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## BULLETIN

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## THE MESSINA EARTHQUAKE.

BY

PROF. W. H. HOBBS,

Secretary Committee on Seismology of the American Association for the Advancement of Science.

On May 3rd, 1887, an earthquake might have been felt in many places scattered throughout about one-half of Old Mexico, as wellas over two-thirds of Arizona and New Mexico. This shock was not chronicled in the world's centers of culture, and even up to the present it has been vouchsafed but little attention; yet it was undoubtedly a far heavier shock than that which has just stirred the emotions and aroused the sympathies of the entire civilized The area of the destructive shocks of the earlier disturbworld. ance exhibits an alternation of mountain and arid plain, much of it inhabited only by Indian tribes with a few scattered ranches and mining camps. Had it been much more thickly settled than it was, it is probable that the loss would have been small. If an army in tents had been encamped upon the site of Messina on the morning of the 28th of December last, the loss to life and property would have been insignificant. This should teach us that though earthquakes may not be prevented, and up to the present have not been definitely forecasted, the destruction which they cause is very largely of man's own making.

If no city had ever been builded upon the site of Messina, it would be a relatively simple matter to establish there a new community housed in essentially earthquake-proof structures. To remove the wreckage of the old city will be, as President Roosevelt has so well said, a task for Titans. The cost of building an earthquake-proof city is greater than that of the usual type by perhaps one-half or even more: but there should on this account be no hesitation with such an object lesson before us. How such a city may be constructed has long been known in part, and the study of the recent California earthquake has furnished a definite answer to many of the problems before unsolved. Methods of building are not, however, the subject of this paper, but in a forthcoming number of the Engineering Magazine, the present writer has set forth the more important of the considerations involved.

So much has been written about the recent Messina earthquake under the mental shock of the terrible suffering and loss of life. that it is necessary first of all to correct a certain amount of misconception and error. Enough has now appeared in print from the pens of scientific writers to make this possible, though a considerable body of such papers has been written before reliable data could be obtained. The most important of the papers which have already been issued have been written by Perret,\* and Wright, † who have been upon the ground since the disaster. <sup>†</sup> By a remarkable combination of circumstances, Mr. Perret reached Messina on the North German Lloyd's steamship Therapia, the first vessel from the outside world to reach the scene of the disaster. His familiarity with the region and his knowledge of the Italian language, gave him opportunities not possessed by most foreign students. Other articles treating of the earthquake, written by geologists in some cases in advance of definite information, have been interesting as expressions of opinion concerning the cause of earthquakes, or have dealt with methods which might be adopted in the investigation of such phenomena. § Again, there have

<sup>\*</sup> Frank A. Perret, "Preliminary Report on the Messina Earthquake of December 28, 1908." Am. Jour. Sci., 4th Ser., Vol. 27, April, 1909, pp. 321-334. See also "The Messina Earthquake," The

Century Magazine, Vol. 77, April, 1909, pp. 921-927. + Charles W. Wright, "The World's Most Cruel Earthquake," Nat. Geogr. Mag., Vol. 20, April, 1909, pp. 373-396.

<sup>\$</sup> Since this paper was written has appeared a valuable paper by Dr. Martinelli of the Central Office for Geodynamics and Meteorology at Rome (Osservazioni preliminari sul terremoto Calabro-Messinese del màttino del 28 dicembre, 1908. (Boll. Bimen. della Soc. Met. Ital. Ser. 3, Vol. 28, 1909, pp. 1-11. 2 Maps.)

<sup>§</sup> Gaetano Uzzielli, "I terremoti Calabro-Siculi del 1908-1909." Rivista Geografica Italiana, Ann. 16, Jan.-Feb., 1909, pp. 44-58.

M. A. Lacroix, "Résumé de quelques observations de M. A. Riccò sur la tremblement de terre de Sicile et de Calabre du 28 décembre 1908." C. R. de l'Acad. Sciences, Paris, Vol. 148, Jan. 25, 1909, pp. 207-209.

William H. Hobbs, "The Latest Calabrian Disaster," Pop. Sci. Month., Vol. 74, February, 1909, pp. 134-140.

<sup>- &</sup>quot;Das italienische Erdbeben vom 28. December 1908," Globus, Vol. 95, Feb. 25, 1909, pp. 110-112.

James Geikie, "Calabrian Earthquakes," Scot. Geogr. Mag., Vol. 25, March, 1909, pp. 113-126. R. D. Oldham, "Recent Earthquakes," Geogr. Jour., Vol. 33, March, 1909, pp. 294-297. (See also the February number of the same journal.)



