Art. II. On the Geological Features of the Bermudas.

By J. M. Jones, F. L. S.

[*Read Nov.* 6, 1865.]

The geological features of the Bermudas are at once interesting and peculiar. The group may be styled a series of sandy islets, more or less covered with cedar trees; for wherever you traverse, either along the shore or on the more elevated land, sand lies beneath your feet, and the cedar tree is rarely absent.

It does not require much stretch of the imagination to conceive the origin of this group, as formations always in progress in different parts of the islands give a clue to what has otherwise proved a mystery.

I have already given an opinion as regards the original formation of these islands in the "*Canadian Naturalist*" for February, 1864. Granting a primitive foundation, most probably the result of volcanic action, at no great depth below the ocean surface, the current of the Gulf stream would supply ample material to form a basis on which the gradual process of islandic formation would be slowly perhaps, but surely developed.

It is to the coral zoophyte, however, that minim in Nature's chain, that the Bermudas owe their existence as a settlement fit for the human race to dwell in. Without its presence the massive barrier reefs which lie around far in advance of the main land acting as walls of defence against the encroachments of the tremendous seas which break upon them, would not exist; and the inhabited districts, where now the neat white dwellings stand snugly ensconced in groves of cedars, would soon be changed to scenes of desolation; for like the locality known as the "Sand Hills" in Paget's parish, the sand would be thrown on shore by the violence of the waves, and the driving gale would hurry it along, burying houses and cedar groves in its course, as it has done in the locality I have alluded to.

Speaking of sand it may be well in the first place to consider the composition of the Bermuda sand. Take it as it lies upon the beach, and you will perceive, without the aid of the lens, that broken coral and shell are the principal ingredients. Pink coloured substances are also seen intermixed. They are fragments of nullipores which coat the reefs and shore rock in abundance. The nullipore

fragments, however, are about in the sand, which is found at a distance from the shore, and this hill sand is much smaller in grain and of a dull white colour; probably owing to the same process which according to Darwin takes place at St. Helena, viz., the drifting up of the sea sand to heights above, and the winnowing occurring during the transit.*

In traversing the islands from one end to the other, and ascending the highest positions, the hills are found to be rounded at their tops. This state arises from the action of the wind upon the masses of sand; and from sections of hill sides laid bare by excavation for road and other purposes, it appears that the same kind of formation has taken place in olden time, the shape of the former hills being clearly defined by the hardened mass which covers the underlying formation, and separates it from the recent one above.

From a general survey of the Islands I take it that they rest mainly on a series of caverns, partly and wholly in some cases filled with red earth; but near the shores of the islands these caverns are kept clear of contents by the waters of the ocean, which every flowing tide, find entrance through channels in the sandstone rock. There are some parts, however, which from observation I am led to believe are not so honeycombed by caverns, and these lie on the south shore of the main island, in Paget, Warwick and Sandy's parishes, where the sandstone has become hardened by some particular process into a very compact and close-grained stone. Of this stone lime is made, and when large houses and public buildings are erected, the contract generally specifies that this south side stone shall be used, it being far more durable than any other found on the Islands. Some persons imagine that the locality where this description of stone is found is the oldest land in the group, but it would be rash to concur in this theory where so many cases of recent formations having the appearance of age occur, and especially when we take into consideration the fact, that calcareous deposits soon become compact under the influence of exposure to the elements. Close observation made by residents on the Islands can alone set at rest

*When I last visited the Paget Sand Hills, a house at the summit of the hills some distance from the shore was almost totally buried, the chimney top being the only portion of the dwelling seen. The sand was still slowly but steadily working its way, and a few years more will no doubt cause adjoining properties to fall a prey to its encroachments.

this interesting question. The cavernous condition of the foundation of the group has often led ignorant minds to suppose that the islands rest upon no secure basis, and the circumstance of brackish water always making its appearance wherever holes are dug to the level of the sea, has given more credit to the statement.

