Preliminary Report on the Messina-Reggio Earthquake of Dec. 28, 1908.

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1. *Introduction.* The Messina-Reggio earthquake of Dec. 28, 1908, was, as far as the loss of life is concerned, the greatest ever recorded in history, and presented to seismologists an object of study of intense interest. By order of Imperial Government, the present author proceeded to Italy, to make seismological investigations respecting the disaster, arriving in Messina at the middle of February and remaining in the stricken districts till the end of April. Professor T. Nakamura, dispatched to Italy also by Government, has studied the effects of the earthquake from the architectural point of view.

2. *Seismogram and time of occurrence.* According to the seismographical observations in Tokyo, the Messina-Reggio earth-

quake was in magnitude about three times larger than the Monteleone (Calabria) earthquake of Sep. 8, 1905. As will be seen from Figs. 1 and 2, the teleseismic movements in Tokyo in the cases under consideration were almost exactly similar to each other, so that the individual vibrations can be identified in the two diagrams. Thus in Tokyo, the earthquake of Dec. 28, 1908, could from the instrumental records be at once ascertained as a great shock, which originated in or near Calabria and consequently produced a large amount of casualty.

In Tokyo, the first preliminary tremor lasted 11m 39 sec., the corresponding calculated (arcual) distance of the earthquake origin being 9930 km. The actual distance between Tokyo and Messina is about 9900 km.

The seismic disturbance reached Tokyo at 1h 32m 08s pm.* (on Dec. 28th). Calculating from the duration of the 1st preliminary tremor, the time interval taken by the vibration of the latter phase of motion in travelling through the distance between Tokyo and the origin is found to be 11m 51s. Consequently, the time of occurrence in the epicentral area ought to have been about 1h 20m 17s of the Central Europe Time. As a matter of fact, a clock in Via Porta Imperiale in the city of Messina and also those of the Railway Station of Villa S. Giovanni were found indicating the time of about 5h 20m, having been stopped by the earthquake shock and left untouched during the several subsequent months. (See Fig. 6.)

3. ***Area of disturbance.*** The motion was distinctly sensible within an area of radius of 200 km or more from the origin. The area of strong motion was, however, much smaller; and the city of Catania, at an epicentral distance of about 85 km, suffered no

* 1st Normal Japan Time, which is 8 hours ahead of Central Europe Time.

harm from the shock. The area, within which buildings were entirely destroyed or very heavily damaged, formed, together with the Messina Strait, an elliptical area, parallel N.–S., of a length of about 30 km and of a width of about 20 km. (See Fig. 3.) The regions of violent motion, which was thus quite limited in extension, included amongst others Messina on the Sicilian side and Reggio on the Calabrian side; the populations of the two cities, together with their suburbs, being about 150,000 and 40,000 respectively. This fact accounts for the great superiority of the amount of damage on the present occasion over that of the previous earthquakes in Calabria and Sicily.

4. *Earthquake damage and intensity of motion.* The enormity of the destruction of Messina is really beyond one's imagination. All the buildings in the city were, with a very few exceptions, considerably cracked or absolutely reduced to masses of ruin, which looked like hills of *debris*; even those houses, whose perimetral walls were not overthrown, had their roofs and floors knocked down from top to bottom, so that the inside was filled with *debris*; it being not rare that 15 or more dead bodies were found buried one upon the other in the space of a single small room at the ground floor. The city streets, whose maximum width was less than about 11 metres were covered by the *debris* of the houses, whose height varied from four to six stories, or from 40 to 60 feet. Especially, the two principal streets, namely, the Via Cavour and the Via Garibaldi were completely blocked by the masses of stones and mud, whose average height was about 5 metres. (See Figs. 7 and 8.) Under such circumstances, it was certainly impossible for the majority of the people to save themselves, even if they had succeeded in escaping out of doors. The approximate total number of the victims was a little over

100,000, of which about 75,000 relate to Messina and the suburbs and the remaining 25,000 relate to Reggio and other places in Calabria.

