II.—*Remarks on the Heavy Swell along some of the West-India Islands, commonly called "Ground" or "North Sea;" and on the Set and Velocity of the Tides, and the Effects produced by their transporting power, among the Virgin Islands.* Communicated by Robert H. Schomburgck, C. M. R. G. S. of London. Read 26th January, 1835.

THE influx of the tide from the sea, near the mouths of large rivers, counteracts their current, and by forcing back their waters occasions a swell which has been called the bore or mascaret. Where the river near the mouth is almost level with the sea, the collision of the contending waters is sometimes tremendous, and causes a wave of twelve or fifteen feet in height. The Ganges, according to Major Rennell, but more so the rivers on the north-eastern coast of South America, have this bore; and Romme observes, "that during three days at the equinoxes, there is a considerable swell at the mouth of the Amazon, which causes such a noise, that it may be heard at the distance of two leagues;" * and in the Tumry channel, river Aourary, the sea rises forty feet in less than five minutes, this constituting the whole rise of the tide, as the ebb immediately takes place and runs with great velocity.

Of quite a different nature, but equally dangerous in its effects, is the heavy swell that may be observed occasionally along the northern coasts of some of the West India Islands; and which has been called by the inhabitants the "Ground," or, in Jamaica, the "North Sea." This rises, rages, and subsides, when the air is calm, when there has been no indication whatever of a previous gale, or even when light airs have for a considerable period preceding come from the southward of east. The waves approach in gentle undulations, but suddenly swell against the shore and break with the greatest impetuosity. The rise takes place sometimes gradually, but more frequently quite unexpectedly, the waves reaching an uncommon height.

A heavy ground sea is distinguished by something grand and sublime. The sea approaches in undulating masses, which suddenly rise to large ridges, crested with foam, and form billows that burst upon the beach with the greatest impetuosity; the spray flying, where the waves dash against cliffs, often more than a hundred feet high, attended with loud roarings resembling thunder, which subside into a rumbling noise, caused by the nodules and fragments of rock with which the breaker was charged when advancing, which on its retreat roll backwards and are again driven forward by the next surge. Wave then follows upon wave in quick succession, there being only apparently a short interval after

* It has been poetically said, that the Genius of the river and the God of the ocean contend for the empire of the waters.

the third. The sea for many miles from shore assumes a peculiar aspect, different tints of blue, from the lightest to the darkest, forming a strong contrast with the snowy foam of the breaking waves, when they strike against a hidden rock, or with the white line visible along the whole coast. The eastern Bahamas, the north-eastern coast of Jamaica and St. Domingo, but chiefly Puerto Rico and the Virgin Islands, and in a less degree the northern Caribbee Islands, are subjected to this ground-sea.

The operating cause of this sudden rise of the sea along shore at these places not being visible, and the air being generally calm when it takes place, the inhabitants have ascribed it to submarine earthquakes, the influence of the moon, and many other phenomena. It may be, however, considered as a rule, that whenever the wind gets to the northward of east for a day or two, there will be a ground-sea at the northern side of the islands; and I have formed, therefore, the opinion, that it is caused by gales in the Atlantic, or on the northern coasts of America. The friction of the wind upon the surface of the water causes little elevations or ridges, which by continuance of the force gradually increases, chiefly when the wind sweeps over a great extent of water. Finding no resistance and having sufficient depth to sink directly down, they proceed with the direction of the wind and remain natural waves, until they meet repercussion from dashing against the shore, when they rise to an elevation much above their natural state. The period when the ground-sea sets in is generally October, and it continues, though with some intermission, till April and May. Any individual acquainted with the coasts of North America, will be aware that during that time frequent storms prevail, and the circumstance that a northern wind either precedes, sets in with, or follows a ground-sea, and that only the northern sides of the islands are exposed to it, confirms me in my opinion. A glance on a chart of the Atlantic Ocean, proves that Puerto Rico and the Virgin Islands oppose the first resistance to the waves caused by a northern storm on the North American coast, or in the Atlantic, from the fortieth to the sixtieth meridian. The wind accompanying or preceding a ground-sea is generally from the east of north; the waves are, therefore, propelled more or less in a western as well as southern direction, and the Bahamas and even Bermuda may escape, whilst the islands from Barbados to Puerto Rico, but more particularly the latter and the Virgin Islands, receive its first impulse.

One might conclude, it is true, on first consideration, that Jamaica, in consequence of its sheltered situation, would be exempt from a ground-sea thus originating; but its north-eastern coast is exposed to the main ocean, though at a distance of 150 leagues from it; and a body of water, driven by means of the prevailing wind

through the passage, would be so affected by the gradually diminishing channel and the projecting head-land of Cape Maize and Cape St. Nicholas, as to increase in velocity, and thus finally break on the north-eastern coast of Jamaica, with more violence than its sheltered situation would lead us to suppose. I must certainly confess, that my opinion has been objected to by many of the inhabitants of the Virgin Islands, who rather attribute the phenomenon to causes arising in the bottom of the sea; in which they consider themselves justified by the extent to which a heavy ground-sea breaks up the bottom—the sea, to a considerable distance from the shore, becoming discoloured—and even anchors being removed from their holding-place, and vessels being driven amongst the breakers and dashed to pieces. But the discolouration of sea, to a greater or less distance from the shore, according to depth, is effected likewise during heavy gales, and is due to the action of the waves. The depth to which the moving action of waves extends has not been properly estimated, in consequence of the difficulty connected with such an estimate, the power of the waves continually varying. Some have considered ninety feet, or fifteen fathoms, the limit to which this disturbing power extends; but this requires confirmation. In the present case, however, the depth near shore is seldom more than from four to fifteen fathoms—in many places shoaling to a few feet—and thus the action of the waves caused by a ground-sea must become apparent; and the moving power of the waves on the bottom will tend to turn up anchors chiefly when the wind unites its powers above with the turbulent character of the sea below. My opponents in opinion have further adduced, that there are likewise northern gales during the summer months in the Atlantic: but these islands are also occasionally visited by ground-sea during June, July, and August. We may call a ground-sea a temporary current, caused by a severe gale, of longer or shorter duration; and every navigator knows from experience how common these currents are, and that they are more particularly felt along coasts and through channels. Major Rennell, in his 'Remarks on the Channel,' observes,—"It is well known how easily a current may be induced by the action of the wind, and how a strong south-west or north-west, and even a north-east wind, on our own coasts, raises the tide to an extraordinary height in the English Channel, the river Thames, the east coast of Great Britain, &c., as these winds respectively prevail." Mr. Boyle proved, by numerous experiments, that the most violent wind never penetrates deeper than six feet into the water; and, consequently, it can only be elevated six feet from the level of the surface where there is no impediment, and where several waves are not heaped together by a violent tempest: the utmost elevation of a natural wave is therefore