In speaking of the cavernous foundation of the Bermuda group, I must not omit to mention a phenomena which may or may not exist in consequence of cavernous communication with the outer sea. Near the eastern end of the main island there is an extensive basin some six miles in circumference, called Harrington Sound. It connects with the sea by a narrow passage at its western end, over which a bridge is placed called "Flatt's Bridge." When the tide without flows, it is carried with great force into the sound through this passage, and likewise when it ebbs, it runs out again with the same degree of force. Now, it would be imagined that with such an increase of water as a flowing tide pours into this lake a rise of a few inches at least would occur: but such is not the case. Not an inch does the sound rise, and when the ebb begins, the waters rush out again to sea with the same impetuosity; yet not an inch has it fallen. Now where does the incoming water at flowing tide go to? And where does the water come from, that replaces the amount lost by the ebb? For there must be some outlet to account for such a singular occurrence. It must be borne in mind that this passage through which the tide ebbs and flows, is the only connection the lake has with the sea so far as can be ascertained. Many reasons have been given, endeavouring to account for this curious phenomenon, but as yet I am not aware of any definite conclusion having been arrived at.

The neck of land which divides this Sound from Castle Harbour is filled with caverns, and presents above ground an uneven and picturesque appearance. Miniature valleys surrounded by rocky ridges, honeycombed into caverns large and small, in the lower parts of which may be seen the clear waters of azure tint, through which the tropic fishes of rainbow hues may be seen floating about; and shrubs and plants of many kinds jutting out of the holes and crannies of the sandstone, while overhead the sage and coffee bushes, cedars and palmettos grow in wild profusion. This is the far famed Walsingham, immortalized by Tom Moore, in his ode to

the Calabash tree, which in his time afforded a cool shade, as it does at the present day, to numerous pic-nic parties.

In this locality, I have noticed a curious circumstance, which lends a clue to the formation of certain cylindrical masses existing on the shore at Harris Bay and other places. Mr. Richard Wood, the owner of this lovely estate, showed me certain trees growing out of the solid rock. The stem of one tree, a palmetto, was closely surrounded by the stone, and fitted as tightly as a stove-pipe does into the stone in a chimney. Now when this tree dies there will of course be left a cylindrical hole, and were the rock it exists in within reach of the waves of the sea, this hole which has had its walls hardened by the water which has during many seasons trickled down the stem of the tree, would become a cylindrical mass standing by itself, while the more friable rock around would be worn away. This condition would exactly account for the curious circumstance I have alluded to as occurring at Harris Bay. At that position and close to high water mark, stands a collection of cylindrical masses hollowed within and marked with rust, which I think may be owing to the decomposition of the tree, which once grew in this cylinder when it was part of the surrounding rock, which has been worn away by the action of the waves or spray, which at this point falls heavily during southerly gales. From appearances I should say that these cylinders contained palmettos from their rounded shape at the bottom, which is characteristic of the tree's growth.

I have at the commencement of this paper alluded to the presence of red earth in the caverns. This red earth exists very generally over the surface of the island, and mixed with sand is the common soil of the islands. I have every reason to believe that it is composed of decayed vegetable matter, and this theory is borne out by an analysis which was kindly made for me by Dr. Albert Bernays, the analytical chemist to St. Thomas' Hospital. Colonel Nelson has expressed his belief that the red earth found in caverns was of animal origin, most probably accumulated masses of guano; but as Dr. Bernays has stated that no animal matter whatever can be traced, I think a vegetable character can only be assigned to it, for I see no difference between the cavern red earth and the surface soil, beyond a more compact appearance in regard to the former.

In observing road cuttings in different parts, we see at once how

these islands have become raised to their present height, Look at a cutting side. Above all you see some few inches of red soil on which trees and shrubs are growing, then two feet of loose sand, gradually hardening as it descends, the whole filled more or less with semi-fossil shells of *Helix Bermudensis* and other land shells. Thirdly we perceive a large cavern partly filled with red earth, an undoubted cavern deposit, then a smaller deposit, and then a regular bed of red earth again—the whole intervening space filled with hardened calcareous rock.

The lowest layer of red earth was once the surface soil, then drift sand came over it, cavernous holes occurred in the drifting sand, perhaps where a dense vegetation grew, the decomposition of which left the small mass of red earth at the bottom. A second drift again takes place, and then we have red soil and vegetation growing again—and so the land rises; but having attained a particular height, and becoming well clothed with a dense vegetation, it is a question whether under existing circumstances a higher elevation will be attained, unless some change should take place in the current of the Gulf Stream, when the Bermudas would most assuredly suffer in no slight degree, and the sand of the shore would make similar encroachments to those taking place in Paget's Parish at the present day.

