NEWSLETTER

FROM

SEISMOLOGICAL SERVICE OF CHILE

XVI

YEAR 1922

ATACAMA EARTHQUAKE

By

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Workshops of "El Diario Ilustrado".

SANTIAGO DE CHILE

1926

Transcript C. Vigny 13/2/2024

THE CHILEAN SEISMOLOGICAL NETWORK

The main seismological observatory is located in Santiago and has the following geographical coordinates:

Lat. - 33° 26' 42" S.
Long. - 70° 41' 34.5" W. of Gr. - 4h. 42m. 46.3 s.

and is located at an altitude of 581.18 meters above sea level. The subsoil is composed of trachytic-basaltic and andesitic rocks.

The instrumentation consists of the following pendulums:
Two Stiattessi horizontal components.
Two Bosch-Omori horizontal components.
A Wiechert pendulum, with two horizontal components.
A Wiechert pendulum, vertical component and other minor instruments.

The seismological network of the country, is still incomplete and consists, at present, besides this main observatory, of two third order stations, located, one in Copiapó with a horizontal Wiechert pendulum of two components and 135 kilos of weight, and the other in Osorno, with an equal pendulum. In addition, 15 Agamennone sismoscopes have been distributed in different localities; but their information is irregular, not being able to demand better attention from the observers, since they are people who have volunteered benevolently for this.

The Dirección de los Ferrocarriles del Estado, graciously contributes to the formation of this seismological network, for which it has ordered the Chiefs of all its stations to send their seismic observations on a monthly basis.

Likewise, the Drinking Water and Sewage Inspectorate has ordered some of its Administrators in various cities of the Republic to observe seismic phenomena and to send the information collected to the Seismological Service.

These two Public Departments deserve our gratitude and that of seismological science in general, since they contribute to form that wealth of observations, which is indispensable for this new science to advance its investigations, on the real and true basis of the phenomena that have occurred.

Thus, by gathering all these observations and leaving aside the doubtful ones, we have been able to count this year with a number of approximately 3,000 valuable observations, which have served to form this Bulletin.

"Carlos Bobillier,
Director of the Seismological Service of Chile.

THE SEISMICITY OF CHILE DURING THE YEAR 1922

In the year 1922, 823 earthquakes and 70 microearthquakes were registered in Chile. The month of greatest seismicity was November, with 390 tremors, and the month of least seismicity was June, with only 7 tremors.

The distribution of the instability in Latitude, presents a pronounced maximum in the seismic focus of Copiapó, with 584 tremors and two secondary maximums that correspond: one to Santiago with 195 tremors and the other to the departments of Vallenar and La Serena, with 123 tremors. The region of the country north of the 23° parallel has remained calmer.

The most important seismic movement of the year was the Atacama Earthquake of November 10 at 23h. 53m. 30s. (Chilean official time), which caused enormous damage in the cities and towns of the province of Atacama, as detailed below. Its meridian macroseismic extension was 2,400 kilometers, from Pisagua to Chiloé. The isoseist of the maximum degree (X to XI of the international scale) includes all the valley of the Huasco, since greater destruction is noticed in the constructions of Vallenar and Freirina, that in the similar ones of the valley of Copiapó. On the coast the destructive action of the earthquake has been much less, probably due to the fact that the populations are built, in many parts, on a rocky subsoil and also because most of the constructions are of wood or of light materials, better tied than in the buildings of the localities of the interior, which in some cases lacked even foundations.

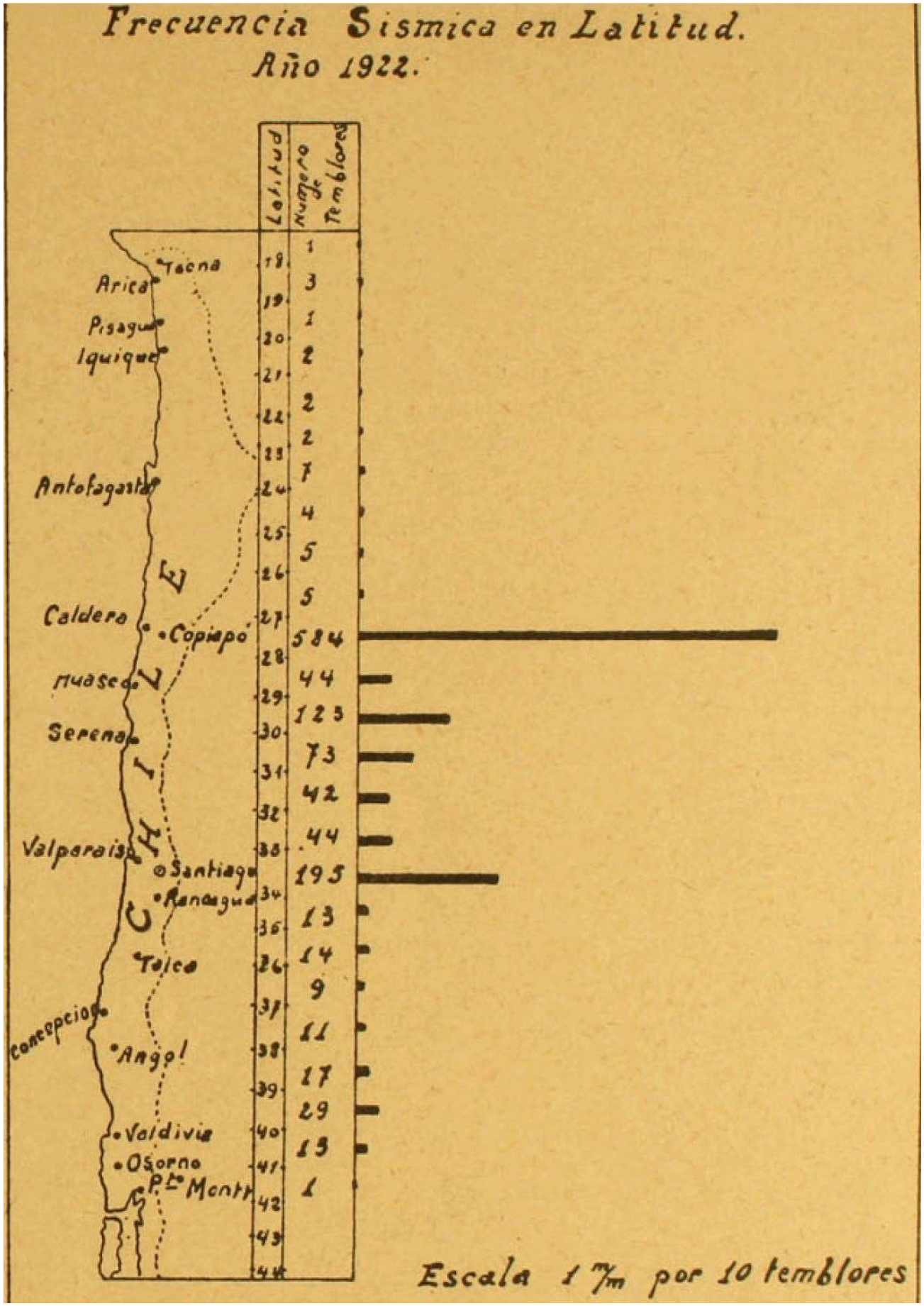
This earthquake was followed by a tsunami, which struck the coast causing great damage in the ports of Chañaral, Caldera, Huasco and Coquimbo. The main movement of the waters of the sea comprised three flows and three consequent ebbs; the first took place 20 minutes after the earthquake and was not in the form of a violent wave, but the waters began to rise with some speed, but without its speed being greater than the slow march of a man; the most violent movement of the waters was the second ebb, producing, then, a withdrawal or precipitous descent of the waters that continued below the zero level, thus originating the third flow that was the largest. In Chañaral, Caldera and Huasco the maximum height of the waters was 5.50 meters above zero and in Coquimbo + 4.60 meters. [1] In these ports, the greatest damage was caused by the tidal wave and due to the fact that the sea flooded some towns and low neighborhoods, causing light wooden constructions to float and causing them to collide with each other due to the ebb and flow of the waters.

