ART. XVII.—*The Geology of Fernando de Noronha.* Part I; by JOHN C. BRANNER. With a map, Plate V.

THE island of Fernando de Noronha has never attracted much attention, owing to its small area, its want of commercial importance, and its somewhat forbidding character as a landing place, and partly also to its having long been used as a place of exile and punishment for criminals. Prior to the visit of the writer the geologic observations made upon the island of Fernando were very few; the only ones worthy of especial notice being those of Charles Darwin in 1832, made while on the voyage of the Beagle and published in his Geological Observations in 1844, and a few observations made, along with the collection of specimens, when the Challenger touched here in 1873. A careful survey would have been made by the Challenger party had permission been given by the Brazilian officers in charge; but owing to the care exercised in the supervision of the convicts and to a misapprehension of the objects of the survey, this permission was unfortunately withheld.

In 1876 I visited Fernando as a member of the Imperial Geological Survey of Brazil, and the following brief notes are the first to be published giving any of the results of my observations upon its geology.

With the accompanying map the reader will scarcely need any observations upon the geography of this group of islands, while the illustrations will convey a sufficiently clear idea of the surface features of the place to dispense with detailed descriptions of topography.

The form of the ocean's bottom around this island, however, is worthy of note as indicating the relations of the group to other islands and to the Brazilian mainland. For the facts bearing upon this subject we are indebted to the deep-sea soundings of the Challenger expedition. It was formerly supposed that Fernando was simply the original northeastern extremity of the South American continent, now separated from Cape St. Roque by a shallow channel. The deep sea soundings have shown, however, that the Fernando group is an isolated one, and that the channels separating it from the Rocas, from St. Paul's Rock and from the Brazilian mainland, are profound ones. The channel between Fernando and St. Paul's Rock is more than 14,000 feet deep, while between Fernando and the Brazilian mainland the depth is over 13,000 feet. To the northeast, six miles from the island, the sound

ings show a depth of more than 6,000 feet, while to the southeast, at the same distance, the depth is 3150 feet, and at twelve miles, 4920 feet. This group of islands, therefore, rises abruptly from the ocean's floor. The currents and surf that strike it from the east are unchecked by shallows on that side, so that it receives the full force of the waves and is consequently being cut away at a rapid rate.

The island is of volcanic origin, there being no sedimentary rocks upon it. The volcano which once existed here ceased action long ago, and the powerful surf which constantly beats upon the island has since cut away the cone, and is now fast diminishing the remnants of the original island. Moreover, the usual chemical processes of disintegration, hastened and deepened here by a very great precipitation falling upon rocks highly heated by exposure to a tropical sun, has covered the interior of the island with a deep soil mingled with rock fragment which, together, obscure the geological details over the main body of the island. Its original lofty central portion has gradually yielded to these disintegrating influences till only the great Peak and its smaller companions remain to suggest the former elevation of the group. A large portion of the island is now under cultivation, and the loose blocks, which might otherwise have been of some service in suggesting, at least, the distribution of the rocks, have been gathered from the fields and built up in stacks or stone walls, or used to make roads or houses. The lands that formerly sloped at a low angle into the sea have been encroached upon, cut down and swept away by the ocean currents until the island is now walled in for the most part by high, precipitous cliffs; the ancient sandy beaches which at one time bordered its southeastern shores, and which were probably fringed by coral reefs, have been almost completely obliterated. The more rapid destruction along the shores and the slower weathering of the interior brings into close proximity two topographic types, and almost any view which includes both shore and inland topography shows the more graceful lines of the old topography in strong contrast with the newer, bolder, and more angular cliffs and escarpments made by the steady encroachments of the sea upon the land.

The best, and almost the only, good rock exposures are about the shores; but many of these are difficult or impossible of access on account of the lack of boating facilities at the island, and because of the violent surf which so generally prevails. In addition, the rocks are so broken, faulted, and thrown into confusion, that it must be confessed my study of the place was far from satisfactory. I endeavored especially to construct an accurate map of the island, and to collect typical rock speci-

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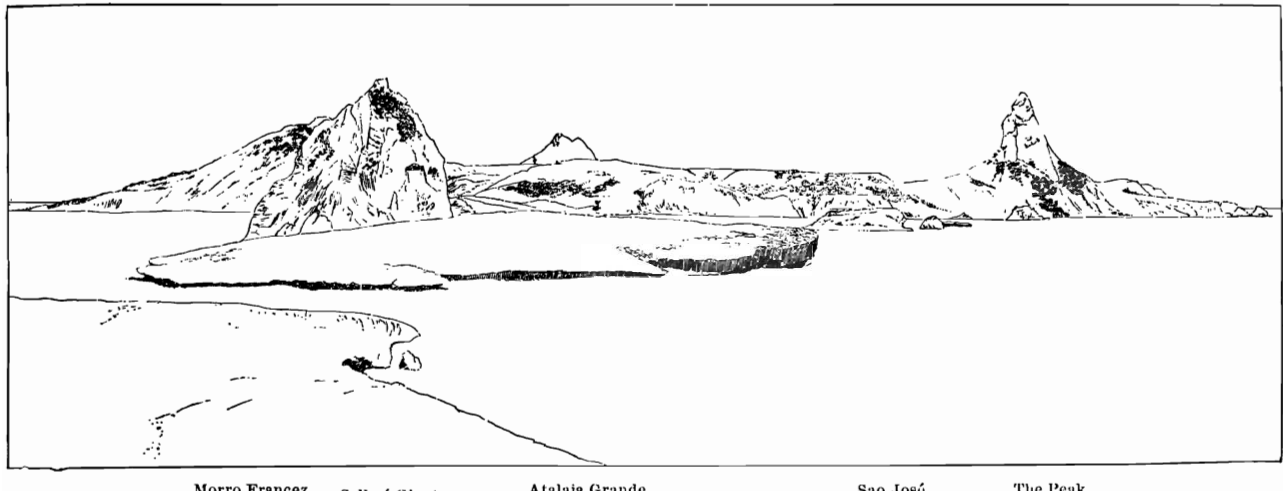

Sketch of the Island of Fernando de Noronha taken from Ilha Rapta.

mens. The results of these endeavors are to be seen in the map published herewith—which does not differ materially from the French map published in 1873—and in the petrographic work kindly done by Dr. George H. Williams. The drawings are made from sketches and photographs taken by the writer. Unfortunately the dry, sensitive plates so universally and successfully used nowadays for photography were not then to be had, and the clumsy apparatus I was obliged to use prevented my obtaining some very desirable views.