To show the gradual formation of the Bermuda shores, we have only to take a walk along the sandy beaches, where we see large masses of sand, intermixed with gulf weed and debris of all kinds, in the form of a low wall above high water mark. These masses have been placed there by the action of the waves during storms. They are gradually hardening, and in process of time will become sandstone rock. On these masses again at intervals are thrown drift matter and tree trunks, some of large size, as I have seen myself. Among the roots of these trees are frequently seen pieces of stone of far different composition to any found on the Islands. These stones have undoubtedly been carried within the entwined roots of those drift trees from the continent of America. They are generally pieces of hard trap, at least all those I have been able to procure are so according to Professor Dawson.

I was not aware of the real origin of these foreign fragments when I hammered them out of the shore rock, about high water

mark, until Mr. Belt drew my attention to Darwin's statement in regard to similar occurrences on the shores of Pacific Islands. These foreign stones may be seen *in situ* at Point Shares in the shore rock. Pieces of decomposed iron are also found imbedded in the shore rock, brought there no doubt by wreck materials.

In considering the geological structure of the Bermudas, we cannot help noticing the similarity that exists in many instances between the accumulations occurring in the sandstone, near shore, and those on the shores of Pacific islands, and other places where calcareous deposits occur. On the south shore of the main island of Bermuda, I found in the friable cliffs some curious tubular bodies, hard and compact, which left a cast in the sand on removal. I thought they might be fossilized roots of trees. However, on comparing notes with Darwin's account of Pacific calcareous deposits, I found that the same substances had been found at King George's Sound, on the S. W. coast of Australia, and at the Cape of Good Hope. He styles them "branched bodies." "These branches," he says, "are absolutely undistinguishable in shape from the broken and upright stumps of a thicket; their roots are often uncovered, and are seen to diverge on all sides; here and there a branch lies prostrate. The branches generally consist of the sandstone, rather firmer than the surrounding matter, with the central parts filled either with a friable calcareous matter, or with a sub-stalagmitic variety; this central part is also frequently penetrated by linear crevices, sometimes, though rarely, containing a trace of woody matter. These calcareous branching bodies appear to have been formed, by fine calcareous matter being washed into the casts or cavities, left by the decay of branches and roots of thickets buried under drifted sand. The whole surface of the hill is now undergoing disintegration, and hence the casts which are compact and hard are left projecting. In calcareous sand at the Cape of Good Hope, I find the casts quite similar to those at King George's Sound; but their centres are often filled with black carbonaceous matter, not yet removed. It is not surprising that the woody matter should have been almost entirely removed from the casts on Bald Head, for it is certain that many centuries must have elapsed since the thickets were buried." In concluding his observations on these branched bodies, Darwin says: "Reflecting on the stratification of

the deposit on Bald Head—on the irregularly alternating layers of sub-stalagmitic rocks—on the uniformly sized and rounded patches, apparently of sea shells and corals—on the abundance of land shells throughout the mass—and finally on the absolute resemblance of the calcareous casts to the stumps, roots, and branches of that kind of vegetation which would grow on sand hillocks, I think there can be no reasonable doubt, notwithstanding the different opinion of some authors, that a true view of their origin has been given here."

Now, I have every reason to believe that these branched bodies found in sandstone cliffs at Bermuda, have originated in the drift sand covering shrubs or trees, when in a living state; but from observations I have made I consider their formation to have differed from that of Darwin's specimens. Rain water coursing down the opening made by the protruding stems and branches, would cause the sandy particles around to cement together, and form a hardened crust, which, like the cylinder of the palmetto I have spoken of, would, when the surrounding friable sandstone around was cleared away, stand firm. I am led to suppose this course of formation, on looking at a specimen which is hollowed at its centre, presenting as it does an appearance that would indicate such a course. On the rocky shore immediately beneath the cliffs from whence I obtained these specimens, large masses of sandstone rock lie detached from the cliffs, and these detached rocks as well as the cliffs, are perforated with holes, doubtless the casts of branched bodies which have shaken out from their original positions.