twelve feet. It has been objected, that if the ground-sea originated with gales in the Atlantic, the whole surface between these islands and the scene where the gale took place would be agitated; and I agree with them, but surely it cannot be supposed that there should be accidental or compound waves the whole distance. We have seen that a natural wave, according to Boyle, can only be elevated twelve feet in deep seas; according to others, twenty feet: and as the originating cause ceased with the gale, and the undulations are afterwards only propelled by previous waves, they must lose in height, and become, at a great distance from the spot of the gale, and where the wind does not sweep over a great extent of water, less perceptible than on coasts where impediments are thrown in their way. The northern wind acts, however, still upon them, and prevents their altogether subsiding; and in consequence of the earth's rotation, they receive a more or less western direction: arriving, therefore, at this archipelago, they find their way obstructed by reefs and shores, are acted upon by repercussion, and by the dashing of several waves together that loud noise is caused which accompanies the heavy swell or ground-sea; and which I have known to continue for a week or two when a northerly wind was at the same time prevailing. A southern gale will likewise produce a heavy swell on the southern side of these islands; and during the gale of the 30th and 31st of August, 1833, this was felt with great violence on the southern shore. But, generally speaking, neither in force nor duration are these surges to be compared with those of the northern side; the group of the Virgin Islands being protected in this direction by the Caribbean Islands or by the Columbian coasts, and not exposed to the swell of the main ocean.

I observed previously, that the Virgin Islands and the northern shore of Porto-Rico are most exposed to a ground-sea; and, indeed, the diversity in the line of the northern coasts along these islands, and their present aspect, prove evidently the strength and battering power of the waves. The seaward front of the small islands Camanoes, Guana Island, Jost Van Dyke's, Tobago, Loango, Green Island, and Thatch Kay, as well as the shore at Tortola from Josiah's Bay to Cane-Garden Bay, and the whole northern shore of St. Thomas, consists of perpendicular cliffs of mostly unstratified rocks, presenting a front in which the force of the waves has formed cavities, chiefly where the broken wave was driven by local circumstances more in one direction than in another. I have observed several instances where the water, after having finished the vault, has worked its way upwards through the rock until the compressed air found an egress. The noise which is caused by the blast of the compressed air, held between each wave as it rolls into the cave, is considerable, and when heard at

a great distance may be compared to the discharge of heavy artillery.

The situations mentioned previously offer scarcely any beach, or, where this is the case, they have been defended by coral reefs, which break the greatest force of the approaching wave, and prevent it from making inroads upon the land; nevertheless, a heavy ground-sea will tear up large pieces of coral and throw them on the beach. It would appear that nature has provided defences wherever the land becomes less precipitous, and protecting cliffs are not opposed to the battering power of the waves, which otherwise would become a continued and powerful agent of destruction. All the bays along the northern shores of Tortola, St. John's, and St. Thomas's, which, through their situation, are exposed to a ground-sea, are thus more or less protected by coral reefs.

Partial shingle beaches are to be met with at the extreme ends of the bays, where they bound on cliffs, and prove the effect which the breakers have had on the solid gneiss-rock. Ballast Bay offers almost the only example of an entire shingle beach on the northern side; and its position fits it to receive the nodules brought down by the mountain torrents or torn up from the opposite cliffs at Richmond Hill, which consequently appear among the specimens of rock composing this beach*.

In consequence of the ground-sea, weeks sometimes elapse before a boat is able to land in some bays on the northern side of Tortola; and planters frequently find it most difficult to ship their produce.

The cultivation of the smaller Kays has been to a great extent, for the same reason, given up; and amongst other instances, I remark Great Tobago, the former owner of which narrowly escaped starvation; a heavy ground-sea setting in and making all communication with the larger islands impossible, while the Kay itself having been only recently cultivated, had no resources of its own to satisfy the wants of the inhabitants for any length of time. Guana Island labours under the same disadvantages, and all communication is sometimes for weeks interrupted.

The northern shore of Anegada is almost constantly exposed to a heavy swell, but in a severe ground-sea, the waves approach "mountain high," and when drawing near the island, appear

* A bay on the southern side of Great Tobago is remarkable for the regularity with which the breakers grind down the angles of such pebbles as are too heavy to be transported, and become now the sport of the surge. Pieces of granite, in which hornblende prevails, receive a perfect elliptical shape, as if they had been formed by the chisel and compasses. I have several specimens in my collection of geological series of these islands which are really beautiful. Jasper, in consequence of its more slaty nature, does not form a spheroid, but its upper surface becomes flat, and it is distinguished by its stripes of different colours, and its perfect smoothness, as if it had been polished.

as though about to precipitate themselves over the land, which very likely would be the case, were it not for the protection of a continued barricade of coral reefs. The breakers, however, have forced up sand which forms small hillocks on the north-western part of the island, the largest being even forty-feet high; and the parts behind these hillocks have been also thus inundated, a second and even third range of hills being there formed of inferior size, the sand of which is now consolidated and covered by a species of *arundo* and the *suriana maritima*. After these little hillocks have stretched for some miles in an easterly direction, the shore takes a rocky appearance, and instead of sand, detached pieces of limestone and coral are heaped up, reaching often a height of thirty feet and more, forming a protection to the land behind; which otherwise would be scarcely sufficiently defended, as the reef approaches here almost to the shore, and consequently does not break the force of the waves, the velocity of which is the more increased by the coast-line here forming a sharp angle.

