

The Tocopilla earthquake

May 9 1877.

Study of an eyewitness.

This earthquake destroyed the three cities of Cobija, Tocopilla and Guanillos (northern Chile) by subsequent sea outburst.

From

Otto Harnecker.

(Z.Z. Engineer in Ligua (Chile).)

Translated from Spanish

From

Rudolf Franck.

(Currently owner of the German Institute in Quilpué (Chile).)

Frankfurt a. Oder

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Translation notes - translation by DeepL - 02/03/2022

1. an unknown length unit 'Span. meilen' is used several times. It translates in miles (1.6 km). However, Harnecker 1895 written in Spanish (from which Harnecker 1897 is translated in German) uses the unit 'legua' (4.8 km). We assume Span. meilen is a mistake made by the translator (R. Franck), that we did not correct.

Foreword.

The author, who was deprived of the fruits of his life's work by the terrible catastrophe described here, publishes his experiences here for his German compatriots in the hope that not only the shocking natural events and the questions they pose to us, the riddles they pose to us, but also his practical experiences and the conclusions drawn from them can still be of interest and use to some in the old and new fatherland. It is true that twenty years have passed since the events described - but who is able to say when and where a repetition may occur, whom it may affect?

Some years ago the author has written in a brochure: Ueber Erdbeben, translated by R. Franck, Rostock 1892, he dealt with the views of Falb and after his compilation about the earthquakes of the year in 1894 the "deutsche Nachrichten" Valparaiso of June 11, 1895, No. 2487, and of July 13, 1895, No.2499, he believes to have refuted Falb's theories, as also his predictions have not been confirmed by facts at all.

The earthquake of 9 May 1877 In Tocopilla.

Contents: - Introduction. - Memories of the moment of the catastrophe. - Preceding signs of it, - Movements of the earth - Effects of the earthquake: in the mountains, in the plain, on the beach, on the buildings and inside the houses. - Subterranean noise. - Duration of the earthquake. Exit of the sea. -- General exaggerations. - Definition of the wave, - swelling of the sea, - effects of its natural excitation. - Hour of the last exit of the sea. - The height reached by the sea. - Reflux, - Confirmation of the three movements, - Direction of the same. -- New theory of the author about the cause of the earthquakes, the eruption of the volcanoes and the uplift of the mountains. - Will the phenomenon recur? -People's instinct, -Historical data. - Deductions. - Important measure. - Precautionary measures, - The traveler, - In the mines. - Buildings - conflagrations. - Fragile objects. - Money boxes, etc. - Landing stages. - Smaller vehicles. - Steam and sailing vessels, - Height at which building is allowed. - Conclusion.

Some notes for science and practice.

Fourteen days of terror have passed since the 9th unfortunate event, and the intimidated minds are still dominated by tenacious restlessness; there are absolutely no reasons that explain in a definite or halfway satisfactory way the origin of this unforeseen event, which lack then causes the impossibility to give certain signs that could allow a prediction about the conclusion of this catastrophe for now or for a more or less long time. Everybody understands how probable it is that from one moment to another a similar case repeats itself, that a new chapter of misfortune begins, especially for those who are already ready to surrender to a trust without suspicion.

There are various causes for this abnormal state of mind, and it is good to know some of them in order to understand them; only then will one be able to patiently encounter those who are actually or apparently **indifferent**, **who** are represented in large numbers and boast of this quality.

In the suffering of his present material situation, the unfortunate castaway of this place also feels his mind numbed, to which also the tenacious memory of his lost belongings contributes, a memory that does not leave him! The cloudy horizon of an uncertain future, the critical situation of the moment, which leaves him still without hearth, without clothes and even without food, the constant roaring and trembling of the earth, but above all the indelible impression, which one receives in the critical moment of the collapse, all that was enough to paralyze even the strongest mind.

Let us visualize this moment for a while.

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It was a dark night; The clock showed 8½ p.m., when suddenly the earth shook strongly, not more strongly than had been felt repeatedly by night or day; but the force of the quake this time grew rapidly to such a degree that it caused veritable vibrations and shifts of the earth's surface. It was impossible for us to stand upright in those moments without taking the steps of a drunkard in order to restore the supreme equilibrium.

The earth's crust - a weak vault above the mighty inner sea of fire - resembled in its terrible convulsions the shuddering movement which the bridge of a frail ship suffers during storm whips.

The demon of destruction made his entry into our unfortunate place and with great pomp he announced himself.

