

ARTICLE IV.

ON THE TOPOGRAPHY AND GEOLOGY OF SANTO DOMINGO.

BY WILLIAM M. GABB.

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INTRODUCTION.

The present memoir is the result of a three years' reconnoissance of the greater part of the Republic of Santo Domingo, and comprises a description of the geology of about 15,000 square miles, or about half of the island, of which the sister Republic of Hayti occupies the western one-third.

The examinations and surveys were made during the years 1869, '70 and '71, by the author, aided by a corps of assistants varying in number from three to six, besides two draughtsmen, who were employed most of the time in preparing a series of maps of the topographical portion of the work. The geological work was mostly done by the author, assisted at times by two of the party.

The origin of the work is perhaps anomalous in the history of geological surveys. The Government, with an enlightened policy in advance of the majority of Spanish-American nations, felt the necessity of a careful geological examination of its territory, to ascertain the exact facts in regard to its mineral resources. At the same time, in consequence of the numberless revolutions through which the country has unhappily passed during the last three quarters of a century, it was so crippled financially, that it was clearly impossible to find the funds necessary for the expenses of such an enterprise. It is not necessary to record the details here. Suffice it to say that, finally, a contract was made with some gentlemen in New York, who pledged themselves to pay the costs of the work, receiving a grant of a portion of land belonging to the government, to reimburse themselves.

In the meantime, the writer was selected by the diplomatic agent of the Government in the United States, and on the completion of the negotiations, he began his examinations early in 1869. The manner in which he has been sustained and assisted by both the contracting parties is alike creditable to each, and leaves him nothing to complain of on either side.

The assistants were at first but three, Mr. S. Speare, Mr. William Curtis and Mr. C. Runnebaum. Mr. Speare had been previously engaged in the copper mines of the Nigua, and his acquaintance with the country and the people made him very useful, especially at the beginning. He continued with the party until the close of the work. Mr. Curtis, being soon found incompetent, was dismissed in July, 1869, and Mr. Arthur Pennell engaged in his place. Both this gentleman and Mr. Runnebaum continued to the end of their work, employed in making topographical surveys. During 1869 Mr. William Barnes and Mr. A. Bonaczy were also engaged. The latter was employed part of the time with the topographical parties, and for a year assisting in detailed geological labors. Of the former but little need be said. "*De mortuis nil nisi bonum.*" At the end of a year he was discharged and went to the United States, where he died shortly after. It was found necessary for Mr. A. Pennell to do all of his work over again. In the early part of 1870 Mr. L. Pennell joined the party as a topographical assistant, and remained in that capacity until the middle of 1871, when a better position in the United States induced him to leave. During almost the whole of the work Mr. Juan A. Read has been engaged as topographical draughtsman, and during the last half Mr.

J. de la Cruz Martinez has also been employed in the same capacity. In 1869 Mr. Charles Ohle was sent to the country by the contracting parties in New York, but independent of the survey, to examine the gold placers more in detail than was consistent with the character of our work. I have availed myself of his results in the Jaina region.

For the draughtsmen, the map, photo-lithographed from the manuscript, speaks itself. They need no higher praise from me than an exhibition of their work. To the Messrs. Pennell, Messrs. Runnebaum, Bonaczy and Speare, I owe sincere thanks for their hearty coöperation in all of my plans, and for the zealous manner in which they prosecuted their work, often at the cost of great personal inconvenience and discomfort incidental to out-of-door work in the rainy season of the Tropics. I would be remiss were I to forget to acknowledge our indebtedness to the various officers of the Government with whom we have been brought in contact. From the President, General Baez, and the Minister of the Interior, Mr. Gautier, down to the lowest official, we have experienced, almost without exception, only courtesy and kindness. Their assistance and attention have materially lightened our labors and forwarded the work. To mention a few would be invidious, and to name all of our kind friends would be almost to write a directory of the leading men of the Republic.

The topographical map is based entirely on new surveys over all of that region where our work extended. These surveys were conducted by triangulations from two carefully measured base lines, one near Bani, the other in the northern valley between Vega and Moca. All of the principal roads on the north side, all of the passes east of the Constanza route, and all of the roads on the south side, as far west as Azua, were carefully chained. The coast-line, from Monte Cristi to Azua was also re-surveyed, as far as practicable, by chaining along the beaches elsewhere by triangulation. These coast and road lines were used also as bases for triangulations; one system of work thus assisting and at the same time checking the other. We also availed ourselves of the local surveys of the British and American naval officers in Samaná and Calderas Bays, as well as of the table of astronomical positions on the coast in the United States sailing directions. Among the latter, however, there are occasional discrepancies which render them a little doubtful. It will be thus seen that every precaution in our power was exercised to make the map accurate, so far as the limited force and time at our disposal would permit. At the same time, it must be borne in mind that it is but a reconnoissance at best, and that it cannot be more than approximately accurate in the details. The whole of the Haytien part, as well as that portion west and northwest of Azua and the Constanza road south of the mountains, is copied from the map of Sir Robert Schomburgk.

