

THE EARTHQUAKES OF NUEVA VIZ-
CAYA (PHILIPPINE ISLANDS)
IN 1881.

BY

ENRIQUE ABELLA Y CASARIEGO.

Ingeniero Jefe del Gro. de Minas.

[Translated by G. Nembrini, Esq.]

REPORT presented to H. E. the Director-General of the Civil Administration of the Philippine Islands, on a journey undertaken for the purpose of studying *Earthquakes experienced in Nueva Vizcaya during the year 1881.*

There are two maps: one of the whole island of Luzon, showing the relative position of different places cited in the report; and the other, of the agitated province of Nueva Vizcaya.

The following is a copy presented to the "Seismological Society of Japan" by the Inspector-General of Mines, Enrique Abella y Casariego.

[NOTE.—Earthquakes became weak during October.]

YOUR EXCELLENCY:

The communication in which Your Excellency was pleased to instruct me on the 22nd November, respecting the study of the circumstances connected with the succession of earthquakes experienced in the province of Nueva

Vizcaya, contained two principal points:—The first had a scientific character, because treating of seismic phenomena considered in themselves, and of the physico-geological conditions of the affected districts. The second, although more difficult of treatment, was nevertheless not less important from a governmental point of view, because Your Excellency as well as the Government-General of these islands, having similar ideas, could not but be concerned about the continuous commotion in the province considered as a public calamity by affecting the mental and moral condition of the people, and the public and private interests of the districts. Alive to the importance of these two interesting points, I undertook my journey with all the rapidity which the unfavourable weather and bad state of the roads permitted, crossing the province of Nueva Vizcaya from North to South, noting in each locality at the time all particulars which had not previously been brought under my notice. During these studies I had frequent occasion to witness the shocks which agitated the district, and to observe their temporary as well as permanent effect upon the ground, the buildings, and the people,—to note their intensity and direction, and also the subteranean noise which accompanied or preceded them.

As assistance in hastening the accomplishment of my task, I was fortunate in finding that the old and venerable missionary of Dupax, the Right Rev. Father Antonio Xabert, was a diligent observer, who had registered all the more considerable seismic movements which had occurred during the year in the province. He had the kindness spontaneously to place at my disposal all his observations, which I am constrained to acknowledge with gratitude in this report.

Ever since the month of July of the preceding year, 1880, in which the great earthquakes of the island of Luzon happened, the province of Nueva Vizcaya has not been

without shocks from time to time, but some of these were so slight that the majority of the inhabitants did not notice them. In the month of July of this year, however, these movements began to become more sensible. On the 27th of that month, at 5 p.m., a strong shock was felt, damaging several of the few masonry buildings. This was the forerunner of the seismic activity now to be described. From that time began a decided and seldom interrupted series of slight and strong shocks, the maximum intervals between which did not exceed three days. Without any interruption of the series of shocks, on 1st September, at 12.20 p.m., a sudden, strong, quiet trembling motion was felt, similar to all the shakes which have agitated and still continue to agitate the districts. From that moment a considerable increase of seismic activity was developed, on such a scale that the shocks were felt at intervals of an hour or a minute, and sometimes continuously with palpitation of the ground, only interrupted by the interpolation of more serious shocks. This of course could not fail to produce upon the terrified inhabitants of that splendid province a painful and nervous moral tension.

During the month of September, (as can be seen by the catalogue of Father Xabert, attached to this report, Table No. 1,) thirteen very strong earthquakes were felt, besides numerous slight shocks. We must observe here that only the most important shocks were recorded, the remainder although quite sensible, being too numerous to mention. I had occasion to observe on the 30th September at 10h. 40m. a.m. in the open country, one of those belonging to the first category, from a detailed description of which it is possible to gain an approximate idea of the intensity of the others.

I was proceeding on horseback from Aritas towards Dupaz accompanied by an assistant officer, Don Enrique de Almonte. When passing through the village of Tambong belonging to the latter of those districts,

we heard (approximately towards the north) thunder, so perfectly similar to that of atmospheric storms, that I glanced up, looking at the thick clouds overhanging the summits of the surrounding mountains. But hardly five seconds afterwards our horses stopped, spreading out their legs in order to assume a more stable attitude, and staring about in a frightened manner. We then suddenly felt a sharp vertical movement followed by a horizontal one, which was so decided that we saw the road and the surrounding ground move about a metre on each side of our horses' heads, which served as a point of observation and comparison inasmuch as they tended in virtue of their inertia to keep steady. At the same time the ground swelled, and continually during the movement opened and shut itself in a multitude of small cracks of from one to three millimetres in width, through which the waters of the puddles sank. All this was accompanied by a peculiar noise produced by the undulation, and by the movements of the bushes and canes which formed the fences round the houses, which were swinging and shaking against one another. This phenomenon lasted from 30 to 35 seconds, after which the former calm and silence succeeded, only broken by the prayers of the Indians and the tramping of our horses as they resumed their march.