The work which has hitherto been done upon the rocks of Fernando will be referred to by Dr. Williams in his part of the present paper. I wish to add, however, that the statement made by Dr. Alexander Rattray* to the effect that granite forms part of the peak and of "other hills, headlands and rocks" is erroneous. There is no granite on the island, so far as I was able to discover.

Amphibole-trachyte occurs at the base of Atalaia Grande and to the west of it. The beds from which the specimen (No. 10) was taken are soft and appear to be decaying rapidly. The exposure has a northeast and southwest trend at this place. The same kind of rock (No. 121) occurs on the east side and about the base of the Morro Francez where it is traversed by dykes of hornblende-augite trachyte (?) (No. 129). The soft whitish and cream-colored amphibole-trachyte which occurs at the bases of some of the hills and notably about Atalaia Grande is called *tauá* by many of the inhabitants. This is a Tupi word however, meaning clay, and is the one given on the Brazilian mainland to clays of any kind, and is doubtless applied to these soft rocks on account of their slight resemblance to hard clays.

Hyalotrachyte occurs in several places. The principal localities are between the mouth of the stream flowing into the Bahia do Sueste and the old Fortaleza dos Leões. The rock (No. 19) is white and almost as soft as chalk, and breaks into irregular lumps. Here and there through the mass are lead-colored patches. It is supposed by the people on the island to be kaolin, and samples of it are said to have been taken to Europe to be tested for the manufacture of porcelain.

Phonolite.—Most of the isolated topographic prominences in the eastern portion of the island, with the exception of the Morro Francez, are composed either wholly or principally of phonolite, while its lower elevations are of some variety of basalt, loose fragments of nepheline-dolerite being of frequent occurrence about the fields on the plateau above the village. These prominences are the Peak and the southwestern prolongation of the hill from which it rises, the Pedra da Conceição,

* Jour. Roy. Geog. Soc., vol. xlii, 1872, p. 43.

a small peninsula northeast of the village, the Sella á Gineta,* the summit and southeast face of Atalaia Grande down to the water's edge, and to all appearances the Alatainha or Atalaia Piquena, and the Morro do Sueste. No phonolite was found in the western portion of the island. In all cases, excepting that of the Pedra da Conceição, these phonolites have the appearance of having been injected as dykes into older rocks.

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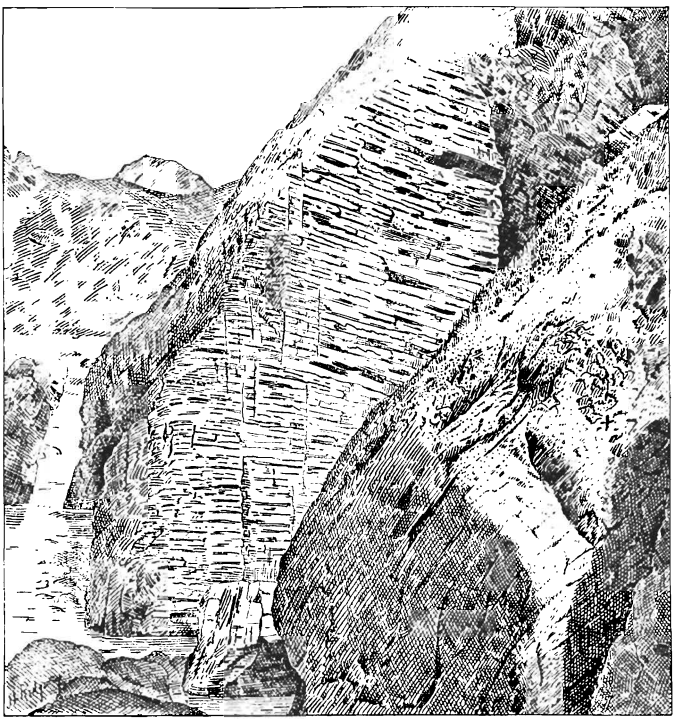

Phonolite columns of Atalaia Grande.

They seem to have cooled irregularly, but for the most part, from the sides. The older and more soluble surrounding rocks have, of course, been removed by denudation. Mr. Darwin says of such masses of phonolite that they have probably been formed by "the injection of fluid feldspathic lava into yielding strata."† In all the cases mentioned above, the rocks have a

* This island was not visited by the writer. As seen from Ilha Raza and Ilha Rapta, its rock had the appearance of phonolite and was so regarded. The examples collected by the Challenger party show beyond question that this supposition was correct.