That each member of the party shall receive the full share of credit or discredit to which he is entitled for the degree of accuracy of his work I insert the following list: For myself I do not claim any further credit or responsibility in the topographical work than must necessarily attach to the chief of a party, in that he must answer for the reliability of the employees under his charge. So far the responsibility is mine. Beyond that I take great pleasure in awarding to them all of the credit.

The Survey of the Province of Santo Domingo was made by Mr. A. Pennell, assisted by Mr. Runnebaum; that of Vega, by the same party, with the additional assistance of Mr. L. Pennell; that of the Province of Santiago, north of the Yaqui, by Messrs Runnebaum and L. Pennell; that of Santiago, south of the river, Samaná and all that was done in Azua, by Mr. A. Pennell; and that of Seybo, by Mr. Runnebaum. Most of the road and coast surveys were made by Mr. Runnebaum and Mr. L. Pennell.

Heretofore, the Island of Santo Domingo has been practically a perfect *terra incognita*, geologically. In 1858 Mr. T. S. Heneken published a short description of the northwestern part of the Republic, principally noteworthy on account of its inaccuracies. I have said all that is necessary on this subject in the text and have nothing to add here. The valuable papers of J. Carriek Moore, George B. Sowerby, and Dr. Duncan, in the Quarterly Journal of the Geological Society of London, made the fossils well known, but threw but little light on the geology of the country. In the early part of 1871 I published a very short resumé of my results to that date in the American Journal of Science. The short sketches accompanying the report of the United States Commissioners can hardly be said to have contributed much to our knowledge of the geology, and beyond these, nothing has been published.

I. fusiformis. Gabb, n. s.

Shell minute, short-fusiform, spire twice as long as the mouth, whorls seven, flattened on the sides, apical angle wide, suture obsolete, surface polished; body whorl sub-angulated below, slightly convex and produced in advance. Aperture sub-angulated, lips simple, columella slightly twisted, anterior end produced so as to form a small but well marked lip-like canal. Length .08 inch, width .04 inch.

ARCHITECTONICA. Bolt.

A. quadriseriata. Sby., sp.

Solarium, id. Sby., Quart. Jour., Vol. VI, p. 81, pl. 10, fig. 8.

Id. Guppy, Quart. Jour., Vol. XXII., p. 291.

Common.

TORINIA. Gray.

T. rotundata. Gabb, n. s.

Shell moderate in size, spire elevated, apical angle rounded; as also the outer margin; base of body whorl convex; outer margin marked by two large ribs with a smaller one between; upper surface with four ribs, under surface with five or six, of which one forms the umbilical margin and is strongly crenate; umbilicus broad, inner face of the whorl marked with two large and three linear alternating ribs; the whole surface crossed by strong lines of growth breaking the revolving ribs and producing a cancellated appearance. Aperture nearly circular. Diameter .5 inch, height .35 inch.

Rare. In the sculpture of the upper surface, this is not very unlike the preceding species, but its rounder form sufficiently distinguish them.

CONUS. Linn.

It is with decided reluctance that I have taken up the enumeration and separation of the Cones of Santo Domingo. I am safe in asserting that I have never undertaken a more difficult task, and while I have almost suffered under an embarrassment of riches in the great numbers of specimens I have had to study, that same profusion is rather the source of the difficulty than a means of relief. With a few shells, a fictitious division can easily be made; but in series of hundreds, nay thousands, where opportunity exists for the study of all the varieties, this labor is not so easy. I have based the following arrangement on the careful and prolonged examination of over 2,300 good specimens, and believe that, in the main, I am more correct than my predecessors could have had the means of being. Since I have been obliged in most cases to work in this difficult genus without the advantage of the color patterns, and therefore to depend almost entirely on form, my results cannot have that certainty which accompanies the study of recent shells. Still I have had this assistance in part, and have availed myself of it. By comparison of the larger suites at my disposal, I have learned that the apical angle, within certain limits is, of itself of little value; the presence or absence of spiral striæ on the tops of the whorls is not always a safe character, but the most variable one of all is in the surface striæ or grooves on the sides, more especially at the anterior end of the shell. In recent specimens, where the colors are so marked, this latter character is but little noted; but in the fossils it

