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National Mining Society

SANTIAGO DE CHILE

Report on the Copiapó earthquake December 4, 1918[1]

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[1] Mine Service Report I Jeolojia

At the beginning of the current year I received from the Minister of Industry the assignment to investigate the effects of the Copiapó earthquake of December 4, 1918.

I had fourteen days for this study. Therefore, and taking into account that the urban area of Copiapó was the one that had suffered the most as a consequence of the earthquake, I had to restrict my investigations to the city itself and its surroundings. However, I had occasion to go to the port of Caldera for a few days, where they could provide me with data on large movements of the sea during the earthquake and where I would probably find an opportunity to verify a permanent uplift or sinking of the coast.

For the rest, the present exposition is based in part on information whose veracity was impossible for me to verify personally. Of the numerous pieces of information, I have only used those which came from persons who, because of their position and individual qualities, inspired confidence in the accuracy of their observations. Very important and reliable data, I thank Mr. Luis Sierra Vera, who also provided me with the data on the time, duration and other phenomena of the earthquake which I transcribe below.

The main movement was preceded the same day by premonitory tremors of little importance. The first one took place at 0 h. 30', the second one at 7 h. 43'. The main movement started at 7 h. 44'. It began with weak movements, which gradually passed to a tremor of greater degree. The most violent tremors lasted 3 minutes. There followed oscillations of lesser degree that lasted two minutes 53 seconds, so that the total duration of the movement was 6 minutes.

No subway noises were heard, neither before nor during the tremor.

The movement was composed of horizontal oscillations with no particular direction predominating. Simultaneously with these movements, numerous vertical blows of great violence were perceived.

Among the effects of the earthquake, the damage caused to houses stands out in the first place. A superficial inspection of the most damaged streets reveals the action of a vertical force. In favor of this supposition we have:

1° The collapse of flat roofs without this being accompanied by serious damage to the surrounding walls that support them;

2.° Regular cracks from roof to ground in the dividing lines of the houses;

3.° Numerous formations of cracks that start from the corners of doors and windows towards the roof, on one side, and towards the floor on the other.

The damages indicated in Nos. 2 and 3 are typical for irregular vertical shaking or subsidence of buildings, because the points at which they occur are the weakest in the case of the stresses we are considering. During my activity as a technical expert, appointed by the Courts of Justice, in mining damages in the most populated parts of the Rhenish-Westphalian coal district, I have always had the opportunity to verify these facts. With this, we must reject the affirmation of some inhabitants of Copiapó that only oscillatory movements of the ground could be observed, The violence of the vertical blows is demonstrated by the following fact: The iron bottom box of the Municipal treasury, placed on a wooden box, was pushed violently upwards and left in the paper of the wall well-marked traces, whose height, deducting previously the one that corresponds to a probable sinking of the ground, allows to form an idea of the violence of the movement.

However, there is no doubt that the main cause of the destructive work was the horizontal component. On the direction of the horizontal movements there is great diversity of observations. Some observers believe to have verified a direction W. E., others, a direction N. S. Mr. Sierra, whose data on this point are the most reliable, describes the earthquake as a shaking without predominance of any particular direction. The cracks opened in the ground during the earthquake, of which I will speak in more detail later, also did not present a uniform course. Likewise, the damage caused by cracks in the houses is regularly distributed in the surrounding walls, with no particular direction predominating.

The destructive action of the earthquake in the city was enormous. Out of 1630 houses, no less than 344, that is, 20.9%, were totally destroyed; 349, that is, 21.3%, with considerable damage and the rest, 944, that is, 57.8%, suffered minor

damage. Perhaps no house was spared intact from the catastrophe.

To have an exact idea of the influence that the earthquake of December 4, 1918 had on the destruction of the city, it is necessary to consider, even if only briefly, the different types of constructions, the state of the buildings and the subsoil of the built-up area.

The city of Copiapó is built mostly on the clayey sands and fluvial deposits of the Copiapó River and in a very unfavorable situation, since it is exposed, as it was in 1906, to flooding by the rising waters of the river.

The houses are for the most part, very old. Many of them are 60, 80 and more years old. Those 10 to 15 years old are very few and are located mainly in the center of the city. With respect to the regime of ownership, the leasehold prevails. The number of privately owned houses is very small. Due to the decay of the city caused by the abandonment of mining, the number of inhabitants decreased in the last decades, a decrease that was accompanied by a decrease in the rental fees. As a consequence, the maintenance and renovation of the houses was neglected. Add to this the damages caused by the aforementioned flood of 1906 and it will be understood that on the date of the earthquake of Copiapó the state of the constructions was deplorable.