Copyright, 1909, by Underwood & Underwood, N. Y. PLATE 1.—ONE OF THE PRINCIPAL RESIDENCE STREETS OF BAGNARA. Here, as through all the devastated regions, shattered walls are being torn down as fast as circumstances permit.

appeared articles written by skilled observers and writers not primarily of a scientific character, but which include data of much general interest, for the psychology of a great earthquake cannot be wholly overlooked by the student of the physical phenomena.\*

First of all it should be stated that the sympathetic volcanic phenomena first reported from Etna and the Lipari Islands (and also Virginia) did not occur (Riccò). Perret reports that both Etna and Stromboli were unusually active on December 25th, but "Neither showed sympathetic action at the time of the quake or immediately after." Just so at the time of the Calabrian earthquake of September 8, 1905, it was credibly reported that Stromboli had been thrown into quite an unusual state of activity. This report has been incorporated into the scientific literature of the earthquake, but a later and more thorough study shows it to have been without foundation.<sup>‡</sup> This conclusion is, morover, in confirmation of experience both in this and other districts.

Again, it was claimed that the Lipari or Eolian Islands had disappeared, which would have indicated a most remarkable change in level of the sea bottom in the vicinity. This was, as could have been confidently stated by any seismologist, only a rumour of the kind that finds ready credence at such a time.

In a general way, experience has shown that a great earthquake renders a district comparatively immune from destructive shocks for a period usually measured at least in decades. The recent Calabrian disaster, coming as it did after the destructive shocks of 1905 and 1907, seemed at first to offer an exception to this rule. A more careful examination, in the light of all the facts, rather confirms than contradicts the general principle which has been established. If we recall the greatest of the earlier earthquakes in the same region-that of 1783, with its death roll of 30, 145 and its property loss, according to Baratta, of more than three billions of dollars <u>t</u>-we find that in this instance there were two main destructive shocks, one of which occurred on February 5th and the other on March 28th of the same year. The first of these destroyed especially the towns in the western section of Calabria and those across the Strait in Sicily; whereas the later one affected particularly the borders of the great granite masses lying to the eastward. If we regard an earthquake as a local "letting down"

<sup>\*</sup> F. Marion Crawford, "The Greatest Disaster of History." The Outlook, April, 1909, pp. 673-690. Robert Hichens, "After the Earthquake." The Century Magazine, Vol. 77, April, 1909, pp. 928-930.

<sup>+</sup> Gaetano Platania, "Il terremoto Calabrese dell' 8 settembre 1905 a Stromboli," Mem. della Classe di Scienze della R. Accademia degli Zelanti, 3a serie Vol. 5, 1905-6, pp. 79-87.

<sup>#</sup> In Calabria 29,515 persons and \$26,000,000. Baratta, I terremoti d' Italia, Turin, 1901, p. 288.

The Messina Earthquake.



of the strains which exist in the rocks due to the continuous action of compressive forces, as is now more and more generally held by geologists, then such a partial and local operation of the process is to be expected. Larger displacements which result from this letting down by instalments throughout extended zones which encircle the globe, have been observed to alternate throughout the zone, and so far as a rather indefinite kind of earthquake forecast has been possible, it has been on the basis of this hypothesis.\*

If now we examine the Calabro-Sicilian province during the last few years in terms of this hypothesis, we find that earthquakes of strong or destructive violence visited it on November 16, 1894,<sup>†</sup> September 8, 1905,<sup>‡</sup> October 23, 1907,<sup>§</sup> and December 28, 1908.

The shock of 1894 resulted in the death of over 100 persons, while 460 were severely and more than 500 slightly wounded. The property loss in Calabria was estimated at \$5,000,000, or about that of the Charleston earthquake of 1886; and in addition, within the province of Messina, some 200 houses partially collapsed, and almost 10,000 others were more or less damaged. The earthquake of 1905 destroyed the lives of 529 persons, severely wounded 877 others, and resulted in a property loss officially estimated at nearly \$10,000,000. In the quake of 1907 the death loss was 175, besides which some fifty or more persons were wounded. Of the property loss no estimates are known to the writer. Measured thus in terms of the damage which they have wrought, each of these quakes is properly rated as of destructive violence.