This unusual alteration of the sea was felt from the coasts of Peru to the Chiloé archipelago.

The entire area affected by this earthquake continued to have high seismic activity throughout the rest of the year.

It is worth noting that this earthquake of November 10, was preceded by a strong earthquake of grade VII, which shook the same area on the 7th at 18h. 22m. (Chilean official time) and continued shaking in Copiapó three more times on the 7th, four times on the 8th and twice on the 9th.

[1] Report of the Engineer of the Public Works Department, Mr. Eduardo Aguirre


Frecuencia Sísmica en Latitud.
Año 1922.
Latitud
Número de temblores
Tacna
Arica
Pisagua
Iquique
Antofagasta
Caldera
Copiapó
Huasco
Serena
Valparaiso
Santiago
Rancagua
Talca
Concepción
Angol
Valdivia
Osorno
P.to Montt
CHILE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
1 3 1 2 2 2 7 4 5 5 584 44 123 73 42 44 195 13 14 9 11 17 29 13 1
Escala 1 7m por 10 temblores

THE ATACAMEÑO EARTHQUAKE AND TIDAL WAVE

The Earthquake

On November 10 at 23h. 53m. 30s. (Chilean official time) or at 4h. 36m. 16.3s. Gr. of the 11th, the sensitive movement began in Copiapó; at that instant the telegraph offices of Vallenar and Copiapó were in communication; Vallenar was sending and 14 the 23h. 53m. 20s. said "it is shaking" when the telegraphist who was listening in Copiapó did not notice the slightest oscillation; so that there has been a difference of 10s. in the initiation of the tremor between these two cities, which are 141 kilometers apart.

The cities of Copiapó, Vallenar and part of Freirina are located on inconsistent soil and are generally made up of poorly constructed and poorly preserved buildings. Most of the houses are made of adobe or mud walls, with partitions of slats, cane or branches covered with mud and with visible construction defects, so they had to suffer great damages and misfortunes.

There were no fires in Copiapó, Huasco or Freirina; in Vallenar there were two fires and an oil lamp fire. They were soon extinguished.

We must say that we have no instrumental observations, because the Wiechert pendulum of the Copiapó Seismological station overturned and broke and in the instruments of the Santiago Observatory, which were then used without damping, the needles jumped from the first moment crumpling and tearing the papers. Only an imperfect seismogram could be obtained and this was provided to Mr. Bailey Willis, an eminent geologist who was commissioned by the Carnegie Institution, to study this earthquake in the same field.

Only the next day was it possible to finish arranging the instruments.

Copiapó. - The Chief of the Copiapó seismological station, Mr. Luis Sierra, who was calm enough to observe the different phases of the phenomenon, says the following: At 23h. 53m. 30s. a formidable noise of 5 degree began, similar to a strong thunder that woke up those who slept and filled with terror to all. Immediately began an earth movement of V.o. intensity (Rossi-Forel scale) that lasted about 30 seconds, increasing the intensity to VIII degree for about 20s. and then came the oscillations of the maximum degree that lasted three minutes: then the intensity decreased little by little to IV or II degree for several minutes, to increase to VIII degree and to decrease, finally, definitively. In total, the tremor lasted or was sensitive to man for about eleven minutes.

The oscillations were sometimes horizontal, sometimes vertical, undulating, in all directions. During the main phase, the ground shuddered suddenly and violently, it was tossed like a sea of raging waves. The ground cracked in a NW. to SE. direction and missed the feet of the inhabitants. The cracks were many meters long and from 3 to 10 centimeters wide. Many people were falling because they had lost their balance and many were holding on to other people. We noticed violent and very violent vertical movements from NE. to SW. Buildings swayed in all directions and, yielding to the violence of the movement, collapsed, throwing their roofs to the ground and forming confused heaps of ruins. During the greatest violence of the earthquake, some lightning or electrical discharges were observed to the NW. The noise that accompanied the tremor, the roar of the falling buildings, the creaking of the ground, the panicked screams of the inhabitants, the cries of the wounded, etc., formed a horrifying and indescribable picture. The electric light, telephone and telegraph poles, when overturned in large numbers, threw their wires to the ground and made it even more difficult to walk through the streets. The population remained all night in the streets, promenades, squares and neighboring hills, in the open air.

