EARTHQUAKE PATTERNS

New research at the Institute's Seismological Laboratory sheds some new light on earthquakes —and challenges some long-standing beliefs

LIKE CYCLONES, landslides, volcanic eruptions and a good many of Nature's more violent manifestations, earthquakes have always been considered unpredictable, haphazard occurrences. But new research at the Institute's Seismological Laboratory now challenges this long-standing belief.

In a recent study of all great shallow earthquakes which have occurred in the world since 1904, Dr. Hugo Benioff, Associate Professor of Seismology, has found that each of these 48 quakes—no matter where it occurred—was related to the others. All the quakes, in other words, were related in some form of world-wide stress system.

Dr. Benioff further found that, though major quakes used to occur at closely-spaced intervals, with long rest periods between the periods of intense activity, they have now settled into a routine of one great shake a year.

If this was not actual earthquake prediction—the goal of all seismologists—it was at any rate another long step toward it.

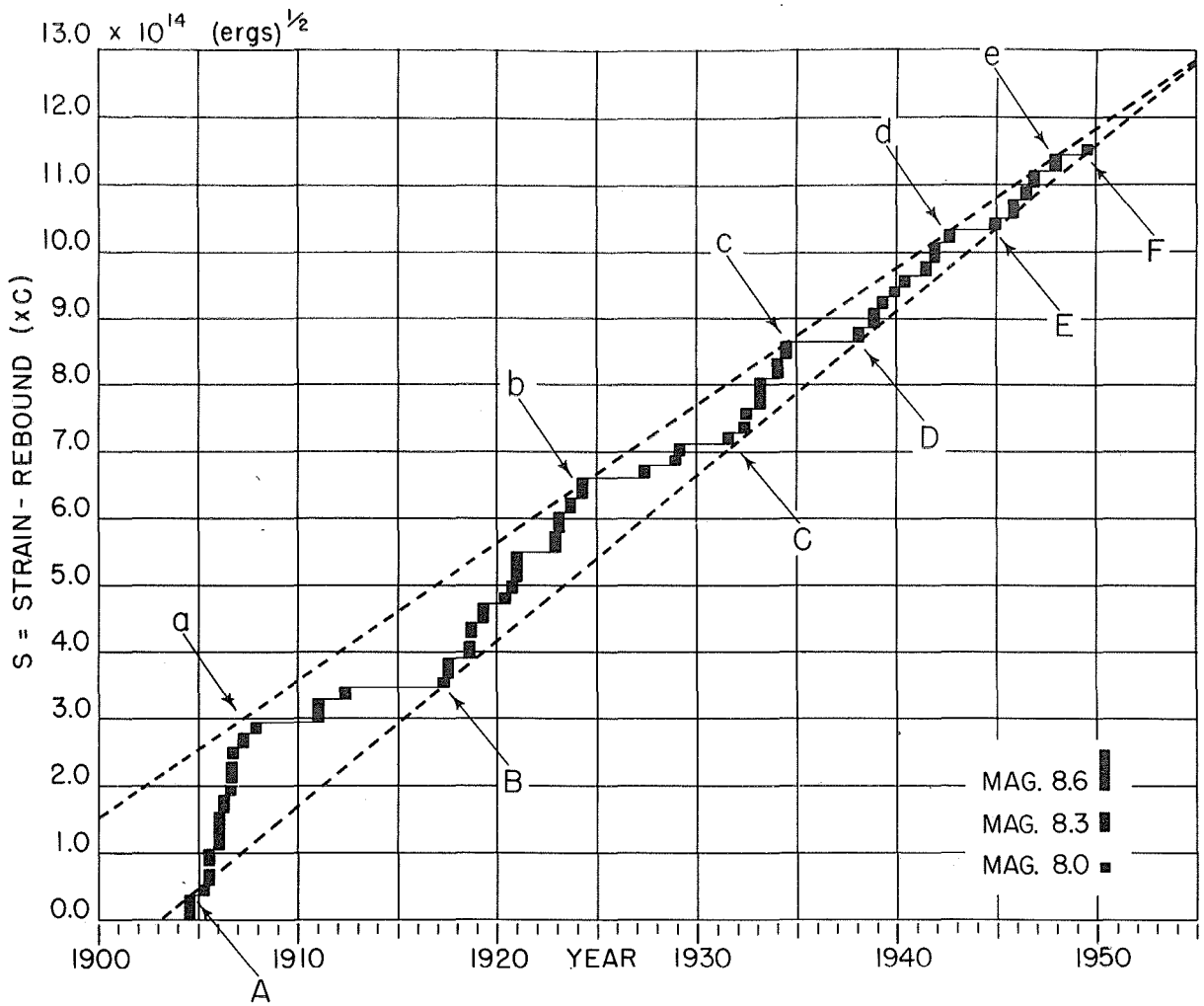
Since 1904, Dr. Benioff found, the stress or strain which accumulates constantly in the crust of the earth has been released in five active periods, each consisting of a whole series of earthquakes. Each of these active periods has been followed by a quiescent interval of little or no earthquake activity, during which crustal strain again accumulated. Apparently, Dr. Benioff reasons, there is some global force, like a huge key, which alternately locks and unlocks earthquake faults (cracks in the earth's crust) simultaneously throughout the world. When the faults are locked together, strain builds up but there are no quakes. When they are unlocked they move apart, rocks begin to slide and the earth quakes.