† Geological Observations, second edition p. 27.

columnar structure either very plainly or partially developed. The somewhat irregular columns lie for the most part horizontally, as is well shown in the dyke exposed at the Horta do Pico, southwest of the Peak. On the southeast side of the Atalaia Grande the columns are nearly horizontal, with a tendency to radiation from the center of the hill. Specimen No. 5 is from the nearly horizontal columns of phonolite exposed on the southwest side of the Atalaia Grande. Similar columns appear to form the whole south face of this peak, and are well exposed near its base where they are washed by the surf. As the peak is ascended the columns have a northward dip which increases toward the summit, so that a north-south section through the Atalaia Grande would expose the fan-like radiation of the columns above mentioned. The preceding cut, from a photograph of an exposure on the south side of Atalaia Grande, fig. 2, illustrates this point. No. 40 is from the summit of Atalaia Grande. Nos. 41 and 42 are from a loose block about 4×3×2 feet, found between Atalaia Grande and the Morro do Meio, the hill lying immediately north of it. This rock was not found in place on the island. It splits readily into slabs very like the phonolites from the Pedra da Conceição.

In the Sella á Gineta, fig. 4, the columns of phonolite are imperfect and vary somewhat in direction. Seen from São José some of the columns curve from a horizontal position on the left both upward and downward toward the right, radiating from a horizontal axis. In the Peak too, the direction of the columns varies in some cases as much as fifty degrees. The lowest rocks of the Peak exposed in place are the irregular columns upon its eastern side. The colums are here very nearly vertical; but higher up even upon this side, they twist and bend to the northeast and thus form the overhanging projection which is so remarkable a feature of this great rock. The curving of these columns prevents the falling of the most picturesque part of the Peak.* On its western side the columns stand at various angles with the meridian, and usually at a high angle with the horizon. Their direction and position, as well as the character of the rocks, leads to the conclusion that the Peak is part of a great dyke, the only remnants of which now exposed are the upper portions of the Peak itself, and the columns at the Horta do Pico, a short distance to the southwest. Specimens 51, 52 and 88 are from the highest accessible part of the Peak on its southwest

* Mr. Darwin calls attention to the disposition of phonolites to take on grotesque shapes. (Geological Observations, second ed., pp. 97–8). On Fernando these grotesque shapes of phonolite peaks are due to columnar structure when the axes of the columns change their directions. For a discussion of the curving and radiating of columns of igneous rocks see J. P. Iddings in Am. Jour. Sci., May, 1886, and Professor T. G. Bonney in Quart. Jour. Geol. Soc., vol. xxxii, 1876.

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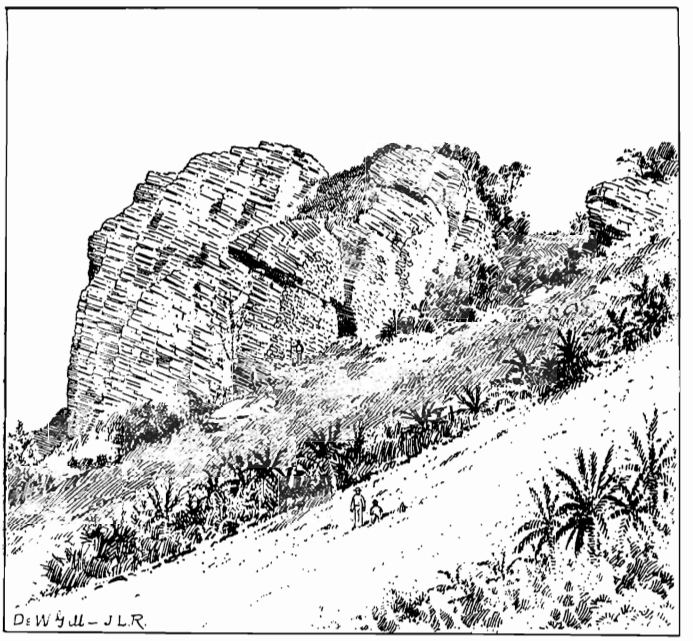

Dyke of phonolite, near the Peak.

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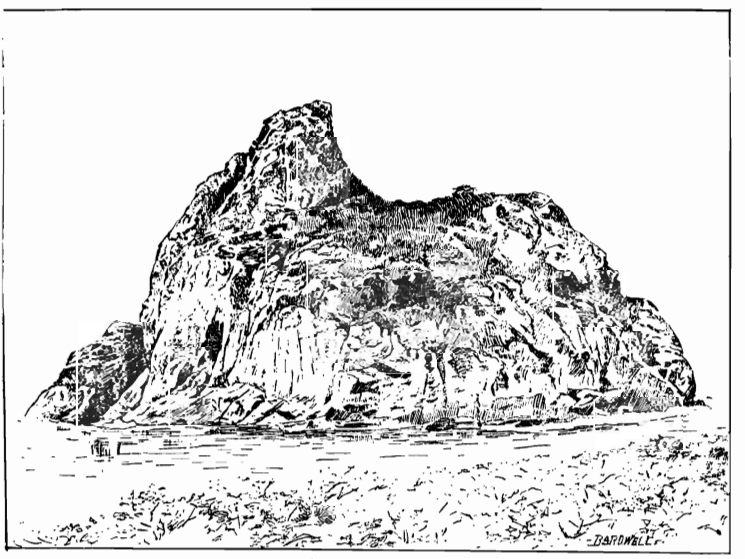

The Sella á Gineta or St. Michael.

side. The rocks of the summit are rudely columnar as is shown in the accompanying cut. The ledge just northwest of the Horta do Pico, fig. 3, shows the columnar structure of phonolite better perhaps than any other exposure upon the island. In most of these phonolites the metallic sound produced by striking with a hammer is very marked, especially when a somewhat thin slab is separated from the mass. From this peculiarity the Brazilians frequently call this rock "pedra de toque," which is the equivalent of our word "clinkstone."

The Peak is the most striking landmark in the South Atlantic ocean; it is 1000 feet high,* with the upper portion perpendicular or overhanging in such a manner as to make the summit quite inaccessible. The few drawings of this peak that have been published are taken from the same point—the anchorage—and even the best of them, that in the Challenger reports, conveys but a poor idea of its grandeur. Seen from other points it presents a striking variety of outlines.