In what follows I will only refer to the main types of buildings in use, each of which is linked to the others by transitions. The proportion in city building is about the same for each type, as will be seen from the statistics I give at the end.

The oldest and cheapest houses and in which, for this reason, people without means of fortune live, are those of tapiales. This type of construction is used for the main interior walls. The material is made of blocks of 1 m. high, more or less, 1.5 m. wide and 0.5 m. thick, made of clayey material deposited by the Copiapó river, which is compressed and molded. The blocks are placed one on top of the other up to a height of 2m. or so; except for rare exceptions, without the intervention of reinforcement or mortar of any kind. As a general rule, not even the precaution of increasing with straw the resistance of this material, so little coherent due to the amount of sand it contains, is taken. Generally, on these blocks are still placed some rows of adobes of the same material, on which the scissors rest. The walls are covered with a thin layer of mud whose adherence is increased by means of wedges and nails that are introduced in holes made for this purpose in the walls.

The roof, which is in most cases quite flat, is composed, also in the other types of constructions, of an armor covered with reeds or totora. To protect it against wind and rain, it is also covered with a thin layer of mud. This deteriorates, but not uniformly. This requires repairs every year or two, which, for the sake of simplicity, are limited to covering the roof with a new layer. Thus, after a few years, very thick layers are formed, which compromise the stability and resistance against shaking.

Advantageous for its cheapness is also the construction, very used, of adobes, whose material is the same as that of the walls; but the walls are thinner, so that the whole building is lighter. For the rest, the placement of the adobes and their covering with mud, does not differ from the previous case. The adobes are often reinforced by means of wooden sides.

This modification constitutes, in a certain way, a transition to modern constructions, but more expensive, which preferably use cane and pitch.

The pitch is gathered in thin bundles and placed between straight feet fairly close to each other. Everything is covered with a layer of mud in the usual way. The adherence is in this case much greater.

When Guayaquil cane is used, canes are nailed horizontally between the right feet, one on top of the other. This results in two cane partitions, one inside and the other outside, and the gap between them is not filled. This construction is very durable and, thanks to its elasticity, very resistant to shaking; but it is not very widespread because of the scarcity of cane, which is imported from Ecuador. For this reason, it is found mainly in commercial houses and the rooms of wealthy people.

These four types of buildings are distributed in the following proportions among the 1630 houses observed:

Tapiales.....44026,8%.

Adobes .....34921,3%.
Brea .....40524.7% Brea .....40524.7% Brea .....40524.7% Brea .....40524.7% Brea
Guayaquil cane.....44627.2% Guayaquil cane .....44627.2% Guayaquil cane .....44627.2% Guayaquil cane

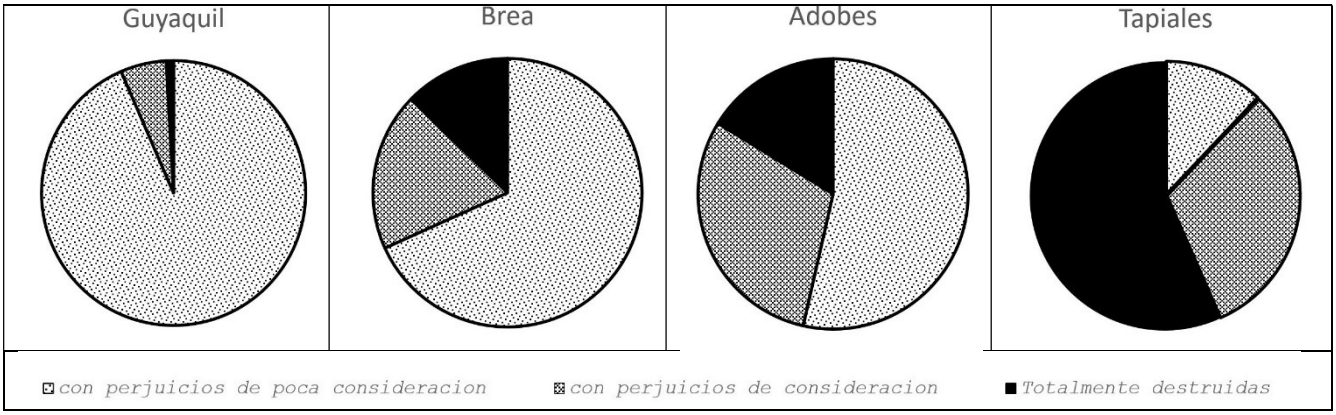
There are other types of constructions, but they are so few in number that they do not deserve to be taken into account.

If we consider the damage caused by the earthquake in these different constructions, we will see that the destruction is much greater in the houses of walled walls. These, already weakened by crumbling or cracking in the contact surfaces of the blocks, would not have resisted an earthquake of a regular degree, somewhat lower than that of December 4.

