The Antiphysical Review

Founded and Edited by M. Apostol **230** (2021)

ISSN 1453-4436

Watch the little ones: they may announce disasters

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I learnt recently from seismological authors that a large number N of earthquakes with magnitude greater than M, occurring in a long time T in a seismic region are fitted by the well-known Gutenberg-Richter relationship

$$\lg(N/T) = -\lg t_0 - \beta M \ , \tag{1}$$

where t_0 and β are fitting parameters.[1] For instance, a set of 3640 earthquakes with magnitude $M \geq 3$, which occurred in Vrancea between 1981 and 2018, leads to $-\lg t_0 = 4.92$ (t_0 measured in years) and $\beta = 0.98$, with an estimated 15% error; a useful parameter is $r = 2\beta/3 \simeq \frac{2}{3}$.

The earthquakes may be correlated: a main shock may be preceded by correlated, smaller foreshocks, and it may be followed by correlated, smaller aftershocks. According to the theory,[2] the time τ elapsed from the occurrence of a foreshock with magnitude M to the occurrence of a main shock with magnitude M_0 (or the time from an M_0-main shock to an M-aftershock) is given by

$$\tau = rt_0 \cdot 10^{-\frac{3}{2}[(1-r)M_0 - M]} \ , \tag{2}$$

or, with the parameters given above,

$$\tau = 10^{-(2.54 + M_0/2 - 3M/2)} \, days \ . \tag{3}$$

The background parameters t_0 and r (β) can be derived for any seismic region (the parameter r varies in the range $\frac{1}{3} < r < 1$). By inserting them in equation (2), we can estimate the time which may elapse from an M-earthquake to an M_0-main shock (if they are correlated). We can see that in any moment we may expect a large earthquake. The time τ is shorter for a greater M_0 and a smaller M. The smaller the correlated foreshock, the nearer a large main shock: watch the little ones, they may announce big disasters. If $M \longrightarrow 0$ is correlated with an M_0-main shock, we are already at the moment $\tau_0 = 10^{-(2.54 + M_0/2)}$ days when this main shock occurrs. We do not know the moment of occurrence of the earthquakes. At any moment a "big one" may appear.

For instance, an $M = 3$-foreshock may announce an $M_0 = 7$ main shock after 41.5 minutes; or an $M_0 = 6$-main shock after 2.19 hours; or an $M_0 = 5$-main shock after $\simeq 7$ hours.

References

[1] T. Lay and T. C. Wallace, *Modern Global Seismology*, Academic Press, San Diego, California (1995).

[2] B. F. Apostol, "Correlations and Bath's law", Res. Geophys. **5** 100011 (2021).