It would be interesting to know whether this peak had undergone any marked changes since the discovery of the island in 1503, but unfortunately we have no detailed description of it as it appeared at that time, and the oldest drawing, that made by Ulloa in 1745, is clearly too imperfect to be trustworthy. It is evident, however, to one on the ground, that it is being slowly thrown down under the combined influence of sun and rain and the daily changes of temperature. Climbing up the accumulation of talus that slopes down from the base of the solid part of the peak to the seashore, it is noticeable that this material, loose as it is, stands at an angle of unstable equilibrium, and when disturbed in any way, miniature avalanches of loose stones slide down the slope, sometimes a hundred feet or more. Wherever this debris is stable there is sufficient soil upon it to support vegetation; and it is thus covered here and there with small tomato plants that have escaped from cultivation. In many places it was noticed that these plants were freshly broken and bruised by fragments that had fallen from the peak above.

From top to bottom two great joints divide the Peak into three vertical sections. Into these crevices fall fragments of stone, which, heated and expanded during the day by the powerful rays of the sun, and cooled and contracted by the cool rains, or at night by radiation, wedge themselves deeper and deeper into the crevices and thus push off pieces large and small. Some years ago, no one seemed to know how many, the little fort near the base of the peak was almost completely demolished by a great mass of rock that fell from the Peak and rolled

* My own triangulation makes its height above tide 332 meters. Mouchez gives it at 305 meters.

down its sloping base. On another occasion, a convict, who had a little garden close under one side of the rock, found it one morning buried beneath a heap of stones.

From the east or northeast the upper portion of the Peak presents the rude outlines of a human face. Fig. 5 is made from a photograph taken looking up from the beach.

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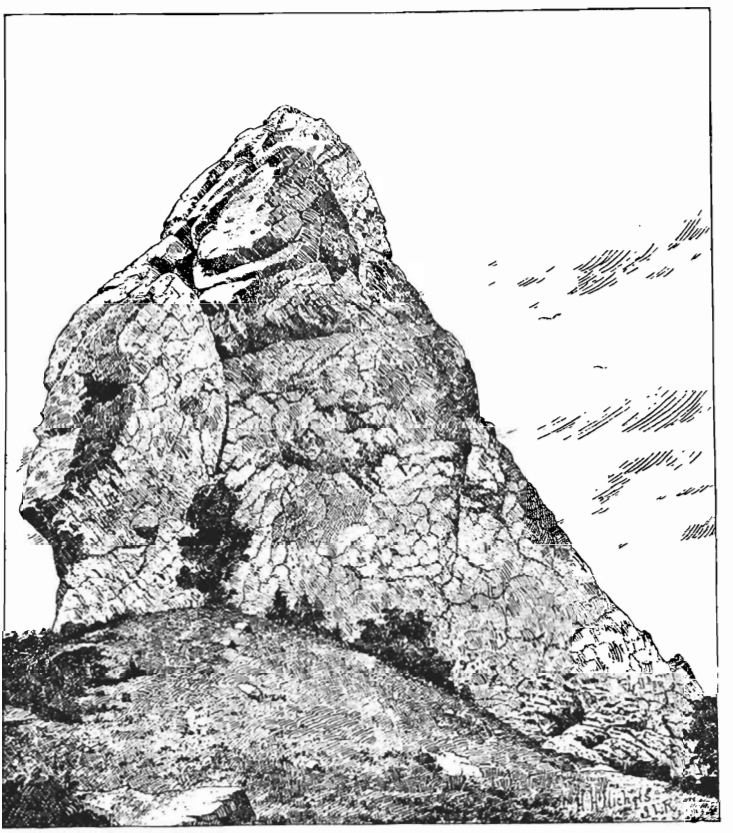


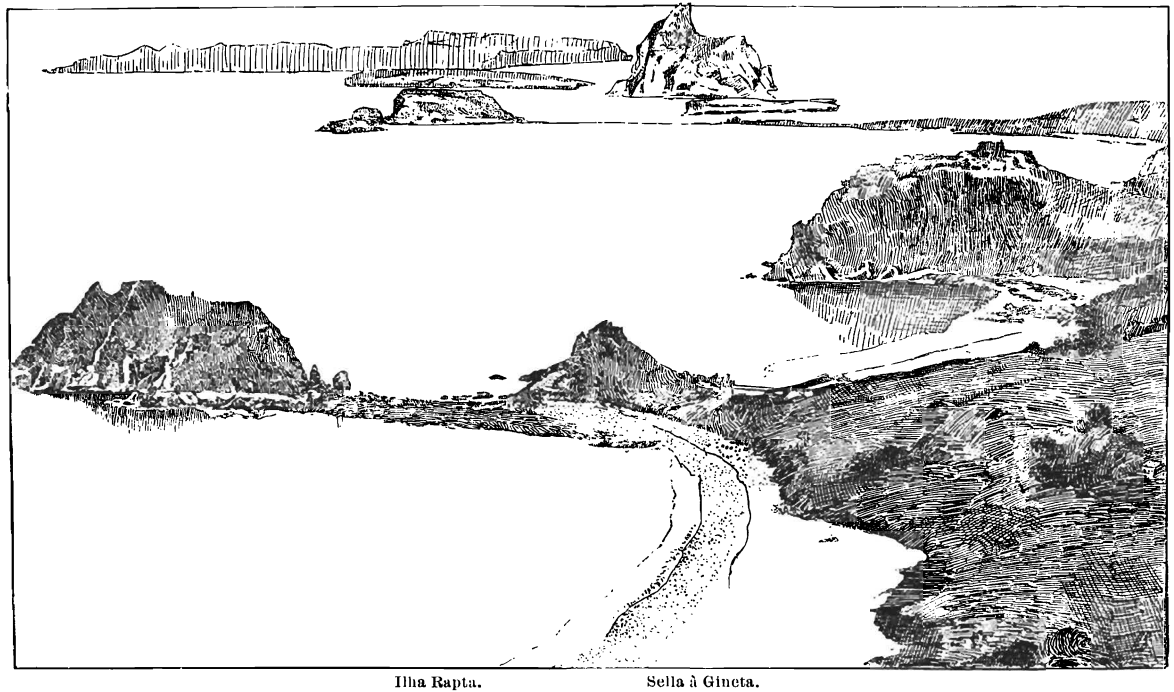
The Phonolite Peak of Fernando de Noronha, from the beach.