There extends from the western end of Anegada, in a south-westerly direction, almost to the eastern end of Jost Van Dyke's, a shallow ground, consisting of transported sand heaped up, perhaps for ages, and which may be considered as the parent of most of the shallows in Drake's Channel.*

The tidal stream, which flows over this bank, and which, during the flood-tide, runs to the south, finding its way obstructed by the Island of Tortola, sets along its northern shore almost in a western direction till it flows between the west end of Tortola and Thatch Island, into Drake's Channel; here it sets east, and escapes between St. John's and Norman's Island. The transporting power of the waves, the average velocity of which cannot be considered to be more than two miles in an hour, would be scarcely strong enough to remove quantities of sand and deposit it in other situations: but the waves, during a ground-sea, having once torn up particles of sand and set them afloat, they are easily transported by the tidal stream; and the discolouration of the sea and the different tints of the water, already described, are nowhere more observable than in the direction of this extensive bank. The sand which thus escapes is transported to a greater or less distance until it is deposited: the check being produced by some projecting point or contracted channel, through which the tidal stream forces its way, or by the counteraction of the respective tides; and thus the foundation for a sand-bank is laid.

I have found several shallows to the northward of Thatch Island

* I have carefully sounded this bank, but as I do not find it noted on any of the previous charts, I do not know whether it has increased or decreased. It is known by the name of the "Middle Ground;" and its least depth was, in 1831, seven fathoms and a half.

and Tortola, which are not in the old charts: whether these banks escaped the surveyors, or whether they have been formed since the late Spanish surveys, can only be left to conjecture. It has been stated, that the ground-sea has its origin between the islands which are subjected to it; but the fact, that a severe ground-sea often rages on the northern shore of Tortola, whilst on the northern side of St. John's there prevails a perfect calm, contradicts this remark, and is another proof that we must look far out at sea for its originating cause. The Island of Tortola protects almost completely the northern side of St. John's, and prevents the waves from having effect. Where St. John's is exposed to the open ocean, as between the two islets, Whistling Bay and Mingo, we find the ground-sea raging again, and the bays protected by coral reefs.

To one who crosses, during a severe ground-sea, from the southern side of Tortola to the northern, where the breadth of the island is but inconsiderable, the strange spectacle is afforded of the sea, which on the southern side is perhaps "as smooth as glass," on the northern shore tossing, foaming, and roaring, as if agitated by a severe gale. The effect is most curious, and if it were not for the warning that is heard long before the cause becomes visible, one might fancy the wand of a magician in play.

The northern coast of Porto Rico is subjected to a ground-sea, of scarcely less force, which has had the same effect on its coast as at the Virgin Isles. The 'Old English Pilot' observes, that the sea along the north coast of Porto Rico "eats sometimes very ragingly." The force of the waves that batter against the cliffs on which the Moro stands is amazing; and any observer will agree with me, that the spray is sometimes carried more than a hundred feet high. I was told that, several years ago, a brig, in consequence of carelessness, became here unmanageable, and was soon dashed to pieces against the cliffs, but few of the crew escaping.

In order to arrive at accurate conclusions whether the opinion which I have formed of the originating cause of the ground-sea is correct or not, it would be curious to compare the log-books of vessels crossing the Atlantic when there were heavy ground-swells on the shores of the Virgin Islands; making allowance for the time which must elapse before the effects of a storm can influence the sea along these shores, and also paying regard to the magnitude of the waves, as on that circumstance depends their velocity.

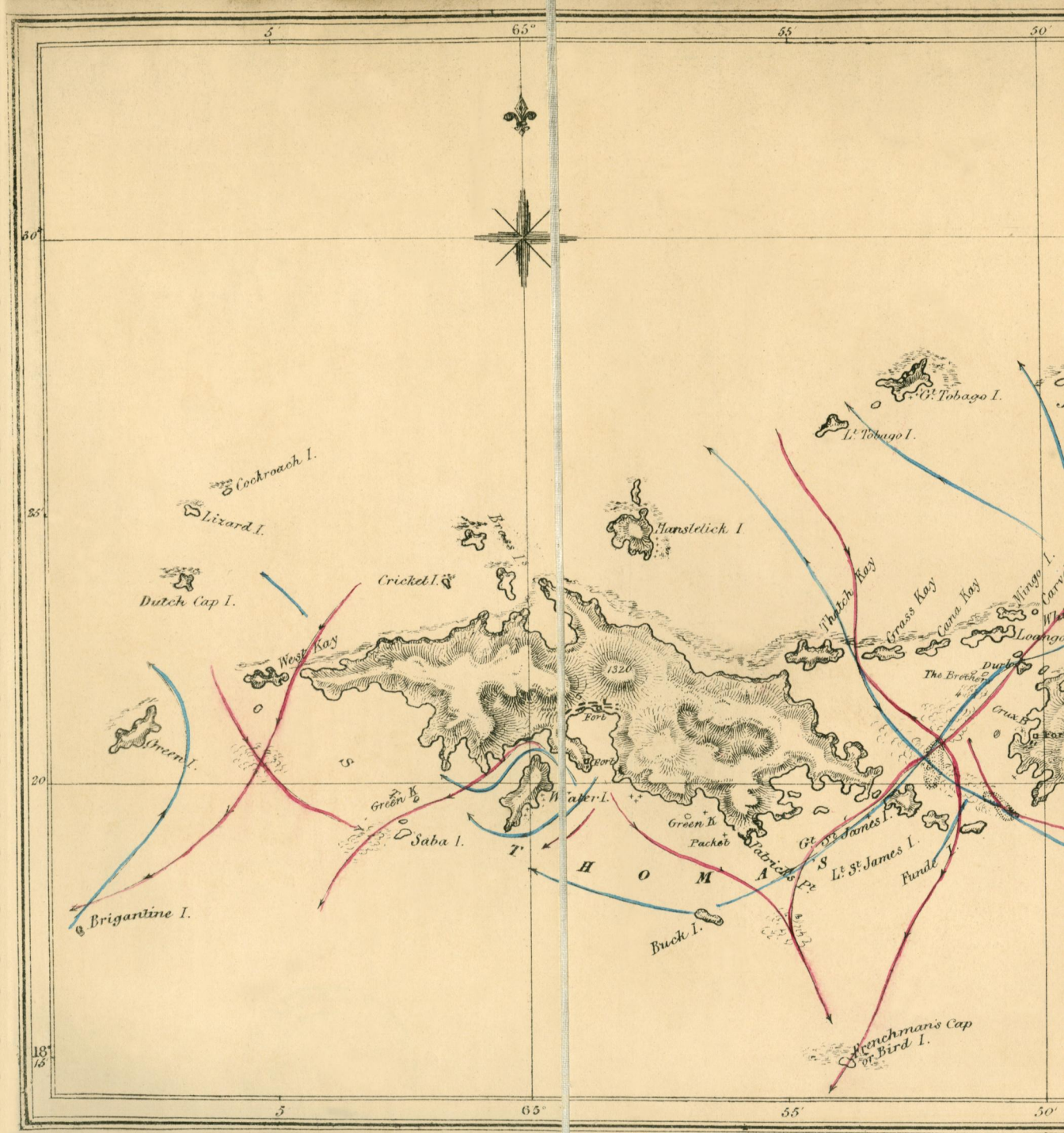
The obstacles opposed to the tidal wave between the Virgin Islands cause great irregularity in its set and velocity; and though coasters reckon upon a windward tide from the moon's rising to her zenith, and upon a leeward tide from her zenith to her setting,