becomes of the greatest importance to ascertain how far it can be depended on. I find that the character of this spiral ornament, *when present*, is of much greater value than the fact of its actual presence or absence. Again, in many species, especially in young specimens, the whole or a part of the surface may be marked by raised ridges or simple striæ. These may be smooth, or they may bear small tubercles. The presence or absence of these tubercles is usually of no importance in specific determination. But raised ridges never widen so as to produce flat ribs; that is to say ribs proper are never interchangeable with regular impressed grooves. In a shell which is sculptured in its young stage and smooth when old, or in a variable species, sometimes sculptured and sometimes plain, it is an invariable rule that the sculpture disappears first from the part nearest the angle, and almost always some trace of it, albeit very faint, is discernible at the anterior end. In the variably sculptured species, there seems to be no connection between the disappearance of the striæ on the side and on the top of the whorl. The latter may be used guardedly; but a determination of cones, without the colors must be rather an adjustment of averages than a dependence on fixed specific characters. Of course there are some marked forms to which this statement will not apply, but it is true with reference to the greater majority of the species.

C. pyriformis. Rve., Icon. Conch. sp. 70.

C. solidus, Sby. Quart. Jour., Vol. VI., p. 45.

C. solidus, Guppy. Quart. Jour., Vol. XXII., p. 287, pl. 16, fig. 1.

C. solidus, Sby. Conch. Ill., fig. 76.

C. recognitus, Guppy. Proc. Sci. Assn. Trinidad, 1867, p. 171.

A very common fossil, found living at Panama. I have compared excellent fossil specimens retaining their color pattern with the recent shell and find them indetical in every respect. The shape is variable, the sides of the spire are always more or less concave, but the elevation of the apex changes greatly as the shell grows older; the young specimens being usually much more elevated than old ones. The species can be distinguished from all of the others by the rounded angle of the body whorl; though in two or three cases a slight angulation could be detected.

C. consobrinus. Sby., Quart. Jour., Vol. VI., p. 45.

C. granozonatus, Guppy. Loc. cit., Vol. XXII., p. 287, pl. 16, fig. 5.

Sowerby notes the variations of this shell. I have young specimens that are crossed over the entire surface with beaded linear ribs, and every intermediate stage to entirely smooth shells. The species can be recognized by its elevated, coronated spire, and the general resemblance of its form to that of *C. cedo-nulli*; *C. granozonatus*, Guppy, is the young costate form of the species.

C. catenatus. Sby., Quart. Jour., Vol. VI., p. 45, pl. 11, fig. 2.

C. interstinctus, Guppy. Loc. cit., Vol. XXII., p. 288, pl. 16, fig. 3.

Sowerby's description is from a young shell and Guppy's from an adult. I have duplicates of both figures, and a full connecting series. It is not impossible that this may also include the form described by me as *C. Floridanus*, in the American Journal of Conchology, although none of the fossil specimens agree exactly with my recent shell. The points of resemblance are—general form and details of surface, but the only specimen I have seen of *C. Floridanus* is perfectly straight from the angle to the anterior end, while all of the fossils are slightly curved.

C. stenostoma. Sby., Quart. Jour., Vol. VI., p. 44.

Id., Guppy. Loc. cit., Vol. XXII., pl. 287, p. 16, fig. 2.

Approaches *C. tornatus*, Brod. in form.

C. Orbigny. Audouin, Mag. de Zool., 1831, pl. 20.

C. planicostatus, Sby. Conch., Ill., No. 15.

C. gracilissimus, Guppy. Quart. Jour., Vol. XXII., p. 288, pl. 16, fig. 4.

Varies slightly in proportionate height and width; young specimens being more slender than older ones. The number of the revolving ribs is also variable; one of my specimens showing nearly twice the usual number, while in a fragmentary specimen, having all of the other characters, of size, shape, elevated and coronated spire, number of whorls, &c., the surface is nearly plain, being only marked by faint revolving ribs, showing a marked beading.

The locality of the recent shell has been heretofore in doubt. Audouin says his specimen probably came from China, and a recent specimen in the Museum of Philadelphia Academy is also without a local label. But finding the species fossil in the West Indies would induce us to look for its living representations either in the Caribbean or Panama region, rather than in the Eastern seas.

