

*THE EARTHQUAKES OF ISCHIA.*

BY

DR. FRANCIS DU BOIS.

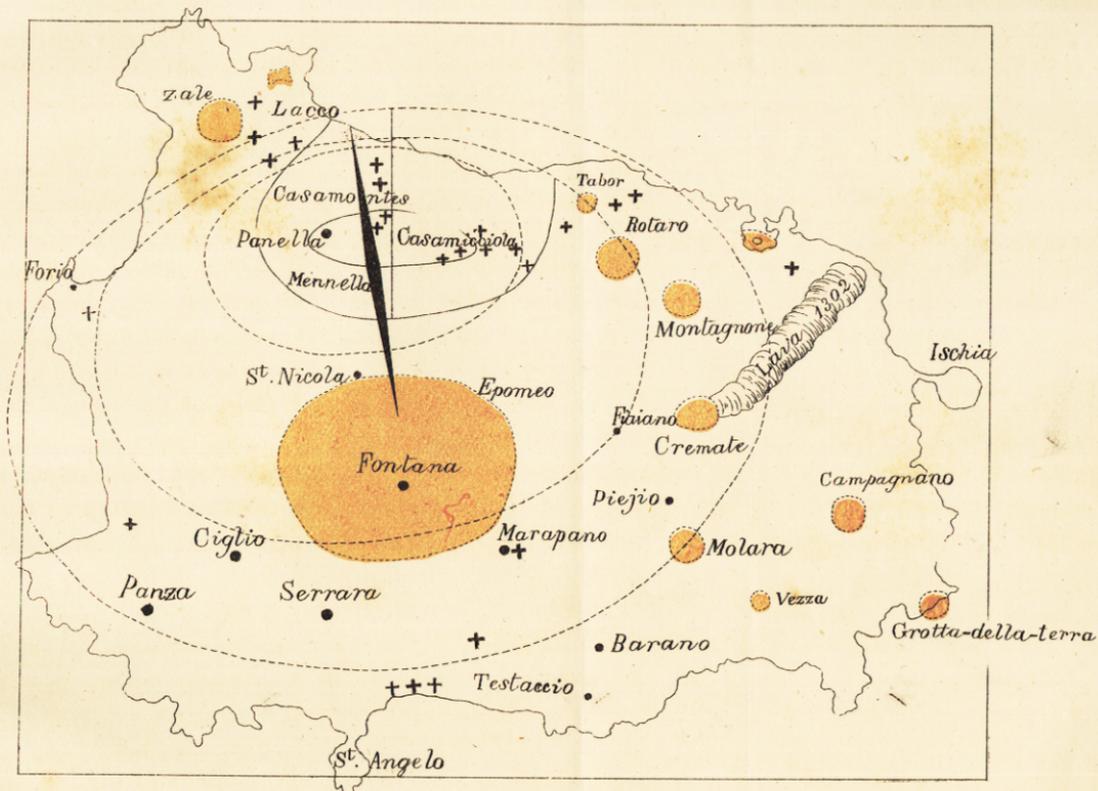
[READ DEC. 20TH 1883]

In the compilation of this article on the earthquakes of Ischia I have made copious use of the following materials:

1. Several articles in "Nature" and other periodicals.
2. Several communications from J. Johnston Lavis Esq.
3. A report by Prof: Guiscardi on the Earthquake of 1881.
4. A notice by Prof: Palmieri on the same Earthquake.
5. Murray's Hand-book of Southern Italy.
6. A lecture by Prof: Rossi of Rome on the Earthquake of 1881.
7. A number of Italian newspapers and illustrations, for which I have to thank Cav. Eugenio Martin-Lanciare, Chargé d'Affaires of the Italian Legation in Tokio.

INTRODUCTION.

Naples is situated in  $40^{\circ} 52'$  of north latitude, and  $40^{\circ} 15'$  east longitude from Greenwich. It faces south and south-east, and fronts upon a bay deservedly considered one of the most beautiful sites in Europe. Its mean annual temperature is  $61^{\circ}$  Fahrenheit, in July it is  $76^{\circ}$ , and in January it is  $46^{\circ}$ . The bay forms an immense rectangle, in which Naples occupies the northern angle. Just opposite is the promontory of Sorrento and the island of Capri, a continuation of the same,—a mass of limestone forming part of a transverse ridge of the Appenines, not in the least volcanic in its nature. The north-east side of the rectangle is mostly formed by the base of Mount Vesuvius. Here we find Portici, Resina, Herculaneum,—names familiar to all readers. The north-west side of the bay extending from Naples to the island of Ischia presents us with an



## ISLAND OF ISCHIA

Scale  $\frac{1}{80000}$ , Isoseismals of 1883.....of 1880 —. Hot springs—and Fumaroles +  
 Old Craters ● (See H.J. Johnston-Lavis, "Nature," Sept 6<sup>th</sup> 1883)

uninterrupted succession of volcanic phenomena, the Punta di Posilippo composed of volcanic tufa, the charming little island of Nisida an extinct crater, which however gave evidence of vitality until the beginning of our era. Just beyond we come upon almost sacred ground in volcanic history. In the neighbourhood of the bay of Pozzuoli we see the celebrated Grotto del Cane in which there is a spring of carbonic acid gas which flows out just as if it were water. Near to this is another grotto where ammoniacal vapours remain steadily at a certain level producing a very peculiar effect upon the legs of those standing in it. (?) We also have the Solfatara, a semi-extinct volcano, the temple of Jupiter Serapis with its three columns presenting remarkable evidence of subsidences and elevations, the Monte Nuovo a volcano which beginning to form on the 29th of September 1538 had by the end of the third day accumulated ejectamenta to form a mountain 440 feet high. With the exception of two smaller eruptions on the next succeeding days, this mountain has since remained quiescent. The Cape of Misenum, which is an extinct crater, closes the bay of Pozzuoli on the west. Fourteen miles distant from Naples is the island of Procida,  $2\frac{1}{2}$  miles long, and "composed like Ischia of pumiceous tufa separated by beds of "pumice and of fragments of cellular lava which dip outwards "as if they had proceeded from a crater situated on the north "east. Breislak and Spallanzani from an examination of both "islands concluded that they were once united and formed "part of an immense crater." Tradition tells the same story. The little island of Vivara between Procida and Ischia is an old crater, crescent shaped, anciently forming part of its larger neighbour.