no dependence can be placed on this, the tides differing often one or two hours, so that the change from ebb to flood sometimes precedes the rising or setting of the moon, though it more commonly succeeds it. The windward tide, or that which sets to the south and comes from the Atlantic, on running through these islands makes high water, whilst the ebb or lee tide sets to the north-west. The flood tide, very probably, does not extend far south, being there overcome by the currents existing in the Caribbean sea, swelled by the flow of water which issues from the large rivers Orinoco, Essequibo, Amazon, &c.; and the northern or lee tide I conceive to be of still more limited extent, being overcome by the general W.N.W. current so soon as it leaves the Virgin Islands.

Through the greater part of the year an almost regular tide takes place alongshore among the Virgin Islands; but it is different in mid-channel, where the flood-tide continues to run south, while the ebb has already commenced to set to the north-westward alongshore. As an example, on the western and northern shores of Tortola, the flood acquires its highest level, at full and change, at ten o'clock; and the same takes place fifteen minutes later on the southern side. But at mid-channel, between Tortola and St. John's, it continues to flow to the windward for an hour and a half to two hours longer. The pressure of the ebb-tide appears, however, to be of minor force, perhaps from the circumstance that the flood-tide comes from the main ocean, whilst the ebb has not so extensive a range; and, consequently, the difference of the time between the reflux of the tidal stream near the shore and mid-channel is not so considerable as in the former instance, seldom amounting to more than from thirty to forty minutes.

The time during which the flood-stream continues to run to windward in the middle of the channels (*i.e.*, between shore and shore of the different islands) is not everywhere the same among the Virgin Isles, but suffers great modifications; and whilst to the east of Mary Point (the northern angle of St. John's) it often amounts to an hour and a half, or two, it is scarcely more than forty-five minutes to the westward of it. Droghers or coasters, acquainted with this fact, when bound to the westward, make short tacks alongshore from Mary Point to Pelican Bay, avoiding the shore of Tortola as much as possible, and thereby escaping much of the influence of the north tide; whereas vessels less acquainted, using the whole sea-room afforded by the channel, are much retarded in their progress.

The direction of the tides is also much cut up and altered in force by the winds, and various impediments which present themselves in the form of promontories, narrow passages, reefs, shallows, &c.; and it is only with time and by experience that a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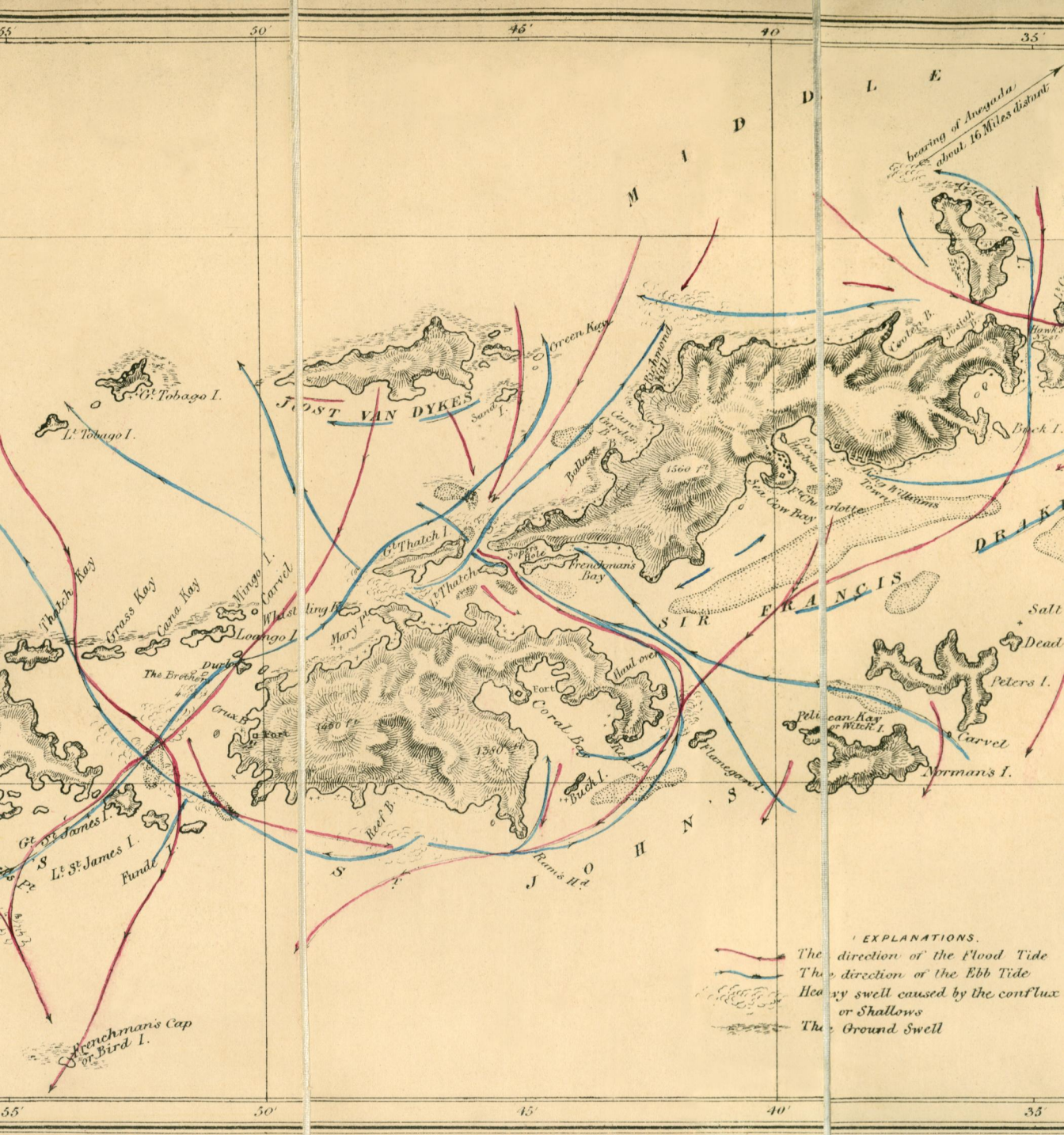