C. marginatus. Sby., Quart. Jour., Vol. VI., p. 44.

A well-marked species having no close allies. Its broad short form, deep revolving sculpture and high non-coronate spire at once distinguish it.

C. mus. Huass, Enc. Meth., Vol. I., part 2, p. 630.

Four specimens only were found, but they are unmistakably members of this well known West Indian species.

C. planiliratus. Sby., Quart. Jour., Vol. VI., p. 44.

Id., Guppy. Loc. cit., Vol. XXII., p. 287, pl. 16, fig. 7.

C. Stearnsii, Con. Amer. Jour. Conch., 1869, p. 104, pl. 10, fig. 1.

A long narrow species, characterized by revolving impressed sculpture. The tops of the revolving ribs are smooth, but in the intervening grooves the lines of growth are elevated, producing a tendency to punctate character similar to that observable

in some species of *Actæon*. In some of the specimens the sculpture is faint or wanting near the posterior angle. I have compared my fine series of fossil with Mr. Conrad's type specimens of *C. Stearnsii* from Florida and find no difference except that in his shell, which is very young, the sculpture is only visible on the anterior half. The shape, the angle and character of the spire, the *character* of the sculpture, in short all of the details agree perfectly.

Compare *C. minutus*, Rve. Conch. Icon., No. 259, apparently a very young shell. Reeve describes his species as having entirely different colors from Conrad's, especially in that it has two revolving bands on the middle. The angle of the whorl is dotted with reddish brown as in *C. Stearnsii* and the surface is smooth. The resemblance therefore between *C. minutus* and *C. Stearnsii*, are these of form and of the red spots on the angle; the differences are the general color and the smallness of Reeve's species, while Conrad's is sculptured over half of its surface. But this sculpture is not an essential character since I have a series showing that the whole or only half of the surface may be sculptured, and if this much difference is demonstrated to exist, why may not a very young specimen, the size of Reeve's vary still further. While not prepared to assert their specific identity, I consider their resemblance sufficiently near to warrant a critical examination.

C. Haitensis. Sby., Quart. Jour., Vol. VI., p. 44.

C. symmetricus, Sby. Loc. cit., p. 44, pl. 9, fig. 1.

C. Domingensis, Sby. Loc. cit., p. 45.

I have studied over 700 specimens of species and have tried by every test known to me, to divide it into two or more groups, but without success. Sometimes it is perfectly straight and regularly tapering on the sides, sometimes gently convex; the spire varies from flat to elevated, the whorls being flat or grooved above, and striated or plain, with a rounded or sharp angle; the surface of the body whorl is either smooth or marked over a part or the whole, by ribs which may be in part or in whole, plain or beaded; and the shell varies from thin to massive. I do not wish to be understood that these characters run in groups. On the contrary, they are so intermixed that there is no possibility of separating them. But in this otherwise protean species there is a single character which, when obtainable, is constant. The color pattern is fortunately preserved in a large number of specimens and irrespective of their form, density or surface is invariable. It consists of a dark ground, with light cloudings elongated transversely and more or less connected by dashes and lines. The pattern is not unlike that of *C. testudinaria*, but the shell, in average specimens is more in form like *C. purpurescens*.

? *C. proteus*. Hwass, Enc. Meth., Vol. I., part 2, p. 682.

I have a series of eight shells before me, having the shape and size of this species, and differing only in color pattern. Seven of the series show more or less traces of color. In two of them the marks are slightly confused, although they are rather closely placed and distinctly spiral; but the other four have dark spots with well-defined margins and arrayed in regular revolving rows. These rows are about seven in number although one specimen shows but five, while another eight.

C. Berghausii. ? Michelotti, Descr. Foss. Terr. Miocene de l'Italie Sept., p. 342, pl. 13, fig. 9.

Id. Hörnes, Foss. Moll. Tert. Wien., p. 19, pl. 1, fig. 3.

I refer this species doubtfully to the Italian form on the strength of a single specimen. My shell seems to have all of the characters of form as figured by both the above authors, except a slightly higher spire. In colors, it agrees with Hörnes' figure in the arrangement of the elongated spots on, and above the angle, but those on the sides of the whorl are much more numerous and smaller.

C. cedo-nulli. Brug. Enc. Meth., Vol. I., part 2, p. 601, pl. 316, fig. 1-9.

I have 847 specimens of this one species, and in only two of the entire series, have I been able to detect the faintest trace of color. In both cases it consists of broad, badly defined longitudinal bands of dark color more or less broken.