The blocks were placed one on top of the other; they simply overturned and in some cases crushed the inhabitants. The resistance of the cane houses of Guayaquil has been much higher. The damages consisted almost exclusively of cracks of little importance and the fall of the rebound. The rare cases of serious damage or total ruin must be attributed to age or construction defects.

A regular resistance, although less effective, have demonstrated the houses of tar, This construction is also very light and elastic. There is no doubt that if Copiapó had been built with a lighter material, planks, tar and cane, as happens in the ports of the province, we would not have been able to consider this earthquake as of a maximum degree in the scales commonly in use.

The number of adobe houses totally destroyed or with considerable damage is quite large. Unfortunately, as I have already indicated at the beginning, it has not been possible in the course of my investigation to establish a separation between the adobe buildings that do not employ any framework or skeleton and those that employ wooden or other types of framework; but it is certain that the percentage of houses of this nature must have favorably influenced the reason between the percentage of houses seriously damaged and those with little damage.



Guayaquil.....446

Completely destroyed.....	4	0,9%
With significant impairment.....	255.6%.	
With minor damages..	417	93,5%

Brea.....405

Completely destroyed.....	548.4%	548.4%
With significant damages.....	8120,0%.....	8120.0%
With minor damages...	29071	.6%.

Adobes.....349

Completely destroyed.....	5716.3%.	
With substantial damages.....	1010630.4%.	
With minor damages...	18853	.3%.

Tapiales..... 440

Completely destroyed.....	249	56,6%
With significant damages.....	138	31,4%
With minor damages.	53	12,0%

With respect to the importance of the subsoil in the distribution of damages in the city, it is difficult to make a statistical evaluation. It seems to me, nevertheless, that the part of the city that is on a firm subsoil has suffered, in general, less, in spite of having many houses of unfavorable construction and of great age. This is explained, because the firm subsoil transmits more uniformly to the buildings the oscillations; whereas the alluvial, clayey and sandy soils and little compact, on which part of the city is found, presented cracks and local elevations of the land, that indicate tensions and not uniform efforts in the subsoil and whose unbalance must produce naturally, more serious damages in certain buildings.

I was able to observe numerous cracks and variations of the local level, as concomitant phenomena of the earthquake, in the Garden of the German Lyceum and in the vicinity of the corral of the municipal Inspection of Public Works, in this place had the main crack a length of l00 meters more or less and a width of 0.30 m. Its course was 75° S.0. The perceptible depth reached 0.70 meters. Further down it was full of clods and earth. One of the two cracks in the garden of the German Lyceum, measured 8 m. long, 0,20 m. wide and a measurable depth of 630 m.[2] Its course was N.S.

On one side of this crack, the ground had been uplifted and consequently experienced a great shaking. It could not be a landslide or a fault. I was assured that similar phenomena had occurred in some streets; but I have not been able to verify these assertions.

Regarding the formation of cracks on solid ground, I have not been able to find out anything. It is worth mentioning an interesting fact: shortly after the earthquake, a large amount of water flowed into the Agustina and Bateas mines in Tierra Amarilla. The mine was already suffering from the great abundance of water. As the water supply varied according to the shift in which the water from the Copiapó River was distributed, there was no doubt that the water came from the river. The earthquake caused such a considerable increase that it was feared that the whole

[2] ***nb***. *This value of 630m is what is written in the original document, it cannot be right !*

mine would be flooded; but after a few days the normal flow of water was restored. This phenomenon can be explained by the formation of a new group of cracks that provided a new path for the river water towards the old cracks that gave access to the mine. When these cracks were formed, the fluvial clayey sediments were probably removed, which were dragged and gave the water a muddy and dirty aspect. As the water was again reduced in quantity and recovered its normal appearance and coloration, it can be deduced that, because of the impurities dragged, the system of cracks was closed, apparently of little importance.

No permanent subsidence or uplift has been observed. This, at least, is the result of my inquiries. My inquiries on the coast showed negative results. In Caldera, where the tremor acted with force, eyewitnesses told me that the sea, shortly after the tremor, retreated enough to rise up to 5 m. above the normal tide, This movement was repeated four or five times, but none of the observations allow to deduce even a minimum variation of the level of the coast.

With this the data on the action of the earthquake is exhausted, as far as it refers to my personal investigations. I will add in appendix some information that refer to the surroundings and to some distant points of Copiapó. I owe them mostly to Don Luis Sierra Vera.

Naturally, we cannot vouch for the accuracy of this information.

APPENDIX

BOILER.

