

Concerning the drift overlying the tertiary clay at Sancati, it is obvious from the regularity of the strata, and from the very perfect state of preservation of the shells imbedded in it, that it has not undergone any violent disturbance since their deposition. The species collected by us in the above-mentioned oyster-bank are the following:

<i>Venus mercenaria</i> , plenty.	<i>Buccinum undatum</i> , rather rare.
<i>Mya arenaria</i> , plenty.	— <i>plicosum</i> , abundant.
<i>Ostrea borealis</i> , a bed several feet thick.	<i>Nassa obsoleta</i> , abundant.
<i>Arca transversa</i> , very abundant.	— <i>trivittata</i> , abundant.
<i>Solen ensis</i> , abundant, but very brittle.	<i>Scalaria groenlandica</i> , rare.
<i>Astarte Cartanea</i> , rather rare.	<i>Balanus rugosus</i> , very abundant.
<i>Cardita borealis</i> , rare.	<i>Serpula</i> , forming a layer several feet thick.
<i>Cumingia tellinoides</i> , rather rare.	<i>Pagurus pallicaris</i> (claws).
<i>Crepidula fornicata</i> , abundant.	

Now these are, without any exception, the same species that are found living on the shore of Nantucket and Cape Cod, and as they are all in their natural position, the bivalves having almost always the two valves united, and the *Venus* being commonly half open, just as they are found on the beaches when the muscles have relaxed after death, we may fairly infer that in this part of the continent at least, the climate has not undergone any considerable change since the deposition of these fossils.

The presence of a stratum of disintegrated shells of the same species, resting upon the undisturbed oyster-bank, may easily be accounted for by a somewhat more violent action of the tides, which deposited in this irregular manner a part of the shells which were washed off, from the oyster-bank itself, in the same way as is the case now among the Nantucket shoals. Indeed there is to be found on the slopes of every shoal ridge, a region from which the dredge brings up nothing but loose and broken shells. This region is so characteristic and so constant, that one of us has designated it in his "Report on the Distribution of Animals among the Shoals*," under a peculiar name, as the *Region of Broken Shells*. According to Capt.

* See Proceedings of the Boston Natural History Society.

Davis's view, the shells are deposited in this way by the tidal current along the shoal ridges, which act as so many nuclei.

Until last year it was assumed by the geologists of this country that there were no fossils to be found in the drift, south of Lake Champlain and the State of Maine, when one of us had the good fortune to discover several species in the drift of Brooklyn near New York*. Similar fragments, especially of *Venus mercenaria*, have since been found in the cliffs of Point Shirley, in Boston Harbour. Now, as the fossil shells in both places are of the same species as those of Sancati Cliff, there is every reason to consider them as belonging to the same period, their more or less perfect state of preservation depending merely upon local influences. It ought further to be stated, that wherever the shells are worn or broken, and the strata which contain them coarse and irregular, it is either in such places where the tidal currents must have been violent, so as to carry and deposit promiscuously heavy pebbles and minute shells, as in the cliffs of Point Shirley; or in such places where we must suppose that floating ice was at work, carrying indiscriminately heavy materials, pebbles and boulders, together with oysters and other shells detached from the neighbouring flats, and heaping them up in the corners of bays and sounds. This seems to have been the case with the coarse deposits of Brooklyn, where oysters and *Venus* are generally found imbedded in a reddish loam intermixed with pebbles and boulders, many of which are distinctly scratched, thus reminding us of similar actions which you have described in Fundy Bay and in the St. Lawrence; whilst in other places, like Nantucket and the bays and fiords of Maine, a more quiet action prevailed, so as to allow the shells to be preserved in their natural place and position after death. [Among the drift fossils collected at Augusta, on the Kennebec, there are many which have preserved their colour in a most perfect manner, especially *Astarte* and *Mytilus*.]

Finally, the fossils of the drift of Nantucket bear such a striking similarity to those of the newer pliocene of the Southern States, that they become a natural link between the northern and southern deposits. Instead of considering these as so many distinct formations; we should therefore henceforth look at them as mere modifications of the same deposit, being the result of the same agencies, viz. oceanic tide-currents along the whole coast of the United States, combined with gradual and secular oscillations of the whole continent, the local strength of the tidal currents affording a sufficient explanation for local diversity in the arrangement and size of the materials in each locality.

Viewed in this light, the drift formation, heterogeneous as it may appear at first, can be cited as a fair illustration of that great principle of yours, that it is by the application of actual causes that we arrive at a true understanding of the origin and diversities of geological formations.

* E. Desor's Letter to M. de Verneuil, in the *Bulletin de la Société Géologique de France*, 1847. A most interesting collection of the drift fossils of Brooklyn has since been made by Mr. Redfield.

How far this theory of the tidal current applies to the more ancient geological formations of this country, we shall attempt to establish in another letter.

3. *Notes on some Recent Foot-prints on Red Mud in NOVA SCOTIA, collected by W. B. WEBSTER of KENTVILLE.* By Sir CHARLES LYELL, P.G.S.

I BEG to present to the Society some impressions of footsteps which Mr. Webster has sent me, at my request, from the mud-flats of Kentville in Nova Scotia.

In my 'Travels in North America,' vol. i. p. 168. plate 7, I have given a plate and description of some of these foot-prints made by the sandpiper (*Tringa minuta*), which I saw daily running along the water's edge in the Bay of Fundy. The deposit there consists usually of red mud, with which the waters are charged by the undermining of cliffs of red sandstone and soft red marl. The tides rise very high, and when they are lowest, large areas recently overspread with red mud are laid dry, and are often baked in the sun for many days, so that the mud becomes consolidated and retains permanently the impressions of rain-drops, and the tracks of birds and animals which walk over it.

Mr. Webster tells me, that the divisibility of the solid mud into layers arises from the deposit of each tide being separated by a layer of sand or loam thrown down when the tide first rushes along the bank. The sandy particles being the heaviest are first deposited, and then the thin layer of mud on which the birds walk when the tide recedes. On examining these specimens, I perceive that while some of the foot-prints standing out in relief on the under-sides of the slabs are casts of impressions made in a subjacent layer, and therefore do not correspond with the imprints on the upper side, some of the projecting feet-marks, on the contrary, which are almost equally sharp, are formed by the forcing down of the soft mud, beneath which there was a sandy layer.

On some of the specimens will be seen the foot-print of a cat, which was no doubt in pursuit of the birds, and which was walking with its claws drawn in. In this case the weight was so great that the foot has displaced several of the underlying laminae of mud and sand, and has caused them to be uneven, without effacing the bird-tracks previously formed there. On other specimens, worm-like tracks, similar to those we often meet with on older rocks, are visible.

Some of the specimens are in their natural state, and have remained entire; but most of them have been slightly baked in an oven by Mr. Webster to enable them the better to bear their weight in travelling.