The intensity of earthquake motion in Messina was, when estimated from the overturning of bodies, found to be equivalent to an acceleration of about 2000 mm per sec. per sec. This is a little smaller than the seismic intensity in the city of Nagoya on the occasion of the great Mino-Owari earthquake (Japan) of 1891, where the maximum acceleration of motion was 2600 mm per sec. per sec. The population of Nagoya in 1891 was 165,339, which was nearly equal to that of Messina and the vicinity, and of which only 190 were killed in the earthquake. Thus, even supposing the intensity of seismic motion in Messina (1908) to be equal to that in Nagoya (1891), the number of the persons killed in the former city was about 430 times greater than that in the latter. That is to say, about 998 out of 1000 of the number of the killed in Messina must be regarded, when spoken in comparison to a Japanese city, as having fallen victims to seismologically bad construction of the houses. The Mino-Owari disturbance was at least 10 times larger in extension, and 4 or 5 times greater in intensity, than the Messina earthquake; the total number of the killed being, however, only 7273.

5. *Origin and cause of earthquake.* Judging from the form and position of the area of violent motion (Fig. 3), the origin seems to be situated in the Messina Strait. Further, the directions of the maximum earthquake motion, deduced from the observations of overturned bodies, at Messina, Canitello, Villa S. Giovanni, Archi, Reggio, Gallina, Pellaro, and Lazzaro, seem as shown in Fig. 3 to radiate more or less accurately from a point (marked by an *asterisk* in the figure), which is situated in the

Strait and between Messina and Reggio, a little nearer to the latter than to the former; the approximate position of the point or epicentre thus determined being

$$\begin{cases} \varphi = 38^\circ\ 7'\tfrac{1}{2}\ \text{N.} \\ \lambda = 15^\circ\ 35'\ \text{E. of Greenwich, or } 3^\circ\ 9'\ \text{E. from the longitude of Rome (Monte Mario.)} \end{cases}$$

Again, according to the seismographic records obtained at the seismological stations of Messina, Catania, Mineo, Mileto, and Valle di Pompei, the direction of the very first displacement of the earthquake motion at each of these places, which was well defined, was *divergent*, that is to say, directed *outwards* from the centre. This is rather contrary to what would take place had the earthquake, as popularly supposed, been caused by a violent volcanic explosion in the Strait; since, in the latter case, the initial motion at a place sufficiently near the centre of disturbance would be directed *inwards*, the second or counter motion being directed outwards.* That the cause of the Messina earthquake was not in a volcanic explosion seems also likely from the relation of the seismic disturbance in question to the other destructive shocks in Southern Italy.

The earthquake was probably caused by the sudden formation or extension of a crack within the earth's crust in a ESE and WNW direction, whose plane was nearly vertical or inclined slightly towards NEN.

6. *Tsunami* (*maremoto*). The seismic disaster was aggravated by "tsunami" or tidal waves, which originated in the Messina Strait and attained a considerable violence on both sides of the latter. (See Fig. 9.) From accounts of the eye-witnesses,

* This characteristic of motion due to an explosion has been verified in the experiments with dynamite at Akabane, Tokyo. See the "Publications," No. 21.

it seems that the waves followed the earthquake shock after a time interval, which varied at the different points on the coasts of the Strait from a few minutes to about 10 minutes.

The destructive effects of the *tsunami* were manifested along the Calabrian coast for a distance of about 38 km between Cape Pezzo on the north and Saline and Cape dell'Armi on the south; and along the Sicilian coast for a distance of nearly 100 km between Grotto (5 km to the north of Messina) on the north to the vicinity of Catania on the south. The greatest damage was caused at the south-western part of the coast of Calabria between the towns of Pellaro and Lazzaro, both inclusive, where the force of water threw down a railway bridge girder of about 42 metres length; shattered and washed away many dwelling houses, leaving behind only their basements; and carried off the sandy shore ground to a maximum breadth of about 100 metres. This last phenomenon, which was observable also notably at several places between Reggio and Villa S. Giovanni on the Calabrian side, and at Messina and Giampilieri on the Sicilian side, seems to have been more or less combined with the sinking or settlement of the soil, such that certain buildings, formerly at some distance from the beach line, are now standing quite close to, or even in, the water. On the coast of Sicily the force of the *tsunami* was most violent and shattered some number of the houses at Giampilieri, which is opposite to Pellaro. A few houses were also destroyed by the waves at Messina near the mouth of the Torrente Portalegni, at Schiso, and at Riposto.