The castle of Ischia stands on a precipitous rock separated from the island. The picture it offers to us as we approach is one not easily forgotten, for it is wondrously beautiful.

"The island of Ischia is about 20 miles in circumference, "the length is  $5\frac{1}{2}$  geographical miles, greatest breadth about 4 "miles. The total population of the island is about 25000." Distance from Naples 20 miles. The island is of purely volcanic origin and consists of one large central crater sur-

rounded by a dozen parasitic ones and the accumulated product of its many eruptions.

The present island was originally submarine. This is evidenced by the presence of shells similar to those now found in the neighbouring sea at a considerable height upon its side.

The limits of the original submarine crater are approximately marked by the line of the road which surrounds Mount Epomeo.

The principal road of the island starts from the town of Ischia and makes the tour of the island back again to Ischia. There is a cross road from Castellamare to the neighbourhood of Barano. This cross road follows more or less exactly the lip of the old submarine crater. With the exception of the roads about Casamicciola and Lacco, these are the only roads on the island.

Let us make a tour of the island starting from Ischia northwards.

Almost immediately we come upon the Lava del Arso. This is the lava-current of 1302, the last eruption in the island. There is no crater properly speaking. The distance of La Cremate the point of issue, from the sea is  $1\frac{1}{2}$  miles. The eruption lasted 2 months. There is a spring (temp  $93^{\circ}$ ) near here called **Acqua Pontano**.

Just beyond the lava current about 1 m. from Ischia is the Bagno d'Ischia lying in a beautiful position on the borders of a little harbour. This was once a small lake formed in an old volcanic crater. Two springs constitute the Bagno d'Ischia, **Acqua della Fontana** and **Acqua del Fornello**, with temperatures varying from  $131^{\circ}$  to  $138^{\circ}$ . On the high ground behind the lake is the fine extinct crater of Montagnone, Westward stands Monte-Rotaro an extinct crater. Still further Monte Tabore. The road we are following skirts the base of all three in succession.

“Monte Tabore is composed of trachytic lava, resting on  
“a bed of clay in which are found marine shells of some species  
“still living in the Mediterranean. On the shore at the base of  
“this mountain is the **Acqua di Castiglione**, temperature  $167^{\circ}$

“at its source. The sand on the shore near it is so hot that  
 “it raises the thermometer in a few minutes to 212° (?) and  
 “there is a hot spring in the sea itself at a short distance from  
 the beach so that one is enabled to take hot sea baths in the  
 open sea. “The Stufe di Castiglione situated on the hills above  
 “are vapour baths which issue from orifices in the lava at a  
 “temperature of 122° in the lower, and 133° in the upper  
 “stufa. The Stufe di Cacciato are of the same character as  
 “those of Castiglione their temperature being 160°. The noise  
 “of the water boiling beneath can be distinctly heard.

Casamicciola is the collective name for an assemblage of  
 villas, bathing establishments and villages. At about the  
 center is a hill called the Collina di Casamicciola on which  
 stand the hotels. To the west of this hill upon the sea shore  
 lies the village of Lacco Ameno. Eastward of the hill on the  
 sea shore lies the Marina of Casamicciola. Between this hill  
 and Mount Epomeo is a depression which Rossi claims to  
 be part of the lip of the old submarine crater. At any rate it  
 is just here, between Mount Epomeo and the hill of Casamic-  
 ciola on a saddle which separates the valley running up from  
 Lacco Ameno from the valley running up from Casamicciola  
 that all old Casamicciola and Menella stand, that all earth-  
 quakes affecting Casamicciola have worked their greatest  
 damage.

Casamicciola is noted for its hot springs, the most cele-  
 brated is the **Acqua di Gurgitello** (Temp. 162°) with extensive  
 bathing establishments. Near here is the **Acqua di Cappone**  
 (Temp. 98°) Near this is the Aqua del Occhio. Further up  
 is the **Acqua di Tamburo** containing so much gas that it makes  
 a noise resembling that of a drum. The temperature varies  
 from 155°—210°. The Aqua Ferrata; Aqua aurifera Argentea  
 the Aqua Spena Pollastro with a temperature varying from  
 167° to 180°. **Acqua Collata** 178°. The **Acqua Collata** varying  
 from 178° to 190°. The **Acqua della Sciatica** with a tem-  
 perature of 144°. In the valley running up from Lacco Ameno  
 we find the **Acqua della Rita** ranging from 149° to 158° and  
 the Stufe and springs of **Frassi and Monticel**, the former emit-  
 ting vapour at 126° the latter at 203°.

“Casamicciola is celebrated for its manufacture of bricks, tiles, and pottery in general, which are exported to Naples. The kilns extend along the whole length of the shore of the **Marina**.

In Lacco Ameno there are two hot springs, San Restituta (Temp. 135°) and the Regina Isabella (Temp. 106°) rising near each other. On the seashore the water exudes at 112° and near the little island of Capitillo it raises the thermometer to 171°.

Just beyond Lacco Ameno are two spent volcanoes Monte Ricco and Monte Maricocco. The large promontory butting out here is formed by the lava of the latter.

On the road from Lacco to Forio we meet the **Stufe di San Lorenzo**, natural vapour baths (Temp. 135°). Nearer the shore in the same neighbourhood is the **Aqua di San Montana** (Temp. 131°). The ground around is sufficiently hot to raise the thermometer to 122°.

Forio is three miles from Casamicciola. A hot spring, **Acqua di Francisco Primo** rises here at a temperature of 113°.