The Wiechert pendulum of the seismological station overturned and lay long and wide on the floor. The doors of the apartments of the Liceo Fiscal, a building that resisted the earthquake, opened with a clatter, several plates jumped, breaking the drawers and loosening the screws. The small tower of the school "Bernardo O'Higgins" pulled from the SE. towards the S. The cemetery was devastated by the earth movement; the discovered corpses and a pestilent atmosphere formed a macabre picture. Many

mines in the Copiapó department collapsed. On the railway line between Copiapó and the port of Caldera, the rails were separated, in some sections, up to five meters.

The buildings in the city of Copiapó suffered damages that are estimated as follows: 40 eye of the houses on the ground; 45% standing, but in a state of demolition; 15% in good condition or easily repaired. The monuments of "Atacama", "Manuel Rodriguez" and "O'Higgins", fell from their bases in NE. to SW. direction. The few reinforced concrete constructions, such as the drinking water tank in Copiapó and a tomb in the cemetery, resisted perfectly well without showing any cracks.

Casualties in Copiapó: 70 dead and more than 100 injured.

Tierra Amarilla. - All the rooms were left in terrible condition and many were completely destroyed. The railway line was removed and sunk in several parts, the telegraph line was destroyed. Casualties: 4 dead and several wounded.

Caldera. - In this port, the buildings are generally made of wood and calamine (galvanized iron), so they were able to withstand the strong oscillations of the ground. The damages suffered were caused by the tidal wave.

Chañaral. - At 23h. 55m. 00s., according to the Governor's report, a subway noise was felt coming from far away and an earth movement of somewhat slow oscillations, but of sufficient force to alarm the entire population that fled out of their rooms. In this port, as in Caldera, the tidal wave caused all the destruction.

In the interior of Chañaral, the Potrerillos Mineral railroad was destroyed in several sections due to landslides. The same thing happened on the telegraph line.

Vallenar. - Undoubtedly, the earthquake was much stronger in Vallenar than in Copiapó. It started with a vibrating noise, as if coming from the Andes mountain range, followed almost immediately by the earth movement, with very fast oscillations, very strong and without a fixed direction, in the form of a whirlwind. Mr. Moya, teacher of the Commercial Institute of Vallenar, says: "My wife had not gone to bed and opened the door immediately when the tremor started, however, the house in front was already on the floor. This gives the idea of how strong the tremor was from the first second. The force of the movements was so great that it was difficult to stand upright; there were some who grabbed hold of a tree and it seemed to them that someone was pulling them off first in one direction and then in the other. I cannot exactly estimate the duration (of the oscillations of the maximum degree), but I think it prudent to estimate 3 minutes. It continued to shake, at intervals, all night and the next day. Afterwards they have subsided, "but do not go below 5 to 6 tremors a day." (Letter of November 18).

The city was totally destroyed, leaving standing, but in bad condition, very few buildings. The church and the Prat theater remained in good condition. The drinking water tank of Vallenar, built of concrete with good cement, in spite of being on a soil of the Huasco River, withstood the earthquake very well in the buried part, but it presents tears along the line of the lintels of the windows that have the walls at little height from the ground.

Numerous cracks were opened in the ground, in some parts of 1 meter deep, 20 to 30 centimeters wide and 15 to 20 meters long. Between the cracks many cones of 15 centimeters high were formed, with a small mouth at the vertex as a crater, composed of very fine sand. The streets were filled with debris and it was not possible to walk on them. The drinking water cannons were broken and the irrigation ditches were erased by the debris. The river supplied water to the inhabitants. The railroad service suffered enormous damage, especially on the lines to Huasco and La Serena. 4

According to some inhabitants, there was a terrible subway noise during the tremor and it continued for a long time afterwards.

Casualties: The population of Vallenar, with approximately 8,000 inhabitants, had 550 dead and 1,000 injured.

Freirina. - Forty percent of the houses were ruined, the rest were seriously damaged. Roads were interrupted and the railroad line that connects to Vallenar and Huasco was severely damaged.

The Freirina church, built of reed partitions, shows minor damage.

Casualties: There were 18 deaths and about 100 injured. In the entire department of Freirina, the dead total 60.

Huasco. - Some neighbors say that during the tremor it was impossible to stand up and open the doors to get out. Numerous cracks formed on the road to Vallenar and it was impassable. There were landslides of hills. On the railroad to Vallenar, the ground sank in some parts, leaving the line in the air; in other parts the ground slid, forming curves where there were none or straightening those that existed.

Victims: In Huasco there were 8 deaths.

Huasco Bajo. - The population was very deteriorated.

Casualties: 12 dead and several injured.

San Felix, El Transito, Alto del Carmen, Juntas and Pampas. - These towns were isolated from the large centers, without resources and with roads, telegraph and telephone lines interrupted,

Carrizal Alto. - The population suffered great deterioration.

Province of Coquimbo

La Serena. - The very strong earth movement lasted about five minutes and was of the same intensity as the earthquake of 1918 (May 20), which destroyed some buildings.

The population suffered many damages. Thirty houses were reduced to ruins; the building of the Intendancy was left in bad condition; in the barracks of the Arica Regiment the pavilion of the infirmary was destroyed; the telegraph and telephone poles fell down, the electric light was cut. There were several wounded.

Vicuña. - The buildings of the Governor's Office, Police Headquarters, High School and others were left in ruins. The other buildings of the town suffered considerable damage. There were no personal injuries. -

El Tofo (ore). - With serious damages.

Cruz Grande. - With serious damages.

Chungungo. - Several houses destroyed

Tongoy. - The buildings were left in poor condition. There were no personal injuries.

Elqui. - It caused many damages in the population. The buildings of the Governor's Office, Women's High School, Jail, Church, with many deteriorations.

Rivadavia. - The tremor was very strong, but did not cause considerable damage.

Illapel. - It was felt very strong, lasting three minutes; but it did not cause considerable damage. The tremors continued at short intervals.

The cities and towns south of Illapel were not damaged.