Terrified, the inhabitants leave the unsafe hearth; some forget in the confused flight the caution to extinguish fire and light at home. Thus, the glow of several conflagrations was soon seen illuminating the darkness in an ominous manner,

The earthquake had called the beneficent fire to its aid to transform it into a terrible ally of its work of destruction. But the fire could be isolated and its rage localized and fought by the power of men. Perhaps thus the terrible wrath of nature against her harmless creatures remained unfulfilled. Two elements were not enough, and therefore they immediately called and obtained the help of a third, the most forceful of all: water.

But it was not the fertilizing water that falls directly from the sky and drops modestly on the roofs, respecting the houses; this time it had a much more terrible origin.

What a moment, when our place saw itself frightened by the earthquake and the threatening violence of the fire at the same time. While otherwise the peaceful inhabitants of the seashore were accustomed to see the waves breaking at their feet, harmlessly bathing the soles of their feet in it on days of high tide or of the storm wind whipping the tide, however mighty, this time it goes further: this time they realize that this same sea swells and grows faster than the high tide and rises higher than the highest limit of it, that it overflows and floods the dwellings of the people.

In view of this perilous observation, which some people made clear and to which we will return further on in a closer look at the natural event, there was no one who would have bothered with clarification about the context of these terrible acts.

A single feeling animated all, nipping any bold curiosity or love of property in the bud. The instinct of preservation ruled unrestrained. The love of life, even bare life, triumphed when one saw oneself threatened by this new enemy, - and rightly so! Once the sea, due to a mysterious force, had gone out and seemed unbridled enough to flood the earth, could anyone determine in advance the limits of its flood and name the level before which it would stop? - Could anyone determine the height at which this flood would be above the original level, a level which the sea had treacherously abandoned? - Was it going to recapture in one stroke the loss of centuries? - And should perhaps the immense driving force that pushed the sea above its limit be born of a power that corresponded to the immensity of the ocean?

Considering such questions, there was no boundary that could not be reached by water, and no height that could not be exposed to flooding.

And who estimated the speed with which the tide would rise? -

Compared to it, the speed of a Giessbach rushing down from the mountain would only be a turtle's pace.

The hurry to the heights corresponded to this; it was accomplished with the whole effort of our forces. But a force majeure again set its limit to this flight. Not the tiredness of our feet, nor the exhausted breath, but something far more frightening and independent of us commanded us to stop!

Who knows the layout of our place, knows that about 700 meters from the beach and almost without the mediating transition of a slope, steep mountain slopes of the already steep terrain of our coastal chain cut off the horizon. Stones and rocks, their supporting surface weakened by the nail tooth of time, lost their balance at the onset of the earthquake; with a roar they crashed down into the plain, safe bombs for those whom the sea pursued.

What a location!

Some more foolhardy ones, of which those, made headless by the strength of an immediate danger, do not see another closer one, ventured with hands and feet up those mountain slopes, but when they learned the next day that in the neighboring town of Punta Blanca these landslides had claimed eighteen victims, they knew that they had been saved, as it were, by a miracle.

Her guardian angel had guided and preserved her!

That is why we repeat;

What a cruel situation! What fury of the elements!

Only one of them, the air remained faithful, and also it, the mediator of the sound, served only for the proclamation of an unfamiliar and frightening roar.

The dull surf behind, the crashing of the earth ahead, and the dismal rumble and echoing thunder at our feet! -

What a gruesome situation! The sea turned into a vast grave and the mountains into serving graves of the dead!

We said earlier: The memory of those moments of suffering, of the incessant earthquake, of the subterranean noise and the impossibility of a satisfactory explanation of the events still keep the spirits full of suspicion and distrust.

And in order that this distrust may cease, an elimination of ignorance is necessary; gradually science will then draw one of its happy conclusions in the further pursuit of the enlightening circumstances.

The pain-relieving time heals all wounds, wraps everything in soothing oblivion; it will also erase the still clinging painful memories.

But when do the earthquakes rest - when? - Not until the cause that causes them ceases, a cause that comes from nature.

Nature, beneficent creator, careful guardian of thy creatures! It seems that in the pursuit of your continuing work of creation, you have not been able to carry out the development plans of your secret workshops without spreading death and dismay among your children! -

Dozens of people, hundreds of quadrupeds and birds lie lifeless along the Meares beach. Beings that need air and solid ground, you handed over with one blow to a completely foreign element, the water; and not content to take their lives, you refuse to keep them back and hurl them dead back to where you carried them away.

Thousands of sea creatures, from the innumerable species of fish to the long line of crustaceans and mollusks, which, relying on you, are perishing in the water on the shore - you let them perish, die on dry land!

Isn't it natural to ask yourself, "Have you taken a wrong step?"