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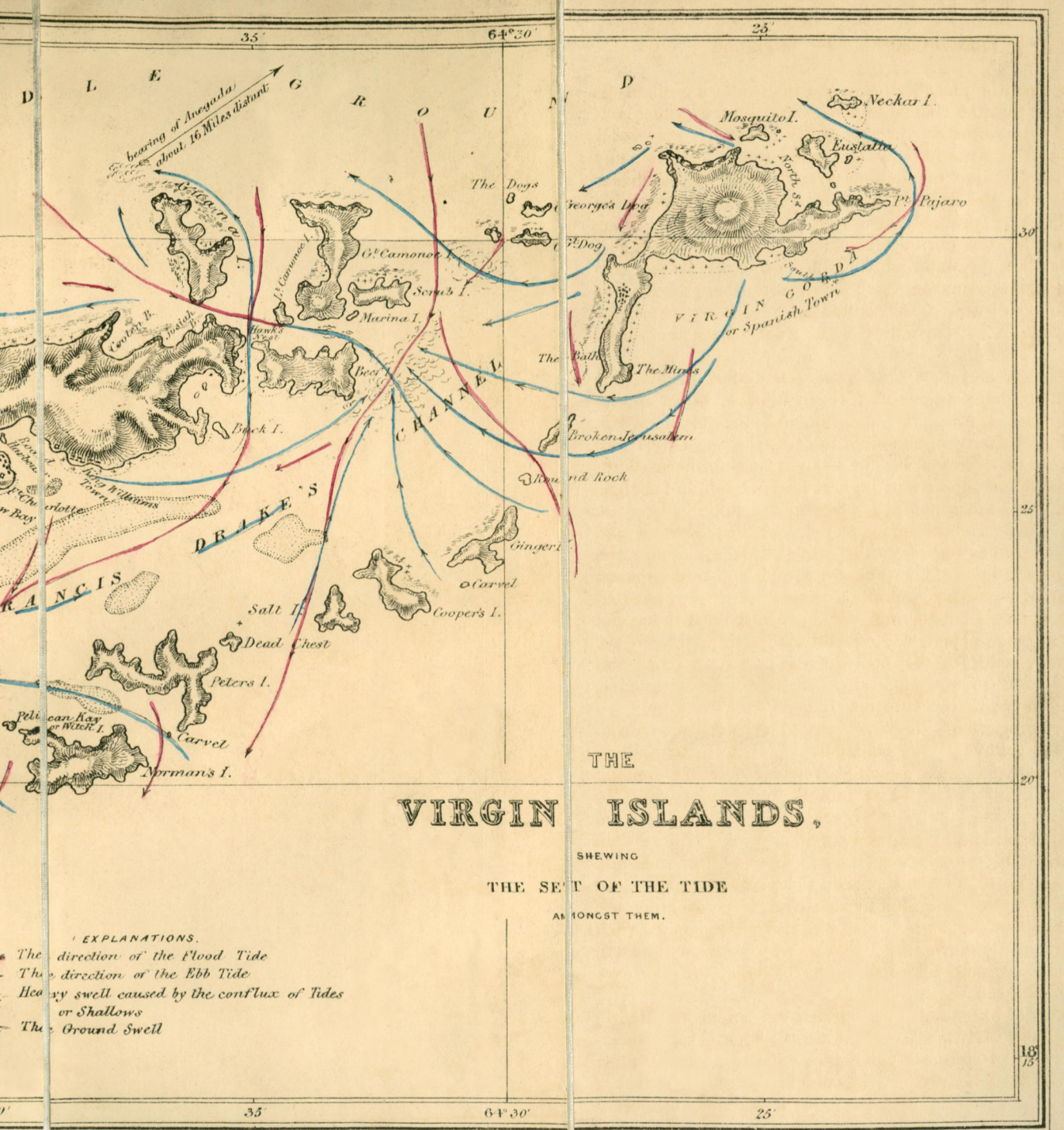

THE VIRGIN ISLANDS,

SHEWING

THE SET OF THE TIDE

AMONGST THEM.

EXPLANATIONS.