Duration of earthquake: 6 minutes Direction: 80° N.W. The cross of the church fell forward in the same direction. Heavy shelves moved in the same direction. Almost immediately after the earthquake the sea began to retreat and had forward and backward movements. Departure of the sea at Puerto Ingles. The normal tide is more or less 27 m. measured on the beach; the sea came out, where the beach begins to the north, 39 m. These tides are almost equal in almost all the beach; but towards the south the fluctuations of the tides were in a point 24 m., in a second point more towards the south, 17 m. and at the end of the beach, 55 m. In Calderilla the normal tide is 11 m. at the beginning of the beach next to the bridge and here the sea rose 48 m. after the earthquake, and at the opposite south end 141 m. horizontal. I have not been able to observe any uplift or subsidence of the coast. Cracks: on the Lawn-Tennis beach, 200 m. from the beach, cracks formed and followed the beach. Damage: glassware was broken in the warehouses. There were no cracks in the houses, not even in the old houses. All the houses are made of wood (planks). The lamps were shaking. It was difficult to walk during the earthquake. The water in the wells remained constant. No subway noises were heard. After the quake there were subway rumbling noises until January 17, 1919. Vertical movement could be felt in one's own body. There were jiratory movements of the objects, but this was only observed in the heavy bodies, because the light ones followed the direction indicated above. On a dusty board, clusters and piles were formed, as when hitting from the bottom upwards. Three kinds of movements were observed: vertical, horizontal and rotary.

2.-The railroad dock suffered from the earthquake. The sea slowly receded, leaving the passenger dock dry after 8 hours. The movement was slow. The sea returned slowly flooding the beach and almost covered the pier, reaching the amplitude of the movement 4.5 m. vertical. The length of the pier is about 70 meters. On board the crew felt the ropes swaying and creaking and there were alarms among the crew. Regarding variations in the level of the coast, it can hardly be affirmed that the level is the old one, or that it has experienced such a small difference that it has not been possible to appreciate it. On the high seas there was a strong shaking and the ship was shaken, the passengers believed that there had been a collision.

3.- The main direction of the earthquake was 0.E. No vertical shocks were perceived.

Large movements after the earthquake. The sea retreated four or five times and rose up to 5 m. above the normal tide. The swell produced by the earthquake had a S.N. direction, which is considered out of the ordinary. Strong movement of the ships anchored in the port. Stresses in the anchor chains and mooring of the ships.

NORTE AMARGO: (Between Copiapó and Caldera):

During the nights of December 5 and 6, many loud subway noises were heard in the ravines.

POTRERO SECO:

Regular damage to walls and houses. Nothing happened in Hornito.

SUNKEN VILLAGE:

There was a very strong tremor.

PUNTA COLORADA:

The tremor was felt slowly. The train was stopped. Transverse oscillations, slow as if in a hammock. Duration of the tremor: 2 minutes. At kilometer 530 between Almirante Latorre and Quebrada Grande there was a landslide that obstructed the track. Train moved along the track, the wheels moved a little.

PÚQUIOS:

It is not possible to specify from which direction the movement came: The phenomenon began with little noise, but before starting the strong vertical movement there was a subway noise, hoarse and loud. Subsequently and until February strong noises are felt, some short and dry as discharge of cannons and other long and intermittent as echoes, but without movements. In the town of Puquios there was no building that did not suffer something. Several houses and walls fell in streets along and across. In the injenio of the Dulcinea mine, including the houses of the administration and workers, almost nothing was left standing; these, including the administration, were made of walls, adobe or adobe. The enclosures and corrals almost all fell, but not overturned, as is almost always the case, but completely demolished. In the workings there are two piques of 35 m. deep. The water in them has increased by more or less 25%. In several places there have been small cracks, or rather, superficial cracks in the vega terrain. Several wells in the area have not been altered. There have been no changes in the relief of the soil.

SAN ANTONIO AND LOROS:

Several houses damaged by the earthquake, some destroyed and numerous walls on the ground. Several irrigation canals completely collapsed. In the Fuerta (hacienda 2 or 3 miles from San Antonio) the houses fell down.

TIERRA AMARILLA:

The earthquake was felt, less than in Copiapó. It did not cause much damage

THREE BRIDGES:

Many vehicles obstructed the roadway.

VALLENAR:

Strong tremor. People go out into the street and into the courtyard. Many objects fall. In the building of the Industrial Section of the Technical Commercial Institute there are cracks (predominantly vertical) almost always on the E. and 0. sides; in the other directions there are none. The openings in the walls in the vertical direction are very noticeable in the contact of the adobe bricks with the right feet. They have separated so much, that the light passes through and can be seen on the other side. On the second floor there is almost no damage, except in the Industrial Section where there is only one floor with small cracks in the north and south walls.

CLEMENS LINNEMANN.

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