

HYDROGRAPHIC YEARBOOK

OF THE

CHILEAN NAVY

YEAR IV.

SANTIAGO

IMPRESA NACIONAL, BANDERA, NUM 29

- 1878 -

METEOROLOGY.

SOME DATA RELATIVE

To the earthquake of May 9, 1877, and to the sea upheavals and other phenomena occurred on the western coasts of South America.

In compiling here the following data, we do not propose to make any study of them; they are merely intended as a means of facilitating the consultation of the special men who deal with the important phenomenon of earthquakes; but in any case we have endeavored to collect the most authoritative, hoping that this collection of observations will be of some use.

Seafarers may also be interested in learning about the phenomena that occur on the coast, i.e. the seismic wave that develops over large proportions.

I.

FROM VALPARAISO TO MAGALLANES.

At 8.^h30.^m P.M. on May 9, 1877, an oscillatory movement of the ground was felt in Santiago de Chile, soft and prolonged, which lasted for the space of a minute or more. Many people did not perceive the movement, but others experienced a certain faintness similar to the first symptoms of dizziness, and the same thing happened in the Constitución river and other points. The direction of the movement was believed to be from N. to S., judging by a pendulum that, oriented from E. to W., stopped its movement, and also by the oscillation of the gas lamps that kept for a long time their movement from N. to S. and vice-versa.

The tremor, in Santiago, was not preceded by a precursor noise, as often happens, and the same thing occurred in most of the Chilean localities where the oscillatory movement of the earth was perceived.

The following day (10), the telegraph announced that in Valparaiso the same phenomenon had been experienced, and that, in addition, the sea was in continuous movement of ascent and descent, every 15 minutes, rising and falling 2.2 meters between the ebb and flow, which gave an excess over the ordinary high tide of 0.7 meters. This phenomenon continued until the afternoon of the 11th.

The weather appearance was good, and the atmosphere clear, having blown during the day a regular breeze from the SSW; but which dominated with considerable intensity offshore, on May 9, as will be seen below.

At once it was announced that in the ria of Constitución the tremor had been felt at 8.^h40.^m P.M. of the same day 9; but as in the previous points, soft and prolonged, from N. to S., and only perceptible to few people. However, the sea began to withdraw slowly about 11.^h15.^m p.m., the flow returning 20.^m later, with great noise. It was, then, the first flow at 11.^h35.^m, and the second a few minutes past midnight, and about 12^h15.^m A.M. of the 10th.

A third flow, quite large, was verified at 5^h A.M. on the 10, in circumstances that the high tide of this day should take place at 11 in the morning. The small ebbs and flows were many on the days 10, 11 and 12, already very small on the last one.

As the waters of the Maule descended before the first flow, they produced an extraordinary current, dropping so low that they left the ships in the estuary dry. The flow was also violent, cutting the moorings of several of them, stranding them on the shore or on the island. One of the ships was dragged out to sea, with complete loss of its moorings. All the vessels experienced more or less serious damage.

This tidal flush and the unusual movement of the waters of the sea in Valparaíso, made us suppose that an earthquake could have occurred in the north of the Republic; since the phenomena verified on our coasts on August 13, 1868, with the earthquake that destroyed Arequipa, and several towns of the Peruvian coast, were remembered.

After such antecedents and fears, the cable and the different telegraphic lines were transmitting us the effects of the tremor and the disastrous consequences, greater the more we advanced to the north; but before entering to compile the data that it has been possible to obtain, we will follow the phenomenon that took place on the coast of the South of Chile.

PUERTO DEL TOME.. { Latitude S. 36°37'
Longitude W. 72°58'

According to a note from the maritime subdelegate of the port of Tomé, the tremor of the 9th was not felt in that locality nor was any subterranean noise experienced; but at 12^h.30^m. A.M. on the 10th and part of the 11th, flows and ebbs were noted in the waters of the sea, repeating the high tides every 30 minutes; the waters rose and fell 1.2 meters more than with the spring tides (syzygian tides).

TALCAHUANO.. { Latitude S. 36°43'
Longitude W. 73°07'

Ten miles farther S. in the bay of Concepción, the phenomenon was more or less identical.

The maritime governor of Talcahuano describes the tidal flush as follows:
"The movement of the sea occurred at the entrance of May 10, without producing damages of any nature in the population or in the bay.

"The first impression of the movement was made felt by an ebb of the sea that unlayered an extension of 200 meters, leaving some ships in very little water, stranded others and all the boats dry. At 12^h.30^m. A.M. came the flow and rose over the highest tide 1.11 meters and continued in this trepidation every half hour until 3h. A.M.; succeeding a slow swell which reached at its maximum height at 1.95 meters, descending accordingly in the same manner.