The Tsunami

A few minutes after the tremor (20 to 30 minutes depending on the localities), the tidal wave occurred, causing great damage and casualties along the stretch of coast between the ports of Chañaral and Coquimbo, that is, from Latitude 26° to Latitude 30°; but the alterations of the sea were significant from the southern coast of Peru to the island of Chiloé.

In general, the intensity of the earthquake has been much less on the coast, where the buildings resisted the shock of the earthquake without great damage, due to the greater firmness of the soil. A proof of this is the fact that the tall old chimneys of the old Edwards foundry in the port of Chañaral resisted the earthquake perfectly.

As we said at the beginning of this Bulletin. There were three outflows of the sea and consequently three ebbings; but these main movements of the waters of the sea, were followed by other smaller flows and ebbings, which did not cause damage and which became smaller and smaller and ended at about 5:30 a.m. on the 11th.

The first ascending wave was carried out without violence, as well as the following ones; it is said that in Coquimbo, the boys entertained themselves in walking backwards before the ascending wave, without the water reaching to wet their feet. The second flow took place 15 minutes after the first one, with the waters rising a little higher than in the first flow (+ 3.00 to + 2.40 mts., depending on the localities). The descent of the waters that followed this second flow was the most violent movement, since the sea retreated precipitously and descended below zero level (-5.80 mts. in Coquimbo); then the third ascending wave, maximum, took place around 1h. of the 11th, with greater rapidity; but without being violent; the sea rose this time + 5.50 mts. over zero in Chañaral, Caldera and Huasco; in Coquimbo it reached + 4.60 mts.

Alterations of the seabed in some ports - It was said that this earthquake and tidal wave had produced upheavals of the seabed and even of the coast. But the soundings carried out by the Navy's "Aguila" drill ship, showed that no such thing had happened. This scampvessel made a detailed study of the seabed in the port of Carrizal Bajo, and it was possible to verify a small subsidence of the sub-marine soil in the part of the sack of the port.

In Huasco the sub-marine level did not suffer any alteration. For the soundings made in 1923, by the same ship, agree with those of the survey of the plan of the port of Huasco, carried out the previous year (before the earthquake). The coastline extending to the SE. of the railroad pier, seems to have experienced a small subsidence; but this has not yet been verified by the Hydrographic Office, nor has it been ascertained whether the shape of the contour of the coast has changed at that site.

The soundings carried out in May 1923 in the port of Caldera, show that the seabed has not been altered, nor the contour of the coast of the port.

We give below the data that we have been able to gather on the proportions of the tidal wave in the different ports of the republic, ordering them from North to South.

Arica. - The sea became rough and came up to the shore of the Municipal Park on the south side and up to the Tacna railroad line on the north. It caused damage to the dock under construction.

Iquique. Sea agitation, without causing damage

Gatico. - Agitation without exit from the sea.

Antofagasta, - A few minutes after the tremor the sea made small outflows and at 1h. 30m. a great wave swept the place called de la Isla, flooded the passenger dock, the Resguardo, the baths and some houses of the Avenida del Brasil; then the

sea withdrew, leaving a vast portion of land dry and many small boats stranded. A few minutes later there were new outbursts of the sea that also caused damages.

Taltal. - About 20 to 30 minutes after the tremor, the tidal wave occurred, which carried away eight boats and caused other minor damage.

Chañaral. - A few minutes after the earthquake, at 12:15 a.m., the sea began to gather and made a slow, low outflow. This was followed by two other outbursts. The last one being the most formidable and destructive. This maximum exit of the sea must have taken place at 1h. 25m. in Chañaral; which is deduced of the report of the Ing. Mr. E. Aguirre that cites the case that a neighbor of Chañaral, that had its house to borders of the sea, put in movement its clock of pendulum that had stopped with the tremor; the waters in its maximum ascent reached to + 2.40 mts. on the floor of the rooms and they hid the clock that remained marking to 1h. 25m.

The sea invaded the entire lower part of the city, which is the most important part of the city because of its commerce, and caused the destruction of the commercial street "Merino Jarpa". The buildings of the Railway Station, the Maestranza, School No. 3, the foundry of the French Company, the theater, the pump, the hotels, etc. were also destroyed. More than a kilometer of the population, with a width of more than 500 meters was flooded, destroyed and reduced to rubble. Among the debris of the Savings Bank, the bottom box, weighing 5 tons, was found 15 meters from the place where it was located.

The enormous destruction suffered by the invaded neighborhoods, both in Chañaral and in the other ports, was due to the tendency of the wooden constructions to float, to the collisions of one with another and to the different pressures that their walls had to withstand due to differences in level between the exterior liquid and that which penetrated or had already penetrated into the interior. Referring to this last part, the engineer Mr. Eduardo Aguirre, already mentioned, says the following: "In constructions well joined to the water it was introduced very slowly to the interior, so that the greater height of the exterior liquid produced important pressures in the walls, Inversely, during the refluxes the water from outside withdrew with relative celerity and the interior took time to drain, originating pressures in the opposite direction to the preceding and much more dangerous, because the constructions ordinarily lacked elements to support horizontal thrusts directed from inside to outside, while in the other case the walls found support among themselves... Thus, the most common cause of the collapse of the best executed buildings was the rupture of the walls towards the outside, due to the effect of the water load that, when the sea withdrew, took a long time to empty. The destruction of the building of the store of the Sensores, Rubio Bros., in which the walls collapsed towards the street turning on the foundations, as if these had been a hinge, is an example of what has been explained. It was said of this construction, which was of reinforced concrete and as it was destroyed by the tidal wave, pessimistic judgments of the system were issued in the locality. In fact, it was made up of a weak iron skeleton, formed by right feet of two rails of 10 kilos per meter, with a filling of bad concrete without sand, of 0.25 mt thick. The panels between the right feet, when filled, had two cross suspenders of 25 mm square iron. The rest of the framework was made up of other iron bars, brackets, and poorly chosen and poorly placed connection plates of low resistance. The concrete, extremely porous, had a dose of cement only admissible in filling cubes and there was almost no interlocking of the walls with each other and with the roof, it goes without saying that there was not the slightest adherence between the iron and the concrete. Externally, the walls were covered with a thin expanded metal mesh, for stucco with a mortar plaster. The Torres y Cia. warehouse in Huasco was damaged for similar reasons. Another example of the destructive action of the sea by differences of level, are the damages caused in the abandoned building of the coal bunkers of the Navy in the port of Caldera; here the deteriorations have been produced with the first ascents of the water, because the fallen materials were thrown inwards and the walls are depressed in the same sense".