All shocks have not presented such distinct and noticeable oscillations as that I have just mentioned, this kind of earthquakes being generally confined to the North and South parts of the province (Abungol and Caraballo). That we felt it so strongly on the 30th is undoubtedly to be explained by our passing along the Northern Slope of the great Caraballo. The peculiar and true nature of the shocks, especially in the centre of the province, is that the sensation is *almost absolutely vertical*, comparatively slight, and of short duration, except in cases of greatly prolonged seismic activity when the shocks follow almost

without interruption. Such continuation of shocks is probably due to different and distinct vibrations, but the effect is nevertheless that of a very prolonged earthquake.

I have been able to establish the probable *centrum* of the agitated region, my observations on which I will now summarize.

First. The thunder which always precedes the shock by a few seconds, is heard most distinctly towards the middle of the province in the neighbourhood of Bambang. The most important circumstance is that *the interval between the sound and the movement is always shorter the nearer the observer is to that town*, and especially when on the surrounding heights clear of the deadening effects of the valley's alluvium. The sound of the shock and the movement, although sensibly successive in these places, become *very often* mingled together. On the other hand, towards the frontiers of the province there are observed:—1st, a sound of subterranean thunders; 2nd an interval of rest and quiet, sometimes of five or six seconds; and 3rd a vertical shock accompanied by a noise which we may call the "squall" of the seismic waves, followed without interruption by a *horizontal* movement of oscillation. When we observe the cracks produced in the masonry buildings of Bambang, we also come to an analogous but more certain conclusion. But above all in order to give the theory of Mallet its proper place in our own deductions, we must note that the walls of the buildings exclusively employed in this province do not contain any tie work (which so much tends to diverge the direction of breaking lines), but are composed of irregular blocks of stone united with mortar generally of such excellent quality that it is difficult to break it even with a mason's hammer, indeed easier to break the stone itself than the adjoining cement. It is also very important to remember, that while cracks produced in the buildings of villages at a distance from Bambang shew,

more or less visibly, an inclination to the horizon, in this town they are perfectly horizontal; so that for instance two complete cracks in its church-tower divide the tower into three complete distinct blocks, which have not yet fallen, partly doubtless, on account of the excellent material, but principally from the circumstance that the shocks sustained by the tower were purely vertical movements; while it is most probable that if a horizontal shock had occurred the upper portions of the tower would have fallen.

This town has also suffered much other damage in its masonry buildings. Of the few others it is possessed of, the Tribunal is very seriously damaged; one of the schools is full of cracks, while the other has fallen. The monastery is entirely in pieces; and the church has suffered severely. It is to be noted that all these buildings are roofed with "côgon" (tiles.)

All these peculiarities lead us to conclude with sufficient certainty that the seismic vertex of movement which agitates the districts lies at or about Bambang; that is to say, the active centre of subterranean vibrations must be a point in a vertical line below the vicinity of Bambang. Which is that point?; or at what depth is this active centre of seismic disturbance situated? It is believed that it is not far from the surface, and I adduce for your excellency's consideration two principal reasons for maintaining this deduction; namely the almost simultaneous occurrence of sound and movement at Bambang, and the comparative intensity and localization of the shocks.

In order to gain all possible particulars on this point, I addressed myself to the Jesuit Fathers of this town, believing that in their observatory I could ascertain not only observations of ordinary seismic movements, but also of micro-seismic disturbances, and also because I should be in a position for examining all their records—although rather vague and indeterminate—from other localities on the island,

communicated by wire through the Central Telegraph Office. And I feel myself bound to make known the kind support I received from Fathers Ricart and Faura, and the attention shewn me by this latter distinguished meteorologist who has charge of the observatory, who favoured me with his tables and seismological records of every kind, from which I have obtained the data upon which table No. 2 of this report is founded.

Comparing this table with table No. 1, two general and important facts seem to be elicited. In the first place it will be seen that in the beginning of July, an eruption of the volcano of Mayon in the province of Albay began, and in the same month a commencement of seismic activity took place, in a series of movements in Nueva Vizcaya which culminated in the severe earthquake of the evening of the 27th, while on the 28th the eruptive action of Mayon became more powerful. However, the notable shocks so strongly felt in Manila from the 14th to 17th of April, do not appear to have been observed in Nueva Vizcaya, nor do they seem to have exercised any influence on the state of Mayon, notwithstanding that Manila occupies an intermediate position, and is nearer to either point than they to each other.

These two facts, which in a certain sense seem to be contradictory, can nevertheless be explained if we admit the natural interpretation which results from them, namely:— It may be supposed that there exists a certain internal relation between the seismic movements of Nueva Vizcaya and the eruptions of Mayon, as is shewn by the coincidence of the phenomena; as the eruption of Mayon, beginning on July 6th, was able to transit toward the North-West a portion of its activity, which manifested itself on the 13th in the seismic movement of Nueva Vizcaya, and of this a part was stored up in a latent state which manifested itself on the afternoon of the 27th with an intensity suf-

ficient to transmit towards the South-East a certain quantity of fluid material, which appeared on the 28th in Mayon in the considerable increase then noticed in the eruption.