The *tsunami* was feable in the northern entrance of the Strait, where the narrow channel turns towards ENE and makes an angle of about 60° with the axis of the main portion of the latter.

7. *Cause of tsunami.* In Fig. 4 are indicated the direction

of the *tsunami* at different places on the two sides of the Messina Strait, determined chiefly from the observations of trees bent or broken, and from bodies displaced, by the waves; each of the numbers denoting the height reached by the water.* One remarkable fact is that the *tsunami* was strongest at those places where the earthquake shock was *not* most violent, indicating the probable non-coincidence in position of the origin of the earthquake with that of the *tsunami*. The main centre of the latter phenomenon was probably between Pellaro and Giampilieri, somewhere near the place marked *B*. It is also possible that there existed a secondary centre of the *tsunami* about the epicentre of the earthquake, marked *A*; or, again, that the two centres *B* and *A* formed together a continuous zone of disturbance.

The production of the *tsunami* was probably in a measure due to the communication of the seismic energy to the water of the Strait which forms a sort of fluid pendulum, but principally to the sinking or depression of the ground under the portion of sea in question. This latter action might consist in the settlement through a height of 1 or 2 metres of the loose superficial deposits of the bottom of the Strait, as was actualy verified along the coasts of the latter.

8. *Relation of Messina-Reggio earthquake to other great destructive earthquakes in Central and Southern Italy.* In Fig. 5 are indicated the position of the area of violent motion (acceleration of the seismic motion=about 2000 mm per sec. per sec.) of the Messina-Reggio earthquake and those of the twelve other great destructive shocks which happened since 1638 in Central and Southern Italy. The thirteen earthquakes, numbered from 1 to

* For many of the exact determinations of the height of water I am indebted to the kindness of the zealous *tsunami* investigator, Prof. G. Platania.

13 in order of date, may be divided into three groups *A*, *B*, *C*, as follows :—

Group *A*	1	March 27, 1638.
	2	Nov. 5, 1659.
	4	Jan. 11, 1693.
	8	Feb. 5, 1783.
	9	March 28, „
	12	Sept. 8, 1905.
	13	Dec. 28, 1908.
Group *B*	3	June 5, 1688.
	5	Sept. 8, 1694.
	7	March 29, 1732.
	10	July 26, 1805.
	11	Dec. 16, 1857.
Group *C*	6	Jan. 14, 1703.

These three groups of destructive earthquakes form together a continuous seismic zone, which extends from the neighbourhood of Central Italy, through Calabria, down to the vicinity of Catania. Among the earthquakes of group *A*, the numbers 9 and 12 may be regarded as forming a secondary or radial seismic line.

Fig. 5 illustrates very clearly the principle that *great earthquakes* in a given region occur, not everywhere at random, but along a definite line of weakness in the earth's crust, namely, a seismic zone. Further, the areas of violent motion of the different earthquakes are almost perfectly exclusive of each other, whence it may be concluded that the great disturbances are not repeated from one and the same centre, but happen successively from different points or portions along the seismic zone. In other words, the places seismically most dangerous in Central and Southern Italy are exactly those points along the seismic zone here defined

which have not yet been visited by a very violent shock. The two cities of Messina and Reggio-Calabria, which formerly had not been shaken by a great telluric convulsion originating from a centre close by, had evidently their turn on the present occasion, and for that very reason may be supposed as being free from the danger of a future seismic catastrophe. Even in the case of a great earthquake occurring along the seismic zone, the intensity of motion at these two cities would, on account of the distance from the centre, not be so very strong, and a certain precaution taken in the construction of houses would be sufficient to prevent the loss of life and property.