We cannot believe it until we have examined again the signs with which you have revealed yourself to our narrow comprehension.

Perhaps these perceptions will open a narrow door to the light of truth, and their teachings may serve us for news and benefit for the future.

* * *

Two elements show themselves to our senses as active. The earth and the water were the hearth of the struggle; the fire, the work of man, was extinguished by the water and thus lost its activity; the fourth element, the air, remained a silent observer.

According to people who had a fine ear, the earth along the beach had been showing disturbing sounds for some time. They clearly distinguished a strange sound, like that which occurs in a steam boiler just before the water comes to a boil.

The truth of this important observation, which was received with disdain by the general public, was confirmed after the disaster.

The subterranean sounds that are heard now, whether they are isolated or precursors of earthquakes, are identical to those.

Therefore, they all must have one and the same cause, which, as we see, has been announced for some time. Unfortunately, it announced itself in very weak signs and our inexperience was still too great for us to be able to understand the far-reaching nature of these signs. Nevertheless, although the natural phenomenon with its destructive power surprised us so suddenly, it did not fail to announce itself to our senses, or rather to those of some favored ones, in preparation.

Among the leading signs we must also count the strong earthquake of Oct. 26 last year (1876).

We experienced it in Toco, 18 spanish miles (*cf translation note*) away from our port site. There it was so strong that it almost completely destroyed all the officers working there.

This was the first attempt of the nature, the first attempt, the first syllable of the word RUINE, which was not spoken to its full extent until the 9th, so that in those misfortune offices no stone remained on the other.

since that 26th (oct. 1876) new strong earthquakes were silent until the force gathered for the main thrust on May 9.

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This terrible earthquake did not in any way foreshadow its imminence, everything was breathing peace and tranquility at that time. The earth seemed to be a corpse. But it was only apparently calm; it was only asleep in an agitated dream. Therefore, when the ominous moment had come, she arose overexcited, as if struck by an electric shock, and her trembling became extreme when the following three movements united:

- 1) An accelerated motion inherent in the waves of the sea (undulation).
- 2) A movement of alternate rising and falling, and
- 3) An extraordinarily violent shock.

It was as if a large part of the surface of the sea, together with its wave motion, was slowly rising and falling, a phenomenon which was accompanied by trembling, as if a resistance had to be defeated, comparable to that which a thin board offers to the friction of the saw teeth cutting through it.

If we apply what has been said to the earth, we find that it moved in the general direction of the coast, that the coast rose and fell during some moments, and that it trembled during this movement.

It is necessary to note that we did not perceive these movements entirely at the moment of the catastrophe, but that they were forced upon us for the most part by the effects of the phenomenon. If, nevertheless, in these data we establish the anteriority of the cause before the knowledge of its effects, then it happens, so that one can visualize the latter when discussing it. This otherwise not quite admissible method shall serve us in this case like a kind of lighthouse - match fire, in which the light - the cause - produces the reflex, the effect, in order to increase the clarity in a certain, definite sense.

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On the mountains, the landslide caused by the earthquake has been general.

At our place there is a gorge, through which a road runs for 4 Spanish Miles (*cf translation note*). It is bordered on both sides by steep mountain slopes; it cuts through the entire coastal chain. The whole path is covered with earth debris, which proves that the earthquake shook with equal force the whole immense mass of this mountain range.

In the plain, which consists of dry sedimentary soil, small openings have formed in the earth and sand and dust of the surface have been moved in a way as if they were scattered through a sieve.

On the beach, after the catastrophe had taken place, the sand trembled in a movement similar to the one mentioned above.

The following effects are produced on the works of man:

Partial disintegration of the chimneys of all the smelting furnaces; the new ones remained undamaged.

All the structures that escaped the sea flooding did not suffer from the earthquake because they were built of wood; only an insignificant loosening between the solid cement base and the rest of the structure was noticeable.

Inside the apartments, all fragile things suffered in closets or on boards with east-west direction; much less damage was observed in those with south-north direction.

* * *

Some of the subterranean sounds have been of extraordinary strength, and their sound has been compared to the crashing of objects and to the roar caused by rocks bursting together in a mountain water.

Some of these sounds were perceived alone, others simultaneously with earthquakes. Since they are the effect of a certain cause, like the thunder of lightning, their influence on man was similar to that of the rolling of thunder.

As soon as they sounded, everyone remained spellbound by terror and suspicion; silent and pale, they resembled columns of thought, which one could see the desire to be able to open their ears further for the better perception of such strange sounds.

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The first earthquake lasted 2-3 minutes; from this moment to the first sea outburst another two minutes passed, so in total 4 or 5 minutes.