One mile further near the shore rises the hot spring, **Acqua di Citara** of which Constantin James says “renommée depuis les temps les plus anciens comme possédant des vertus heroïques contre la stérilité, elle n’a du reste presque rien perdu aujourd’hui de sa célébrité. De jeunes femmes privées du bonheur d’être mères viennent chaque année à Citara d’où la plupart emportent de douces esperances qui se justifient plus tard”. Near here are hot wells and ancient vapour baths.

The road now mounts through Panza near an old extinct crater  $2\frac{1}{2}$  miles from Forio then more rapidly to Ciglio and still more rapidly through Serrara to Fontana which is just about the centre of the old crater. The lip of the crater is completely broken down on the south side while on the north it rises into the peak of Epomeo from which there is one of the most beautiful views imaginable. Here there is a little church and monastery half built in the rock dedicated to St Nicolas. Old Typhoeus however does not seem inclined to give up his patrimony without a struggle. The road now descends 2 miles to Moropano then 1 mile to Barano. Here the road

bifurcates, one branch turning northward back to Casamicciola, the other one continuing along the bases of Monte di Vezza and Monte Campagnano, two extinct volcanoes. From here we go on to Ischia from which we started.

There are very few hot springs on the southern side of the island.

In ancient times long before our era the island was several times colonized but each time the inhabitants were driven away by volcanic outbursts. Since the beginning of our era several eruptions have been noticed, but not with sufficient detail to be of much use. The last eruption took place in 1302, when the Lava dell' Arso was formed near the town of Ischia.

## EARTHQUAKES

### I

February 2<sup>nd</sup> 1828. 10.15 a. m.

The shock of 1828 was one of the most violent of modern earthquakes though confined to a limited district. It was not felt on the adjacent coast or islands. Slight movements had been felt at 3. a. m. at Imola, Faenza and Forli (on the road between Bologna and Rimini, North of the Appenines) At 7 a. m. slight movements were felt at Foggio, San Severo, Barletta, Bari, also north of the Appenines, but much nearer the heel of the boot. The motion was from east to west.

In Ischia itself the earthquake consisted of an undulatory motion lasting four seconds. The sea was quite calm and remained so all day.

The disturbance was not preceded by any remarkable phenomena, except that in the morning Vesuvius sent forth smoke, flame, and stones. The springs did not exhibit any change that was specially noticeable.

Immediately before the shock, in the space of three seconds, three loud explosions were heard, which appeared to come from beneath upwards, or from the interior of Epomeo outwards; these explosions were very remarkable along the coasts of Casamicciola, Lacco, and Forio; but where the shock was most severe, that is that part of Casamicciola lying

between Fango and Casamenella they were scarcely remarked.

In Casamicciola a part of the buildings fell together. Twenty eight persons were killed and many injured. In Serrafontana, Forio and Testaccio (south of Barano) no damage was done; but Lacco suffered remarkably.

The corpses were found in such positions as to indicate that persons had not even the time to be frightened so much so, was this the case that Colvelli in his description was inclined to ascribe the whole thing to an electric discharge.

## II

March 4th. 1881. 1 p. m.

The centre of disturbance seems to have been Casamicciola some damage was done where. There was a severe shock lasting some seconds which was followed six minutes after by a slighter one on March 4th 1881.

The following is the substance of a report signed by Guiscardi and dated the 21st August 1881.

At about five minutes past one in the afternoon of the fourth of March 1881 there was a shock felt in Casamicciola and a few moments later the ground was shaken again. Many houses fell; others were badly damaged; others less so: and others again remained uninjured. Many inhabitants were buried under the ruins where they perished. Shocks were also felt on the 6th the 7th the 15th and the 17th of March.

The intensity of the shock and the consequent havoc were not in proportion. The report ascribes this in most part as due to the bad construction of the houses—being mostly built of rubble. But even making all allowance for this, a great want of proportion between the shock and its effects is still noticeable. As can be seen from photographs, the walls are not wanting in thickness. Houses are never so badly built in Italy as to come down without very good cause.

Two areas can be distinguished in the extension of the seismic wave. The one is circumscribed by an elongated ellipse, the long axis of which runs from east to west and extends from Santa Barbara to Fango. In this area (which is just the depression between the hill of Casamicciola and Mount

Epomeo) is included the greatest amount of damage.

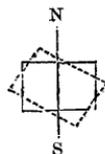
The next area is bounded by the sea, and a curve starting at Punta Porso, passing along the base of Tabor and Rotaro, by the Casa Pizz, through the hamlets of Stennechia and Spattara back to the shore again at Lacco Ameno. Within this area the shaking of the soil was still felt, but much less so than in the smaller ellipse.

Outside this second area effects of the earthquake are to be noticed at Santa Lucia del Vajola near Forio. In the south of island damage was done at Barano, Moropano and Fontana. Fontana is due south from Casamicciola standing in the very center of the old crater. Fontana, Moropano and Barano are on a straight line.

Outside of the island, the earthquake was felt at Vivara, Bacoli, and as far as Ventotene in the Ponza group (Ventotene being about 25 miles due west from Ischia). Vivaro is the little island between Ischia and Procida. Bacoli is a little village on the coast near Baie. Here the shock was only noticed by one person, a lawyer named Cirillo.

It is to be noticed that the shocks outside the island were at the most so slight, that their very existence has been denied, and that they are not necessarily connected with the Ischian earthquake.

Several landslips occurred. These were mostly on made ground such as roads and vineyards. In the ground only one crack about  $\frac{1}{2}$  of an inch wide, direction W.  $30^{\circ}$  E., was discovered. A square pilaster attached to a wall, at the height of the wall was found to have gyrated from S—N passing through W. some  $5^{\circ}$ . (See diagram)



Two other pilasters intended to ornament the wall to which they were attached were broken on a level with the top of the wall—the detached portion of the one fell down and the other gyrated like the one just-mentioned.