Tokyo. July 20, 1909.

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Seismographical Observations in Tokyo.

Principal Portion of the NS Component.
Magnification=20. Pendulum Period=48.5 sec.

The letters a, b, c, d, e, f, g, indicate some of the approximately corresponding vibrations in the two seismograms.

Fig. 1. Messina-Reggio Earthquake of Dec. 28, 1908.

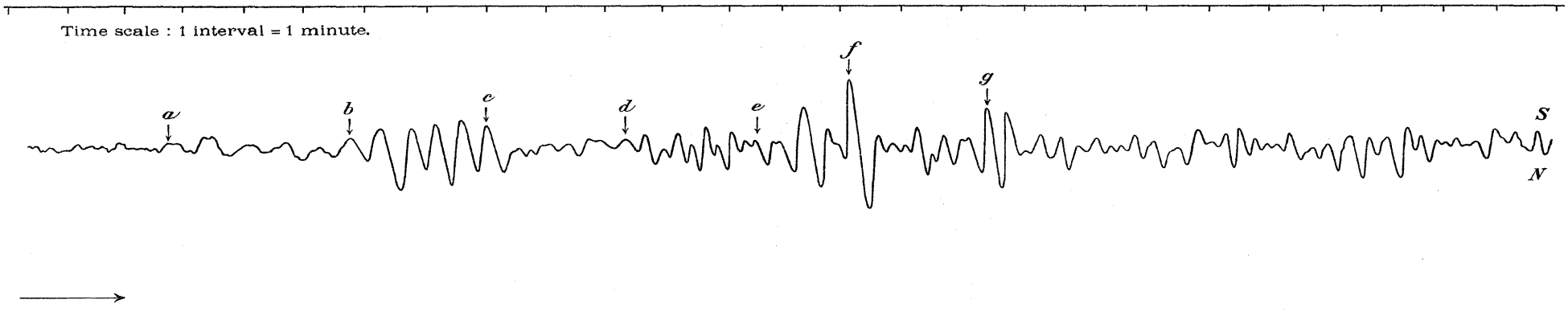


Fig. 2. Monteleone (Calabria) Earthquake of Sept. 8, 1905.