That the notable seismic movements felt during August, but not observed in Nueva Vizcaya nor on Mayon, do not correspond with this hypothetical line of subterranean activity, may be explained by the fact that Manila, instead of lying on this line, has probably direct connection with a nearer force than those of Banajas, Maquiling, and Taal. Nevertheless the active period of Nueva Vizcaya as well as those of Mayon is perceptible at Manila by very noticeable and curious microseismical activity. The last hypothesis of independent seismic foci for Manila and Nueva Vizcaya seems to have held good in the earthquake experienced on the 4th of October at 2 p.m., which, (noted in Taal as intense, and at Manila as quite sensible), I had the opportunity to witness at Bayombong. With regard to the usual series of shocks, the result there was very strange, because this earthquake having reached that province (Nueva Vizcaya) with its horizontal component of motion, not only disturbed the uniformity of the shocks which were almost exclusively vertical at that focus, but might also be observed by the long duration of mild swinging to be felt, which indicated that the vibration focus lay at a great distance, most probably—according to the telegrams contained in Table 2—at an intermediate point nearer to Taal than to Manila.

These purely theoretical but rational considerations might be farther extended, serving to throw more light upon this important question, were the notes from the provinces more numerous and more exact in their determination of time and intensity. In this way we should be able in most instances to judge in a relative degree pretty exactly of the position of seismic centres, and the relation existing be-

tween them and the volcanic focus of Luzon, and to predict with more or less certainty phenomena from antecedent dangers threatening certain districts.

But departing from general considerations and reverting to a comparison of the tables, we observe that of the *thirteen* strong shocks felt during the month of September in Nueva Vizcaya, only those of the 1st, of the early morning of the 18th, and those of the evening of the 20th, were sensible at Manila; whilst the earthquake of the 28th was felt at Lingayen and La Vinon, and that which happened at 10.40 a.m. on the 30th, at Bacolor and Tarlac. This last was not recorded by the apparatus at Manila, but only—as we have already seen,—that of the early morning. However, according to my own observation I am sure of this earthquake having taken place in Nueva Vizcaya, and though strong, it was not so strong as that of 10.40 a.m. which I have particularly described. This fact may be explained by the inclination in different directions which the vibratory force may assume, even although it proceeds from a single point or seismic centre, producing in one direction a movement which will be propagated in the surface to a greater distance. It would be impossible to graduate the relative intensity of the motions of the soil in Nueva Vizcaya by estimating the distances to which these have been propagated, even had the observations been more numerous as well as more precise.

But, however, this may be, the positive fact which may be deduced from this comparison and from the considerations we have just laid down, is that the vibrations of the soil in Nueva Vizcaya were transmitted to distances relatively very small, so that the very numerous shocks of the second and third orders were felt only from the Northern slope of Caraballo to the Southern part of Abungol. There were noticed outside of these limits only some of the strongest motions, which were perceptible in some provinces

or others according as the direction of the impulse of the original shock was more or less inclined to the horizon. These movements also acquire a special character of oscillation when they leave the province and pass the mountains, beyond which only their horizontal component survives, which likewise becomes gradually weaker and at last disappears towards the south in the extensive plain of Nueva Ecija, Bulacan, and Manila. And this plain being situated about 300 metres below the average level of the Magat valley, the angle of emergence of the vibrating undulation is somewhat acute because the active centre of the seismic vibration for the province lies near to the surface in Nueva Vizcaya.

But even supposing the centre of vibration were at a great depth, still the angle of emergence for very considerable distances could vary but a few degrees, so that the two components, horizontal and vertical, would change very slowly and produce movement very similar in intensity, notwithstanding the diversity of rock, through which the original wave had to pass, absorbed and distributed unequally its initial intensity. Therefore, applying this deduction to the observations above noted of the diminution of the interval between the sound and shock as the observer approaches Bambang, where the two are simultaneous, it results—so far as facts founded on insufficient observation can be trusted—that the centre of seismic vibration, which is according to our former reasoning in a vertical line below Bambang, is but a small depth below the surface of the ground in Nueva Vizcaya. But it is not possible to solve this important problem without accurate record of intensity and inclination at various points in the disturbed area.

However, this determination, although from a scientific point of view most interesting, as we might from it obtain a knowledge of the composition of the lower soil, still could

hardly afford us any information for immediate practical application, the force not being known which at any given moment might be developed at the centre of activity.