"The base of the oscillation added to the high tide (syzygian tides), which reaches 1.78, was 5.68 meters.

The greatest flow flooded Piscuan Island (400 meters long), in the Talcahuano floodplain, and destroyed part of the railroad fence.

"The sea remained in a repeated oscillation of less than 1 meter for 3 days until it returned to its ordinary level".

1 CORONEL BAY... { Latitude S. 37°01'
Longitude W. 70⁽¹⁾°10'

The maritime subdelegate of Coronel describes the events in the bay as follows:

"At 8.^h30.^m the evening of the 9th, a small earthquake was felt which, judging by the small number of people who felt it, must have been almost insensible; but at dawn on the 10th, between 2 and 9 o'clock in the morning,

⁽¹⁾ Obviously a typo: the longitude of Coronel is 73°

COQUIMBO BAY... { Latitude S. 29°56'
Longitude W. 71°20'

According to information communicated by the maritime governor of Coquimbo, the tremor of the 9th took place "at about 8^h15^m P.M. producing a prolonged earth movement that lasted no less than 4 minutes, according to the most general version; but without precursor noise, in such a way that for many it passed unnoticed. Most of the people who felt it claim to have experienced it as a dizziness of which they were not aware, until by the oscillations or movements of the lamps they came to know that the earth trembled. The night was dark, cloudy and calm, with the barometer reading 761.5 ^{m.m.}

"At 10h37m P.M. it was noticed that the sea was retreating although slowly, fleshing out an extension of 8 to 10 meters, after which it returned to take its place rising little by little more than 1.5 meters above the ordinary high tide level.

"All night from the 9th to the 10th a small movement of ascent and descent was noted, which was regularly effected between 5 and 15 minutes, the sea rising and falling to a little more than 1 meter, this movement producing a strong undertow that lasted until the morning of the 11th, when everything returned to its normal state.

"With the exception of the corvette of S.M.B. *Amethyst*, which was under way, all the ships in the port had 110 meters of chain at the bow to the N. and as many meters at the stern. Due to the effect of the undertow produced by the ebb and flow, the moorings were loosened a little until the vessels were lurching for four quarters. Only the Guatemalan boat *Palatine*, which was anchored very close to land in the S. corner of the bay, cut the grating, being the only incident that occurred in the port.

PORT OF HUASCO... { Latitude S. 28°27'
Longitude W. 71°19'

In the port of Huasco, the phenomenon was somewhat different from those mentioned above. The maritime subdelegate expresses himself this way with respect to the tremor of 9:

"The tremor took place at 8^h.20^m. P.M.; it was strong and was prolonged in the direction of NE. A SW. for 3'. No misfortune on land or sea. The state of the weather was good.

"At dawn on the 10th, eddies were noticed in the waters of the bay, and at about 8h A.M., the sea lowered about 2 meters vertically, entering at once a swell that did no harm, remaining afterwards very calm, as in ordinary times."

PORT OF CALDERA... { Latitude S. 27°05'
Longitude W. 70°53'

The tremor was felt at 8^h.30^m. P.M., on the 9th. In the port of Caldera its duration was estimated at 3 minutes, and there were many ebbs and flows in the sea, continuing the agitated water throughout the day on the 10th.

In the city of Copiapó, 42 miles to the east, it took place at the same time, but its duration was estimated at 4 minutes.

On the nights of May 7 and 8, great underground noises were heard.

The tremor of the 9th was oscillatory from NW. TO SE. In the following days strong underground noises and repeated tremors were experienced, reaching their number to 27 until the 16th, 7 of them having been very strong.

BAY OF CHAÑARAL DE LAS ANIMAS... { Latitude S. 26°22'
Longitude W. 70°42'

The tremor was felt in Chañaral very hard and of long duration: the sea immediately overflowed and destroyed a large part of the population, whose losses were later estimated at 181,000 pesos, according to official documents.

BAY OF EL PAPOSO... { Latitude S. 25°02'
Longitude W. 70°30'

According to communication sent by the maritime subdelegate of Paposos, the tremor was felt at 8^h.20^m P.M., estimating its duration at 5 minutes. The direction of the movement was from NE. TO SW. The tremor began without noise and slightly, increasing little by little until finally there was a moment in which the shaking of the earth was so strong that it was almost impossible to stand up. The impression that it caused in the population was terrible, as it is easy to suppose, thinking all to flee to the hill for fear of the invasion of the sea: but fortunately there were no misfortunes to lament.

The buildings are made of wood, so they suffered very little; but not so the enclosures and divisions of the fields, which were made of stone, which were cracked and demolished almost in their entirety.