- The direction of the Flood Tide
- The direction of the Ebb Tide
- Heavy swell caused by the conflux of Tides or Shallows
- The Ground Swell

arle St. London 1835.

navigator may become acquainted with the different sets in the channels and passages. During the period that I re-surveyed the Virgin Isles, I paid particular attention to this subject, and I must freely confess that it was full of difficulties. The accompanying sketch of the Virgin Islands, on which the different courses of the tides have been represented, will elucidate the following remarks:—

There are four great outflows for the southern or flood-tide, namely,—1. Between the western end of Virgin Gorda and Peter's Island, which space affords passages to the tidal stream entering between Virgin Gorda and the islets to the east of Tortola. The conflux of so many branches creates necessarily an eddy tide, which we find to the east of Scrub Island. The chief mass of the stream directs its course thence westerly to the passage between Salt and Peter's Islands, a branch escaping between Broken Jerusalem and Round Rock.—2. Between Norman's Island and St. John's. The stream to the west of Road Harbour, in Tortola, and to the east of Mary Point, at St. John's, are directed towards this passage, and unite to the north-east of Red Point, at St. John's, one branch flowing thence towards Ram's Head, and the other to the south-east.—3. Between the western end of St. John's and the eastern end of St. Thomas. The southern tide is here of considerable strength, and causes nowhere between these islands so heavy a swell, the waves becoming often mountains high, and the extent of water over which the eye sweeps offering the aspect of a raging war between wave and wave. After having cleared the passages the stream of the flood-tide directs its course towards Frenchman's Cap, or Bird Island, with the exception of a branch which runs towards Reef Bay, in an eastern direction.—4. Between the western end of St. Thomas and Culebre. A branch of this great outflow sets through the passage between the western end of St. Thomas and West Bay, running off towards Brigantine; a stream strikes, however, to the south-east. Having cleared the different passages, the southern tide is now acted upon by the trade-wind, and flows off south-west until it is turned by the current existing in the Caribbean Sea. I am inclined to think that its whole range does not amount to more than 60 miles.

The ebb-tide, with a few exceptions, takes a more decided north-western direction. Its first great outflow is between Guana Island and Tortola, its second between the western end of Tortola and Mary Point, and its third between Green Kay and Thatch Kay. The velocity with which the northern tide runs through these three passages is nowhere surpassed, though it has a great many by-ways for its outflow, which the map will point out. From the harbour of Tortola a stream of the ebb-tide sets easterly, which is again met by another coming from the passage at Peter's Island, and by a third from the Round Rock passage; they unite off the

southern bluff point at Beef Island, causing an eddy tide and a considerable swell.

Frenchman's Bay is divided from the mainland of Tortola by a small and shallow channel; generally speaking, the tide here sets west. This would be its natural direction during ebb-tide, and the reverse during flood; but at that period the tidal stream running with great velocity through the passage between Tortola and Thatch Island, it finds itself a second time compressed by the narrow passage between Frenchman's Bay and little Thatch Island; the waters on escaping this compression extend and come in contact with the bluff at the tower, and a re-flux takes place towards the passage, which acts as an in-draught, forming consequently at flood-tide an eddy race around the whole island.*

This passage is said to have become deeper within the recollection of many of the inhabitants; if this be really the case, it must be in consequence of the transporting power of this local current.

The velocity of the tides between the Virgin Islands depends very much on local circumstances. Where two streams unite, after having made their way through different passages, the velocity is generally increased. The southern tide is of considerable force between St. John's and St. Thomas's; I have known that tide to be so strong, that six able boatmen could make no progress or head way for hours; it must then have run at the rate of five miles.† The same is the case between St. John's and Tortola shore. But the north-western tide is of still greater strength than the flood-tide, though the latter comes from the Atlantic: the prevailing current in the latitude of these islands setting W.N.W., the flood-tide has to overcome its opposing force, which weakens its velocity. This is not the case with the ebb, where the set of the tide and current being nearly the same, the latter adds its force to the first and increases its velocity. I have seen many vessels, on beating through these islands during a north-western tide, fixed to one and the same spot for a considerable time; and others come to an anchor, relinquishing the contest with so heavy a lee-tide. The tides have their greatest force at springs, but especially at the day of full and change; and the tide which happens at the time this takes place is considerably stronger than the previous one. The velocity of the northern tide is strongest between Beef Island and Comanoe, and it is often impossible to cross from one island to the other during such a tide. The attempt proved nearly fatal to Mr. L., of

* Anegada, inside the reefs, offers a similar instance on a larger scale: the current is here however permanent, which is not always the case at Frenchman's Bay, but chiefly when a strong northerly wind prevails during the period when the southern tide is predominant.

† I scarcely need to observe, that when miles are here spoken of, nautical are intended, 60 of which make a degree.

Beef Island, who, returning from Comanoe, thought himself strong enough to contend with the opposing tide, but was soon deprived of his oars, which were instantly swept away. Finding that the northern current set him to leeward he used the seats of his boat as paddles, which met, however, the same fate as the oars. Meanwhile the tide changed, and at day-break he found himself drifting towards the Round Rock passage. Without fresh water, or a morsel to eat, his boat became the sport of the changing tides for the next two days, sometimes so near Beef Island that he could not think but that the boat would be drifted ashore, and a southern tide then sweeping him towards the Round Rock or Broken Jerusalem. Nearly overcome by hunger and thirst, and given up for lost by his relations, he was at last discovered, on the third morning, by some people from Spanish Town, who hastened to his assistance.

A very strong northerly tide runs likewise between Tortola and Thatch Island, which but lately offered a more tragical instance of its force. An African purposing to return from Belmont estate, at Tortola, to Thatch Island, late in the evening, on finding that his companion declined to set off at so late an hour, thought that he could manage the boat alone. He was never seen again; the keel and broken timbers of the boat were found on the eastern end of Thatch Island, and told his fate. Not able to stem the tide, his boat was probably driven against the rocks and split to pieces. The oars, some time after, were picked up in one of the Bays on the north side of St. Thomas's.

The tides are so powerful in some of the passages between the smaller Virgin Islands that the buoys attached to the ropes which indicate where the fish-pots are placed, sink so that the fishermen cannot haul them except at slack tide, when the buoys become again visible. The great strength of these tides is, however, only partial: their average velocity in general does not exceed a mile and a half or two miles, in ordinary cases, in the channel, and probably decreases at some distance out at sea.

The medium of the perpendicular rise of the tidal wave between the Virgin Islands does not amount to more than two feet, being at spring tides 26 to 36 inches, and at neap tides 16 to 18 inches. These comparatively low tides tend to prove how little tide there is in the Atlantic near the equator; and though there is no great range of coasts to produce a considerable elevation, the narrow passage and channel of which this group is composed might have led us to expect a different result. The accumulation of water in consequence of the trade-winds and the equatorial current, may, in some respects, prevent a higher elevation; and accordingly we find that beyond these latitudes the tide rises to a greater height, even where the range of coast is not so extensive, as from 8 to 10

feet at the Canaries,—from 4 to 6 at the Cape Verd Islands,—and from 5 to 6 at the Bermudas. The sandy shores and beaches of the Virgin Islands are flat, or very gently sloping, which we may take as a proof that the tides have never been of greater height there, at least not for several ages; and the progress of the tidal wave must consequently be very trifling.