The visible effects produced on the soil of Nueva Vizcaya by such continued vibrations, are only remarkable on account of their rarity and insignificance. With the exception of the temporary small cracks to be seen in the valleys during shocks, and which soon disappeared, I had only occasion to observe three crevasses of small width in the slopes of diorite, and at points where the superficial crust was considerably decomposed by atmospheric action, and the positions favourable to the impulse of vibration. However, other facts were related to me which occurred before my arrival at Bambang, which I took care to have corroborated by examining several witnesses in the presence of the Right Reverend Missionary of the village. The witnesses said that towards the end of July—they did not remember the exact date, but it probably coincided with the great shock of the 27th—they observed that the river Aboat—an affluent of the Magat which flows near the village—suddenly dried up (an occurrence which had never happened before) and remained so for about *two hours*, after which the waters re-appeared with considerable increase of volume, and having a reddish colour only known during high freshets. After a few hours its course, volume, and condition became normal. This phenomenon has an easy probable explanation through the slipping down of steep banks in narrow parts of its upper valley, in which way its flow was obstructed until the water had time to accumulate and pass over or demolish the obstruction.

And though the constitution of that homogeneous dioritic soil without faults or irregularities in the whole extent of the province allows us to suppose *a priori* a great resistance and a lack of permanent and considerable disturbance of the strata, like those which are commonly observed in

other localities, nevertheless it continued to be intensely agitated by seismic vibrations, as has been the case with Nueva Vizcaya, and this fact considered by itself is a powerful reason to suppose with great probability of truth that the danger which the people of the province run is very remote, unless the intensity of the shocks increases. Possibly the contrary may take place, and the shocks may go on decreasing through the extinction of the focus which produced them. It is to be desired that this may happen soon, so that the suffering inhabitants may return to their normal habits and labours, which have been more or less disturbed since the beginning of the seismic phenomena. From this moral point of view the effects of the commission with which Your Excellency was pleased to instruct me, could not have been more satisfactory, and I feel myself obliged to represent it to you. In consequence of a telegram received from Your Excellency, the zealous and distinguished Governor of the province had prepared the inhabitants for my coming, so that all the subordinate chiefs and others officers of Nueva Vizcaya called on me for advice as to the danger to which they were exposed, and which they believed so great that they were already prepared to emigrate with their families to contiguous provinces to escape a catastrophe which they anticipated. My explanations, however, succeeded in inspiring in them a certain amount of courage and confidence, because they saw from the elementary simplicity of these the distance of the danger. Consequently they desisted from their purpose of emigration, and my visit produced in them a sentiment of profound gratitude, which it is my agreeable duty to ascribe to the wise provision of Your Excellency and the superior authorities of these islands, who have always interpreted the fatherly feelings of the Supreme Government in the metropolis.

Therefore if the scarcity of exact and positive data to serve

as foundation, and especially the incapability of the undersigned, have produced no more than the very poor scientific result which I have the honor to submit to Your Excellency, still my journey in that province has had an excellent moral effect on those afflicted inhabitants, whose thanks I beg to present to you.

I have, etc.,

(Signed) ENRIQUE ABELLA Y CASARIEGO.

Manila, the 20th of October, 1881.

TABLE No. 1.

DAILY NOTES of the Principal Earthquakes in Nueva Vizcaya from the month of July, 1881, registered by the Right Rev. Father Antonio Xabert y Rogner.

- July 13.— 4.00 a.m. (rain until 10 a.m.)
- „ 25.— 3.50 p.m.
- „ 27.— 2 and 4.30 a.m.
- „ 27.— 4.50 a.m.
- „ 27.— 4.10 p.m. (strong).
- „ 27.— 7.00 p.m.
- „ 27.— 8.00 p.m. (continual shocks during the whole of the night.)
- „ 28.— Shocks during the whole day.
- „ 29.— do. do.
- „ 29.— 6.00 a.m. (one strong shock ; others frequent, but not so strong.)

- Aug. 1.— 11.25 p.m.
- „ 3.— 10.25 a.m.
- „ 4.— 0.10 a.m.
- „ 8.— 9.50 a.m.
- „ 8.— 1.16 p.m.

- Aug. 9.—11.30 a.m.
" 9.— 7.30 p.m.
" 10.— 5.20 a.m.
" 10.— 4.00 p.m.
" 10.— 5.00 p.m.
" 10.— 6.30 p.m.
" 10.— 9.00 p.m.
" 11.— 5.20 p.m.
" 11.— 6.00 p.m.
" 11.— 7.50 p.m.
" 11.— 8.20 p.m.
" 13.— 5.47 p.m.
" 17.— 7.45 a.m.
" 17.— 9.20 a.m.
" 18.— 8.45 p.m.
" 18.— 9.00 p.m.
" 18.—10.55 p.m.
" 19.—Gale and stormy from 9 a.m.
" 20.—to 8 a.m.
" 23.— 4.15 p.m.
" 24.— 8.05 a.m.
" 24.— 2.40 p.m.
" 24.— 3.50 p.m. (and other lesser shocks.)
" 27.— 2.30 p.m.
" 28.— 4.00 p.m.
" 31.— 3.00 p.m.
" 31.— 7.23 p.m.
Sept. 1.— 5.34 a.m.
" 1.— 8.33 a.m.
" 1.— 0.20 p.m. (terrible shaking.)
" 1.— 1.32 p.m.
" 1.— 3.35 p.m.
" 2.— 2.40 a.m.
" 2.— 7.55 a.m.
" 2.—11.45 a.m.