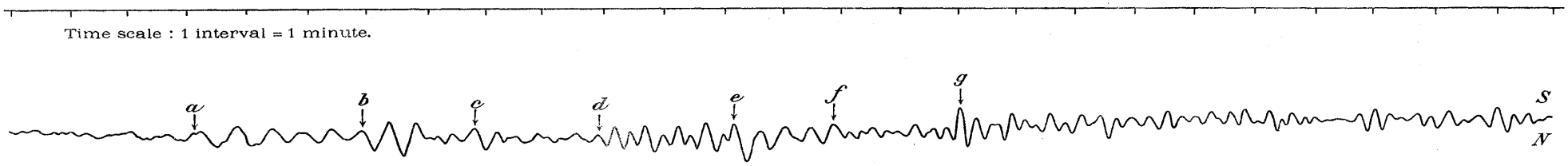
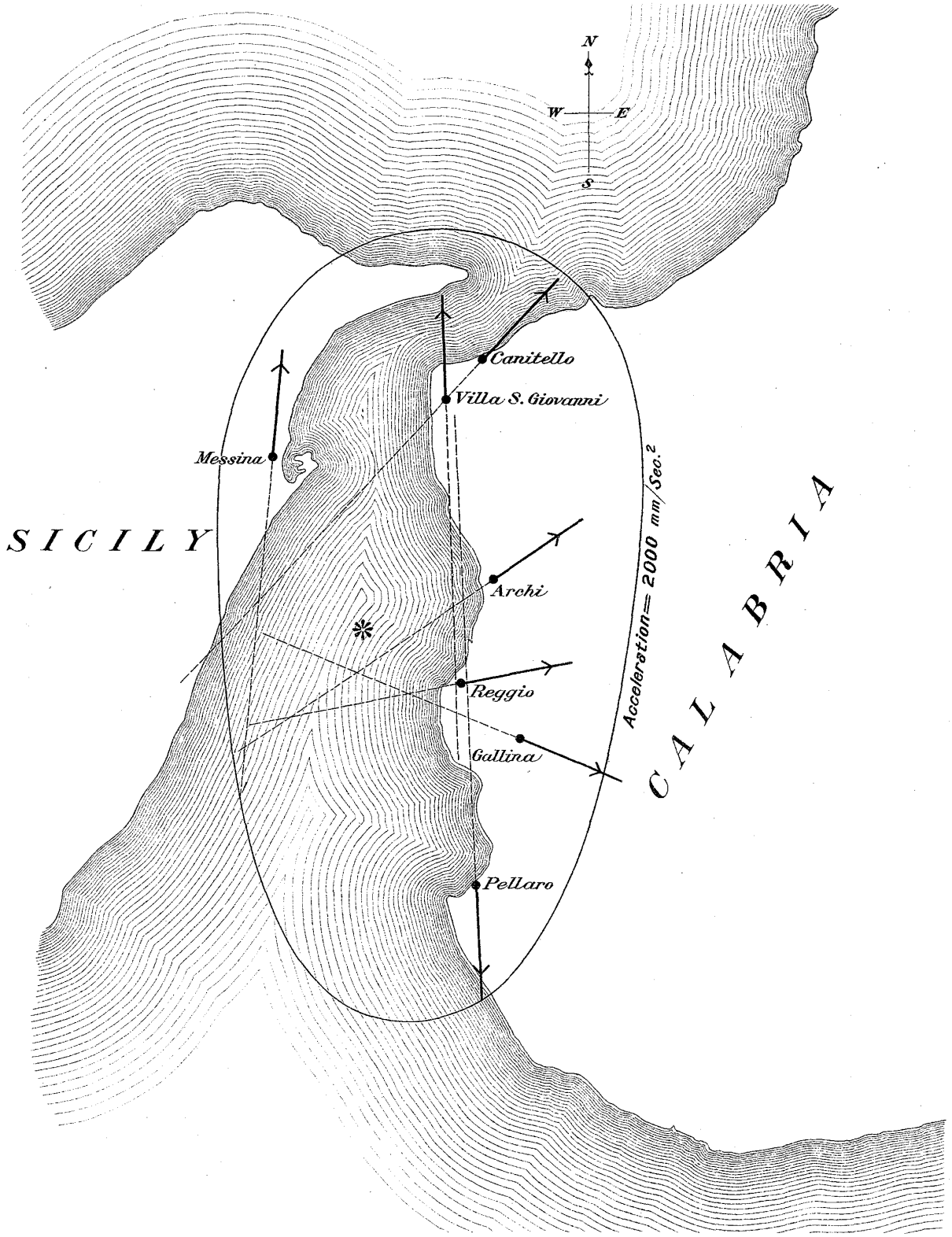


Fig. 3. Messina-Reggio Earthquake of Dec. 28, 1908.

Map showing the boundary of the area of great seismic damage and the direction of the maximum motion at the different places.

Arrow (⟶) indicates the direction of maximum seismic movement. The oval is the boundary of the area, within which the intensity of motion was equal to, or greater than an acceleration of 2,000 mm per sec. per sec.



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Map showing the direction and height of the ***Tsunami*** (maremoto) at different places on the coast of the Messina Strait.

Arrow (⟶) indicates the direction, and the numeral the height (in metres), of the ***tsunami***. (B) is the approximate position of the principal centre, and (A) that of the secondary centre, of the ***tsunami***.