The sea remained calm at the moment of the earthquake and in the following moments; but then it began to become agitated, moving away from and approaching the coast, without experiencing notable variation with respect to the ordinary level; but at the end there was a rise of 2.5 to 3 meters above the highest tides, overflowing the sea through the low places without causing any damage.

The state of the atmosphere on the 7th, 8th and 9th was cloudless, completely clear, although a little suffocating; but on the 10th it became cloudy, threatening rain, which began in the early morning of the 11th, raining all day with considerable force and continuing until the morning of the 12th with some interruptions, the weather clearing again.

The quakes followed on the night of the 9th every 10 minutes, more or less, decreasing immediately, but recurring frequently throughout the month of May, until mid-June.

III.

COASTS OF BOLIVIA AND PERU.

On the Bolivian coasts the earthquake of the 9th was much stronger and notably more intense and disastrous than in northern Chile. We will continue from south to north noting the details that have reached us, but choosing as much as possible the most reliable ones.

ANTOFAGASTA... { Latitude S. 23°41'
Longitude W. 70°25'

We extract for this point a communication of Don Ramon 2nd Arancibia, published in almost all the newspapers of the time.

"At 8 h. 30 m. P. M. of the 9th, the earth began to oscillate, slowly at first and then gradually increasing to the point that the buildings shook like a reed; the earth seemed to flee under the plants and the creaking of the timbers; the ringing of the bells and the screams and cries and prayers of those who begged for mercy, terrified and made one lose one's senses.

"The earthquake was not preceded by any precursor underground noise, as is usually the case, the oscillation was sudden and apparently from north to south.

"In the warehouses and houses there was not a bottle left, not a jug, nothing in any cupboard; everything went to the ground falling to pieces.

"According to the calculations of people who retained a little cold blood, the earthquake lasted from 2.5 to 3 minutes at full strength.

Hardly had the inhabitants of the town been able to breathe, a terrifying scream escapes from the overwhelmed inhabitants of Antofagasta: "The sea! the sea is advancing!

"The sea, which in Antofagasta is always boisterous and agitated, had remained without movement; but suddenly a monstrous wave rushes over the first buildings facing the beach and sweeps them away.

"A house was swept intact (it was made of wood like all the others) up to 125 meters from the coast, carried by the sea like a simple small boat; boats and other smaller vessels were driven to the town's main square.

"The damage caused by the sea has been immense, causing a loss of 600 to 700 thousand pesos.

"It kept shaking from minute to minute with more or less force."

According to Captain Castillo, second commander of the armored ship *Blanco Encalada*, the earthquake began at the same time mentioned above and lasted for more than 5 minutes.

The impression that was experienced on the vessel at the time in Antofagasta, was of oscillation from stern to bow, with the ship's bow to the north.

The sea began to withdraw a few minutes after the earthquake, leaving the harbor basin dry and the rocks that serve as a barrier well flushed out, returning immediately to the coast without much noise. From this moment an undertow was produced which caused a current in the sea, from N. to S., with a force of 8 miles per hour. During the phenomenon the vessel tacked lively and kept her bow between E. and W. through N. The sea and wind were SW. The same effect was experienced by the sailing vessels off Antofagasta, which numbered 6 to 7. There were many continuous ebbs and flows which seemed to have their origin in the N.

The sea overflowed onto land reaching a vertical height of 3 meters above the level of the common high tides.

People who experienced the earthquake on the ground and who were calm enough to notice its effects, have stated afterwards that during the tremor it seemed to them that "they were stepping on papers or tin sheets and that the ground was completely hollow". The earth undulated noticeably in a very perceptible manner.

There were people who estimated the duration of the earthquake at more than 10 minutes, counting the time from its beginning until the end of the ostensible movement.

According to data reported by Lieutenant V. Cueto, officer of the armored ship *Blanco Encalada*, the following phenomena were also noted.

"The compasses experienced until minutes after the earthquake a NE. deviation of about a quarter. The barometer dropped about 2 millimeters with abruptness. The air was more fiery than in the moments before the earthquake. The sky, which had been clear during the day, began to cloud over, with a stratus crossing the sky from NE. to SW. persistently. The seismic wave was not felt as those produced by the winds, but as a sudden elevation of the waters, marked by the sounding line at 3.5 meters and with powerful currents in direction E.-W. and on the contrary. These currents were felt about 15 minutes after the great shaking and with a force of 8 to 10 miles. They changed every ten minutes. Apparently, in Antofagasta, the wave penetrated from Punta Tetas. When the *Blanco Encalada* was outside (12 o'clock at night more or less), a current was noticed that forced her to make use of her engines at every moment to avoid being anchored in the direction of Chimba creek. The vibration produced on board by the shaking of the waters was similar to that which would be produced by the violent dragging of the ship on a rocky bottom".