- Sept. 2.— 8.00 p.m. (and other lesser shocks until the 3rd
at 4 a.m.)
- „ 3.— 9.50 a.m.
- „ 3.— 9.30 p.m. (and during whole night.)
- „ 4.— 8.30 a.m.
- „ 4.—10.40 a.m.
- „ 4.— 2.30 p.m. (and others.)
- „ 5.— 7.16 a.m. (and several others.)
- „ 6.— 1.30 p.m.
- „ 6.— 3.10 p.m.
- „ 6.— 3.30 p.m.
- „ 6.— 6.08 p.m. (and several others during the even-
ing.)
- „ 7.— 6.30 a.m.
- „ 7.—11.20 a.m.
- „ 7.—11.54 a.m. (dreadful; at night innumerable
shocks.)
- „ 8.— 6.30 a.m.
- „ 8.— 5.20 p.m.
- „ 8.— 5.40 p.m.
- „ 8.— 7.45 p.m. (strong.)
- „ 8.— 8.52 p.m. (and others during whole night.)
- „ 9.— 4.40 a.m.
- „ 9.— 6.05 p.m.
- „ 9.— 9.20 p.m. (and others during the night, with
gale.)
- „ 10.— 7.25 a.m.
- „ 10.—11.00 a.m.
- „ 10.—11.40 a.m.
- „ 10.—12.00 noon.
- „ 10.— 2.40 p.m.
- „ 10.— 7.36 p.m.
- „ 11.—10.40 a.m.
- „ 11.—10.50 a.m.
- „ 11.— 1.30 p.m.

- Sept. 11.— 5.30 p.m. (and many others.)
„ 12.— 5.00 a.m.
„ 12.— 7.45 a.m.
„ 12.— 8.00 a.m.
„ 12.— 9.03 a.m.
„ 12.— 5.46 p.m. (and many others.)
„ 13.— 6.05 p.m.
„ 13.— 8.00 p.m. (and many others during the night.)
„ 14.— 1.00 p.m. (an interminable series of shocks
began, lasting till 5 a.m., and
several after noon.)
„ 15.—A few weak shocks.
„ 16.— 5.45 p.m. (several weak shocks.)
„ 17.— 9.20 a.m.
„ 17.— 9.37 a.m.
„ 17.— 9.54 a.m.
„ 17.— 9.57 a.m.
„ 17.—11.00 a.m.
„ 17.—12.00 noon (and many others continuing till
1.50 p.m.)
„ 17.— 2.45 p.m. (strong.)
„ 17.— 4.30 p.m. (and during all the afternoon.)
„ 18.— 4.55 a.m. (*dreadful*.)
„ 18.— 7.50 a.m.
„ 18.—10.00 a.m. (and others.)
„ 18.—11.40 p.m. (*horrible*.)
„ 19.— 9.35 a.m.
„ 19.— 4.18 p.m.
„ 19.— 8.00 p.m.
„ 19.— 8.25 p.m. (and during the night.)
„ 20.— 6.07 a.m.
„ 20.— 9.10 a.m.
„ 20.— 2.55 p.m. (*dreadful*, and many others.)
„ 21.—10.00 a.m.
„ 21.— 0.55 p.m.

- Sept. 21.— 2.23 p.m.
„ 21.— 4.40 p.m. (and many others till 9 p.m.)
„ 22.— 2.00 p.m.
„ 22.— 3.15 p.m.
„ 22.— 7.10 p.m.
„ 22.—10.15 p.m. (and others.)
„ 23.— 1.55 a.m.
„ 23.— 2.46 a.m.
„ 23.— 5.10 a.m.
„ 23.— 6.05 a.m.
„ 23.— 6.35 a.m.
„ 23.— 6.44 a.m.
„ 23.— 7.03 a.m.
„ 23.— 3.30 p.m.
„ 23.— 4.00 p.m. (and others.)
„ 24.— 8.00 a.m.
„ 24.— 8.45 a.m.
„ 24.— 1.55 p.m.
„ 24.— 9.05 p.m. (all weak shocks, new moon.)
„ 25.— 4.00 a.m. (three weak shocks.)
„ 25.— 1.30 p.m. (do. do.)
„ 25.— 7.35 p.m. (During this evening, although threatening very much, little rain fell and little electricity was noticed. This was noticed during the whole of the earthquakes.)

„ 26.—10.47 a.m.
„ 26.— 1.00 p.m.
„ 26.— 4.12 p.m. (during rain.)
„ 26.— 7.12 p.m.
„ 26.— 8.54 p.m.
„ 26.— 9.00 p.m.
„ 27.— 2.00 a.m.
„ 27.— 8.05 a.m.
„ 27.— 3.25 p.m.