The church of Santa Maria della Pietà was reduced to ruins. In front of it was a little open space cut off from the street by an iron railing. Two columns of stone supported the iron railing and the iron gates. These pillars were square,

9 feet high and ten feet wide. Each one was made of seven pieces and had on its top a cornice also of stone made of a single piece. The lower four fragments of the left hand pillar gyrated together as if on the tipped end of the right hand anterior corner so that the left hand corner has re-entered about 25 millimeters on a length of two feet, making an angle of about 2°. The fifth piece from the bottom remained stationary because it was fixed by the iron hinge of the gate. The sixth segment has gyrated like the lower ones, only it has come forward, the anterior edge protruding two centimeters, the posterior three centimeters.

The seventh fragment is also displaced but inversely to the one below—the front advancing four centimeters and the posterior right hand edge only two centimeters.

The lower four pieces of the right hand pillar have not moved. The others with the exception of the fifth were moved similarly to the lower four of the left hand pillar. The cornices of both pilasters were impelled outward from E. W. that on the left less than that of the right hand, the greatest advance being 1½ inches.

The parrochial church has its right side facing SE. Along the aisle are three chapels. The altar table of the the third is displaced so that its left side is six centimeters from its original position.

Three doorways in the whole place showed slight evidence of rotation.

At Lacco Ameno the shock was very perceptibly felt. The houses were only slightly damaged but the church very much so. In the third chapel on the right, the crucifix was found leaning against the painting behind it, and a chandelier on the altar of the second chapel fell on the table as if impelled in the same direction as the cross, that is from E. to W.

The Captain of the Carbonieri Bonu relates that on the fifth of March he went to Casamicciola, and saw the Church of the Purgatorio all cracked (fissura). On a wall of this Church facing almost south in a niche there was a statue on a pedestal. This statue showed its right side, having turned

to the West which was seen by the mark the turning had left upon the dusty pedestal.

The proprietor of the hotel Bellevue states that three small statues on the altar of a little church in the neighbourhood turned completely round, and that workmen in the neighbouring field were thrown on the ground.

A young country fellow showed the effect the earthquake had on him by repeating twice in an East West direction the motion which gymnasts call "spinta simultanea delle braccia in avanti" which he followed by a contrary motion. He accompanied the forward movement with a sound as from a base drum. Turning to look at Epomeo he found it covered with clouds.

Some ladies in Casa Pizzi felt the house rise while it was in part ruined.

A few days after the earthquake the microphone gave no results whatever.

It has been said that the mineral waters changed their level; but it is not known who made such observations. No importance can be attached to such reports. Moreover many of these springs are subject to normal variations.

I supplement this report by an extract from a notice by Palmieri.

A great subterranean noise as of something falling was heard, a cloud of dust arose, and the upper part of Casamicciola had crumbled. The Mayor of the place Dombre and several others who were in the streets at the time and only a short distance from the scene of disaster, are agreed that this was the beginning and the end of the affair and that it was accomplished in an instant. An apothecary who was afterwards saved almost by a miracle, relates that he heard a certain noise making him think of an earthquake and at the same moment he saw his shop crumbling about him. The inhabitants on the shore only

---

*Note.* I have translated this report at length and insisted upon all the minute evidences of impulsion and rotation simply to show how very little of it there is any evidence of, in comparison with the other deplorable effects of the earthquake, for between Barbara and Fango hardly a house was left standing.

felt a slight shock and they were far from suspecting the extent of the disaster. Three clocks although oscillating in diverse planes all stopped at the same time. About 120 persons perished under the ruins. By far the greater number of them were inside their houses. Very few were on the street, there not being time to get there. The corpse of a shoemaker was found in the very act of sewing a shoe he held between his knees. A woman was found dead in the act of darning a stocking. There does not seem to have been time enough even to get frightened.

There was no observed change in the mineral waters.

There was no motion perceptible in the microphone three or four days after the disaster.

There was a slight shock previous to and several shocks subsequent to the disaster.

The disaster was almost instantaneous and then all was over. The area of the disaster was restricted. The line of demarcation was very evident. Just beyond this the damage was very slight and at some little distance further the earthquake was hardly felt at all.

Where the earthquake was most intense the damage was very great, indeed hardly a house remained standing

### III

August 28th. 1883.

At the height of the bathing season when thousands of persons from all Italy and other parts of Europe were gathered together in Casamicciola, called thither by the great reputation its waters enjoy for the cure of nervous and rheumatic complaints; at an hour when the tired labourer was retiring to rest; when many of the inhabitants were gathered in the cafés smoking, chatting and drinking; when others had congregated in the theater; when many of the guests in the hotels were just beginning some festive entertainment, suddenly there was a crash, the ceilings and the roofs fell in, and 5000 human beings lost their lives.

It is rather difficult to know exactly when the earthquake took place. From the fact of a clock having been found stopped

at 9.20 it is inferable there was a shock at that time; but the clock may not have been correct. The great shock took place at about 9.30 and was so severe that people in the theater were thrown in a heap and the petroleum lamps overturned. The summer theaters in Italy are generally very light structures without any roofs. This theater is one of the very few buildings which were not destroyed. One remarkable fact is that the houses of the *marina* (on the sea shore) suffered much less than others in their immediate neighbourhood, or even farther away from the seismic vertical. This however is not peculiar to this earthquake, but is common to all Ischian earthquakes.

“The first symptom was a distant sound like that of a carriage, almost immediately accompanied by a tremor, then a terrific explosion shading off into a number of reports. Those in the mesoseismal area felt the blow and report apparently simultaneously; the walls fell before any attempt at an escape could be made”

There were several landslips. Two in particular on the northern slope of Epomeo over Lacco Ameno were rather extensive “The fissures were such as take place along the edges of all landslips. The presence of vapour for a short time after the earthquake was easily explained. The locality is part of the old fumarole area of Monte Cito, where alun was manufactured centuries ago. The rock is much decomposed by the continued escape of acid vapour and only required the earthquake to shake it down. When the displacement took place a large surface of hot and moist tufa was exposed which no doubt for some time gave off a quantity of vapour.”

No change of level in any locality, or in the fumaroles or mineral waters has been satisfactorily made out.