What is this "global force" that locks and unlocks the faults? Scientists can only guess at the answer today. Possibly the earth becomes alternately smaller and larger. When it spins faster, due to slight changes in the tidal forces exerted by the sun and moon, it may become larger—so that the seams may be opened enough to unlock the tensions stored up in the faults.

In his study Dr. Benioff also discovered that strain was generated in the earth's crust at a remarkably constant rate—but it was released at an irregular rate. Major quakes used to occur at closely-spaced intervals. After a period of constant activity, there would be a long rest period of several years before activity began again. Since 1904 these periods have been getting progressively shorter. Now (since 1948) we have entered a new phase, where strain is being released at the same rate as it is generated. This means that as long as this normal regularity lasts we should have approximately one great quake a year on this planet.

The earth's crust, which is made of ordinary rocks, has considerable rigidity and strength. But it is constantly subjected to forces which cause it to be compressed in some places and dilated in others. These forces are usually resisted by the elastic strength of the crust and the frictional strength of the fault surfaces, but sometimes this strength is overpassed and there is a sudden movement of the fault blocks. The rapid movement under friction—often involving the displacement of thousands of cubic miles of rocks—sets up elastic waves which spread out in all directions. This is an earthquake—a jar to the earth's body, caused when the strained fault suddenly gives way, or snaps back or elastically recoils.

Starting with the year 1904, when reliable instrumental observations first became available, Dr. Benioff recently charted what are known as the strain-rebound characteristics of all great quakes which have occurred to date. He included only shallow (down to 45 miles)



ELASTIC STRAIN-REBOUND CHARACTERISTIC. SEQUENCE OF WORLD SHALLOW EARTHQUAKES.

MAG. ≧ 8.0, SINCE 1904

This chart covers 48 great shallow earthquakes which have occurred since 1904. It shows that most of these came during five active periods, that each of these periods was followed by a quiescent period; that the periods have been getting shorter and milder since 1904, that we are now in a phase where we can expect one major shake a year.

quakes—which are the ones that cause most damage. And he included only major shocks—quakes whose magnitudes were recorded as 8 or higher. (Highest magnitude recorded for any quake since 1904 is 8½, a figure reached by earthquakes in Colombia and Chile in 1906; Tien-Shan in 1911; Kansu in 1920; Japan in 1933. The San Francisco earthquake in 1906 had a magnitude of 8¼; the Long Beach quake in 1933 a magnitude of 6½.)

Because these 48 quakes occurred on so many different faults it was not expected that a plot of their strain-rebound characteristics would have any particular significance. The resulting pattern, however, was as orderly and regular as the cutting edge of a saw— with the exception that the teeth near the end were shorter and closer together (see above).

In 1904 we were in the midst of a period of violent earthquake activity which lasted until 1907. Except for two quakes in 1911 and 1912 all faults were then quiescent for almost ten years.

The next period of activity began in 1917 and continued until 1924. From 1924-1931 there was little activity. 1931-33 was another active period, followed by a quiet period from 1933-38. There was activity again from 1939-1942. From 1942-45 there was none. Then another series of quakes occurred from 1945-48.

Since 1904 then, there have been five periods of earthquake activity, and the magnitudes of the quakes in each period are so closely related that they almost make five straight lines on the chart above. Dr. Benioff's conclusion: that the quakes are not independent, since release of strain by one shock affects the time—and presumably the strain-release—of following shocks.

The chart also makes it plain that periods of earthquake activity have not only been getting shorter since 1904—but milder too; until now strain is being released as soon as it generated, resulting in approximately annual quakes. It is impossible, of course, to conclude that earthquake activity is cyclic. The sample—46 years—is hardly large enough to warrant any such conclusion as that. If this is a cycle, however, earthquake amplitudes and periods should soon begin to increase. On the other hand, if this is merely a transient oscillation we are in now, there may be a long quiescent interval before more strain is built up and a period of activity begins again. One thing, at any rate, is certain: as long as the present situation lasts there should be fewer intense epidemics of great quakes.