- Sept. 27.— 8.05 p.m.
„ 28.— 3.34 a.m.
„ 28.— 4.36 a.m.
„ 28.—12.00 noon (and several till 2.30 p.m.)
„ 28.— 3.45 p.m. (*very strong.*)
„ 28.— 4.12 p.m.
„ 28.— 5.35 p.m. (strong and during rain.)
„ 28.—11.10 p.m. (strong, others till 12 midnight.)
„ 29.— 1.03 a.m.
„ 29.— 2.40 p.m.
„ 29.— 2.35 p.m.
„ 29.— 3.20 p.m.
„ 29.— 3.52 p.m.
„ 29.— 5.58 p.m.
„ 30.— 4.20 a.m.
„ 30.— 5.10 a.m.
„ 30.— 5.30 a.m. (*strong.*)
„ 30.— 9.30 a.m.
„ 30.— 9.46 a.m.
„ 30.—10.40 a.m. (*very strong.*)
„ 30.—11.45 a.m. (and several lesser shocks till 5.23 p.m.)
„ 30.— 5.23 p.m. (*strong.*)
„ 30.— 6.03 p.m.
„ 30.— 9.45 p.m.
„ 20.—11.45 p.m. (*strong.*)
Oct. 1.— 7.24 a.m. (and several lesser but distinct shocks
from 11 a.m. till 1 p.m.)
„ 1.— 7.24 p.m. (*strong.*)
„ 2.—No sensible shocks.
„ 3.—Two or three shocks during the morning.
„ 4.—Two very sensible shocks in early morning.
„ 4.—10.30 a.m.
„ 4.— 2.05 p.m. (weak but long.)
„ 4.— 7.30 p.m.
„ 4.—11.20 p.m.

Oct.	5.—	0.05 a.m. (and two during the morning.)
„	5.—	7.20 a.m. (<i>remarkable.</i>)
„	5.—	9.45 a.m. (<i>greater.</i>)
„	5.—	10.35 a.m.
„	5.—	10.45 a.m.
„	5.—	11.00 a.m.
„	5.—	12.45 p.m.
„	5.—	1.30 p.m.
„	5.—	2.35 p.m.
„	5.—	5.15 p.m.

TABLE No. 2.

EARTHQUAKES of the island of Luzon according to seismical observations made at the observatory of the Jesuit Fathers, and extracted from telegrams received from the provinces, from the month of July 1881.

July 16th.—Between 2 and 3 p.m., lasting 5 to 6 seconds in Aparri and Tuguegarao (province of Cagayan), in Ilagan (province of Isabela), and in Caudon and Lavag (Ilocos Sur and Ilocos Norte). Approximate direction North—South. In Manila weak movement North—South at 2.13 p.m., duration 4 seconds.

July 28th.—At Carig (province of Isabela, the nearest place to Vizcaya), at 4.50 a.m. Direction North-East—South-West, duration 30 seconds. Repeated at 4.6 p.m., duration 10 seconds.

At Nueva Caceres (Camarines Sur) at 11.30 a.m. direction North—South, duration 8 seconds. Repeated at 4.6 p.m., duration 10 seconds.

At Manila at 1.55 p.m. two small shocks North-East—South-West.

July 30th.—At Punta Santiago, Taal, and Batangas, at 3.15 p.m. This movement was noted first as a strong one, secondly as a regular one, and lastly as a weak one.

At Manila at 2.16 p.m., weak movement only recorded by Bertelli's pendulum with an amplitude of $1^{\circ}10'$ South-East to North West. The microseismical movements recorded by this pendulum were more remarkable after the 28th, when the prevailing direction was North—South.

[*Note.*—On the 6th of this month between 6 and 7 p.m. Mayon Volcano in the province of Nueva Vizcaya recommenced to be active after six years quietude.]

On the 16th at the same hour another eruption.

On the 22nd at 11 p.m. another accompanied by great noise; and on the 28th another of the same character.

August 14th.—At Isidro (Nueva Esija); Bacolor (Pampanga); Balanga (Bataan); Bulacan, Cavite, Lipa, and Taal (Batangas), Calamba, and Santa Cruz (Laguna), and Tayabas, about 10 p.m., a strong movement but less distinct in the Southern districts. At Manila it was felt at 9.46 p.m., with vibrations of 7 millimetres and a total oscillation of $9^{\circ}12'$, the first impulse being towards the South-West, and the combined direction East 30° North to West 30° South. At 11.8 p.m. a second and weak shock.

August 15th.—At S. Fernando, and Bacolor (Pampanga), Bulacan, Balanga (Bataan), Corregidor, Cavite, Punta Santiago, and Calamba, Santa Cruz (Laguna), at about 9.30 a.m., strongest toward the Southern places. In Manila at 0.15, 1.55, and 3.25 a.m. shocks increasing in intensity, and at 9.13 a.m. trembles of 3 millimetres, and oscillation doubly remarkable. It commenced at East 18° North to West 18° South, with amplitude of $5^{\circ}14'$; and finished at East 33° S. to West 33° N., with amplitude of $2^{\circ}25'$, the pendulum moving at intervals all day long.