MEJILLONES DE BOLIVIA... { Latitude S. 23°05'
Longitude W. 70°30'

"At 7h.45m.⁽⁴⁾ P.M. one of the greatest disasters that are counted in the life of the towns took place in this deposit. At that hour (of the 9th) it shook an earthquake so terrible that it prevented even to be standing, and that produced by consequence that the sea went out of its bosom and dragged with the greater part of the population, leaving two thousand souls, that will have more or less, in the deposit without a drop of water.....

"From the hour of the earthquake up to this moment (the 10th) the earth shakes from 30 to 30 seconds, in a way that makes one fear a repetition of the catastrophe. Of the ships at anchor, several have gone to the bottom and many have been dismantled....."

It is sensitive that these details are not more extensive and circumstantiated.

RIO LOA... { Latitude S. 21°28'
 { Longitude W. 70°05'

To the east of the mouth of the Loa River there were enormous artificial dams built with large rocks by the ancient Indians to channel the river and use its waters for irrigation of the valley; but these old and colossal works disappeared completely with the earthquake of May 9, leaving no traces of human labor, forcing the river to change course because of the debris; This leads us to suppose that this region had not experienced a similar cataclysm in the historical epoch of South America, and that the earthquake of May 9 was much greater for the Loa River than any it had experienced for many centuries.

In Chichiu, a village located 45 miles from the volcano of San Pedro de Atacama, which was built on a rocky terrain, was completely demolished, leaving its remains as if cut with a chisel. On the ground and near the volcano, according to travelers surprised by the earthquake, the stones were seen jumping from the ground with the tremor, making one suspect that this region was near the center of commotion. Flares were perceived that illuminated the desert; but the versions about this phenomenon are not in agreement, neither about the eruption of the San Pedro volcano. The Llullaillaco volcano spewed smoke from its old crater.

The flares were perceived according to some a moment before the earthquake, and according to others during the great shaking of the earth.

In Calama, an inland place, the earthquake was terrible; its humid and flabby ground sank somewhat and the Loa river stopped its course for 24 hours. The earth at the time of the phenomenon, seemed completely hollow under the plants of the observer, as was observed in Antofagasta.

PUNTA DE LOBO... { Latitude S. 21°05'
 { Longitude W. 70°13'

Extracting the data concerning the Peruvian coast that we were able to compile, it turns out that the earthquake and the tidal surge wrecked the ships *Shamrok* and *Marie Antoinette*; 3 more were abandoned and 7 were dismantled. The losses of life were few; but the tidal surge and the direction of the movement are not recorded, leaving blank the time of the phenomenon and all other details that could have shed some light.

PABELLON DE PICA... { Latitude S. 20°57'
 { Longitude W. 70°51'

⁴ Note by Vidal_Gormaz: This time is clearly false.

The governor of the guano exploitations of Pabellon de Pica, reports on 12 May as follows:

"I have the regrets to communicate that in the night of the 9 current, at 8^h15^m P.M., a strong movement of earth initiated that lasted consecutively for the space of 5 to 6 minutes, increasing gradually in force, and resulting in the almost instantaneous fire of Chanabaya, fire that the sea came to dominate immediately, which invaded by 6 times the population, dragging in its reflux all the houses and buildings of the administration that are in the elevated part; the sea could not destroy them, but boarding docks, loading tools, hydraulic machine and fountains have disappeared. All the ships, with few exceptions, have collided with each other, causing notable damages; up to this date 6 have been wrecked, which were thrown to the beach. It is still unknown what kind of personal misfortunes have occurred. In Pabellon, 33 workers were buried under the sand as a result of a landslide.

"The movements of earth after this terrible event have continued and up to this moment (day 12) they are felt, but their intensity decreasing. At the Punta de Lobos depot, the same events have been repeated, leaving the administration houses destroyed without personal misfortune; the shipping docks in a very bad state and two ships lost.....

El *Porvenir* del Callao of 16 May adds: "Throughout the rest of the night (of the 9th) there have been very strong quakes with intervals of seconds, which increases the fear.

"Up to this hour, 11^h30^m A.M. of the 10th, quakes repeat every 5 minutes.

".....The ships that did not leave were rendered unable to sail."

The real port of Chanabaya that had four blocks of destroyed buildings, where the commerce was located in a high plateau at the foot of the hills; at the moment of the earthquake the people ran to the hills, but the stones detached from the top rolled vertiginously toward the chasm causing numerous victims and injuring many.

Moments later, a fire broke out due to the fall of the kerosene lamps, a new enemy that set fire to several points of the destruction caused by the earthquake.