We did not make this estimate with the clock in hand; it is based only approximately and recollectively on this small and terrible passage of time.

Only 5 min. , according to others 10, to save property and life! - We unfortunate and blind people! A fatal destiny makes us work and accumulate for years, long years, so that an unforeseen moment takes everything away from us. And all of us who lived on the seashore, where land and water before peacefully respected their boundaries, we will from now on look at these elements with completely different eyes. As long as the deep memories of the recently experienced disasters last, even the natural high tide will be for us the sign of a possible flood.

The raging of the sea will mean a serious disturbance for us and every earthquake will threaten an unfortunate flooding. This fear will mingle with our dreams and, deprived of the reins of sleeping reason, it will dominantly spin a web of fantastic illusions, always representing the sea as an attacking power against life and property - truly not without justification.

* * *

Wise in the future is the suspicion against the Ocean; its last powerful manifestations make it almost a duty. The beginning of this was observed by some locals, because they hesitated to run away. They saw the sea swell, grow and cross its natural boundary line calmly but statically; then they heard behind them a crashing or crackling in the buildings, and in the end we all observed the mischief done and the boundary line of the flooding.

Some say that the sea overflowed in a wave; we maintain that it was gradual flooding with inflow and outflow, and that such a wave rolling forward and advancing under its own power did not occur at all.

The tendency to exaggerate facts is general, even if, as here, the terrible reality of them exceeds the boldest assumptions in a high degree. That is why the mass of the people speak of the flooding of the sea as of a wave as high as a mountain; the mountains are made to bend like leaves on a tree, all this because the designation as a wave awakens the idea of a force acting more energetically than the mere speech of congestion or swelling, and because the leaf on the tree lets itself be broken with unconditional yieldingness by every gust of wind. Such exaggerations should find no place in the print; statements, which are communicated in such increased scale, lead the history already from the beginning on a crooked way, on which later the investigation of the truth will fall all the more heavily.

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A sea wave is a mound of water which holds one part of its mass above and the other below the level of the sea; while the latter touches the bottom, the former rises; for this reason, as well as because the lower part stops its course, the balance and roundness of the upper part are destroyed, while the latter, falling in an almost perpendicular direction, moves forward. As the wave advances and finds less depth each time, its cupping continues, a process by which wave action and surf are created.

A wave whose extension corresponds to the height reached by the sea inundation would have been 20 to 30 feet above sea level. Its first crest would have formed a true cataract, whose white, abundant foam would have shone in the darkness of the night, while its shattering roar would have echoed with terrifying echoes in the mountains opposite.

Nothing has been heard or seen of this.

* * *

The water needed for its destructive power only the pressure which the weight of the water exerts on submerged objects and was supported only by the daily movement or small wave impact of the same.

Our bay is never completely calm; even in its calmest part it shows waves breaking on the beach. These waves accompanied the sea in its damming and assisted in the destruction of the fragile wooden buildings as well as the solid walls built of cinders.

Towards the south, our bay is protected by a low rise of insignificant elevation; there, the sea has crossed the watershed, reaching 10-15 feet more height than that of the calmest point in the harbor; in the latter, the wave close to the beach has perhaps 1-2 feet height, while there, where it receives its liveliness directly from the sea gulf, it is 6-8 feet high and, moreover, manifests a relative energy. If one adds to the height of the jam that of these waves and their energy, the difference in height here and there is easily explained,

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It was 10 o'clock at night when we descended from the heights to approach the flood line. At that moment, when, driven by curiosity, we were about to cross that boundary line, a new and very strong earthquake occurred. It was a fast and trembling shaking; moments later we heard the buildings crashing again, which had been spared in earlier sea outbursts, but fell victim to this flood.

To a height of 3 or 4 feet more than the first discharge, the water rose. A time of 1½ hours had elapsed between the two floods.

This observation frightened us, and our minds were stirred anew: the force thus continued to work uninterruptedly, and made an increased appearance.

From the absolute calm of the sea to this new excitement, there was a pause of ¾ to 1¼ hours.

No one could be sure whether an even more threatening sea outlet would not occur after another two hours.

A long cruel fear took possession of us.

Fortunately, the sea remained calm after this new exit; it might have realized that there was no more prey for new efforts; the previously inhabited ground had been transformed into a sad, empty sandy area. Thus the sea withdrew sated.