August 16th.—At Manila momentary shocks felt that at 5.02 a.m. being rather the greatest, but the movement of the pendulum decreasing.

August 17th.—At Manila at 8.15 a.m., trembles of two millimetres, and oscillation $1^{\circ}15'$ from N. 10° E. to S.

10° W. At 9.11 a.m. a second but weaker shock. At 11.2.12 another more distinct shock with direction N. 4° E. to S. 4° W.

August 18th.—At Manila at 3.15 a.m. a shock like the preceding one, direction N. 2° E. to S. 2° W. In the afternoon a very strong squall with very much electricity and hail.

August 19th to 22nd.—At Manila, while the storm was passing—which was very intense—on the 22nd, the micro-seismical movement was very distinct from 6 to 9 seconds, sensible and continuous shocks being felt at intervals of 9 seconds.

August 23rd.—At Manila weak oscillation from South-East to North-West: duration 10 seconds. The micro-seismical Bertelli pendulum during the 1st and 2nd of this month generally had a movement from North to South and from North-East to South-West. From the 3rd to 8th it was quiet, at which latter date its real activity commenced, and from the 12th it developed and increased till the end of the month.

[*Note No. 1.*—According to statements of many respectable persons, during the Manila Earthquakes, and according to Father Faura, Director of the Observatory, the existence of a continuous subterranean current might have been noticed by an attentive person, during the great movement of Bertelli's pendulum from the 18th to the 22nd. The engineers who collected these notes while on service at the village Mariguina only noticed subterranean noises on the night of the 17th. This may be explained when we consider that this village is situated on volcanic tufa in which sound ought to be transmitted more intensely and clearly than through the stratum of fine alluvium and mud on which the capital stands.]

[*Note No. 2.*—On the 4th and 8th of this month the resumption of volcanic activity in Mayon was repeated,

considerably increasing on the 21st and 24th; between 6 and 7 a.m. on the 1st, and at 10 to 12 p.m. of the 2nd. In the last notes, which extend only to the 26th, it is mentioned that the split in the mountain facing Legaspi which had been formed on 31st October 1875, was literally filled up, and all its Eastern part was completely white, owing to the ashes discharged from the volcano.]

September 1st.—At Manila at 0.20 a.m. a weak oscillation from North to South (approximately)—duration 5 seconds.

September 4th.—At Albay at 5.42 a.m. an oscillation of little intensity or duration.

September 15th.—At Balanga at 9.50 a.m. oscillation from West to East, duration 5 seconds.

September 18th.—At Manila in the early morning a sensible movement was felt.

September 20th.—Tuguegarao (Cagayan), Carig (Isabela), San Fernando (Union), Bacolor (Pampanga), Lingayen (Pangasinan), and Santa Cruz (Laguna), between 2 and 3 p.m., strong movement. The telegram from the last place mentioned that from 9.30 p.m. of the previous evening several weak oscillations were felt. In Manila at 2.54 p.m. oscillation from North East 4° North to South West 4° South, with an amplitude of $1^{\circ} 4'$.

September 23rd.—At Lingayen (Pangasinan) at 6 a.m. a slight oscillation from South East to North West.

September 27th.—In the province of Union at 2.42 p.m. a strong shock, similar to an oscillation.

September 28th.—At Lingayen at 3.36 a.m. three shocks of little intensity, and in the province of Union at 11.25 p.m. a movement of medium intensity.

September 29th.—At Lingayen at 11.4 p.m. a small oscillation.

September 30th.—At Caudon (Ilocos Sur), Tarlac, and Cavite, between 5.15, an oscillation, which was intense at Tarlac, but weaker at the other two places. Direction

approximately from North to South. In Manila at 5.22 a.m. an oscillation North 20° East to South 20° West, amplitude $0^{\circ} 34'$, duration 4 seconds, with a trembling of 3 millimetres. In Tarlac and Bacolor (Pampanga) at 10.30 a.m. an intense oscillation in the first place, decreasing to a weak one.

The microseismical activity diminished till the 5th, from which day it became gradually more distinct till the 9th, and then diminished again till the 12th. From the 13th till the 16th it gradually increased, on which latter date it decreased, but soon afterwards again increased till the end of the month shewing an oscillation of $24''$.

[*Note No. 3.*—We have no exact information about the activity of the volcano of Mayon during this month, but it continued in eruption.]