The people, somehow recovered from the surprise, descended to attack the voracious fire, and when they managed to suffocate it in part, the sea entered, roaring frightfully, rushing over the population, forcing the workers to run towards the hills to flee from the third enemy, not without leaving many of them among the debris, perishing drowned by the sea.

Until the 15th the sea was rough, and according to the *Nacional* de Lima of 13 May, more than 200 people had perished drowned.

IQUIQUE... { Latitude S. 20°12'30"
Longitude W. 70°14'00"

At 8^h18^m P.M. a dull and formidable underground noise was felt in the direction from S. to N. which was soon followed by a small shaking of the earth in an oscillatory direction. A few seconds later the earth oscillated in such a violent way that it was almost impossible to stand upright, declaring a real earthquake which terrible consequences were not to be expected for a long time.

The movement continued for about 3 minutes, each time with greater force, causing considerable damage to several material buildings, from which some pieces of wall collapsed, as well as immense damage to hotels, grocery stores, china stores, etc., from which shelves bottles, glass and tiles fell, shattering into a thousand pieces.

Falling kerosene lamps caused the fire, and the sea immediately came out with tree-covered waves of 3 meters high that swept over the buildings.

The sea swept the entire stretch of the coast from Puntilla to El Morro.

More than 3 miles covered before by magnificent buildings, large warehouses, industrial establishments, powerful centers of commerce, animation and life, presented the terrifying spectacle of piles of ruins mixed with the debris that the sea did not cease to throw on the beach.

The sea concentrated all its fury in the northern part of the town called *La Puntilla*, where the most valuable establishments that Iquique had in the saltpeter industry were located. That part of the population has been completely devastated.

The Morro neighborhood has suffered as much or more, if you will, than *La Puntilla*. All the docks have disappeared.

On land there were no casualties; but not so in the navy. Many were the unfortunate ones taken by the sea. The havoc in the bay was immense.

A German ship loaded with saltpeter sank, another went to the beach; the tanker went to the island and was left dry, with the same fate befalling a brigantine. An infinite number of smaller vessels and many schooners sank, leaving the sea covered with debris.

Another version. - Iquique, May 10.....

"It was 8^h16^m P.M. The earthquake began with a dull and prolonged noise, which was joined by a strong shaking that increased until it produced a shaking so strong that it was impossible to stand up.

"It was estimated to last 2 minutes, more or less. It was longer than the one in 13 August 1868, but not as strong as this one.

At the moment, terror seized all the spirits, made more frightening by the yells of "help! fire! the sea is coming out!" that women, men and children shouted.

"It is indescribable what happened at that moment when you could feel the buildings creaking, lamps, glass, bottles and all the glass objects inside the houses wobbling from their base.

"All of them could do nothing but save themselves, abandoning when they had and leaving their doors open.

"The earth was still shaking to the sound of a dreadful underground noise, when the voices of fire! fire! fire! were heard in the four corners of the city.

"We cannot express what we all felt, when we found ourselves under the pressure of two calamities that seemed to dispute the primacy; the fire and the sea. We did not know whether to abandon everything to save ourselves from the sea or from the fire.

The fire started 7 blocks from the sea (875 meters, more or less) and two of the pumps had to be placed on the beach to give water to the others; but when the operation began, the screaming "The sea!" went out.

"The sea swallowed the two pumps and their self-sacrificing firemen had to flee to save their lives; for an immense wave that invaded the coast swept away everything in its path.

"The picture offered by the city and its inhabitants cannot be painted, nor can our pen.

"To see the streets full of men, women, children and old people shouting, crying, invoking Providence and calling, who for his wife, who for his children, who for his parents, can never be explained by poor human language.

"The population camped from the house called *Jibraltar*, of Mr. Romero, to the distance of two leagues (9 kilometers) from this port, on the slopes of the hills.

"Only terror could have driven so many to cross the cold, sandy plain and the rocky slopes.

"The earth tremors continued every 5 minutes, more or less alarming; meanwhile the sea was destroying everything in its path.

"What a dreadful night, and what eternal hours we spent until daylight came!

MOLLE... { Latitude S. 20°20'
Longitude W. 70°12'

In this cove the sea totally destroyed the holds of Ugarte, Cevallos and C^a and J. Gilmeister and C^a, with large stocks of saltpeter. There was one victim and heavy casualties in the two ships anchored there, due to collisions between them, due to the strong ebb and flow of the sea.

PISAGUA... { Latitude S. 19°34',5
 { Longitude W. 70°14',5

The earthquake caused in Pisagua great damages in the railroad and its accessories; but it has not been possible for us to acquire details. It was later learned that the earthquake took place off Pisagua at 8^h20^m P.M. according to the observation of the captain of the steamship *Eten*, which was wrecked a short time later on the coasts of Aconcagua and is the most reliable time.