The maps inserted here (see Figs. 1-2) show the distribution of the communes and fractions thereof in which damage resulted from the shocks; and from this it will be seen that though the shocks of 1894 disturbed the shores of the Messina Strait, the others were restricted to the province of Calabria, and but little affected even the eastern shore of the Strait. In the figures the crosses and dots, which indicate respectively the points of greater and less damage, are relative only for each individual shock, and

<sup>\*</sup> G. K. Gilbert, "Earthquake Forecasts." Science, Vol. 29, Jan. 22, 1909, pp. 121-138.

<sup>†</sup> A. Riccò, "Riassunto della sismografia del terremoto del 16 Novembre, 1894, in Calabria e Sicilia." Boll. della Società Sismologia Italiana, Vol. 5, 1899-1900, pp. 157-180.

<sup>‡</sup> William Herbert Hobbs, "Calabrian Earthquake of September 3, 1905," Bull. Geol. Soc. Am., Vol. 17, 1905, pp. 720-721. Also, "Geotectonic and Geodynamic aspects of Calabria and northeastern Sicily," Gerland's Beiträge zur Geophysik, Vol. 8, 1907, pp. 293-362, pls. 2-11. Also, Baratta, "II grande terremoto Calabro dell' 8 settembre 1905," Proc. Verbali della Soc. Tosc. di Sci. Naturali. November, 1906, pp. 1-8. Also, "II grande terremoto Calabro dell'8 settembre 1905," I, Osservazione fatte nei dintorni di Monteleone. Atti della Soc. Tosc. di Sci. Naturali, Mem., Vol. 22, pp. 1-26. G. Mercalli, "Sul terremoto Calabrese del 23 ottobre 1907." Boll. Soc. Sism. Ital., Vol. 13, 1908, pp. 1-8. Map.

<sup>§</sup> M. Baratta, "Il recente terremoto in Calabria (23 Ottobre, 1907)." Revista d' Italia, Nov., 1907, pp. 754-761.



F1G. 1.

Maps to show the distribution of damage from the earthquake shocks of September 8, 1905, and October 23, 1907, within the province of Calabria. The crosses indicate the position of communes and fractions thereof which were more seriously damaged.

no comparison of intensity is possible between the different maps. The shocks of 1905 were extremely slight on the Calabrian coast of the Strait, despite the early report that Reggio and other places had been completely destroyed. Not a crack was made in the walls of any house in Reggio at this time. The heavier shocks were to the northward in the valley of the Mesima to the west of the Calabrian mountains, whereas the heavy shocks of 1907 were largely restricted to the area southeast of the same elevated masses.

Though the current reports of the recent earthquakes mention damage mainly in the coastal towns, it is almost certain that later reports will show that damage has been great in many of the small hill towns, their sufferings being, for the time, eclipsed by the greater catastrophe in Messina and Reggio. The commission of surgeons which left the coast and struck inland in Calabria a few days after the main shock, found many towns in which most of the houses had collapsed with consequent great loss and destitution. \*

The late earthquake in Calabria and Sicily came without any recognized warning at 5:20 A. M., December 28, 1908, the initial shock continuing for about 32 seconds. By some of the refugees this shock is said to have been preceded for a few seconds by a singing sound like a far away wind storm, which sound rapidly developed into a rumble and roar when the movement began to be felt (Perret). In the city of Messina itself there was a Vicentini seismograph set up within a specially constructed earthquake cellar, and this instrument continued to register the earth vibrations until the arrival of the heaviest shock. From its records it appears that ten minutes before the main shock, there was a very light movement which increased for ten seconds and then faded away in intensity during a second period of the same length. As with all great earthquakes, the initial heavy shock was followed by others. At Catania, fifty were registered during the first day, each of them less heavy than those that went before. During the night of the 29th, thirty-eight shocks were felt at Messina. Two of the aftershocks of the first ten days which succeeded the disaster were much more heavy than those which had just preceded them. On January 2 at 9:40 P. M. there was a shock heavy enough to throw down walls in Messina which had not been completely leveled by the initial shock. Also at 6:28 P. M., January 7, there were shocks heavy enough to fell some of the walls which were then still standing (Perret).

<sup>\*</sup> Oldham, Geogr. Jour., March, 1909, pp. 294-295.