Victims in Chañaral: 16 dead and 4 missing.

Caldera. - In this port, as in the port of Chañaral, all the damages were caused by the tidal wave.

According to the maritime Governor, the first exit of the sea was at 0h. 10m. then the waters withdrew and advanced several times slowly, without producing great damages; but at about 3h. (?) of the 11 took place the greater flow that originated the flooding of the buildings of the guardhouse, customs, station, maestranza of the railroads, etc. In the railroad station, the water rose to + 2.40 meters above the ground, leaving very clear demonstrations, so it is calculated that this height corresponds to + 5.50 meters from zero. During the ebb, part of the foundations of the railroad pier were visible and in the maximum ebb, a good part of the hull of the "Blanco Encalada" was exposed, sunk in 25 meters of water. The customs building, which was made of wood, was detached from its foundations and was able to float, thus dividing into two parts; one turned 90.0 and remained standing, the main door facing the population; the other part went to collide with the station's warehouse and collapsed. Many railroad cars, detached from their bogies, sailed a long way. The schooner "Blanquita" and several smaller vessels were dragged towards the coal bunkers where they capsized.

Huasco. - The plant of the town of Huasco is at a certain height above the sea and was not reached by the tidal wave, but the Laja part of the port, between the town and the beach, where are the docks, warehouses, customs, was destroyed. The seawall suffered great damage. The hull of the steamer "Galvarino", wrecked some time ago, was thrown on the beach. The lowlands at the mouth of the Huasco River were flooded for an extension of 1 1|2 kilometers. The cargo launches and boats were swept away. There is no exact data on the times of the exits to the sea, because there have been no people who approached the beach, keeping only two inhabitants in the upper part of the population.

Peña Blanca (south of Huasco). - The sea swept away the few cesspools and the inhabitants escaped by fleeing to the top of the dunes.

Carrizal Bajo. - The tidal wave destroyed the railroad dock and the Smelting Co. suffered extensive damage to its facilities, locomotives, cars and electric motors.

The sea entered about 2 kilometers inland, causing damage to the railroad yard and station.

Coquimbo. - According to reliable observers, the first rise of the waters took place half an hour after the earthquake and reached + 2.30 above mean tide. A quarter of an hour later, the second rise of the sea occurred and another quarter of an hour later, that is to say, around 1 a.m. on the 11th, the third maximum rising wave took place, which reached + 4.60 meters. In some parts the sea rose up to 4 blocks, flooding the working class settlement of "Victoria", a neighborhood of about 200 houses, which were swept away by the waters. The tidal wave destroyed the warehouses and offices of the railroad, part of the seawall, and the passenger pier. Vicuña Mackenna Square, Maestranza Mac-Auliffe, The Coquimbo Agencias Co. sail factory, fishing company, refrigerator and radio-telegraphic station were damaged.

Victims: Due to the flooding and destruction of the town of "Victoria", 24 people died and some were injured.

Los Vilos. - The tidal wave destroyed a dozen fishermen's houses and a large part of the pier.

Other ports. - In Valparaiso and other southern ports, the tides were only exceptional, causing no major damage.

Effects of the earthquake on the San Felix and San Ambrosio Islands. - These islands, located to the west of Chañaral and 900 kilometers from the coast, are not inhabited by man, but there is an abundance of sea birds and fish.

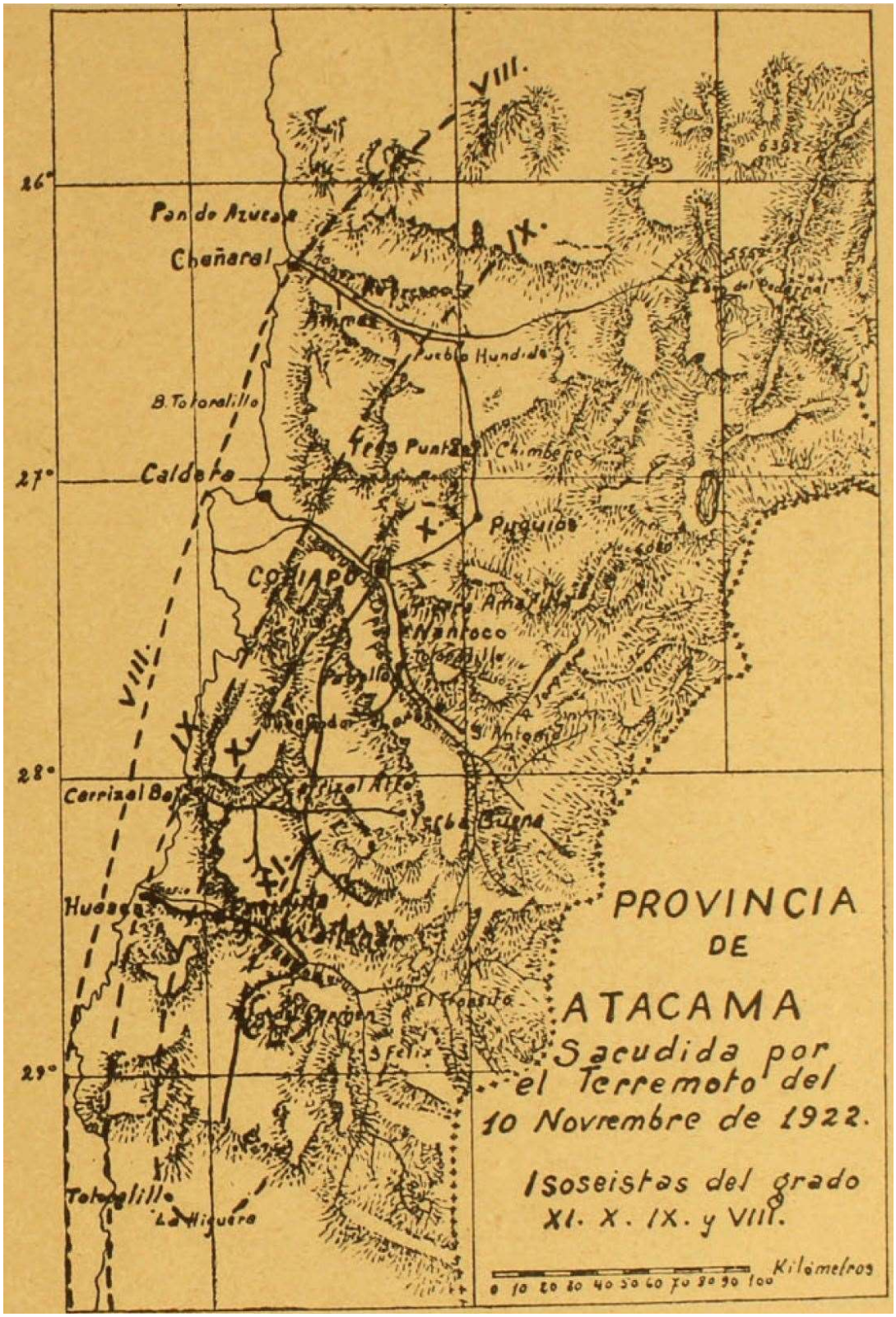
In April 1923 they were visited by the North American geologist Mr. Bailey Willis, who came to Chile commissioned by the Carnegie Institute to study in the field everything related to the earthquake. The Chilean Government provided Mr. Willis with the "Aguila" scamper of the Chilean Navy to visit these islands. The result of this visit can be read in the report that Mr. B. Willis passed to the captain of the "Aguila", which in its main part reads as follows: "The islands of San Felix and San Ambrosio are remains of currently inactive volcanoes. They represent minor parts of the walls of several large craters, one south of St. Ambrose, another south of St. Felix and a third where Peterborough Cathedral stands. Since there had been no lava eruption or change of form by volcanic activity for centuries, it follows that these ancient volcanoes cannot be considered as the "center" or origin of the earthquake cited."

