

Our Risk from Earthquakes

With Earth Always in Tremor, Quakes Are Possible Everywhere, but Likeliest Where Land Formations Are Newest

By **ANGELO HEILPRIN**

DRAWINGS BY G. PATRICK NELSON

A QUESTION that is frequently put to the geologist after every destructive happening in the earth's crust, such events as the late eruption of Vesuvius or the earthquakes in California and Jamaica, is, Are we likely to have a similar occurrence before long? or its variant, Can such occurrences take place in regions which are thought to be immune from nature's ravages?

The omniscient scientist who is still puzzling over what has recently happened in a far off portion of the earth's surface, trying to ascertain the cause or causes of the complex activities which have destroyed towns, villages, and scattered habitations, which have disturbed balances within the earth and out of it, and which have interjected new features into the business responsibilities of communities, finds himself besieged with the inquiry as to the well being of the earth at large, the possibilities and probabilities, near or in the future, of Chicago, New York, and Philadelphia, and the problems that attach to the resisting power of skyscrapers and the effect of subway spaces upon the movement of a portion of the earth.

The inquiries are in themselves sufficiently harmless and seemingly simple in their solution; they touch no problem in the physics of our planet which has not already been long studied and investigated; they deal with no problems in science that involve new conceptions in the theory of matter. Yet they are of a kind that the geologist is least prepared to answer, however ready he may be to express himself in interviews shortly after an occurrence.

A Discomfited Prophet

AT the meeting of the British Association for the Advancement of Science held in Birmingham, England, in 1886, which was presided over by a geologist of rare acumen and learning, the presidential address was in part devoted to a survey of the physical features, as far as they had been developed by geological conditions, of the Atlantic basin and of the eastern border of the American continent, and from these features the thesis had been elaborated that in the region under consideration no great earth displacements or movements were likely to occur at any early period, nor any convulsions that were dependent upon such displacements. The earth in this quarter had seemingly attained a degree of stability which nature's forces were no longer likely to disturb, and man could rest secure in the consciousness that in those parts the earth had been completed and no adaptations toward a probable change need be contemplated further. During, or shortly following, the reading of the address referred to, word was received of the destruction in great part, and through earthquake movements, of the city of Charleston—a singular and bitter commentary on the prophecy of science, a lesson that geologists who are addicted to prophesying on what might be termed slender evidence should take well to heart.

The layman may at this point be tempted to ask, Are there then no lessons that are taught to the investigator by earthquake and volcanic phenomena which would permit him to read the future, as far as this class of phenomena was concerned, for a given region of the earth's surface? The geologist in Japan, where some two thousand or more earthquakes, and some earthquakes of fair quality, are recorded every year, has no difficulty in forecasting the probable future; the same would be true of the investigator stationed among the central islands of the Malay Archipelago, in the equatorial Andes or Central America, or in the shadow of Vesuvius and Etna. What might be expected from the future is well indicated in what has taken place in the past or in what is taking place in the present.

The same might be thought true of the scientist who had the California region for his station; but was there a geologist wise enough to predict the likelihood of a catastrophe such as that of April 18 of the last year, any more than there was a scientist to predict the earthquakes which wrecked Caracas in 1812 and Lisbon in 1755, or the more recent quakes of the Simla region in the Himalayas, and of Kingston? The California geologist was well acquainted with the minor earth movements, some of them indeed sufficiently severe, of his region, and he well knew

from all kinds of geological evidence that the Western California region was a weak one; but he was not willing to assume from this knowledge so vast a measure of danger as was implied in the partial destruction of San Francisco, Santa Rosa, San José, and other California towns.

No more willing is the geologist to assume a likelihood of danger from eruptions of some of the most exquisite of our mountain forms,—Mount Hood in Oregon, Rainier and Baker in Washington,—and yet he has learned to know some of their danger signals. Mount Baker was in eruption as late as 1870, and steam is still to be found issuing from crevices and rents in the interior of the crater of Rainier. We are in the habit of describing these volcanoes as extinct or dormant, or verging on extinction; but in the case of none of them does observation extend so far back as the interval which separated the cataclysmic eruption of Pelée in 1902 from its precursor in 1851, or that which by more than a hundred years removed the earlier eruption of Tarawera, in New Zealand, from that of June, 1886, when the famous Pink and White Terraces, the frequently designated "eighth wonder of the world," were destroyed.