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The approximate measured height reached by the flooding sea between the later designated ends was 30-45 feet. To determine the exact height, it is necessary to know the height of the sea level at that hour. No one at the site had observed a recession of the sea before or after the first discharge; we do not think we are mistaken in supposing such a subsidence; and if it did not follow this inundation, it certainly preceded it. Among the observations supporting us we cite the following:

The beach was covered in certain places with a species of mollusks, which in ordinary life is called "coco"* (crazy). These mollusks live below the surface of the sea even at the lowest tide, and they almost stick to the rocks. When the sea receded, they were left on dry land, and they let go to reach water again; but in doing so, they were surprised by the returning sea tide and thrown onto the beach. Heavy iron parts, plates, wheel parts, etc. have completely disappeared, no doubt because they remained below the present sea level where the sea backflow threw them.

Let it be enough for this time with these observations. If we let the light, which has been presented by these observations, roam on the cause, which gave life to the mentioned movement of the earth, the following results:

At the time of the catastrophe, we all felt the oscillatory movement that made us sway from side to side in order to maintain balance.

* Typo in the original. Probably 'loco'

From the greatest change in the position of the objects on walls running east-west, apart from other reasons, the assumption arises that the oscillation waves had the direction north-south or south-north; for in the return of the objects to their equilibrium after the course of each wave, a speed was shown which was different from that which the movement of the walls had, and from this difference in speed a collision between the two objects must necessarily arise. This collision could not take place where the objects vibrated independently of each other, as they did on the walls directed from south to north.

The slow movement of the lowering and raising of the earth remains sufficiently proved by the slow flood and its return.

The movement of the trembling is indicated with clarity by the sifting of sand and dust on the surface of the earth; to prove the existence of such a movement, the landslides, the formation of small fissures in the earth and the sudden eruption of wooden buildings also serve.

It was the meeting of these three moving forces that produced the terrible effects of the earthquake.

none of the three contributing forces could have produced the whole sum of these consequences on its own.

The movement of trembling was faster than that of swinging, and the latter again faster than that of sinking: neither of the former could have produced the slow rise and fall of the sea.

Having arrived here, we should conclude with this information by expressing our opinion about some practical conclusions that result from the observations of the effects of the earthquake; but apart from our interest in the present subject, we have so far only mentioned the immediate cause of our misfortune; for the three movements that constitute the earthquake are only the consequences of a certain cause. Their investigation is therefore of the greatest importance.

Let us therefore venture forth with our judgment in this regard, although we must decide to solve this difficult problem, as in arithmetic, by means of the rule of wrong position.

The cause of the earthquake on May 9 is the same one that causes the slow uplift of the whole South American west coast. This force has its enormous workshop in the interior of our earth; on the one hand it is carried by the fiery core, on the other hand it finds its resistance in the earth's crust.

This force, whose intensity is able to lift the immense weight of the mountains, overcoming at the same time the friction of adhesion, is generated by the crystallization of the fiery mass of rock which the interior of the earth holds in the molten state. †)

The fiery rock between the fiery core and the already solidified earth's crust also passes for its part into the solid aggregate state, cooling as a result of the slow cooling of the earth. During the transition from the liquid state to the pulpy and solid state, it crystallizes, just as the granite has also undergone crystallization.

Crystallization is the manifestation of life in the mineral kingdom; only it is quite significantly weaker than in the animal and plant kingdom. The animal shows its life by movement, the plant by growth and the rock by crystallization. Between the perceptibility of this life and that expressed by the plant there is not much more difference than between the life appearances of the plants on the one hand and the animals on the other hand. The animal needs for its life a large stretch of earth; the plant draws its nourishment from the little earth of its environment; the rock nourishes itself from itself, among different individuals of one and the same species, nature permits only small variations; in the same case these differences are more significant with the plant concerning form and size; the rock, on the

†) This theory has been established 27 years ago by us Santiago de Chile.

other hand, can throw its crystallization into very different forms, provided, however, that it submits to a certain system.

Without getting into further details for the time being, we immediately make the following claim:

As animals and plants, so also the rock in its development, through the crystallization, increases in volume (body content), or, what is the same, its specific weight in this state is smaller than that of the fiery liquid body. This increase of the body content generates a force which simultaneously exerts a pressure against the fiery liquid mass and the earth's crust, which mass is forced by this force to flow out through volcanoes. This is how the fire-breathing mountains and their eruptions are formed. And the earth crust lifts this force, forming mountains.

With any lifting of the floor must be present:

1. a moving mass,
2. one that remains at rest and
3. A touch of both.

In order to overcome the coherence existing at this contact, both the lifted mountain masses and the immobile ones tremble; this dissolution of the coherence, which is connected with a friction, produces the violent trembling of which we spoke and which is explained by this.

The pressure against the fiery core and the bark at the time when the resistance of the latter is overcome, communicated itself to the earth as wave movement.