Slaty structure in phonolite.—The Pedra da Conceição is, at high tide, a small island of bare rock just west of the Praia do Cachorro, the landing place next the village; it has steep rugged sides and summit like a steep gothic roof. The place is shown in the left foreground of the following figure 6.

Most of the specimens collected at this locality were taken upon the south end or else upon the summit of this rock.

This locality is not included among those of the columnar phonolite. Mr. Darwin, in his "Geological Observations," remarks upon the occurrence near the base of the peak of slaty phonolite with cleavage. This peculiarity is very marked at the Pedra da Conceição, the rocks dipping sharply to the southwest, and having upon that side surfaces so flat and steep that I was able to hold my place only by clambering along its ridge. This is probably the locality to which Mr. Darwin refers. The rock splits readily into comparatively smooth slabs. A somewhat similar structure was observed in loose fragments found between the Morro do Meio and Atalaia Grande. (Nos. 40 and 42).

Basalts.—Rocks of a basaltic type form the great body of Fernando de Noronha. They occur in all portions of the island, and in masses of all shapes and sizes from thin veins to broad sheets. It was not observed, however, in any of the prominent isolated peaks, like the phonolite, yet nepheline-basalt was found on the summit of the Morro Francez, and augitite in the tuffs upon the east side of that hill. It occurs about the bases of the phonolite peaks, forming the body of Ilha Rapta, São José, Morro Redondo, and the cape near the phonolite peak of the Sella á Gineta. Rocks of basaltic type (limburgite) occur about the base of the Atalaia Grande and along the shores west of the peak. The Dois Irmãos appear to be made up of basalt, and so also the Laja Cape between the Atalainha and Morro Branco. In none of these cases, however, was I able to determine satisfactorily the relations of the basalt and phonolite to each other. Perhaps the most striking exposures of these rocks are to be seen upon the island of São José. The surf has here removed all the débris and uncovered columns of extremely hard nepheline-basanite (No. 31), which are best exposed upon the north side of the island, where a length of about fifty feet may be seen. This rock forms the greater part of São José and the two small adjoining islands, Pedra Furada and Ilha Redonda. In each case the columnar basalt forms the lower part of the island, and massive basalt the upper, while São José is further capped by a bed of the calcareous sandstone like that of which Ilha Raza is made. The columns of São José are usually bent. They vary in size and shape, as well as in position, but are usually hexagonal and about one foot in diameter, and break off in sections from one to four feet in length. The best exposure of the columns is on the eastern side of the island, where they are visible, however, only from the water. Many of them contain irregular masses of peridotite (No. 34) almost as large as one's fist. The broken columns are rolled by the surf upon the beach where they eventually form great black cobbles.



Looking north-east from the base of the Peak.

Ilha Rapta, the most northeastern of this group of islands, appears to be made up for the most part of basalt, these rocks forming its highest portion and its eastern and western extremities. At its east end the basalt is rudely columnar along steep shores 120 feet high; but generally there is a broken slope to the sea, covered, above the reach of the waves, with talus and earth. The western point, about the Espigão, is composed of nepheline-basalt (No. 72.)

The slender neck forming the northeastern promonotory of the main island, appears to be of basalt. The weathering of the rocks at the exposures upon this neck, and especially upon the southeast side, is characterized by extensive exfoliation and a consequent disintegration of the body of the rock walls into great, black, approximately round bowlders. As these masses lie in place they have the appearance of a gigantic rude stone wall built of black bowlders of various sizes. When they fall and come within the reach of the waves, though excessively hard, they are soon smoothed and rounded. The beach on the north side of this neck is covered by vast numbers of these black rounded stones, here facetiously known as "*corações de negro*"—negro hearts. Large blocks of nepheline-basalt (No. 45) cover the summit of the Morro Francez.

It seems probable that, with a few exceptions, the basaltic rocks are continuous from the extreme northeast point of the main island along its eastern and southern side to the bay next east of the Atalaia Grande, though but few of the specimens collected upon this portion of the island seem to have been preserved. It should be mentioned, however, that the great deposit of tuff which forms the higher portions of the shore, just east of the Morro Francez, contains loosely consolidated fragments of many varieties of rocks, among which are augitite (No. 115). The next extensive exposure of basalt (nepheline-basalt) is in the horizontal beds which form the southwest shore of the island from the cape at the Laja just west of the Bahia do Sueste to the Morro Branco, a distance of more than a mile. These basalts have the appearance, from a distance, of being horizontally stratified sedimentary rocks. The uppermost bed along this escarpment is of nepheline-basalt (No. 27), while the underlying beds resemble this in gross structure. (Nos. 28, 29, 30). The lower beds contain amygdaloidal cavities, as do also some of the basalts about the eastern extremity of the main island, notably at the mouth of the stream called Cuyeira.