The mesoseismal area of the earthquake of 1883 corresponds almost exactly with the first isoseismal of 1881. In the mesoseismal area although all but four of five houses were destroyed the walls of many are standing. The roof and floors fell in. Objects are said have been projected considerable distances (a very unsatisfactory expression: one would like to know what object was projected? where it was projected from?

how far it was projected? &c. &c.) The iron tie-bars put into the walls after 1881 are said to have been broken and bent like thin iron wire. The photographs give some evidence of bending but nothing like what the foregoing description would lead one to imagine.

The first isoseismal of 1883 corresponds almost exactly with the second isoseismal of 1881. In 1881 the houses were merely fissured and that not invariably. In 1883 many of the houses fell. The rest require rebuilding. This area is a very large one comparatively speaking, as it includes a part of Forio and Fontana.

The second isoseismal is altogether outside the effect of the earthquake of 1881 with the exception of the towns of Moropano and Barano which were also affected in 1881. In this second isoseismal of 1883 which includes all the rest of the island, with the exception of the eastern and southern coast, the houses are fissured sometimes severely.

“The third isoseismal does not seem to cut the land, its limits therefore are unknown. This area includes the town of Ischia and the southern coast where the effects of the earthquake have been very slight comparatively. The village of Fontana Servata standing on the very center of the old crater has been affected in a very peculiar way. Both in 1881 and in 1883 the shock was almost vertical, similar to what happened in the mesoseismal area, although it stands completely outside of it. In this last earthquake besides the fissures indicating a vertical shock, there are also fissures indicating a wave from North to South at a low angle of emergence.

At St Nicolà which stands on the top of Epomeo on the northern lip of the old crater between Casamiccola on the north and Serrata Fontana on the south, part of the altar has rocked from north to south.

Between St Nicola and Serrata Fontana a rock was ruptured and projected to the South.

Mr Petersen, the engineer of the zoological station at Naples, whilst dredging just about opposite Casamicciola found a number of pieces of pumice floating on the water, some of them as large as a man's head, having quite a fresh appearance.

It is inferable that there was a submarine eruption somewhere near the island, and this might account for the sensation felt on board the steamer which was in harbour at the time of the earthquake, but it might be accounted for otherwise. It might have been shaken down from one of the sea cliffs. Besides if there had been a submarine eruption there would be something more to show than a few pieces of pumice.

*Premonitory signs.* It is extremely difficult to arrive at any reasonable approximation to the truth with regard to any of the phenomena attending the Ischian earthquake. When the subject of premonitory signs is taken up we find ourselves in a maze of confusion worse confounded; as assertions and contradictions succeed each other without end. Was there any seismic disturbance in southern Italy? Yes. Had it any intimate connection with the Ischian earthquake? Most decidedly, says one authority. Not in the least, says another.

Was there any change in the temperature of the mineral waters of Casamicciola? Yes there was. Now surely we have here a premonitory sign. No we have not, because these springs are known to vary  $20^{\circ}$  C. in their normal state. Were there any shocks before the 28th? For a full fortnight before the 28th there were almost daily slight shocks accompanied with subterranean rumblings. Then how is it that no mention was made of such phenomena? The owners of hotels were afraid to frighten away their guests. But then did not the guests feel and hear? No answer.

With so much conflicting evidence before us, let us collect what facts we can and reserve our inferences.

Professor Rossi of the central observatory in Rome has made two reports on the Ischian earthquake of 1883. These reports have not reached Japan where so much interest is taken in Seismology; which is a matter very much to be regretted. Some extracts from these reports however have reached us in the pages "Nature" for August 9th and 16th.

*Rossi's Reports.* Several days before the 25th and 28th of July the microcosmical instruments at Rocca di Papa and the connected microphones in Rome showed a great increase in subterranean activity. The earthquake which took place at

Cosenza and Catanzaro on July 25th seemed to be the one predicted by these movements but their continuance and increasing force showed clearly the approach of a new dynamic effort.

The earthquake of Saturday July 28 was registered by the seismographs in Rome, Velletri and Ceccano at 9.30 p. m. with slow waves from N.—S. and E.—W. The other instruments which register quick movements of the ground remained quiet.

This time as often before, the drying up of wells, subterranean thunder, and slight oscillations of the earth have preceded the catastrophe.

Not only were there for some days beforehand very distinct premonitory signs at Casamicciola of the impending catastrophe but also throughout the peninsula, forewarnings identical in character were numerous and wide spread.

On the island of Ischia there was an extraordinary increase in the temperature of the thermal waters and in the violence of the fumaroli at the spot called Monte Cito. These phenomena were noticed 8 days before the catastrophe occurred. On these important points the evidence which Prof. M. S. di Rossi obtained is abundant. There is less conclusive testimony concerning the shrinking and consequent scarcity of the drinking water in the wells. But he has absolutely certified, that commencing from a period a fortnight anterior to July 28th, many slight shocks of earthquake of almost daily occurrence were felt and subterranean rumblings were heard.

While the above mentioned phenomena were occurring in Ischia without their being communicated to Rome or even for want of means, properly noted on the spot, the existence of unusual subterranean activity was simultaneously marked by the instruments in all the observatories of the mainland. That activity though varying in intensity in different places manifested a general and regularly progressive augmentation. Slight shocks of earthquake were felt at various points—On July 25th the Solfatara of Albano on the extinct Latin volcanoes on the southern side of the Roman Campagna sent forth sounds never before remarked. On the same day a widely extended earthquake reaching from Cosenza and Catan-

zaro (towns respectively on the upper and lower part of the instep of the boot) occurred in Calabria,

On Friday the 27th the hissing noises from the solfatara of Albano were so acute that the people did not dare to draw the sulphur water for those who needed it, and simultaneously the seismic instruments at Pesaro registered severe oscillations. At Vesuvius on the evening of Friday the 27th, shocks were felt with an augmentation of activity. There were shocks at Latera upon the Ciminian volcanoes and shocks at Perugia.