Not far from where I procured these branched bodies, at the S. E. corner of the Paget Sand Hills, cedar and other trees are now being gradually buried under drifting sand; and in years to come when the mass around them has hardened into rock, their stems and branches having wasted away, will doubtless leave behind branched bodies similar to those I found in another position, and also to those found by Darwin at King George's Sound, and the Cape of Good Hope. In some cases the branches may have been formed according to Darwin's hypothesis, by the entire decay of the whole branch, root or stem, and the refilling of the cavity left by sand; but as I said before, from observing that in some cases the centre of these Bermuda branches are hollowed, I must repeat again that I consider a gradual hardening of the sandy particles immediately

around the vegetable matter, first takes place, and when the decay becomes perfect the vacuum is filled by the same material.

Another circumstance I will now relate, which tends in some measure to shew the similarity of the Bermuda phenomena to those of the Pacific. Below the Paget Sand Hills, and on the shelving beach between high and low water mark, stand some remarkable rocks of the same consistency as the shore rock. One in particular stands perfectly isolated from the rest, and by the action of the waves has its base worn away, making it look like a large head upon a short neck. Although these rocks present a curious appearance, I should not have paid particular attention to them had I not found the occurrence of similar shaped rocks recorded in Dana's work, as existing at Waterland, one of the Rawehe Islands, in the Pacific. The rocks instanced by Dana, however, differ somewhat in consistency, being almost wholly composed of large fragments of corals of the *genera Astræa* and *Madrepora*, and imbedded shells, whereas the Bermuda examples were composed of the usual comminuted shell and coral, with imbedded shells. They nevertheless assimilate in many particulars, and afford evidence of similar agencies at work in coral groups, in the northern as well as the southern hemisphere.

From soundings taken along the outer reefs, it has been found that the Bermudas rest upon a partially columnar structure, for immediately outside these outer reefs the descent is precipitous, more especially on the southern side. To the westward, however, the column appears to be continuous for a space of thirty miles, for in that distance occur three or four masses of rock at a depth of about thirty fathoms. These are well known to the fishermen, who reap rich harvests when they visit them, fish appearing always to congregate in greater numbers wherever rocks lie.

It may be well to notice, that this extension of the Bermuda column is directly towards that point of the main land of America, which juts out for a considerable distance eastwardly towards the Bermuda extension, viz., Cape Hatteras. I mention this in order to point out a probability that in ages past the Bermuda column *may have been* attached to the main; for although I conceive, without conclusive evidence to the contrary, that the Bermuda column owes its origin to volcanic action, yet still as it at present remains a mystery, it will be well to consider the question of origin

in every light. Viewing the Bermudas as formerly a portion of the American Continent, let us consider whether there be sufficient ground on which to base our supposition. The Islands are formed, as I have before stated, of sandstone composed of comminuted shell and coral; but the particular stone which I have instanced as forming part of the southern shore, is so compact as to have the appearance of solid sandstone, or, indeed, I may say limestone. Now if we are to identify the Islands as forming part of that main land which juts out in their direction, we must first ascertain if that extension of the main be of similar formation. Speaking to Mr. Hill, the obliging mate of the R. M. S. "Delta," on my return from the Islands in 1860, I found that he was well acquainted with the American coast; and upon enquiry he informed me that the geological character of Cape Hatteras was decidedly a white sandstone or limestone, very similar in appearance to Bermuda stone.

I am sorry I have no specimen of the Hatteras stone, to compare with that of Bermuda, and I also regret that I have not had an opportunity of consulting any work upon the geology of that locality, whereby I could clearly ascertain the real nature of its structure. However, as I merely mention the connection of the Bermuda group with the main as a probability, and *nothing more*, and as my views are decidedly in favour of volcanic origin, we may leave the consideration of the question for future investigation, as I beg to do other subjects connected with the geology of the Bermudas, which, I hope, if life and health be spared me, to treat of in another paper.

Art. III. On Pisciculture. By Lieut. Col. Sinclair.

[*Read Dec.* 4, 1865.]

Most varieties of the fresh-water fish proper of Great Britain are exotics, and were introduced by the learned monks of the ancient monastic orders.

These ecclesiastics expended much labour in preparing artificial lakes and ponds, which now exist, and still contain the scaly descendants of the old stock.

Viz.: Ombre or Grayling —*France* and *Italy;* Pike—*Italy;* Carp—*China;* Bream —*doubtful;* Tench—*doubtful.*

America could introduce *S. Fontinalis*, Pike, Perch, Gasperæux, Striped Bass, Black Bass, Cat Fish, Sun Fish, *S. Confinis*, and two other varieties of Lake Trout, one not yet determined.