The southern tide is predominant during the summer months, *i. e.* from the middle of June to the middle of August; and two tides have been then known to follow in succession, chiefly if the wind has been westerly. The consequence was that the perpendicular rise of the tidal wave was considerably increased, and, as an extraordinary case, the water reached the height of three feet.

There is another circumstance which deserves to be particularly mentioned. At the period when the southern tide becomes predominant, which is generally in the middle of June, the tide sets for eight or ten days continually to the south, with a force very seldom surpassed. It is called by the fishermen 'the St. John's tide,' the day of this saint occurring about that period; and commenced last year on the 12th of June, lasting to the 21st of the same month. The seine-boats could not round fish for the whole week, nor were the fishermen able to discover their pots, the buoys being all sunk. At other times the ebb sets to the north for the course of an hour or two, when the flood begins to flow again to the south.

During the months of September, November, March, and April, the northern tide is prevailing, and of considerable force, being assisted by the current. At this period also the highest water is generally in the morning, and there is only a half-tide in the evening; the reverse takes place during the summer months.

In estimating the transporting power of tides in general, we must be careful not to consider it the same as that of the currents of rivers. It has been stated that a velocity of three inches per second at the bottom of a river will just begin to work upon fine clay, and, however firm and compact it may be, will tear it up; a velocity of six inches will lift fine sand; eight inches, sand as coarse as linseed; twelve inches will sweep away fine gravel; twenty-four inches will roll along rounded pebbles an inch in diameter; and three feet per second will sweep along shivery angular stones of the size of an egg (Encycl. Brit., art. *River*). Considering the average velocity of the tides between these islands to be two nautical miles (·6120 feet = 73440 inches × 2 = 146880 inches ÷ 3600), this would give forty-one inches per second, a greater power than the highest above stated; yet even in the comparatively shallow channels, where we might conclude that the superficial velocity extended to the bottom, the water, nevertheless, remains clear during the strongest tide: thus showing either that the force or

moving power of the tides at the bottom is not equal to their velocity on the surface, or else that their action is inferior to the moving power of river-currents. When the ground-sea is not prevailing, the water in the channels is even remarkable for its clearness, and strangers are often alarmed by seeing the bottom distinctly in eight and nine fathoms water. I have myself distinctly observed at that depth a peculiar kind of sea sponge called 'Java pots' (a species of Alcyonum).*

The unchanged character of soundings for a length of time in places which have been surveyed with accuracy, and to the results regarding which implicit confidence may be given, has attracted already the attention of geologists to the fact, that the transporting power of tides is small. Nevertheless, where channels are contracted, and the general depth is not considerable, and the velocity is increased by other obstacles, they will produce some change at the bottom of the sea, chiefly by affecting the shape of sand-banks where they approach the surface, and are thus besides subjected to the disturbing power of the waves.

There are few rivers which during freshes do not convey a quantity of detritus into the sea, and if their mouths are tidal, this detritus is committed to the charge of estuary tides; if they be tideless, generally deltas are formed. Few of the rivers along the north-eastern coast of South America are tideless, and the quantity of detritus borne down by the Orinoco is carried forward until local currents turn its direction and convey it to distant shores or shallows. In a paper on 'Anegada,' published in the Journal of the Royal Geographical Society of London (vol. ii.), I invited attention to the existence of a current passing that island in a W.N.W. direction, and which I conceived to deposit detritus on its shores.† To this current and its transporting power we must

* Mr. Maclean, a gentleman in Tortola, high in scientific attainments, drew my notice to another phenomenon, which may be observed in the channel between that island and Jost van Dykes, namely, a counter current at a depth from two to three fathoms, to which his attention was first attracted by seeing pieces of wood, &c. moving in a different direction from those on the surface: this statement I afterwards corroborated by my own investigations. In calm weather, when the surface of the sea was unruffled, I went out in a boat, and having attached a lead to a line, to which at intervals of a foot small pieces of deal wood were tied, I threw the lead where the tide was running strong to the south; the upper pieces of wood, consequently, floated in that direction, but those at the depth of eleven feet and upwards pointed to the northward. Either the moving action of the tide, therefore, only extends to that depth, or this arises from the W.N.W. current, which, though too weak between the islands to resist the strong southern tide at the surface, extends to a greater depth than it, and keeps its original course lower down.

† While on the subject of this current, it may perhaps be interesting to observe that I have received since the publication of the above remarks two proofs which are sufficient to substantiate my surmises with respect to this current. In the latter part of 1831 a bottle was picked up on the southern side of Virgin Gorda, which, according

look for the origin of the large sand-bank which extends from the western end of Anegada to within a short distance of the Island of Jost van Dykes, and which is called the middle ground. On its passage along Anegada the current is influenced by the tides of the Virgin Isles, and delivers part of its detritus to the tidal stream, which the usual check of the counteracting tides causes to be deposited. The greatest extent of this bank is in a south-westerly direction twenty-two nautical miles, whilst its breadth varies from one mile and a half to three miles, proving in a striking manner that the flood-tide deprives the current of the detritus which composes the bank. The action of the waves during a gale or a heavy ground-sea possesses more moving power than a tidal stream or current of the greatest velocity; and the sand, once detached from this bank, is set afloat and carried forward and backward by the tide until deposited.

If we cast a glance on the accompanying tidal map of the Virgin Isles, we observe that wherever the stream of flood directs its course through one of the passages after having passed over the middle ground, a sand-bank of more or less extent has been formed. The stream of flood being opposed by the reflux, by headlands, or contracted channels, by sunken rocks, or any other

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to a paper inclosed in it, had been thrown from the ship "Gambia" in the River Gambia; and on the 8th of January, 1833, another bottle was picked up on the northern side of Anegada which contained a paper now in my possession, of which the following is a correct copy—

"*Currents of the Ocean.*—The bottle containing this note was cast overboard from the bark Emerald of London, bound to Jamaica, the 17th day of December, 1831, in lat. 36° 40′ N., and long. 12° 32′ W. by chronometer. Whoever finds it is requested to forward it to the editor of any newspaper who may be kind enough to notice it for public information.