On the afternoon of the 28th renewed activity was manifested at Pesaro (on the Adriatic) and at Fermo in the same neighbourhood: and in short the observations during that afternoon throughout the peninsula, gave indications of a vast subterranean disturbance extending as far as all Umbria, the district of Viterbo and the Marches. All these places are North of Rome.

The direction of these extended movements was everywhere identical with those at Casamicciola, namely from North to South and from East to West.

At the same time also on the morning of the 28th the flow from the principal source of the sulphur streams near Tivoli showed a considerable diminution, while simultaneously an increased quantity of carbonic acid gas was given forth.

The regular observations at Bologna, at Pisanello, near Piacenza, and at Rome, showed that there was a distinct lowering in the levels of the wells before July 28th and a marked a rise after that date. These facts confer increased credibility on the imperfect evidence of there having been a deficiency of water in the wells at Casamicciola.

Moreover on the morning of Sunday the 29th, the usually very cold waters of the solfatara of Albano were in a boiling state.

The intimate connection between the phenomena on the peninsula and the catastrophe in Ischia which had a distinct dynamic and volcanic character, absolutely excludes the idea of a mere local sinking in the level.

A Rhenish Journal states that on Saturday night about the time when the Ischian earthquake occurred, a tremendous

motion of the earth was distinctly felt at Wiesbaden.

On the morning of the 31st of July, also a shock was felt in Oporto, lasting two seconds, with direction east and west.

Two shocks are reported to have occurred on the same day at Gilroy, California.

A telegram from Athens states that a strong shock was felt at Piraeus on Saturday the fourth of August.

I hardly see any possible connection between earthquakes in Wiesbaden, California &c. and Ischia, when in the immediate neighbourhood of Ischia itself there is nothing of the kind. In all the earthquakes of Ischia it may be noticed, that the preliminary phenomena, always take place at a great distance generally on the north of the Appenines. It is difficult to understand why the cause or effect of all the phenomena so exactly and minutely enumerated by Prof. Rossi should be sought for in Ischia. Why should an old volcano near Rome be affected and the whole volcanic region in the neighbourhood of Ischia remain perfectly quiet? In the island itself what were the preliminary signs?

The correspondent of the "Standard" in making the tour of the hospitals, found strong confirmation of the fact that there were signs of danger two or three days beforehand, which can not have escaped the observation of the inhabitants of the island but they were unfortunately, he says, suppressed in order to avoid giving alarm to the visitors and so spoiling an unusually prosperous season.

Now these preliminary symptoms are said to have consisted of great and sudden increase in the heat of the waters; in slight earthquakes and in subterranean rumblings, and that not only once but many times. Now I have yet to see an earthquake that you can suppress — and if there is one thing in this world that you do not get accustomed to, it is an earthquake. Out of the many thousand visitors was there not one who felt these earthquakes and heard the noises? If there had been, the inevitable did you feel it? did you hear it? would soon have made the occurrence a matter of public conversation. The earthquakes and their rumblings must have been very slight indeed. As to the increased temperature of the waters, we know that many of the

springs on the island vary in their normal state and the bathers must have been accustomed to that, or there would have been a talk about it. For we must remember that only two years before there had been a great catastrophe and every one must have had his attention continually drawn to the subject by the newly plastered, or newly rebuilt houses.

Since the catastrophe of July 28th the following earthquakes have been noticed.

July 29	slight shock	in the morning.
Aug 1	slight shock	3. 10 P. M.
” ”	”	4. 50 P. M.
” ”	”	11. 15 P. M.
Aug 2	”	2. 30 P. M.
3	stronger & producing slight damage	1. 15 or 2, 15
8	slight shock	10. 40 A. M.
12	”	morning.

Although the instruments on Mount Vesuvius did not register the shock of the 28th of July they have registered the subsequent one. Some malicious people may be inclined to think that the instruments were not in proper working order at the time of the great catastrophe.

To account for the Ischian earthquake several theories are put forward—one has been suggested to me by Prof Milne he says “Why can not the Ischian earthquake be attributed to the formation of a fissure produced during the process of elevation: the earth oscillations of this portion of the world have formed a subject for every text-book on geology and in Ischia itself there are raised beaches indicative of a recent upward movement”. Mr. Johnston Lavis in a letter to Nature says “In various points that I have examined the coast of the island there was no apparent change of level nor did any success attend endeavours to discover any signs of depression of the surface”.

Then there is the volcanic theory which is best stated by Mr. Johnston Lavis in his own words. A careful examination of observed azimuths and angles of emergence all point to a plate shaped focus whose strike extends in a line from

Fontana passing just west of Menella to near the beach at Lacco. The plane of this fissure is probably roughly perpendicular to the surface but may slightly dip toward the east as the isoseismals are slightly nearer on the eastern side of the seismic vertical which as a necessity is not represented by a point but a line on the surface—the rupturing of this plate-like fissure was apparently greatest at a point nearly midway between its extremities.

That Vesuvius did not or only did to a slight extent sympathise with the seismic movement in the island of Ischia is no proof against the volcanic origin of the earthquake. Admitting the hypothesis of a seismic wave traversing a large tract of volcanic matter underlying southern Europe, such a wave might produce but very slight variation at volcanic vents yet be sufficient to dertermine the extension by rupture of a fissure where the resistance of the rock and the tension of the volcanic matter near the point of extension were nearly equal.

In a paper lately read before the Geological Society of London I endeavoured to prove that the explosive violence of lava is due to the assimilation or solution of water taken up from the water bearing strata it traverses in its passage from the main source toward the surface. Under such conditions we may have very violent phenomena produced locally without any sympathy in neighbouring volcanic vents; which at the same time explains I believe one volcano bursting out in a violent paroxysmal eruption whilst a near companion is in no way affected. Why therefore should an abortive paroxysm disturb a neighbouring active vent as in the present example.

We must expect other shocks more violent in character and that as one follows the other the interval of tranquility will be less until the final eruption bursts forth. The seismic vertical at Casamanello stands in the same relative position to Epomeo that do many of the parasticis cones.