The earth's crust, like any solid body, is elastic; therefore, when it was lifted by the force to a much more significant height than the level held in the future, it also sank far below this level, and so the slow ground lifting and sinking, as well as the deliberate flooding of the world's oceans, took place in intervals of 2-3 minutes.

Just as we, for instance, at a great show of strength, so the earth swells its bosom with power during its majestic work: - a breath which has been very ominous to us!

Let us hereby leave the barren theory in order to turn preferably to the practice, which interests us more for the time being. We will try to answer as well as possible the following burning questions of the day:

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Will the catastrophe be repeated here, and at what time, for instance? What precautions could prevent the ravages of this impetuous enemy?

Concerning the first question, we must admit that a century or more had passed in peace in these regions until the great earth upheaval of August 13, 1868, but only to repeat itself after less than 9 years; now, if this accelerating diminution of peace continues, the terrible event could recur again in even less time. But the people, who always have a true instinct, draw another conclusion, seeing their waiting for a volcanic eruption deceived.

Indeed, the volcanic eruption is a partial derivation of the internal force, and since, as it seems, such has not yet taken place, the population remains restless, unsatisfied, full of apprehension. So much importance is attributed to the activity of a volcano that some believe in the existence of an underground one. It will be difficult to prove the correctness of this assumption. Nor is it necessary, as we shall see later. If we have herewith allowed the instinct of man his right, we consult the chronicle of history. This informs us of the following strongest earthquakes in South America:†)

1747: Callao and Lima earthquake; sea outlet one spanish mile *(cf translation note)* wide; 1200 victims.

1797: Earthquake in Riobamba (Ecuador); shaking from bottom to top; 30000 victims.

†) Extract from different authors by " El Progreso ", La Serena (Chile).

- 1812: Earthquake in Caracas, San Vincente volcano; 10000 victims.
- 1822: February, earthquake in Chile: felt in an extension of 1000 km from N. to S.; ground uplift most noticeable in Valparaiso; some otherwise submerged rocks remained outstanding.
- 1827: Nov. 16, earthquake in New Granada; in the valley of the Magdalena River a thousand holes in the ground were formed, from all of which a large amount of coal gas flowed, causing the suffocation of a lot of snakes and rats in them.
- 1835: February, in Popayan Bogota, Santa Marta and Caracas an earthquake whose sound lasted seven hours without any shaking. It was also felt in Haiti, Jamaica and Nicaragua.
- 1835: February, destruction of Concepcion, Talcahuano and Chillan. Shifts were observed in the level of the land of the south coast.
- 1843: Devastation of Guadalupe Island.
- 1856: Earthquake in the Republic of San Salvador. One counted 180 earth tremors in very short pauses.
- 1862: March 20, destruction of Mendoza; duration not one minute; earthquake was felt in an extent of 60 Spanish miles (*cf translation note*).
- 1868: August. Two whole cities sank near Quito, Ecuador, duration 5 minutes.
- 1868: August 13. Destruction of Arica, Iquique and Arequipa. The victims of 868 amounted to more than 18000.
- 1877: May 9. Earthquake and sea outburst; partial or total destruction of all coastal towns from Chañaral de las Animas to Arica included.

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According to this overview we find 50-15-10-5-8-8-15-5-7-9 years between each two earthquakes as pauses, if we start with the one of Lima and Callao. If we leave out the first one, there remain for the 80 years from 1797 to 1877: 9 earthquakes, so that there are 9 years for each one.

Among these 9, those of **1835 and 1868** have worked in two different places. The greatest rest lasted 15 years, the least **5** !

In view of these exact historical data the question: "Will the event repeat itself?" proves to be useless; because the affirmation of the same results from itself; also the next time is more or less indicated. It remains for us only to indicate the place which will form the scene of the next earth upheaval. For the purpose we will refer for a moment to our theory and possible conclusions of it. The moving inner force has a partial discharge in the eruption of a volcano and a total exhaustion in the uninterrupted uplift of the mountains. No eruption has taken place above the sea surface, below it perhaps; but this assumption is not essential. We believe that many of the subterranean sounds are communicated to us from the depth of the sea:

1. Because they are heard with more clarity on the seashore;
2. because on the bottom of the sea there is undoubtedly the line of contact of which we spoke.

The action of the water on this dividing line, which may have its interruptions and be penetrated by the water, probably contributes to the origin of a certain type of these sounds.