After the catastrophe of May 9, the correspondent of the *Comercio de Lima* in Pisagua, says: "June 19, 1877 - Not many days ago a surprising physical phenomenon took place in this port, which has worried many and alarmed everyone.

"People who witnessed this singular event, say that about 50 meters from the beach appeared in the sea a thick column of smoke, rounded at the top, which was successively rising to a very considerable height, which dissipated shortly after without producing noise or detonation.

"If we are to believe the captain of an English ship, it turns out that Pisagua is on an ancient crater, due to the special configuration of its bay as well as the excessive and incalculable bottom that it still has near the shore.

"A very knowledgeable pilot of this port, as he has been exercising his trade there for many years, says he was surprised, a few days ago, to see that the anchor of a ship gave bottom in 10 fathoms of water (18.2 meters), when before in the same place the bottom was reached only at 45.5 meters.

"I and others observed here another phenomenon: the land has lowered considerably since the earthquake of the 9th; today it bathes in the high tides lands and rocks that have always been dry and with some buildings".

It is sensitive that such important facts have not been ascertained with precise studies and appropriate measurements, because this phenomenon of subsidence on the coast, as well as the uplift of the bottom of the bay, would shed much light on geology.

MEJILLONES DEL PERU... { Latitude S. 19°51'
 { Longitude W. 70°11'

The entire lower part of the city was swallowed by the sea; several entire families perished.

CABO LOBOS... { Latitude S. 18°45'
 { Longitude W. 70°23'

The earthquake and sea movement was terrible, but there was little loss of life.

It is regrettable the lack of details on this point and the preceding one. We have not been able to find the time of the phenomenon or to know how the various events unfolded.

BAY OF ARICA... { Latitude S. 18°28'
 { Longitude W. 70°20',5

The sea came out making great damage to the Salinas railroad. A boat was lost, and the sea was experiencing great ebb and flow.

PASAMAYO... { Latitude S. 11°30'
 { Longitude W. 77°14'

There were five landslides in the port; but no details could be obtained about the sea and the earthquake.

PACASMAYO... { Latitude S. 7°25'
 { Longitude W. 79°34'

The phenomenon was also experienced in this port, but no data was received.

Sometime later it was reported that the seismic wave had reached the Mexican coasts in a sensible way; but we were not able to obtain certain details.

IV.

MEDITERRANEAN TOWNS OF BOLIVIA AND PERU

CITY OF LA PAZ (Bolivia)... { Latitude S. 16°29'
 { Longitude W. 68°11'

The tremor of the 9th was felt very strongly in La Paz, but did not cause any damage.

COROCORO (Bolivia)... { Latitude S. 17°12'
 { Longitude W. 68°30'

The tower of the church of Corocoro was knocked down by the tremor.

DESAGUADERO (Bolivia)... { Latitude S. 16°32'
 { Longitude W. 69°03'

The tremor caused the houses to suffer a lot.

SANTIAGO DE MANCHACA (Bolivia)... { Latitude S. 17°02'
 { Longitude W. 69°12'

The earthquake was strong and made the church collapse. The time is not given.

TACORA (Bolivia)... { Latitude S. 17°43'
 { Longitude W. 69°47'

It was said, according to information from a muleteer, that the tremor of the 9th caused the colossal mountain of Tacora to collapse.

TACNA (Peru)... { Latitude S. 18°00'
Longitude W. 70°18'

According to *El Porvenir* del Callao of 19 May: the 9, a little before the sea left Arica, a strong and prolonged tremor was felt in the city of Tacna, which fortunately did not cause more damage than a deep alarm in the population, in spite of having the intensity of an earthquake.

According to the *Revista del Sur*, "it had been many years and perhaps as never before that Tacna had not received such copious and continuous rains.

"From the day of the catastrophe to date, the sun has not let us feel its burning rays. It was only yesterday, Saturday, and for a moment it was visible, but immediately it gave way to the clouds that, pregnant with water, do not cease to hover over our heads.

"There is no building left where water has not penetrated... The rains continue.".....

AREQUIPA (PERU)... { Latitude S. 16°24'
Longitude W. 72°01'

According to communication of the prefect of Arequipa, this city is located 23 leagues from the coast and that of Nueva Carolina at 11, is in ruins.

"This makes (he says), with foundation, to suppose that the terrestrial commotion has had its center in the interior of the continent and in the region that includes Tarapacá, Iquique and Arica.