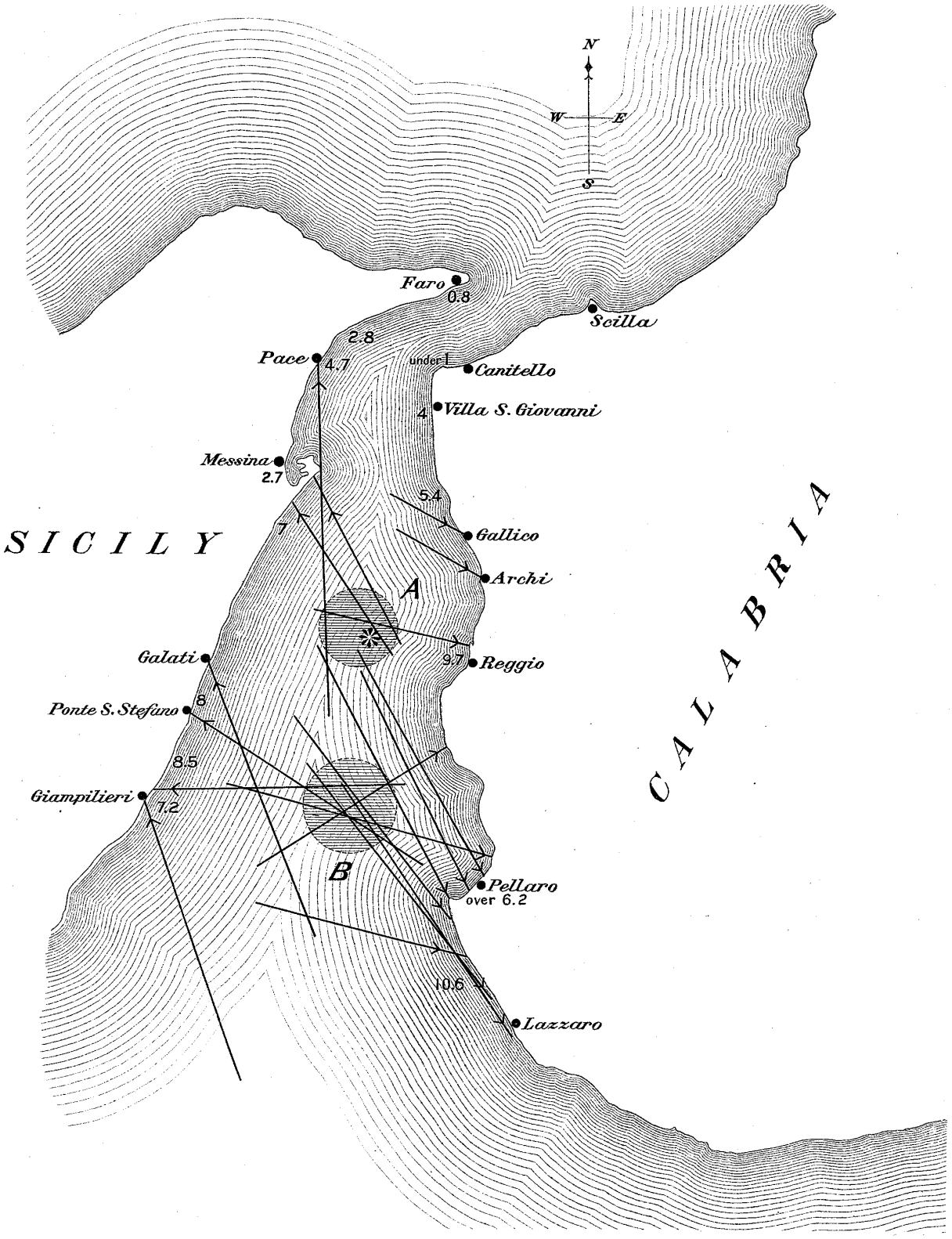
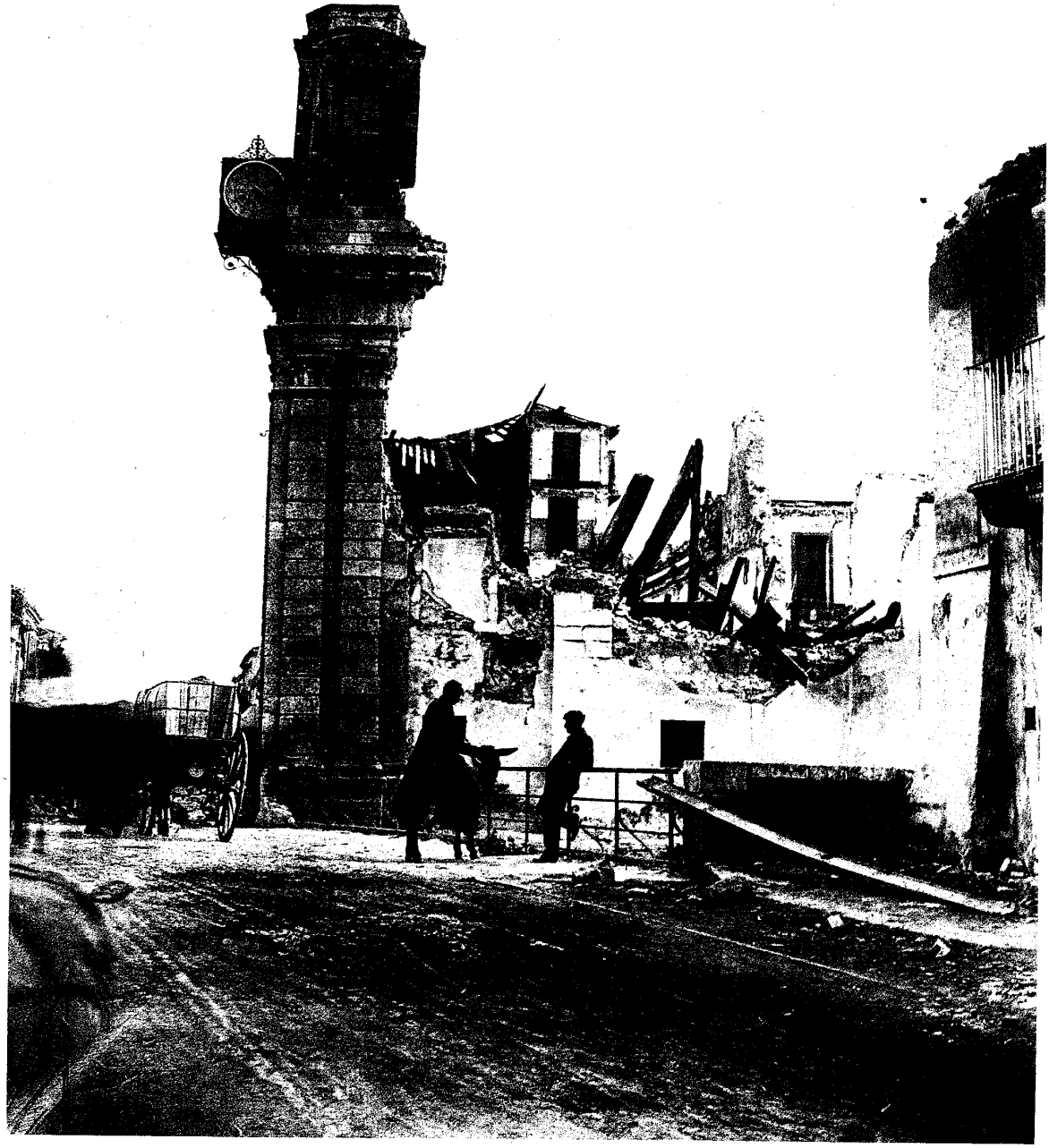


Fig. 5. Map showing the Mutual Relations of the Great Destructive Earthquakes in Central and Southern Italy.

The shaded area, No. 13, is the violent motion district of the Messina-Reggio Earthquake; the other areas, Nos. 1 to 12, are the similar districts for the previous 12 great earthquakes.



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