Some of the rocks of the basaltic type occur next the base of Atalaia Grande on the south side, but on account of the soil which covers this part of the island it was not possible to determine satisfactorily their relations to the phonolites which

make up the body of the hill. The limburgite (No. 14) of the west base of Atalaia Grande forms a dyke either in, or west of and adjacent to, the amphibole trachyte (No. 10) mentioned elsewhere. Inasmuch as the eastern side of Atalaia Grande is exposed in one place down to the water's edge and is seen to be composed entirely of phonolite, these dykes of trachyte and limburgite are probably exterior to the body of the hill. Limburgite (No. 65) was found also in the peak of volcanic tuff which rises upon the narrow neck connecting the Sapato with the island. It there occurs associated with travertine (No. 66) and volcanic bombs. (Nos. 3 and 58). The two small isolated rocks known as the "Dois Irmãos" are not accessible, but as seen from the main island they have the appearance of being composed entirely of rudely columnar basalt.

Volcanic bombs (No. 48) occur in situ on the northern and near the summit of the Morro Francez. The east side of this hill, where it slopes down to the sea, is much checkered by dykes varying in thickness from two feet to eight, which cross each other at all angles. The bench of hard rock which skirts the base of the hill, and which is uncovered at low tide, varies in width from zero to three hundred and fifty feet. On its outer margin it is bordered by calcareous formations. On this bench the dykes are beautifully displayed at low tide. Immediately east of Capim Azul, a cliff more than 300 feet high is composed almost entirely of volcanic bombs and tuffs in beds dipping to the south at a high angle, and capped by jointed basalt. In size these bombs vary from that of a pin's head to the size of a bushel. Volcanic bombs occur also in the tuffs about the western end of the island, but they are nowhere so abundant or of such size as at the cliffs of Capim Azul.

Tuffs.—Tuffs occur about the northern and eastern sides of the Morro Francez, but are especially abundant about the western end of the island, where some of the beds are more than one hundred and fifty feet thick.

From the east side of the Morro Francez near the Pontinha are heavy beds of loosely consolidated tuff (No. 118), consisting of a mixture of angular fragments of rocks of many kinds which vary in size up to that of a millstone and larger; the beds slope down to the immediate beach of solid rock. This loose material is unlike the basaltic tuff of the western end of the island; it is greenish gray and without any appearance of stratification, while that of the Sapato and Capim Azul is more or less stratified and brownish.

The cliffs about Barro Vermelho and for some distance along the south side of the island, extending from the bed of volcanic bombs at Capim Azul to or near the Portão, are of some form of tuff (No. 62). The rock is soft and reddish, and

forms upon decomposition a deep red earth which gives name to this part of the island—" Barro Vermelho," red mud.

The Portão.—The extreme western portion of the island lying west of the Portão Grande is known as the Sapato (the shoe). This is one of the most interesting and impressive places on Fernando. The waves have cut away the soft beds

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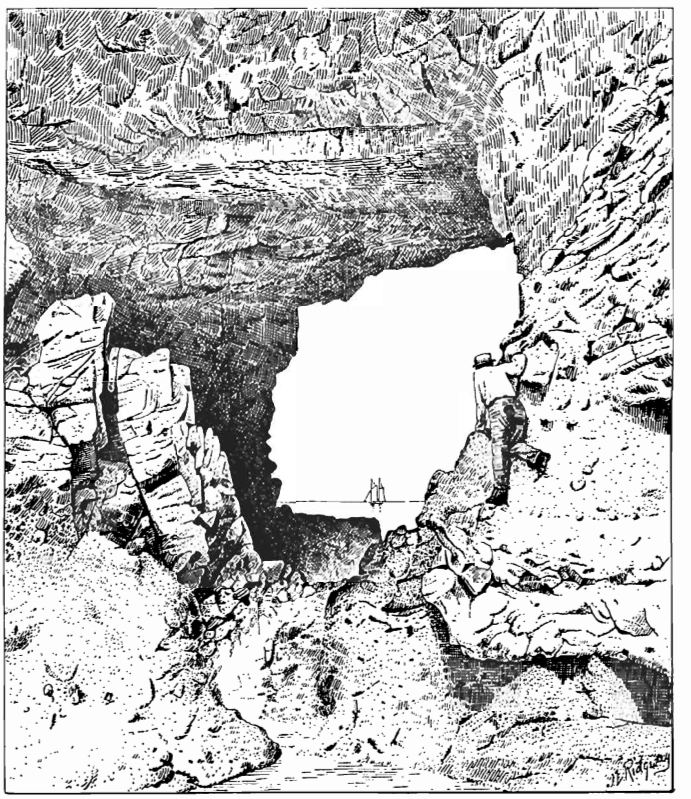


The Portão.

of dark brown basaltic tuff which here form the greater part of the strata of the island, until there remains little more than a narrow neck of steep and rugged cliffs, some of them eighty meters high, at whose breccia-covered foot breaks a ceaseless and violent surf. At one place an opening or tunnel has penetrated the isthmus; and this is the Portão Grande of the inhabitants of Fernando—" the hole in the wall " of English sailors.

The Portão beds of tuff (No. 54) are more homogeneous than those at Capim Azul. The individual fragments into which it breaks upon disintegration are seldom more than two inches in diameter, and the weathered surface of the beds has a lumpy rough appearance. The beds are regularly stratified, the dark brown material being streaked with lighter and darker bands. They dip southwest and southeast at an angle of nearly 45°, the opening being cut in a kind of syncline whose axis dips to the south. Overlying the tuff is a bed of hard rock containing many rectangular crystals, specimens of which unfortunately have not been preserved. This hard but much jointed rock fills the little depression, or syncline, in the tuff, and forms a nearly horizontal roof for this natural tunnel. The triangular gap between the tuff and its overlying bed is filled with irregularly stratified fragments which could not be examined.