Professor Rossi of Rome who is also a strong partisan of the volcanic origin of the Ischian earthquake insists upon the fact that Casamicciola or at least that part of it which suffers the most is on the point of intersection of a longitudinal fracture coming from Mount Epomeo and a transverse fracture

representing the brink of the old submarine crater. That it was just astraddle of the lip of this old submarine crater that the most damaged portion of Casamicciola stood. That the longitudinal fracture will account for the damage in Lacco Ameno and that this longitudinal fracture is just the principal one of the Ischian volcanic system as it lies in the axis of the ellipse of the two craters, that is of Epomeo itself and of its predecessor, coinciding with the line of the falling away of the Crater towards the south.

Professor Rossi also lays great stress upon the premonitory signs which he has noted. I doubt however very much whether all the signs he has noted have produced as much impression upon others as upon himself.

*The theory of Luigi Palmieri.* Earthquakes which are generated by subterranean impulses have certain common characteristics which are as follows:—

I. All Earthquakes of a certain intensity which have been the cause of ruin and devastation have been felt over an *extended region* and the extent of the region subjected to the shock has always been more or less proportional to the vehemence manifested within the central area.

II. There has never been a case recorded where an earthquake of sufficient intensity to overthrow houses has accomplished its work in a single shock. Violent shocks succeed each other at first with short intervals, then with longer intervals and lessening intensity. The first shocks at the most only partially destroy the houses which afterwards fall with other earthquakes. Hence the popular belief that an earthquake must have its echo.

III. During a seismic period between one shock and another the earth apparently is still subjected to a tremulous movement perfectly appreciable with proper instruments, and this movement is noticable for many days.

IV, Shocks generally last several seconds and almost invariably the length of the shock has a certain affinity with its intensity. We may always be sure that weak shocks of long duration are never local earthquakes. On the other hand a shock lasting but a few seconds is never one of remarkable intensity.

V. The sea suffers extraordinary agitation, its waves often rolling several kilometers into the land.

VI. The water of springs generally gives warning of the terrible phenomena either by becoming low or else becoming turbid. Often indeed there is an unusual agitation among domestic animals.

These being without doubt the characteristics of the greater number of earthquakes there are nevertheless others which present a very different series of phenomena. A subterranean falling in of the ground whether accompanied with depression of the soil or not may produce the effect of ruined houses. Again we may have the same effect produced by an elevation of the soil relatively long without any shock at all.

In 1861 a part of the town of **Torre del Greco** was raised a meter and a half above sea level. All the houses one after another fell without there having been felt the least commotion of the ground or the least shock. The ground was undergoing a slow elevation during which it cracked giving forth frequent signs of heat and various gases. All this damage was accomplished in less than 36 hours and while the whole length of the street called Copotone lay in ruins, the rest of the town remained intact.

In the beginning of May 1877 in Marano of Calabria, many, in fact most of the houses fell in with a certain leisure one after the other: no one having felt any shock and the soil was observed to be cracked and evidently depressed. Here also the damage done was very much circumscribed.

Gaetano Torre, a civil engineer, in a pamphlet published in 1871 mentions the fact that he was witness of depressions in the valley of the Velino in Abruzzi, in a town where numerous springs rich in carbonic acid eat into the calcareous rocks below and deposit large quantities of carbonate of lime on the ground.

These movements of the soil by which houses may be laid low through subterranean caving whether slow or rapid have not the characteristics of those previously described. They are generally confined to some definite town and if they

last any time the houses fall without any appreciable commotion of the ground: they seem to fall of themselves. But if they happen suddenly they do the work at once and repetitions of the shock if there be any, are very slight and of no importance. The surface of the ground may have been moved and yet there be no depression if a subterranean arch exists as has been noted by **Fuchs**. Seismic apparatus in this kind of earthquake will always remain quiet even if placed at a short distance from the scene of disaster nor can they ever give those useful preventive indications which are the principal object of Seismology.

Volger believes that all earthquakes are caused by subterranean falling in or by fractures and fissures. If this were true seismology would be impossible. In fact this is probably rather the exception than the rule when we think that the earthquake of Lisbon caused all Europe to tremble; that the earthquake of Calabria caused all Sicily to tremble terribly shaking up the sea: that the shocks followed each other with variable intensity lasting sometimes 50 and even 60 seconds; that large gaps in the earth were opened and shut; that the heaviest objects were elevated in the air, it would be impossible to ascribe all this to subterranean falling in or a fissure. Real earthquakes, those to which seismology devotes itself are the effects of the same endogenous activity which also produces Volcanoes. Fuchs believes that such earthquakes should take place only in the neighbourhood of volcanoes, but then we should be obliged to consider as non-volcanic some of the greater and most disastrous of earthquakes which have shaken the soil of Europe to say nothing of those in Asia and America.

Apart from the probable caverns caused by the thermal waters rich in carbonic acid coroding the trachytic rock there is at a still lower level a bed of clay the extent of which is unknown. All the bricks, kitchen utensils and tiles manufactured either in Naples or on the island itself are made of this clay which is extracted from deep wells and subterranean galleries. The engineer Alexander Giordano who in 1834 was sent by the Government to examine these excavations

reported that they put the buildings of Cassamicciola in the greatest danger. He proposed the discontinuation of many workings, and that none in future should be opened at a less distance than 300 meters from the buildings.

If Casamicciola had been merely shaken by an earthquake these immense caverns so long as there was no falling in should tend to diminish the shock according to a law of Pliny which has ever been held true by seismologists. In the earthquake of Melfi, Barile although nearer than Rapalla to the seismic center suffered less, just because it was built above a lot of grottoes.

In order to reconcile the great damage done with the restricted sphere of action and the suddenness of the effect there are but two possible hypotheses. A tremendous subterranean impulse similar to a mine exploding at a very slight depth or else a great caving in of the subterranean soil. I do not repudiate the first, but I think the second much more reasonable. I can understand the first causing a slight earthquake but not being the efficient cause of such a disaster.