"C. W. Nockells, Commander.
"(Signed) "C. O. Hodgson, "E. M. Geachy, } Passengers.

"Note.—Two bottles are thrown overboard here, both of the same import. Two more were also cast overboard on the 5th inst. in lat. 41° 48′ N., and long. 13° 49′ by chronometer. The winds for the last three days have been from N. and N.W. to S.W. For eight days previous it blew a continued and heavy gale from S.W. and W.N.W., lying-to the whole time, and drifting from lat. 41° 28′ 237 miles to the northward."

The southern current along the coast of Spain and Portugal had probably drifted this bottle towards the mouth of the river Gambia, where it may have been taken up by the western current and drifted towards Cape North, and thence by the N.W. current to the shores of Anegada. If we calculate, therefore, the direct length of the three main courses of the currents, we have a distance of 4796 nautical miles, and the bottle having been taken up on the 743rd day after its having been thrown in the water, supposing it to have been drifting continually during that period, the mean velocity of all three currents would be ·26 knots in an hour, or nearly seven miles in a day; the difference in the winds, and perhaps other circumstances and detentions not included.

The above calculation of the velocity of this current is necessarily vague; nevertheless, it may afford an addition to our knowledge of the general velocity of currents; and the drifting of these two bottles establishes the truth of my former remarks regarding the current passing Anegada.

obstacles, however small, is forced to deposit its sandy particles; and the foundation of a sand-bank once laid, it is well known how soon it accumulates.

The shallows in Sir Francis Drake's channel are, therefore, derived from sandy particles which have been carried from the extensive bank to the northward of the Virgin Isles, and which the flood-tide has deposited. I do not think that the shallows have shifted much since their existence, in consequence of the nearly equal counteracting effect of the tides; we may find them, however, somewhat increasing towards the northward, because, as already alluded to, the northern tide is, generally speaking, the stronger of the two; and though the flood-tide carries the sandy particles in its train, it is the northern or ebb-tide which causes them to be deposited. At this moment these sand-banks can scarcely prove of any danger, and I doubt much whether they ever will be so, unless some violent convulsion of nature or a hurricane of uncommon strength should detach such a quantity of sand from the middle ground and from the land, that changes of more serious character than ordinary should be the consequence. The shallowest part in the channel is abreast of Peter's Island, where there was in February, 1833, only four fathoms water.

Before I conclude these remarks, I shall add some observations which may prove of advantage to the navigation of these channels. The passage between St. John's and a small bay lying midway between the former and the eastern end of St. Thomas' is often selected by vessels bound for St. Thomas', and which may have made the Virgin Islands to the northward of them. This should not be attempted, however, when there is a northern tide, and the wind any way to the south of east, as vessels will then almost certainly be set on the reef, being unable to stem the force of the northern tide, which is so strong here that droghers have given this passage the name of "the current-hole." This passage is especially dangerous during the spring months, when the northern tide is stronger than at any other period, and the instances are not few of vessels having been set upon the reef in this direction when the danger was quite apparent. When the tide sets to leeward, vessels beating to windward through Drake's Channel should make short tacks along St. John's shore as soon as they have reached Mary Point, or else stand over towards Jost van Dykes, and try to fetch the passage between Thatch Island and Tortola; having reached Pelican Bay or Witch Island, the northern tide trends to the eastward and favours a vessel as far as the north-eastern entrance to Drake's Channel. Should the tide, however, have changed meanwhile, and at her arrival off Beef Island be flood, the stream there branches off to the south-west, and short tacks should be made along Beef and Scrub Islands until the Kays

called the Dogs are weathered. Should the contrary be attempted, a strong southern tide is apt to set the vessel towards the Round Rock or Broken Jerusalem, and some efforts would be necessary to make good what has been lost. Vessels beating to windward outside of St. John's, when there is a southern tide, should keep the land aboard as much as possible: it is, however, different when the tide runs to the northward, when they ought to stand out.

II.—*Extracts from private Memoranda kept by Lord Prudhoe on a Journey from Cairo to Sennar, in* 1829, *describing the Peninsula of Sennar.* Communicated by Sir John Barrow, Bart. Read 9th February, 1835.

March 10.—KARTOOM is situated on the Bahr-el-azrek, about two miles from its junction with the Bahr-el-abiad; it has only sprung up into a town within four or five years, in consequence of being fixed upon as the residence of the Sandjar or governor, who is lodged in a tolerable house of mud. There are about thirty other mud houses in the town, the rest being built of doorah-stalks;—both with respect to walls and roofs they resemble small wheat-stacks or bee-hives.

There are no trees, and the position appears to have been chosen for its bare, ugly plain. Courschied Bey governs from Berhee to Sennar, and receives in pay 680 purses a year, 3,500*l*. There are barracks for the Nizam (800), whose commander is the Kaimacam, lieutenant-colonel. The climate is healthy except during the Khareef (after the rains), and at that period Sennar is the most healthy of the Soudan possessions of the Pacha. The natives are of two sorts, the free cultivators and the Mowelled. These latter are a peculiar race: they are descendants of slaves, who from generation to generation live at large, and pay their masters monthly a part of their gains, which the men derive from labour and the women too often from prostitution. If two slaves of different masters marry, the children become their joint property; and it is not unusual for six or even more masters to possess as property a single slave. If a woman has a child without marriage, it belongs to her master. Some of the great Sheicks have five or six hundred Mowelled, who may be sold like other slaves, and are frequently light-coloured and handsome. In appearance there is no difference between the Mowelled and the free population. The proportions of each depend on the state of society of the district: thus, in the island of Sennar, the great majority were Mowelled, while in Dar Shagei there were hardly any. The whole country to the south of Khartoom, bounded on the east by the Bahr-el-azrek and on the west by the Bahr-el-abiad, is called