"It is believed, and perhaps not very unwisely, that the cause of all the calamities of the S. is in the volcano Llaga, situated in the mountainous region of our (Peru) limits on the S. with Bolivia. "

HUANTACONDO (PERU)... { Latitude S. 20°51'
Longitude W. 68°47'

We extract the following details from the *Estrella* de Iquique:

The tremor of the night of the 9th lasted 2 minutes in the small town of Huantacondo, destroying with its impetus most of the rooms. It was followed by a dreadful darkness caused by the dense dust that rose and the cliffs that with dizzying rushed from the hills to the bottom of the valley. A rain of fire could be seen falling in the midst of the darkness, which was nothing more than sparks produced by the stones as they violently collided with each other in their swift rush.

At the time of the catastrophe, two loud detonations were felt on the shore side in succession, like those produced by the boom of a cannon.

The oscillation was from NE to SW.

The day after the earthquake there was a big windstorm and on the 13th there was a heavy snowfall that lasted until the end of the 15th.

TARAPACÁ (PERU)... { Latitude S. 19°56'
Longitude W. 69°35'

According to *El Porvenir* del Callao, of the 16th, the earthquake caused considerable damage, destroying two thirds of the population. There were no victims.

The newspaper *La Reforma* estimates the losses caused by the earthquake at 300 thousand pesos.

MARQUESAS ISLANDS

(From the *Messenger of Tahiti*, of June 1, 1877)

"News of great interest has been received from the Marquesas Islands by the last mail. The excessive dryness has produced there, as elsewhere, the opposite extreme, flooding. The rainy season began in the middle of March and still reigned the last 20 of May.

"The persistence of the rains has been such that the rivers have acquired a violence that, according to the oldest inhabitants, they have never seen before. From 10 to 18 May, above all, the weather was variable. All the streams of water overflowed because of a real deluge that overflowed on Nukahiva. The damage was considerable. The Vaitu bridge, the only one that had held up until then, was washed away. The Queen's River completely devastated the road leading to the Oata valley, as well as part of the mission. The road leading to the French valley is completely washed away. The amount of stones and debris that has accumulated there is incalculable. The bay of Akapei, where the residence is located, has been for several days nothing but a vast torrent.

"The water ran to overflowing in the surroundings of the residence; a part even of these surroundings has been taken away.

"The Ocean has also played its part in this weathering. A well-characterized tidal wave hit the shores of Nukahiva. Fortunately it was not very strong at Tahio-ac. On the 10th, about 4 o'clock in the morning, the sea, otherwise calm, left its bed and advanced to the beach road, which it completely covered. It then retreated until it left dry a space of 20 meters beyond the last piles of the pier. At once an oscillatory movement took place. Suddenly the sea was very low, suddenly very high. This seesawing motion lasted all day. The average difference in level is estimated at about 4 meters.

"The tide has been most violent at Anaho, in the N.E. part of Nukahiva, where it has caused damage. Several European buildings, among others a house belonging to M. Hart, have been swept away by the sea, which has gone as far as 200 meters into the land. The employees of M. Hart, awakened at once, barely had time to run at full speed to the mountain.

"This extraordinary movement of the sea has made itself felt, it seems, throughout the archipelago and with different characters.

"Thus at Vaithan and Puaman no oscillatory movement has been observed, as the sea has been very low all day (May 10).

"Public and private buildings are in imminent danger because of this continuous humidity. The inhabitants literally live in water, which penetrates everywhere. However, they seem to look at things very philosophically, and consider the present rains as a good for the country, which had suffered from the dryness for so long a time. "

In including the part of this document relating to rainfall, we have sought to compare this year's rainfall with that of the Marquesas Islands.

"On May 10, according to *El Deber de Valparaíso* of June 13, a tidal wave visited the coast of Mexico and washed ashore in the State of Guerrero. In Acapulco the water rose up to the main square. "

In Tahiti Island the overflowing wave was not felt, but in New Zealand it rose 1.5 meters, 24 hours after in Cobija, reaching also the eastern coasts of Australia.

VI.

CURRENTS IN THE SEA ALONG THE WEST COAST OF SOUTH AMERICA AND OTHER PHENOMENA.

The Chilean ship *Maria Luisa*, which was about 100 miles from the coast and on the parallel of Taltal, 25° 24' S. latitude, experienced the earthquake at 8hs. 30ms P.M. on the day of May 9th; calculating a duration of 5 minutes. No current was perceived.

The Nicaraguan boat *Delfina*, according to her captain, experienced in the days 9, 10 and 11 May, a strong sea current from N. to S. On the 10th she was at 32° S. latitude and 74° W. The wind was from the south, chilled and the barometer marked 30 inches 08, English scale.

The Nicaraguan boat *Aguila*, according to its captain, says that on May 11th, being off Puerto Nuevo de San Antonio, 20 miles away, she noticed a strong current in the sea from N to S, which dragged her 50 miles to the S. The wind was south and the ship was heading for Valparaiso.

