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Earthquakes and mountainbuilding

Abstract

Until now the subject of earthquakes has chiefly been treated by geophysicists. The connection with mountain building however is obvious, and therefore a consideration from a pure geological point of view seems to be logical.

The characteristics of the earthquakes which can be considered today as certain are briefly the following:

1. The foci or hypocentres of earthquakes appear practically as a point.
2. The discharge of energy is momentary with the effect of a shock.
3. The quantity of energy and the energy reserves are very great (up to $3 \cdot 10^{25}$ erg).
4. The differences between the quantities of energy are extremely wide and range from 1 millionth to one trillionth.
5. There is a tight accumulation of energy up to the very moment of release.
6. Foci have been recorded down to a depth of 700 km.
7. There are different systems of shocks (main shock with, or without after and foreshocks).
8. The isoseismal lines are circular or deformed according to faulting systems in the earth's crust.
9. The earthquakes can be accompanied by volcanic activities.
10. Effects of light, and changes in the earth's magnetic field have been observed.
11. The arrangements of the foci are generally zonal.

Today it is generally believed that the earthquakes are caused by the abrupt tectomechanical shift of parts of the earth's crust. Considering this theory the following two marginal cases are mentioned:

A cube of rock with an edge's length of 100 m is dropped in an absolutely free fall of 1 m on to a hard elastic ground. The resulting shock

releases an energy in the form of seismal waves of $2 \cdot 10^{17}$ erg. If an energy of $3 \cdot 10^{25}$ erg, which is the energy of the strongest earthquake ever possible, should be produced in this way, it would require a coherent complex of rock of 250 by 30 by 2 km which would have to crash on a whole face after 10 m of free fall.

The second example concerns a horizontal shift with the breaking of a coherent mass of rock by shear. The shear resistance is proportional to the cross section of the rock which is to be broken. If we shear 1 cm^2 of the hardest compact quarzite which has a rigidity of 3000 kg/cm^2, an energy of 10^6 erg is released. To reach an energy of 10^{26} erg, a cross section of 10^3 km^2 of the same coherent rock would have to be broken.

It is obvious that the energy released by a tectonic earthquake cannot exceed the amount of energy that the free falling or the shearing of a complex of rock can produce. Circumstances which hinder or make impossible a seismal shaking in a tectomechanical way are the following ones:

1. The friction of the moving rock faces consumes a considerable amount of energy.
2. The resistance to pressure of the rocks at the relatively small contact surfaces is not sufficient to accumulate these energies in a tectomechanical way.
3. The hollow spaces which are necessary to make possible a free falling do not exist in the interior of the earth's crust. Hollows in the solid of rocks are either filled with water, oil, or gas. Each of these mediums makes a free fall impossible.
4. Mainly the fissuration in big complexes of rocks is so common that the coherent fissureless complexes necessary to accumulate tectomechanically such great energies do not exist. The plasticity of the rocks increases proportionally to the mass and the depth. The really existing possibilities to cause an earthquake by a tectomechanical way are not sufficient to produce one thousandth of the energy as it appears in medium earthquakes.

The isostasy in itself proves a considerable plasticity of the upermost crust of the earth, and suggests in all its aspects the impossibility of producing an earthquake by tectomechanical action.

The folding also is in contradiction to the earthquakes resulting by faulting. The San Andreas Fault in California in no way proves that the great earthquake of San Francisco in 1906 was caused by a tectonical shift. A crack of the layers did not essentially happen during this earthquake, but only shiftings at the faults which had existed millions of years before. The isoseismal lines were deformed in line with the fault because the extention of energy was very much screened at right angles to the fault. Moreover a number of earthquakes do not have oval shaped isoseismal lines. «It ist difficult to find in the historic record as many as twenty earthquakes in which clean-cut surface faulting was observed of sufficient magnitude to indicate a reasonable cause for the shock. Many of the discordant short faults appear to be the result of shaking» (Encyclopaedia Britannica 1960, vol. 7, p. 846). «Even those who recognize the impossibility of the mantle being liquid often speak of the earth behaving like a fluid. The answer may be that the earth can behave as a rigid body to forces of short duration but for long-continued stresses acts like a fluid» (B. F. Howell, 1959, Introduction to Geophysics, p. 238).

Our statement is: Tectomechanical shifts can not cause shakings reaching the force of medium earthquakes. Earthquakes are the cause of the initial main faulting, and thereby they introduce the tectonic of faulting.

As a supposition to explain the cause of the earthquakes the possibility of deep explosions is taken into consideration. This supposition is not in contradiction to the 11 characteristics mentioned above.

Where mountain building is concerned the heat produced by the explosions is of great importance to the migmatisations. Thereby the convection currents are caused and promoted.

In a potential orogen more than 1000 shakings a year by earthquakes can be estimated. This great number of earthquakes releases and promotes the movements of the strained parts of the earth's crust.

According to this conception the mountain building could consist chiefly of three phases:

1. By the effect of heat of explosion accumulated in zones deep in the crust a convection current rises upwards. Melting up of rock, migmatisations, and volcanoes are the results. Simultaneously a convection courrent downwards at the opposite side of the orogen causes the magmatectonic events. Layers of surface rocks are drawn down. The forming of shifts and undershifts is activated by frequent quakes. First the main folding occurs, then the great layers (nappes) are stretched and pulled downwards. In the depths occurs the metamorphose of rocks. With the drawing down of lighter surface rocks into deep re-

gions a foredeep with a well marked negative anomaly of gravity is a known fact.

2. After the burning out and dying away of the explosions the convection currents stop. Crystallization of the melted rocks into batholiths, and extinction of the volcanoes, are the consequences. Under the foredeep the isostatic rising of the mountain body begins and proceeds until the maximum height above sea level and equilibrium of the state of gravity are attained. The uprising causes an overflow and sliding down on the surface of parted elements of layers from the restricted zone of the deep orogen by gravitation.
3. The phase of erosion is characterized by relative tectomechanical inactivity. As the close of the process we note erosion of the mountain ranges and corresponding isostatic rising as well as sinking in the zones of alluvial accumulation (see fig. 7 and 8).

We suppose that the natural explosions could be the result of nuclear events which could happen under certain circumstances in the depth of, up to now, practically unknown configuration. Considering this, we remember that the heat of the sun is produced by the transformation of hydrogen into helium. Hydrogen and helium exist in the uper mantle. Moreover the frequency of the chromospheric explosions on the sun is of the same order as that of the earthquakes.

«In a sense all earthquakes may be thought of as aftershocks of the original catastrophe of the earth's origin» (BENJAMIN F. HOWELL, Jr., in «Introduction to Geophisics», 1959, p. 86).