In order to restore the equilibrium of the internal forces, it is not necessary, as already mentioned, that any volcanic eruption has taken place, because for this it is sufficient a small lifting of the earth's crust, even if it is only a few inches high. This uplift of our coastline and the areas bordering on it will last until the weight of the cordilleras and the resistance of the reaming surfaces make it easier for the inner forces to break through the earth's crust at another point of the globe than to continue the uplift in our hemisphere. Up to now this case has not occurred, and therefore the area inhabited by us continues to rise, although not in a constant manner, from the northern border down to the southern regions. Therefore, all those places which have been shaken with more force have in their favor the probability of remaining outside the range of the next

activity. So it is not probable that our place will be a chosen victim again in a future and next earthquake.

Since this subject gives rise to many associations of thoughts and more or less probable conjectures, we will not touch upon it further in order not to indulge in premature judgments.

The content of the historical census halfway leads us to believe that the next time the earthquake will form its center either north of Arica or simultaneously in the north and south of South America.

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Important for science and of far-reaching importance for practice would be the adoption of the following rule in this whole wide area:

The governments of the various republics would have to determine in an invariable manner, at various points of their respective coastal areas, the mean elevation of the sea surface, in which they would firmly affix the same as a sure, indestructible marker. These marks would provide a base for future conclusions, because the contour line, or line passing through all the territories, would probably change with each earthquake; and if the practical results obtained by this work would bring no immediate benefit to the fellow-living, their descendants would see the fruits ripen and gratefully remember the labors of those who sowed them.

What has been said so far makes it easy to see that such tremendous events as that of May 9 are only necessary manifestations of the progress of creative nature. They are expressions of life of the dormant mineral and results of the great work in the earth's interior. This active work creates mountains and increases the thickness of the earth's crust, which forms only a weak bridge separating us from the fiery core. In order to make this bridge more reliable, nature adds a new pillar to it, and at this insertion, of course, all its unfinished work trembles.

"Rock solid," we say, thinking of a great, passive power of resistance; but to denote a still higher and supreme power, we may further exclaim, "with the vitality of a rock!"

This material, which always so submissively bows to the human will, whether it transforms it into dust, inhales it, or whether it draws its most compact masses through with tunnels; this material, which grants the fine chord of the plowshare free passage and offers the necessary resistance to the chisel of the sculptor, is in these cases only in a state of complete inactivity; It is dead, lifeless, like the decorticated tree, which even in this form hands over its wood for processing, - or like the corpse, which endures anatomical dissection. But like the animal and the plant, only in an immeasurably much larger scale, the rock possesses in its development a manifestation which is not overcome by any power, which shows itself in periodical appearances and which eludes the calculations of men. And although a part of mankind suffers most painfully from these expressions of life of the mineral kingdom, on the other hand whole peoples derive a great - profit from it; they draw their life from the water, which flows uninterruptedly from the snow-covered cordilleras once lifted by this power.

From this point of view, we can rightly assert that Nature has not taken a wrong step in the tremendous and mysterious phenomenon in question; this is already indicated by our little study: and if this study gives us serious lessons, we must consult it as long as there is time, and consider the means by which we may avoid that what we call catastrophe should not again turn into a scourge for our property and life.

Thus, we conclude by indicating the precautionary measures that we have to recommend in the construction of the ruins of May 9.

* * *

Let us begin with the lonely desert traveler who, on his dry wandering after an earthquake of the magnitude of May 9 has occurred, should immediately

enter the roadways, even if they are longer than the mule tracks called "deshechos". The trace of the latter, whether it meanders along the slope of a mountain or draws its wavy lines on the ridge, will always be so completely obliterated that it will be difficult to distinguish with the eye, so that the impossibility of finding the way arises.

An acquaintance who returned from the mine of Conchi to El Toco tells that he repeatedly thought to be stuck; an abyss below and a curtaining mountain wall in front of him: that was his situation! He had to walk for long hours to clear a path for his mount, step by step. Likewise, camp at the foot of rocky hills should be avoided as much as possible.

* * *

Mines. We have already mentioned the 18 victims of Punta Blanca that the landslide claimed. The rancho, the miserable leafy hut that adjoins the mines, cannot be a safe refuge for the weary miner if it is not placed in a place protected from these rock avalanches. In such places, accessible to landslides, the mine managers should be aware of the disaster that an earthquake causes and choose suitable places where their workers can live quietly. And if they do not do so, the authorities must watch over it. During the semi-annual or annual visits, which the mining law prescribes for the guild's deputies, the guild would be able to determine the location by a mere glance upwards. Where the situation of the ground should prevent such a measure, the construction of a small, wood-lined gallery would at least be a safe refuge during such a moment of terror.