Maps to show the distribution of the damage from the earthquake shocks on November 16, 1904, and December 28, 1908, in the province of Calabria and in northeastern Sicily. For the earthquake of 1908 the map is only preliminary and partial. The water wave which rolled in upon Messina a few minutes after the first heavy shock, was much less formidable than first reported. According to Perret, its height at Messina did not exceed 9 feet, though it was somewhat higher at Reggio; but it reached a maximum height on the west coast of the Strait below Taormina. According to Riccò, its height at Messina was  $7\frac{1}{2}$  feet, at Villa San Giovanni, in Calabria,  $12\frac{1}{2}$  feet, at Reggio  $10\frac{1}{2}$  feet, at Pellaro, in Calabria, about 13 feet, and at Giardini near Taormina and at Riposto  $19\frac{1}{2}$  feet. This water wave extended southward from the Strait, reaching Cape Schisò near Taormina 35 minutes, and the Island of Malta 115 minutes after the initial shock was felt at Messina. Villa San Giovanni, across the Strait of Messina, is reported by Perret to have received the wave a few minutes later than Messina. The water wave was preceded by a retreat of the water from the shore.

A separate water wave appears to have been formed within the sea north of the Strait of Messina, since it was felt at Termini Imerese, about 20 miles east of Palermo. According to Uzzielli, a sea wave was also registered at Laguna Veneta off the city of Venice. At Reggio near the railroad station, which is situated on the shore, water shot up in jets out of the ground under great pressure, a feature which is common to nearly all great earthquakes. Along the water front at Messina the quay, which before the earthquake was at the fish market  $6\frac{1}{2}$  feet above sea level, is now submerged. The shore seems to have dropped down in steplike terraces, which are possible of explanation either from local depression of the ground, due to vertical movements of sections of the crust, or from a lurching of loose materials toward the Strait under the influence of the shocks.

The preliminary soundings within the Strait since the earthquake are reported to indicate a change of depth (Riccò), but no definite data are yet at hand. Such changes are, however, to be expected, and it is not unlikely that other changes would be discovered by careful soundings in the Tyrrhenian and Ionian depressions located respectively to the northwest and to the southeast of the Strait of Messina.

It has already been mentioned that the greater part of the loss, which Messina and the other Sicilian and Calabrian cities and villages have just suffered, might have been prevented by the observation of proper building methods. Was the city of Messina wholly ignorant of this fact? Surely it has not been without warnings of its danger. In 1783 it was largely destroyed, the estimated damage as given by Baratta having been in excess of \$3,000,000,000 (if measured by present values), as against \$26,000,000, the total loss in all Calabria at the same time. \* It has long been known that masonry is particularly unsuitable for building in earthquake districts, and if used at all it must be upon good foundations and be well bonded and mortared and in structures of moderate height only. Notwithstanding this fact, most of the houses in Messina were constructed of loose rubble in a weak mortar and with floor joists supported without fastenings in shallow mortisings of the walls. The building laws had often been violated in the excessive heights of the buildings. If a more perfect human deadfall could be constructed, it was, and still is, to be found in the Calabrian



#### F1G. 3.

View of the ruins of the little village of Piscopia after the earthquake of September 8, 1905. In the foreground, note the pile of heavy tiles which have been collected from the debris.

villages, where wall construction of the same type is surmounted by heavy tiles laid upon poles to form the roof (Fig. 3).

After each fresh disaster in Calabria, there has always been some one to point a moral and to urge the use of rational building methods in reconstruction. Fortunately after the shocks of 1905 the plans of the *Comitato Lombardo* were adopted in the new con-

\* In Messina only 617 of the inhabitants were killed and in all Sicily only 630.

struction undertaken, and those villages which were largely destroyed, have now been reconstructed with barracks which, if not earthquake proof, are at least comparatively safe.\* (See Fig. 4.) Ferruzano, in Southeastern Calabria, which was not damaged during the shocks of 1905, but suffered greatly during those of 1907, was apparently rebuilt under similar control, for we are informed that though the recent shocks were heavy there, no harm was done to the newly constructed buildings. A new era has fortunately dawned for Calabria and Sicily, and a sufficiently striking object lesson is to make proper construction a necessity in all



FIG. 4.

View of the new barracks for the peasants in the hill town of Martirano Nuovo, Calabria, constructed on the plans of the *Comitato Lombardo* since the earthquake of September 8, 1905 (after Baratta).

ruined villages. It is too much to hope that those villages which have just escaped, will at once replace their man-trap houses by properly constructed ones, and more disastrous earthquakes may first be necessary. Calabria and Sicily as a whole are still in the age of masonry with which their history began; but the age of wood and of reinforced concrete has now been inaugurated, and the American villages which have been and are still being constructed at Messina, Reggio, Villa San Giovanni, and in scores of other communes, with groups of from 20 to 1500 wooden cottages

<sup>\*</sup> Baratta, "Le nuove costruzioni in Calabria dopo il disastroso terremoto dell' 8 settembre, 1905." Boll. Soc. Sism. Ital., Vol. 12, 1908, pp. 249-337.