"Not less, certain effects of the earthquake are demonstrated, sufficient to indicate a secondary relationship between the volcanic condition and the seismic movement. The cracks and the escape of gas in significant volume are attributed to the earthquake and thus explain the destruction of the colonies of birds and lobsters, formerly very abundant on the island; but now very scarce. Dead birds were found in various parts of San Felix, while the number of living ones was estimated at about 50 or so, The scarcity of lobsters was also ascertained during our stay on the island."

"Captain Stuart D. Campbelli and diver Mauricio Pardeñas, attest that last February there was still much seismic activity on the island of San Felix, accompanied by gas emanations sufficient to make the captain unconscious, and an elevated temperature in the waters near the north and east coasts, especially on the seabed. There is no reason to doubt these assertions, which are in agreement with volcanic conditions as well as with our observations, although the present activity is of a much lesser degree. Given an energetic seismic movement, as there surely was from time to time during the past months, it would necessarily have resulted in the escape of hot gas and consequently the death of birds and lobsters."

"The coincidence of the seismic activity, probably of high intensity, with the location of the volcano, is not accidental. From studies of Coquimbo, Vallenar and Copiapó, as well as Potrerillos, it is known that the earthquake was felt with greater intensity in certain areas marked by geological faults, i.e. by tight cracks hundreds of kilometers long and several kilometers deep in the mainland. The evidence of a fault beneath the San Felix Islands naturally cannot be observed directly, but fragments of other, non-volcanic but fault-like faults have been found. Thus it seems that the location of the volcano and the intense activity of the earthquake are due to the same condition, the existence of a fault in the seabed".

"Geological faults give rise to ridges or mountain ranges by uplift on one side, or subsidence on the other, or by both movements. On the coast of Chile, for example, some parts have been uplifted while other neighboring parts have been submerged by movements on faults directed in the NNE direction. It seems very probable that there exist beneath the Pacific ridges of this course, modified or joined by volcanic masses and represented by the islands of San Felix, San Ambrosio and Juan Fernandez, with various rocks of more or less doubtful position. The suggestion has much scientific interest, concerning the structure of the ocean floor, as well as something practical for navigation in connection with the movements of ocean currents and the possibility of unknown rocks near the surface."


PROVINCIA
DE
ATACAMA
Sacudida por
el Terremoto del
10 Novrembre de 1922.
Isoseistas del grado
XI. X. IX. y VIII.
Kilómetros
0 10 20 30 40 50 60 70 80 90 100
26°
27°
28°
29°
VIII.
IX.
X.
XI.
Pan de Azucar
Chañaral
Pueblo Hundido
B. Totoralillo
Caldera
Chimbero
Puquios
COPIAPO
Nantoco
Carrizal Bajo
Carrizal Alto
Huasco
Totoralillo
La Higuera

CASUALTIES AND DAMAGE CAUSED BY THE TSUNAMI OF NOVEMBER 11, 1922

Ports	Coordinates		Dead	Maximum sea height over 0	Damages
	Lat.	Long			
Arica	18°28'	70°20'			On the dock.
Antofagasta	23°39'	70°24'			Flooding of the dock, shelter and damage to small boats.
Taltal	25°25'	70°35'			Damage to boats and motorboats
Chañaral	26°20'	70°40'		+ 5.50 mts.	Flooding and destruction of the commercial part of the plant.
Boiler	27° 3'	70°50'	20	+ 5.50 mts.	Damage to the wharf, customs house, railroad station; schooners and boats.
Carrizal Bajo	28° 5'	71°12'		He went 2 klms.	Damage to the dock and railroad station.
Huasco	28°28'	71°17'		He went 1.5 klms.	Damages in dock, warehouses and customs.
Coquimbo	29°57'	71°21'	24	+ 4.60 mts.	200 houses in the Victoria neighborhood, railroad station, warehouses.
Los Vilos	31°55'	71°31'			Pier and 12 fishermen's cottages.

