Atlas of aftershocks of the strong earthquakes

Guglielmi A.V., Zavyalov A.D., Zotov O.D.

Schmidt Institute of Physics of the Earth RAS, Moscow, Russia

e-mail: guglielmi@mail.ru

The empirical formula $n(t) = k/(c + t)$ is well known in aftershock physics [Omori, 1894]. This formula is called the hyperbolic Omori law. It describes the decrease in the frequency of aftershocks $n(t)$ over time. The power law $n(t) = k/(c + t)^p$ is also known [Hirano, 1924; Utsu, 1961]. The parameter c is of no interest to us, but the quantities k and p are the most important phenomenological parameters characterizing the earthquake source as a dynamic system. These laws are not completely satisfactory, primarily because in practice the monotonous decline in the frequency of aftershocks is violated under the influence of the pulse, periodic, and stochastic triggers of natural and artificial origin. An example of a pulsed trigger is the round-the-world seismic echo, and an example of a periodic trigger is the free oscillations of the Earth, excited by the main shock [Guglielmi, Zotov, Zavyalov, 2014]. An additional factor leading to non-monotony, or at least to a significant deviation of the real flow of repeated shocks from a hyperbolic or power law, is the nonstationarity of the geological environment in the earthquake source after the main shock.

To overcome these shortcomings, we propose to replace the empirical Omori law with the differential equation $dn/dt + \sigma n^2 = 0$ which describes the evolution of aftershocks. Here σ is the so-called deactivation coefficient of the source, if $\sigma > 0$, or activation coefficient of the source , if $\sigma < 0$. The advantage of the differential equation of evolution is that we can easily take into account the effect of triggers on the source and the effect of nonstationarity of rocks in the source, assuming that the deactivation (activation) coefficient depends on time: $\sigma = \sigma(t)$ [Guglielmi, 2016].

In the report we will formulate the inverse problem of the physics of the source, and we will present the method of its solution. The essence of the inverse problem consists in finding the unknown function $\sigma(t)$ from a given function $n(t)$ obtained from seismic observations. Formally, the problem reduces to solving the Volterra integral equation of the first kind. According to the results of solving the inverse problem, it will be possible to create an "Atlas of aftershocks". The atlas is planned to be composed of blocks of the same type, one for each main shock. The block contains 3-4 sheets, on which the initial information about the event, the result of the analysis in graphical form, and a brief comment are presented. The general conclusion is that the method of the inverse problem of the source (IPS) opens up the possibility of a new approach to the analysis of aftershocks, and the creation of the Atlas based on the IPS solution will provide new material for studying the source that is "cooling down" after the main shock.

The work was partially supported by the Russian Foundation for Basic Research (Grant No. 18-05-00096).