An Elusive Problem

EARTHQUAKES may be due to so many causes, and they are brought about so readily, that the problem of determining when and where they are coming is naturally an elusive one. Any jarring of the earth's surface, any jarring of the earth's interior, can reasonably be assumed to produce a quake of some kind. The slipping of a rock surface, the breaking across of rock masses, an explosion of dynamite, the bursting of a locomotive boiler, the falling in of caves, the movement of cars and wagons, may all be responsible for earth disturbances of one kind or another; and while we may not be willing to say that these disturbances are all earthquakes, they yet all in a way pertain to the class of phenomena of which the earthquake is the dreaded exponent, and all reflect that destroying power which belongs to the major earth movement or earthquake proper. Our planet is in tremor probably at all times and everywhere. Professor Alexander Herschel a few years ago laid the platform of his astronomical observatory in South Africa in a deep excavation, hoping that the removal from the surface would secure for his telescope freedom from all minor disturbing vibrations; but his delicate experiments showed that the earth tremor was a virtually permanent quantity, neglecting no place and appearing at all times.

Volcanic regions are preeminently the regions of those minor jars which are termed earth tremors, and they are also prone to the destructive visitations of the larger earth movement or true earthquake. With hardly an exception every region of active volcanoes is also a region of more or less destructive earthquakes. In such regions there are frequent rock readjustments, many of which follow necessarily upon the work of steam and other explosive gases. But because the active volcanic region is also an active region of earthquake, it does not follow that the most destructive earth-

quake must necessarily be an association of volcanic outburst in the region of its occurrence. We know in many instances the contrary to have been true. The earthquake of Lisbon, one of the most destructive seismic events which history records, though perhaps not the one involving the greatest amount of land movement, took place in an eminently non-volcanic region; and the same is almost equally true of the earthquake of Caracas. Charleston presents a similar forcible example of a seeming non-association, as a primary cause, of the two classes of phenomena.

In stating that these most destructive earthquakes occurred in regions where volcanoes do not exist, it is perhaps not absolutely safe to assume for that reason that their origin was wholly independent of volcanic action,—action that may have taken place at some point distantly removed from the actual scene of the catastrophe. Investigations of many years have shown what would seem to be a more than coincidental relation existing between earthquakes and far removed volcanic activity, whether the one is precedent to or follows the other.

Remarkable Coincidences

THE terrible cataclysm of Mont Pelée, which on May 8, 1902, in hardly more than an instant of time, annihilated thirty thousand inhabitants of the island of Martinique, is by some of the foremost investigators of seismic phenomena thought to have been initiated by or at least directly related to the earthquakes which in January and April of the same year largely wrecked the towns of Chilpancingo in Mexico and Quezaltenango in Guatemala.

And the fact can hardly go unnoticed that the recent California disturbance was preceded only a few days by perhaps the most violent eruption for which Vesuvius has placed itself on record during modern times. The distance separating the California from the Neapolitan region is a vast one, and most geologists may not be willing to admit any relation binding together the troubles of the two. But yet one may ask, Can it not be that both had their origin in some common deep seated or widely acting movement or disturbance in the earth which was in no way local in its operation? Cannot this disturbance, even at a separating distance of several thousands of miles, produce volcanic outbursts at one place and earthquakes at another? The scientist, indeed, finds it difficult at this time to give a positive answer to these questions. The brave investigator, Professor Matteucci, who remained at his post in the observatory which has so often proved a friendly roof to the tourist on Vesuvius, seems not wholly disposed to believe that there may not have been a direct relation existing between the events of Southern Italy and those of the Western United States.

Mont Pelée is removed in a direct line two thousand miles from what has been assumed to be the initiating locus of its disturbance in Guatemala—not nearer than are the volcanic islands of the Aleutian group from San Francisco. And it is at least a significant fact that the fuming new island of that group, now designated Bogoslof No. 3, appeared at almost exactly the time of the California disturbance. In this fact we have merely the repetition of the history of the earthquake of Lisbon, which records that precisely on the day when that city fell the volcano of Kötlogia, in Iceland, eighteen hundred miles distant, broke out in a paroxysm.

The greater number of geologists recognize that there are two broadly marked out areas of weakness in the earth's mass. One of these is represented by the trough of the sea, the oceanic basins, and the other by any region of recently (in a geological sense) constructed mountains. The latter invariably occur close to the oceanic border, or adjoin a region that has at no remote period been ocean.

It follows, therefore, that many continental borders are unstable areas, and the western border of the North American continent is notably so. The oceanic troughs have seemingly for long periods and over large areas been undergoing slow subsidence and breakage, and with each important readjustment of its floor one may well believe that the readjusting process will react upon a land surface somewhere, pushing it aside or rending apart its constructing rock masses. Earthquakes of great magnitude may result