The rock walls of the Portão from one face to the other are a little less than one hundred feet in thickness; the roof is about forty feet above the water at mean tide, and the opening is about forty feet in width. At the time of my visit the water did not have free passage through the opening, the northern entrance being barred by a narrow dyke of very hard basalt, about fifteen feet high, traversing the tuff and standing nearly square across its front.

The process by which the great opening has been made beneath this isthmus is not without interest. The surf about the Sapato is always violent, and especially so upon its south side. The excavation has all been done upon this south side, the character and dip of the rocks contributing largely to the result. If the waves breaking against the southwest dip of the excavated rock were carried up its slope, they were promptly checked by the hard overlying rock which forms the tunnel's roof. When, in the course of time, the wall was pierced, the waves struck the small basaltic dyke referred to above and this has ever since barred their progress. A gap, however, has been made through this dyke where it receives the full force of the waves. The dip of the dyke is toward the south and when the incoming waves plunge through the opening they strike this wall and are thrown off at a tangent, leap high in the air and fall in overwhelming volume and in spray upon the shingle of the northern beach. The swells and less violent waves occasionally lift their great volumes of water and pour intermittent cataracts over the gap on the little dyke, and down the channel which is opened to the left through the tuff between the wall and the overhanging cliffs.

The lowest beds exposed at the extreme western end of the Sapato are of basaltic tuff. The rock is reddish brown, soft and somewhat granular and contains an abundance of included frag-

ments of a great variety of other rocks. The sea has carved out at the base of its cliffs a beautiful and regular bench from twenty to forty feet in width, which runs across the whole western end of the Sapato midway between high and low tides. The beds here dip westward at an angle of about 25 degrees. At the northwestern corner of this exposure a stratum of compact rock (basalt?) about fifteen feet in thickness overlies the tuff and dips 40° to the eastward. Above this is a bed of very hard but much shattered rock which continues to and beyond the Portão of which it forms the roof.

Basaltic tuffs, very similar to or perhaps identical with those in which the Portão opening is excavated continue along the north shore of the island for at least half a mile east of the Portão. The cliffs of this material are usually vertical and capped by a bed of some more resisting rock. From the promontory called Portãozinho, looking northeast along the trend of the island's north coast, one sees rising abruptly from the water a lofty vertical cliff of what appears to be rudely columnar basalt. This exposure was not examined near at hand. Both east and west of this exposure are others of reddish brown rocks resembling in general appearance, and at a distance, the soft reddish palagonite of Barro Vermelho (No. 62). The cliffs of this material have their bases deeply underscored by wave action.

Calcareous sandstone.—Besides the rocks of igneous origin, a calcareous sandstone occurs along some shores. It covers about one-third of Ilha Rapta, a part of São José, and small areas of the main island near the Lancha on the northeast, the high shore west of Atalaia Grande, the shore along the southwest side of the Sueste Bay, and forms Ilha Raza, Ilha do Meio and the Chapeo at the mouth of Bahia do Sueste. The material of the sand-rocks was originally deposited in the form of sand dunes and the bedding shows that it must have been blown by the winds chiefly from a southern or southeastern direction. The deposits are all on eastern or southeastern shores and have no connection with the existing beach. On Ilha Raza, it makes a perpendicular bluff forty feet or more in height; on Ilha Rapta it rises about forty feet above the water, while south of Atalaia Grande it stands at an elevation of at least a hundred feet above the sea. A microscopic examination shows that it has been consolidated by the deposit of lime carbonate dissolved from the uppermost layers by the waters of the rains aided possibly by the spray of the surf. The grains are fragments of shells, corals, sea urchins, foraminifers and other calcareous growths of the shores.

Where these sandstones rise from the ocean, as they do on Ilha do Meio, Ilha Raza, Ilha Rapta and Chapeo, the wind

bedding is found to extend beneath the water,* indicating that the island once stood at a higher elevation. It should be noted, however, that the isolated remnant of sandstone near São José known as the Chapeo, and the western ends of Ilha Raza and Ilha Rapta stand upon waterworn shingle. Inasmuch as the cobbles must have been worn before they were covered by sand, the island must have stood at a level as low or somewhat lower than its present one while the cobbles were being made, and as the wind bedding could not be produced below the surface of the water or in sand to which the waves had access, the island must have been elevated somewhat before the dunes were blown over and deposited upon the shingle-covered beaches.

That they were blown up from the south or southeast is shown by the geographic positions of the various beds, by the absence of such rocks at corresponding elevations on the opposite sides of the islands, and by the internal structure of the rocks themselves, the steeper face of the dune always being toward the north or northeast. But as there is now no beach from which this sand could have been derived, we must conclude that the island was, not long ago, wider to the southeast, and that there were upon that side of it sandy shores, upon which an abundance of organic remains was thrown and ground to sand. These sands were then blown across the island to and upon the opposite shore, burying the former bowlder-covered beach near São José beneath 15 or 20 feet of sand, and piling it up considerably higher than the highest parts of the existing sand-rock. They joined into one what are now the separate islands and places marked as sandstone upon the map.