VICTIMS AND DAMAGE CAUSED BY THE EARTHQUAKE OF NOVEMBER 10, 1922

Cities	Coordinates		Number Inhabitants Commune	Victims		Destroyed Houses	Houses in poor condition	Intensity
	Lat.	Long.		Dead.	Wound.			
Copiapo	27°22'	70°22'	12,572	70	100	40%	45%	X
Tierra Amarilla	27°30'	70°15'	2,356	4	Various		90%	X
Carrizal Alto	28° 5'	70°56'	6,440			Major deterioration		X
Huasco	28°28'	71°17'		8	Various	10%	20%	IX
Huasco Lower	28°28'	71°15'	2,576	12	Various	15%	40%	X
Freirina	28°31'	71° 6'	3,267	18	100	40%	50%	X
Vallenar	28°34'	70°47'	10,765	550	1000	70%	26%	XI
La Serena	29°54'	71°14'	15,240		various	30 houses	50 houses	IX
Vicuña	30° 2'	70°44'	8,845			10 houses	Several	IX
Ovalle	30°35'	71°12'	7,000				few	VIII

JANUARY 1922

Summary of the month

Only eight tremors were recorded this month.

The maximum seismic frequency was obtained, in equal parts, by the Copiapó seismic focus and the Maipo valley, with 3 tremors. The rest of the country remained very quiet. The tremors were of little importance and of small extension; the one of greater intensity was the one of the 20th at 17h. 14m. 54s. that shook with regular force the region between Santiago and Casablanca.

NOTE: The time indicated in this Bulletin is the official time in Chile, i.e., that of the meridian 70°. 41 34"5 = 4h. 42m. 46.3s.

FEBRUARY 1922

Summary of the month

Twelve different tremors were recorded this month.

The maximum seismic frequency corresponded to the Copiapó seismic focus, with 6 tremors; almost the same seismicity was registered in Santiago. The rest of the country has remained very quiet, being noteworthy only a regional tremor in the South, which covered a certain extension.

The most important tremor of the month, was the one of the 3rd at IIh. 44m. 30s., which was classified as a semi-earthquake by the inhabitants of Copiapó; however, the Seismological Service considered this classification exaggerated, since there was no important damage and the seismograms do not indicate such intensity. This tremor was felt from Mejillones to Santiago; thus measuring a macroseismic, meridian extension of 1090 kilometers. The focus of this tremor must be located in the surroundings of Taltal.

The tremor of the 10th at 21h. 50m., shook the area between Corral and Maullín. On the 13th at 12h. 33m. 30s., the area between the Maipo and the Cachapoal was weakly shaken: Santiago, Rancagua.

....El 16 at 0h. 45m. the region between the seismic focus of Copiapó and the Huasco river: Copiapó, Vallenar.

On the 23rd at 4:30 a.m. the small area from Santiago to Casablanca was shaken.

MARCH 1922

Summary of the month

Thirty-eight different tremors were recorded during the month. The maximum seismic frequency corresponded to Santiago, with 18 tremors. The Copiapó seismic focus recorded the same seismicity as the Cautín and Imperial valleys, II tremors. The province of Llanquihue also suffered a large number of local shocks, due to the momentary activity of the Puyehue volcano.

The most important tremors of the month were 14, and of these, the most intense was that of the 12th at 12:13:55 p.m., which strongly shook the cities of Cañete and Angol (Lat. 37° 50'), causing some damage to the prison and barracks of Cañete and the Liceo de Hombres of Angol, cracking some walls. The bridge over the Reihue river also suffered some serious damage. This tremor was felt from Santiago to Chahuiuco, (lat. 40°. 45'), thus covering an extension of 790 kilometers.

On the same day, two aftershocks were recorded, one at 12h. 48m. and the other at 13h. 37m. 30s., which shook with less intensity this same extension of the territory. On the 14th at 21h. 32m. 35s., this same area was shaken again, but more softly and a little less extension, 700 kilometers.

The area between the Imperial and Bueno rivers continued to shake on I4, 15, 16 and 17.

It shook gently, on the 27th at 23h. 21m. 40s., the entire region from Antofagasta

to Santiago, with an extension of 1060 kilometers.

The area between the seismic focus of Copiapó and Santiago, shook twice: on the 8th at 13h. 42m. 25s. and on the 23rd at 16h. 02m. 20s.

APRIL 1922

Summary of the month

Fourteen different tremors were recorded this month, of which five were microearthquakes, registered in the pendulum B. O. pendulums of the Santiago Seismological Observatory.

The maximum seismic frequency corresponded to Santiago, with 10 tremors. It was followed in frequency by the departments of La Unión and Osorno (parallels 40.0, 41.0), with 4 tremors. The seismic focus of Copiapó shook only twice. North of Copiapó it was completely quiet.

Three tremors deserve special mention: the one on the 5th at 1h. 50m. 45s. which gently shook the area between Copiapó and Santiago. The tremor of the 19th at 11:15 p.m. which strongly shook the area between the Toltén River and Lake Llanquihue. And that of the 20th at 1:30 a.m. which gently shook the area between Santiago and Osorno, thus measuring 770 kilometers of meridian extension.

MAY 1922

Summary of the month

Only 9 tremors were recorded this month and of these, two were micro-earthquakes.

The highest seismic frequency corresponded to the Maipo valley with 6 tremors. The Copiapo seismic focus experienced two tremors. The rest of the country has remained very quiet.

The most important tremor of the month was that of the 21st at 10h. 57m. 45s., which shook with regular force the area between the Maipo valley and the department of Parral.

JUNE 1922

Summary of the month

Seven different tremors were recorded this month; of these, two were micro-earthquakes registered in the pendulums of the Seismological Observatory of Santiago.

The maximum seismic frequency corresponded to Santiago, with 5 tremors; the seismic focus of Copiapó shook 3 times. The rest of the country has remained calm.

Only two tremors deserve special mention; the one on the 12th at 1h. 42m. 40s., which shook the small area between the Aconcagua River and the Maipo River, and the one on the 16th at 22h. 14m. 50s., which gently shook the area between the seismic focus of Copiapó and the Maipo valley: Copiapó, Santiago.

MAY 1922

Summary of the month

Only 9 tremors were recorded this month and of these, two were micro-earthquakes.

The highest seismic frequency corresponded to the Maipo valley with 6 tremors. The Copiapó seismic focus experienced two tremors. The rest of the country has remained very quiet.