C. furvoides. Gabb, n. s.

Shell elongately turbinated, narrow, nearly or quite smooth, striated in some cases anteriorly by a few wavy lines; spire acuminate but not very elevated; the first whorls elevated and sloping on the top, acute-angulated; the later whorls more or less deeply channeled and sometimes striated on top. Aperture linear. Color pattern unknown.

About the size of *C. furvus*, Rve., and similar in the form of the body whorl. The spire, however, is much lower and the tops of whorls are markedly grooved in all the specimens I have seen. An unusually broad specimen before me is not unlike a very narrow example of *C. monilis*, which it also resembles in the concave sides of its spire.

C. strombiformis. Gabb, n. s.

Shell large, rather thin, turbinated, spire elevated, convex; whorls numerous, rounded on the angle, rudely nodose and sloping to the suture, which is sharply cut but irregular. Body whorl curved above, pretty regularly tapering in advance. Surface marked by a few distant revolving ribs, which are most prominent, and most closely placed at the anterior end. Aperture moderate, outer lip broadly, but not deeply, emarginate posteriorly. Length 2.6 inches width 1.5 inch.

In general appearance this shell is not unlike an incomplete *Strombus*, but on close examination it proves to be a true Cone. Its blunt rounded spire and the imperfect tuberculation especially of the upper whorls separate it not only from the fossil cones of Santo Domingo, but from all the species of the genus, with which I am acquainted.

C. aratus. Gabb, n. s.

Shell turbinated, apex acuminate, spire varying from nearly flat to elevated; the angle of the elevated apical

volutions minutely crenulated; top of whorls flat or very slightly sloping, covered by well-marked striæ; outer edge sharply angulated. Body whorl straight on the sides or very faintly convex near the angle. Surface covered by distant, well marked impressed lines. At the anterior end these lines become confused and the shell marked by a series of wavy ribs. Aperture linear.

Nearest to *C. sulcatus*, but differs in the straighter sides and more regular sulcation. In size and general form this shell is so like *C. Haytensis* that in view of the variable nature of that species, I could not have dared to separate it, were it not that I find the sulcation very constant in 19 specimens before me, and have *not* found it in the hundreds of examples of *Haytensis*. This seems to be a good distinguishing character.

C. Bonaczyi. Gabb, n. s.

Shell small, convexly turbinated, sides curved, tapering gradually in advance; posterior angle rounded, spire low, apex acute, side of spire concave; surface marked by a variable number of revolving grooves, which are distinctly interrupted by lines of growth; the intervening ribs are flat, or faintly sulcated and show no traces of the growth lines. Top of the whorls very slightly concave, not striated. Length .9 inch, with .5 inch.

This shell has almost exactly the sculpture of *C. planiliratus*, the ribs being somewhat more numerous. But unlike that species it is a short, broad shell with curved sides. Its proportions of length and width are not unlike those of *C. mercator*.

C. Yaquensis. Gabb, n. s.

Shell robust, broad, turbinated, spire low, angle rounded, top of whorls grooved, sides convex below the suture and regularly tapering in advance. Color a dark ground regularly tessellated by light spots arranged in close revolving series.

In size and form, this species is almost identical with *C. cedo-nulli*, but its colors are so entirely different from anything I have ever seen in that species that I have ventured to name it.

STROMBUS. Linn.

S. bituberculatus. Lam., A. S. V., (Desh. Ed.), Vol. IX, p. 690.

S. Haitensis. Sby., Quart. Jour., Vol. VI., p. 48, pl. 9, fig. 7.

An examination of over 100 specimens proves that the tubercles, on which Sowerby depended to distinguish this shell from *S. inermis*, Sw. (= *S. accipitrinus*, Lam.), are not only variable in disposition, but as sometimes entirely absent. The surface is sometimes marked by broad, flat, revolving ribs alternating with fine lines. In other cases only seven or eight broad low ridges occur. The smallest specimens are usually the most close ribbed.

S. pugilis. Linn., Syst. Nat. (12 Ed.) p. 1209.

S. ambiguus. Sby.; Quart. Jour., Vol. VI, p. 49.

S. proximus. Sby., loc. cit., p. 49, pl. 9, fig. 8.

S. bifrons. Sby., loc. cit., p. 49, pl. 9, fig. 9.

S. pugilis. Guppy, loc. cit., Vol. XXII, p. 287.

I admit myself a little surprised that Mr. Sowerby should have been betrayed into making three synonyms for the best known shell of the West Indies.