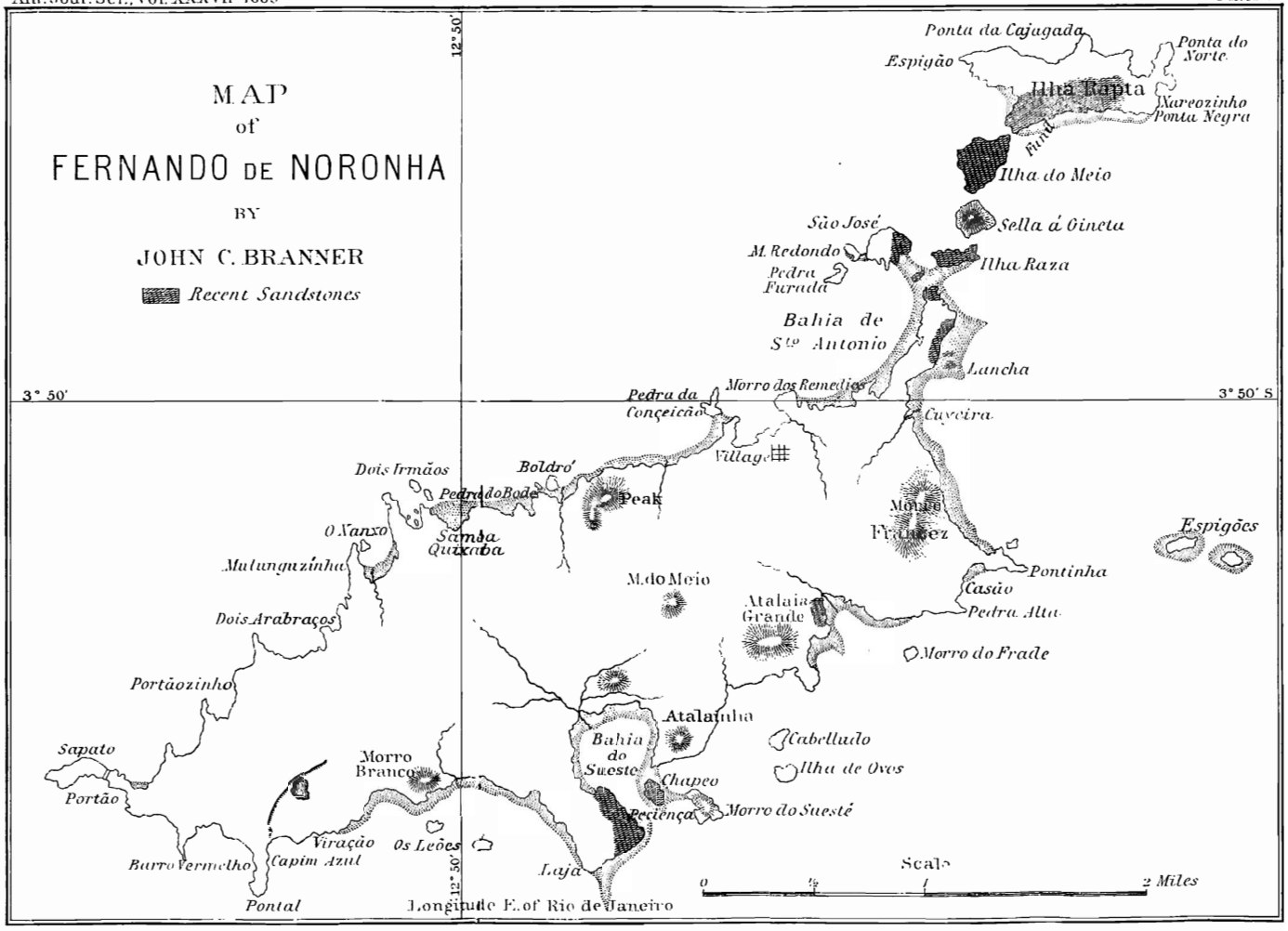
* See also the voyage of the Challenger, by Sir C. Wyville Thomson, vol. ii, p. 100, et seq.

Note upon the Map.—The names given upon the map and in this paper are those used by the inhabitants of the island. Other names have been used by visitors and navigators, especially by English and French-speaking persons who knew but little or nothing of the Portuguese language, or who have had no opportunity of learning the correct names. Inasmuch as these English and French names are not the ones known and used at Fernando de Noronha they cannot be regarded as correct That there may be no misunderstanding, however, about some of the more important points mentioned in this paper and by others who have visited this island, I give a few of the names erroneously used with the correct Portuguese names.

Ilha Rapta has been called *Rat Island* by the English, and *Ile aux Rats* by the French. The word *rapta* is the participle of the verb *raptar*, Eng. *rape.* It is supposed to have been given on account of the place once having been occupied by Dutch pirates.

Sella à Gineta (horned saddle). so named on account of its resemblance to a horned saddle, is called St. Michael's Mount by English and French.

Morro do Frade (friar's hill), so called on account of its resemblance to a monk's cowl, is called *Le Clocher* by the French. *Ilha Raza* (flat island), has been named Egg Island, and *Ilha do Meio* (middle island), has been called Booby Island.


MAP
of
FERNANDO DE NORONHA
BY
JOHN C. BRANNER
Recent Sandstones
12° 50'
3° 50'
12° 50'
3° 50' S
Ponta da Cajugada
Espigão
Ponta do Norte
Ilha Rapta
Nareozinho
Ponta Negra
Rund
Ilha do Meio
Sella á Gineta
São José
M. Redondo
Pedra Furada
Ilha Raza
Bahia de Stº Antonio
Lancha
Morro dos Remedios
Pedra da Conçeição
Cuveira
Village
Dois Irmãos
Boldró
Pedra do Bode
Peak
Morro Fradez
Espigões
O Nanzo
Samba Quixaba
Mutunguzinho
Pontinha
M. do Meio
Casão
Atalaia Grande
Pedra Alta
Dois Arabraços
Morro do Frade
Portãozinho
Atalainha
Sapato
Bahia do Sueste
Cabelludo
Morro Branco
Ilha de Ovos
Portão
Chapeo
Morro do Sueste
Peciença
Viração
Os Leões
Barro Vermelho
Capim Azul
Laja
Pontal
Longitude E. of Rio de Janeiro
Scale
0
½
1
2 Miles