The most important tremor of the month was that of the 21st at 10:00 am. 57m. 45s., which shook with regular force the area between the Maipo valley and the department of Parral.

JUNE 1922
Summary of the month

Seven different tremors were recorded this month; of these, two were micro-earthquakes registered in the pendulums of the Seismological Observatory of Santiago.

The maximum seismic frequency corresponded to Santiago, with 5 tremors; the seismic focus of Copiapó shook 3 times. The rest of the country remained quiet.

Only two tremors deserve special mention; the one on the 12th at 1h. 42m. 40s., which shook the small area between the Aconcagua River and the Maipo River, and the one on the 16th at 22h. 14m. 50s., which gently shook the area between the seismic focus of Copiapó and the Maipo valley: Copiapó, Santiago.

JULY 1922
Summary of the month

The maximum seismic frequency corresponded to Santiago, with 7 tremors; the seismic focus of Copiapó shook only once; the rest of the country remained very quiet.

The most important tremor of the month was that of the 28th at 3h. 21m. 40s., which gently shook the area between the seismic focus of Copiapó and Santiago.

AUGUST 1922
Summary of the month

The maximum seismic frequency corresponded to Santiago, with 8 tremors; the seismic focus of Copiapó suffered 6 tremors and the Aconcagua valley shook twice.

The most important earthquake of the month was that of the 24th at 9:37 a.m., which was felt strongly in the province of Coquimbo and was registered in Copiapó and Santiago, reaching an extension of 560 kilometers.

SEPTEMBER 1922
Summary of the month

Sixteen tremors were recorded during this month, of which five were micro-earthquakes registered in the instruments of the Santiago Seismological Observatory. The maximum frequency corresponded, as in previous months, to Santiago, with 8 tremors. The area between the Toltén and Calle-Calle rivers shook 5 times, gently. The Elqui valley shook 3 times; the rest of the country remained calm.

The most important tremors of the month were three: On the 12th at 23h. 15m. 0s., which shook the whole area between the Elqui and Maipo valleys; La Serena, Santiago. On the 19th at 12h. 52m. 24s., which gently rocked the area between the Limari river and the Maipo river; Punitaqui, Santiago. And that of the 30th at 3h. 15m. that shook, also softly the region between the Maipo river and the Limari river; Punitaqui, Santiago.

aipo and the Toltén river; Santiago, Lastarria.

OCTOBER 1922
Summary of the month

Twenty tremors were registered in this month and of these only one was a micro-earthquake. The maximum seismic frequency corresponded to Santiago, with 9 tremors; the seismic focus of Copiapó shook, in isolation, 5 times; in the South, up to parallel 41°, some strong tremors were felt; thus, the department of Valdivia, between Tolten and Calle-Calle, suffered 3 tremors.

The most important tremor of the month was on the 28th at 3h. 17m. 10s. that

shook the whole South from Santiago to Osorno; this tremor was very strong in Concepción, where it produced great alarm, some walls and partitions were cracked, without causing any disasters; the distance to the focus from Santiago is 348 kilometers and the shaking area reached 760 kilometers.

The tremor of the 3rd at 12h. 14m. 50s. strongly shook the Maule valley and was felt from the Maipo river to the Itata river: Santiago, Constitución, Empedrado, Parral, Quirihue.

NOVEMBER 1922

Summary of the month

A total of 390 sensitive tremors and 55 microearthquakes were recorded. The maximum of seismic frequency corresponded to the focus of Copiapó, with 371 tremors; very close to this frequency must have had the Huasco valley, where the earthquake of the 10th was felt with greater violence than in Copiapó, however the table of seismic frequency in Latitude, only registers 13 tremors for that bona (Lat. 28°-29°) because these were only the main tremors and there was no person who wrote down in detail, as in Copiapó, the other small tremors.

The great earthquake and tidal wave of the 10th of this month, described at the beginning of this Bulletin, had its preparatory movement on the 7th at 18h. 22m., which was felt at VII.° in the valleys of Copiapó and Huasco; there were no personal disasters or damages of consideration; it measured an extension of 860 kilometers.

In Copiapó it continued to tremble with varying intensities, from II° to IV°, three times on the 7th, four times on the 8th, twice on the 10th and before the earthquake of the 10th.

The whole area affected by this earthquake remained in great seismic activity, being noted in Copiapó from November 10 to November 30, 360 tremors of diverse intensities; of these those of greater force were those of the day 26, at 8h. 50m. and at 9h. 26m. 45s. of degree VII.° and VIII.° that caused, in Copiapó and Vallenar the fall of some buildings and walls that had been in bad condition since day 10; in the port of Huasco the sea reached to advance in little extension without greater consequence; these tremors were felt from Antofagasta to Santiago, thus measuring an extension of 1,060 kilometers.

DECEMBER 1922

Summary of the month

During this month, 283 sensitive tremors and six micro-earthquakes were recorded.

The great seismic activity that has occurred since the earthquake of November 10 has continued to shake, this month, almost the entire region between the seismic focus of the Copiapó valley and the Choapa valley, and less frequently further south, as far as Santiago.

The maximum frequency corresponded to the focus of Copiapó, with 173 tremors; the Elqui valley and department of La Serena were slightly more stable, with 101 tremors; in this last zone, on the 24th, eighty tremors of small intensity were recorded in the Tofo ore; and from the 24th to the 28th, thirty tremors were recorded in Vicuña. The seismic frequency of Copiapó had the following variation in the months of November and December: In November, from the 7th to the 30th inclusive, that is to say in 24 days, 371 tremors were recorded, which gives a daily average of 15.4; and in the 31 days of December 173 were recorded, which corresponds to a daily average of 5.58.

The most intense tremors of the month were two: the one on the 11th at 1h. 12m. 56s., which strongly shook the whole area between Copiapó and Santiago and could be felt in Mendoza (Argentina), was of intensity VI in Copiapó and Vallenar; the other tremor took place on the 28th at 7h. 59m. 20s. and shook the same area as the previous one; in Copiapó it was of intensity VII, producing panic among the inhabitants of that city, Vallenar and Vicuña.

All this area, from Copiapó to Santiago, shook with minor and variable intensities between II and IV, fifteen times more in the month.