When did it ever happen that a town was overthrown by an earthquake without occasioning damage at least 60 miles round? When did it ever happen that an earthquake caused one half a town to be overthrown while the other half remained intact.

That the source of the shock at Ischia must have lain comparatively near the surface may be confidently inferred. Had it been more than a few hundred feet deep the waves of such a shock would assuredly have been propagated to a considerable distance all round.

The sudden snap of large masses of rock under great strain may be the origin of the frequent earthquakes of mountain chains such as those so constantly experienced in the Alps. In volcanic regions earthquakes usually preceding and accompanying volcanic eruptions have been plausibly attri-

---

1. It must be remembered that even in this last earthquake the houses of the Marinas have sustained comparatively little damage. To which may be added the opinions of a writer in "Nature" Aug. 9th 1883.

buted to the explosion of elastic vapours. Ischia lies in a volcanic district and is itself of volcanic origin but its earthquakes do not seem to be part of the active volcanic phenomena of the district. So far as information is yet available regarding the recent catastrophe there appear to have been no accompanying volcanic manifestations though there were many active vents where they might have been expected to show themselves.

*Note.* In confirmation of which H. J. Johnston-Lavis writes to "Nature" Sept 6th 1883.

I have visited with care all sites of supposed fissures but after some days of want of shelter and sleep, an abominable starvation diet of bad bread and rotten cheese, combined with continual climbing from daybreak to sunset in an extraordinarily hot Neapolitan summer in the hope of finding some evidence of volcanic action did not meet with the slightest success. I was accompanied in these excursions by my friend Prof. P. Franco of Naples who shared my disappointment and disgust. Holding as I do the volcanic nature of the earthquake the appearance of any such phenomena would have been greedily accepted.

To again quote from the article in "Nature" Aug. 9th.

So far as materials exist for forming a judgment on the subject of the recent earthquake at Ischia, it appears to have been caused by the sudden collapse of some subterranean cavern situated not far below the surface in the Casamicciola district. Such caverns no doubt frequently exist underneath volcanic rents from which large masses of material have been emitted. It is well known to geologists that one of the final phases in the history of a volcano is the subsidence of the cone. This downward movement probably continues during a long period of time. It may be on the whole gradual and imperceptible but if from time to time the roof of the huge vesicles whence lava and steam have escaped should give way, though there may be no perceptible change of level at the surface, such shocks will be generated as to convulse the area with earthquakes. We may infer that the Ischian earthquakes are the result of the former extravasation of volcanic materials and

the "consequent vesticular conditions of the earth's crust at the locality, but we must await the careful collection of evidence before any positive conclusion on the subject can be embraced"

#### RESUMÉ.

What then do we really know about the Ischian earthquakes? Whatever is admitted by all or denied by none may be accepted as true.

All Ischian earthquakes of which any special record has been made resemble each other, in fact are a counter part of one another, differing only in intensity, having a special type of which the following are the common and constant characteristics.

1° If there are any premonitory signs one never hears of them until after the earthquake has taken place. There are always prophets after an event.

2° Great suddenness; there is but one serious shock and all is over. Succeeding earthquakes are of very little importance.

3° Extreme localization. There is not a gradually diminishing intensity of the seismic wave as it recedes from the seismic-center, but the area of damage is clearly marked.

4° The cause of the earthquake whatever it may be, whether it be fissure or the formation of a volcanic rent or a subterranean falling in, or explosion, or what not, is comparatively near the surface.

5° There are no evident volcanic phenomena accompanying the earthquake.

6° If the seismic wave is felt outside of the island at all it is felt very slightly.

7° There is no disturbance of the sea.

8° Three days after the earthquake of 1881 there was not the least vibration of the soil discernible even with a microphone. Strange to say no notice one way or the other has reached me with regard to the earthquake of 1883.

## CONCLUSIONS.

I. That it is very much to be regretted that after the disaster of 1881 no efficient measures were taken to investigate the physical phenomena of the island of Ischia.

II. That it is very difficult to arrive at any positive conclusion from reading the different reports. On doing so, one has an intimate feeling that every one goes there with a pre-conceived theory and only hunts out facts to corroborate it.

III. The fact of the earthquake not having been sensibly felt in Naples or on the adjoining shore should not influence our judgment much either way, for in 1857 Capri scarcely felt the shock which was very severe in the promontory of Sorrento. Now the promontory and the island belong to the same geological formation and are very near each other.

On the other hand the motion noticed by Prof Rossi in his instruments at Rome, and the various phenomena he mentions in connection with the Ischian earthquake, as happening at that time near Rome, are not by any means necessarily connected with the Ischian earthquake.

Although in all Ischian earthquakes some commotion on the continent has been noticed, this commotion has invariably taken place at a very considerable distance, while in the immediate neighbourhood no motion was perceptible. It is very problematical whether these distant motions are anything but a coincidence.

IV. When one thinks of the enormous amount of lava which has been ejected from the many cones on the island one can understand that there may be enormous cavities below the soil.

When we consider the corroding influence of carbonic acid and water: and the great number of hot springs and the quantity of water they are continually pouring forth and have been pouring forth since time immemorial, that cavities may exist becomes still more evident.

If besides this, we remember that sufficient clay is being continually taken out of the soil to furnish bricks, tiles and cooking utensils not only for the island itself but for all the

neighbouring mainland; that this clay is not on the surface but is all taken from excavations and galleries, mined as it were; that this process is by no means a new one but has been going on for generations; we see then causes tending still further to honeycomb the soil. The soil therefore being, cavernous, a sudden collapse is not only possible but probable, and we can understand that it might produce remarkable effects.

V. The great suddenness and localization of the Ischian earthquake, together with the absence of any volcanic phenomena, should induce us to seek some other cause for the earthquake than a volcanic one; and as we have a set of conditions in the nature of the ground itself amply sufficient to account for most of the phenomena, we are justified, in the absence of further evidence in considering this as an efficient cause. Whether the accidental cause was a fissure, a seismic wave, or an explosion or what not, is a consideration which only a lengthened and methodical observation in the future will enable us to find out.