The English ship *Atacama*, which anchored on May 23rd in Valparaiso, arriving from Pan de Azúcar, being on May 10 at 50° S. and 76° 30' W., had a furious gale from the SW. which caused some damages, time that agrees with other versions and with what was stated by the maritime governor of Punta Arenas de Magallanes; but he did not feel the tremor.

It is very sensitive not to have detailed the report, and it has not been possible to complete it.

The Tahitian brig *Tawera* reports that on May 8th (t.a.) she felt a very strong tremor, being at 35° 30' S. and 102° 32' W. The tremor took place at 4h P.M.

The Republic's corvette *Chacabuco*, which was on a voyage from Valparaiso to Juan Fernández, did not feel any tremor on May 9th, and no movement at sea was experienced on the island, as she was able to confirm in the port of San Juan Bautista. Only on her return to Valparaiso did she learn of the earthquake.

This proves that the seismic wave propagated along the Chilean coast, without reaching the 78° W., notwithstanding the facts cited for the Sandwich and Marquesas Islands.

The correspondent of *El Deber* de Valparaiso who was traveling on the steamer *Abtao*, commissioned by the Chilean Government to give aid to the populations destroyed by the earthquake on the coasts of Bolivia and Peru, affirms that a week after the earthquake some neighbors of Tocopilla found on the coast the flagpole of the port captaincy of Mejillones of Bolivia and "also some rails of the railroad of that city." If this fact is true, it would demonstrate the existence of a strong coastal current and certainly contrary to the one experienced in Antofagasta and other points of the Chilean coasts, noticed by the *Blanco Encalada* and other ships. The shape of Mejillones Bay may have caused this strong countercurrent. Tocopilla is distant from Mejillones de Bolivia 62 miles to the N.

The *South Pacific Times* of Callao, after reporting the shipwreck of the English steamship *Eten*, adds the following, which justifies the currents and phenomena that occurred in the sea due to the earthquake of May 9th, not less than the duration of those.

"Captain Mills of the English steamer *Lima*, says: that during his last voyage from Valparaiso to Callao he experienced an extraordinary current that dragged the steamer towards land. This forced him to change course several times to get away from the coast. On the previous voyage she left Islai at the usual time and set a course N 69° W. He calculated to pass 5 miles outside Atico Point, and having sighted this point, he noticed that he was running ashore on the inside of the said point.

"He had, therefore, to change course 21° to the W. in order to escape the danger.

"During his voyages after the earthquake of May 9th, he observed strong currents that drew towards land with such violence that it was essential to be constantly vigilant, changing course to avoid the rocks. It is to be believed that the captain of the *Eten* did not observe this phenomenon in time, and as the night he left Valparaiso it was raining and there was a thick fog, not being able to see the land, he made his ordinary course and the current we have spoken of would drag him towards the rocks of Ventanas Point. There is no doubt of this conjecture if one looks at the *Lima's* logbook.

"Some other commanders have observed the same current, and although it cannot yet be known whether this phenomenon will continue, it would be advisable for those who have not had occasion to observe it to take note of what has been said, in order to march with greater security.

"In almost all the ports between Callao and Valparaiso, Captain Mills says that the sea has been very rough. On June 15 the steamer *Lontué* was unable to communicate with land. The passengers going to the S. had to go to Pisco on the *Lima*, to wait there for the S. steamer.

"The sea was so rough at Chañaral that the boats could not hold alongside the steamer. This agitation did not have the same aspect as on other occasions, as it appeared in different directions and with violent and irregular movements.

"Some tremors are still felt on the coast.

"On July 8, something resembling the northern lights was seen in the atmosphere, in the direction of the mountain range. It is not known whether this phenomenon was caused by some great fire in the mountains or by some volcanic eruption.

"On the 10th, at 7^h25^m P.M. a very strong quake was felt accompanied by a great noise; it lasted about 7 minutes and it is probable that it caused some damage on the coast.

"On the 13th at 3^h50^m A.M. On entering the port of Cobija, such a strong and prolonged shock was felt that the captain of the *Lima* decided not to anchor. It passed soon, and at 1^h50^m P.M., while between Cobija and Tocopilla, another very strong tremor was felt at 8^h30^m P.M.

"The rains continue to fall on the coast, as a result of which many places that are usually dry and completely devoid of vegetation are covered with greenery.

Finally, the commander of the Republic steamship *Abtao*, which traveled the coasts of Bolivia and southern Peru, after the earthquake of the 9th, until the end of the month, repeatedly noticed unusual swirls of currents and marked scouring in the sea, which could only be attributed to the upheavals caused by the cataclysm of May 9th.

Santiago, November 1877.

F. V.G.