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Buildings can be made of lime and brick or wood; a strong earthquake is life-threatening to the former, fire to the latter. The former is better secured by iron beams, which may increase the cost of production by 5%, but instead would provide almost 100% safety. This iron framework usually saves the high chimneys of the smelting furnaces, and it must be properly remembered that these fire towers have a very great height in relation to the diameter of their base. Late or early, but inevitably, the fateful day will come for the opulent capitals of South America. Then woe to their proud palaces and their trusting inhabitants. If iron beams would not serve to enhance their ornamentation, they would make the buildings indestructible, safeguarding property and life. The iron costs little, and the steel drill easily perforates the walls that are to receive the protective beams. Try it at least with a building! Well-built wooden buildings resist the strongest earthquake. The wood does not seem to forget that it was firmly rooted in the ground before it was processed. On the other hand, this flexible material does not resist the penetration of water any more than a spring resists the wind. With advantage, one could continue this comparison as follows:

The body of the building rests on the foundation walls by virtue of its own weight alone, without being further connected to them; the water, overcoming this weight without force, will cause the separation of the supporting surface from the building itself, making the latter afloat; the building will therefore change its place in the worst case; it will, however, by no means be destroyed by the onslaught of the small waves.

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Fires are almost always caused by the fall of small burning kerosene lamps; among these, those that are especially dangerous are those that are decorated with a bronze figure, but which, because of the thin waist of this miniature statue, have a disproportionate height compared to the base. Accordingly, that small and harmless human image can turn into an active communist, of whom one could rightly say that he "smells of petroleum." Since

it is now common practice to use fixed lamps, a wider support surface for them is recommended.

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Objects of all kinds, especially fragile ones, inside the house are to be kept on boards or planks on the walls running south-north. Why, we have already said.

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Cash boxes and book cases remain secured in vaults below ground level against water floods that enter and recede.

* * *

Almost all **landing bridges** are destroyed in these floods and even in times of strong storms; the fact that the deck or floor of the landing bridge is generally nailed tightly to the bridge body is the main cause of this destruction; the water, because of the lighter weight of the wood, and especially because of the pounding of the waves, presses this deck upward from below with irresistible force, and since the whole framework is connected to this floor, a general destruction of the structure takes place; the water tears everything loose and then hurls it against the beach. If this floor is left loosely connected, e.g. hooked accordingly, the sea will then grab this part alone, sparing the bridge body, i.e. the main part.

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For **smaller vehicles**, sloops, boats, etc. we see no means of rescue.

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Sailing ships and steamers sink if the chains at the front and rear of the vessels are not loosened early enough; others lose all their anchors when the chains break, leaving them at the mercy of the currents that throw them onto the beach in ports with extensive beaches. The loosening of the anchor at the stern and the possible lengthening of the chain at the front of the ship are the means to protect it from the currents; only a miracle can prevent the ships from colliding with each other, if they are close to each other.

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If one builds in wise height, as for example the cautious Arica, one exercises the most sacred precautionary measure, which is to be recommended to all those who further throw their hopes on these desolate coasts. Along these stretches of coastline a line crosses the beach, an unforgettable line, an immeasurably long line; its grim line stands out sharply along its entire length, eight degrees down the coast, where it is strewn with sad debris. Through large strips of dry seaweed, interrupted by a thousand ruins, here by a cross, there by ship's planks or an unburied corpse, it distinguishes two distinct regions, one of which is high, the other low.

Forever, perhaps for centuries, the light of the sun and the stars will shine uninterruptedly on the ground of the former, and in the latter their rays may be reflected by the sea. In this latter field there is no firm agreement between Neptune and Vulcan, and the careless mortal will be the victim of their quarrel. But the capitalist will exercise caution, and we conclude by referring to a conversation which one of them had with two of his debtors:

* * *

- "Where did you build again, Mr. G.?" "On the same place as before."
"Ah!.. So that means again on the seashore, you are brave! " "And once again I count on your help. " "Very gladly, sir; but. . . since I know that an insurance company against flooding of the sea is being formed, I think that we should both wait at the base for the beginning of its activity."

"And you, sir, where did they build?" "Far from the beach; I don't want to work for the sea again. " "Very good, my friend. You are wise; ask of me as much as you need."

That is indeed the case. If, God forbid, an event like that of the Ninth should again afflict our place after a short period of rest, as happened to Arica and Iquique, and this or that person again loses his possessions after having barely rebuilt the ruins, he, an unfortunate, will not be denied pity; But he has no special right to it; for anyone who pursues a goal and knowingly exposes himself to a danger that can easily be circumvented proves himself to be either foolhardy or a man of rich pensions or even a squanderer of other people's capital.

Tocopilla, June 1877.