each, cannot but greatly hasten the dawning era when all Calabria and Sicily shall be protected from its greatest scourge.\*

If the cause of the Messina earthquake is asked, it may with some confidence be referred to a sudden relief from local stress due to adjustments of the earth's crust. It is the writer's belief that this adjustment during Calabrian earthquakes has taken place in such a way that individual sections of the crust moved as units between the lines of fracture which bound them. The zones of greatest destruction from the disturbance are recognized to be coincident with lines of fracture, which have been the seats of movement in many earlier earthquakes as well. Perret, following Mercalli, has ascribed the recent movements to a local transfer of deep-seated molten rock (magma), which Mercalli has made a special class of earthquake designated "inter-volcanic." It is highly probable that most earthquakes are of this kind, for we know that great sections of the earth's surface are moved sometimes a distance of many feet in a direction either vertical or horizontal, or generally both, during a great earthquake. Now unless this movement be regarded as purely superficial and affecting only the loose unconsolidated deposits which lie upon the rock basement, and such a view is quite untenable, it is necessary to assume for each vertical movement a horizontal transfer of material beneath the surface. It seems further necessary to assume that this transfer occurs at such a depth below the surface that local removal of load would result in fusion of the rock. Now geological studies have shown that earthquakes are the local jolts which result from interrupted movements of the land progressive throughout centuries.

Thus the earthquakes of the California coast are a necessary manifestation of an uplift of the coast in some sections accompanied by a depression of other portions of the shore, and these molar movements cannot be assumed to take place without a transfer of material—presumably molten—from beneath the country that is sinking to beneath that which is rising: †

This conception is in no way opposed to the view that the earth as a whole is essentially solid, which there is strong reason to

+ See " Earthquakes, an Introduction to Seismic Geology," Appleton, 1907. pp. 33-36.

<sup>\*</sup> Since the above was written has come the news of definite action by the Italian Government. On the 18th of April, 1909, by royal decree No. 1933, a set of regulations was promulgated which must be adhered to "in repairs, reconstructions, and new constructions of the edifices public and private in the villages damaged by the earthquake of December 28, 1908, or by other earlier ones." These regulations have been published by the Italian Ministry of Public Works on April 23, 1909. (Ministero del Lavori Pubblici, Norme techniche ed igieniche obbligatorie per le riparazini, etc., *Boll. Uff. del Minist. del Lav. Pubb.*, Rome, 1909, pp. 57. Also "Relazione della Commissione incaricata di studiare e proporre norme edilizie obbligatorie per i comuni colpiti dal terremoto del 28 dicembre, 1908, e da altri anteriori." Rome, 1909, pp. 111, map.

believe. The core of the earth, if solid, must be so by reason of the pressure upon it, and a local relief of this pressure in the superficial portion due to a local uplift, would temporarily cause fusion of some of the rock, and so permit of lateral migrations. Mercalli's "inter-volcanic" type of earthquake is thus in all probability the normal one, and is connected with changes in level of the earth's surface. Wherever, therefore, portions of the continent are rapidly undergoing changes of level, and such are for the most part in the neighbourhood of the sea coast, there earthquakes must be expected.

It is vain to hope against hope that earthquakes will not return to regions which they have already visited in the past. It is quite within the range of possibility that more careful study by geologists of the rate of uplift within definite dangerous zones, may throw some light upon the future frequency and intensity of earthquakes, in those cases where historic records are insufficient for the purpose. In the writer's opinion, the study of earthquakes, from the geologist's view point, is certain to focus attention more and more upon study of the rate of oscillation of level measured in terms of wave-cutting on shores and of stream erosion as well. It was with studies of this nature that geology was concerned in its beginnings, but attention has since drifted away from the subject. There are, however, few problems of geology to-day so pregnant of important discoveries in the future.

UNIVERSITY OF MICHIGAN, May 18, 1909.

# THE OPERATION OF GEOGRAPHIC FACTORS IN HISTORY.\*

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### ELLEN CHURCHILL SEMPLE.

Man is a product of the earth surface. This means not merely that he is a child of the earth, dust of her dust; but that the earth has mothered him, fed him, set him tasks, directed his thoughts, confronted him with difficulties that have strengthened his body and sharpened his wits, given him his problems of navigation or irrigation, and at the same time whispered hints for their solution. She

<sup>\*</sup> Address delivered before the Ohio Valley Historical Association at its annual meeting, Marietta Ohio, November 27, 1908.