ART. XXIX.—*Note upon the origin of the Phosphatic Formation*; by C. U. SHEPARD, Sr.

CONCERNING the origin of this extensive formation, several explanations suggest themselves. Among these the best answering the purpose at present is perhaps the supposition, that the great Carolina Eocene bed of shell-marl on which it rests, formerly, and for a long period, protruded many feet above the present sea-level, giving rise to a luxuriant soil (analogous to that now existing over portions of some of the guano islands and shores) and which was then depressed beneath the sea, where it under-

went those changes that have resulted in the present formation. For the superabundance of the phosphate of lime in the soil supposed, we would point to the deposition of bird-guano as it is now going on upon the Musquito coast of the Caribbean sea. A layer of such soil, clothed with an abundant vegetation of from three to five feet in thickness, and nearly submerged, and afterwards becoming more or less covered with sand, in the absence of strong tidal action and oceanic currents (and these may have been precluded by shoals and even land in a seaward direction) would give rise to enormous quantities of carbonic acid, whereby the carbonate of lime of the soil and of portions of the upper layer of the marl itself would be withdrawn, and thus permit the segregation of the phosphate of lime into nodules or even into an imperfect stratum. The alumina and oxyd of iron would be precipitated upon, and among the phosphate everywhere as we find them, mingled also with considerable quantities of siliceous matter. The sulphate of lime which occurs intimately distributed through the phosphatic masses, may be supposed to have originated by double decomposition through the meeting of sulphate of soda and chlorid of calcium. The carbonate of lime present in the nodular phosphate, would be looked for, as the residuum of that belonging to the soil and the marl, which the free carbonic acid was inadequate to dissolve. Meanwhile the deposit would be enriched from the precipitation out of the supernatant waters, of the osseous remains of fishes and other marine animals; and to some extent also by those from the land, which the rivers might bring into the estuary.

The nodular phosphates from some portions of the formation strikingly resemble in their color, hardness and specific gravity, the stone-guano (*pyroclasite*) of Mong's island in the Caribbean sea; and like it, decrepitate violently when heated. The Caribbean mineral is known to originate in sea birds, as the process of its formation is still in progress at many places on the Musquito coast. It is not unreasonable therefore, to ascribe the origin of our phosphatic formation partly to the same cause, at least under the modifications above pointed out.

A reason why the nodular layer is interrupted in its lateral extent may be, that the original surface, prior to its submersion, was not everywhere sufficiently above the sea-level to give rise to a soil abounding in organic matter. There probably existed lagoons, whose bottoms were free from the phosphatic deposits, which, in some instances, may correspond to the places where these are wanting, as well as to the ferruginous sand-layer, at Port Royal on St. Helena, Pinckney Island, and other localities, where the stratum of the nodular phosphate appears to find its equivalent in this latter formation.

It is certainly a striking fact, that no remains of plant or animal, then in process of growth, have been detected within the nodular layer. The nodules merely contain occasional casts and imprints of the fossils belonging to the Eocene bed on which it rests. The condition of the waters, either as to what they held in solution or from their temperature, appear to have been incompatible with organic life. Even the remains of fishes and sea-tortoises, whose detached bones are so frequent, would seem to have belonged to individuals accidentally caught within the land-locked area when the changes of level along the coast occurred.

In some instances, where the nodules are small (from two to six inches in diameter), they have evidently been subjected to slight attrition, and assume the appearance of water-worn pebbles, reminding the observer strikingly of diluvial drift. A nearer inspection, however, soon satisfies him that they have merely been subjected to a partial movement, for a slight distance backward and forward, by wave action, without breaking up the general continuity of the layer, or much influencing its thickness in any one place. Nor is this appearance maintained over more than a few acres, when the usually tuberoso and deeply pitted surfaces of the masses reoccur. At St. Helena, on the beach, opposite Port Royal city, at half tide level, there occurs a highly interesting patch of fluvio-litoral marl, two or three feet in thickness, containing 45 per cent carbonate of lime, and literally filled with the blanched but perfectly preserved shells of the following genera:—*Planorbis*, *Physa*, *Auricula*, *Nassa*, with a few *Columellas*. This formation appears to be more recent than that of the phosphatic nodules, which however is here wholly wanting, unless the outcrop of the ferruginous sand, occurring at a little distance to the south of the marl, at or near low water level, be regarded as the equivalent of the nodules. At any rate, it is clear that the marl has not been subjected to the corrosive or solvent agency so apparent upon the superior layer of the Eocene. The freshwater marl above mentioned has its interest heightened by containing the gigantic skeleton of a mastodon, brought to light about a year ago, by Capt. Charles Boutelle, of the Coast Survey, and by him generously contributed to my geological museum in Amherst College. A further account of its discovery may soon be looked for in this Journal.