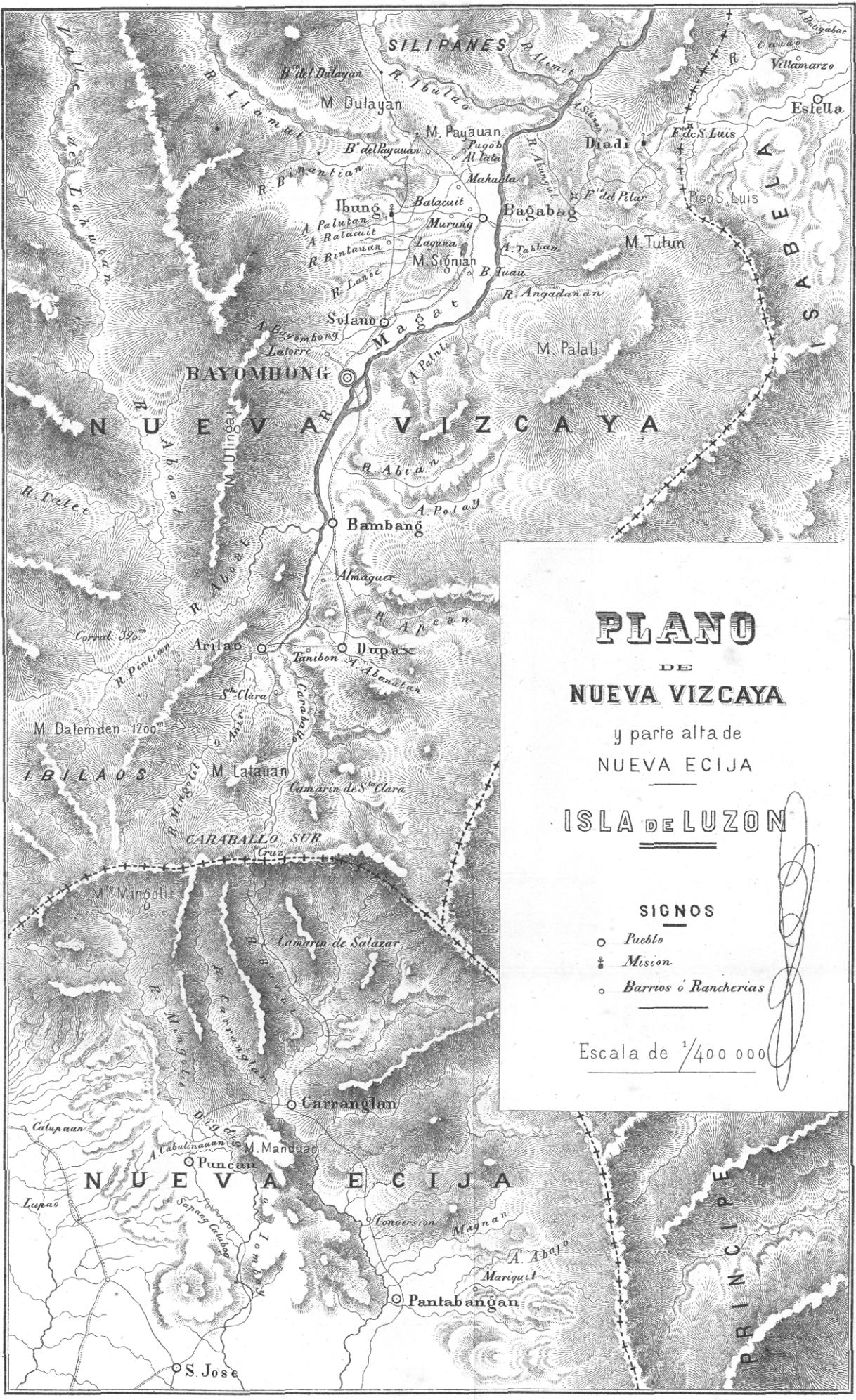
October 2nd.—At Punta Santiago (Cavite), Taal, and Batangas, about 2.30 p.m. movements were felt. They were designated at Taal as being strong trembling, whilst at the other places—although at Batangas loud subterranean noise was heard—they were observed to have a weaker intensity.

At Manila oscillations from North to South at 11 a.m., with amplitude of $6'$; and at 2.24 p.m. with $14'$.

October 4th.—At Tarlac and Bacolor (Pampanga) about 2.30 p.m., an intense and prolonged trembling movement—oscillation in the first place from N.N.E. to S.S.W. and in the second from East to West at the same point. At Manila at 2 p.m. a very weak movement with subterranean noise, and at 2.20 p.m. another and stronger movement of two millimetres—oscillation from S.E. 20° E. to N.W. 20° W.—amplitude $0^{\circ} 30'$.

October 5.—At Appari (Cagayan) at 6.33 oscillation North to South. Duration 2 seconds.

From the 5th to the 11th the microseismical movement was relatively calm, but on the 11th it again increased.



PLANO
DE
NUEVA VIZCAYA

y parte alta de
NUEVA ECIIJA

ISLA DE LUZON

SIGNOS

- Pueblo
- ⊕ Mision
- Barrios ó Rancherias

Escala de $\frac{1}{400\ 000}$



