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Earthquake Productivity

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The ability of earthquakes to trigger other seismic events (or aftershocks) is characterized by productivity. Productivity determines the number of events within the spatiotemporal interval resulting from a stress disturbance caused by another earlier earthquake. This concept was used by Utsu [1] to develop a model for the occurrence of aftershocks. Since the advent of epidemic seismicity models (e.g., ETAS [2]), the study of productivity properties has become a major task. Initially it was assumed [3-5] that the number of events triggered by an earthquake with magnitude m changes as a Poisson process with intensity $K\exp(\alpha m)$.

Recent studies [6, 7] showed that the number of events with $M \geq M_m$ - ΔM, triggered by an earthquake with magnitude M_m, is a random variable that obeys an exponential distribution (the law of earthquake productivity). In [6, 7] the regional differences and a decrease in productivity with depth were revealed. Using Japanese earthquake statistic, it was shown that the productivity law is satisfied over a wide magnitude range (ΔM = 6) [8]. In [9] it was shown that the productivity law is satisfied for weak mining-induced seismicity ($0 \leq M \leq 3.3$) in Khibiny massif. The seismic productivity of mining blasts (the number of events triggered by blasting) also obeys the earthquake productivity law [10].

These results led to the conclusion that productivity does not depend on the type of source and is determined by the stress-strain state and physical properties of the medium. This conclusion is also confirmed by the increase in earthquake productivity with increasing watering of the environment [11].

Thus, the earthquake productivity law, like the other two laws of statistical seismology (Gutenberg-Richter and Omori-Utsu), is universal. The combination of these three laws allows to theoretically substantiate Batht’s empirical law [12], as well as generalize it by the time factor [7, 13]. A combination of the productivity and Omori-Utsu laws results a model for the duration of the dangerous period of aftershock activity. By combining the law of productivity and the model of aftershock decay with distance from the main shock, one can derive the distribution of the region where strong aftershocks are expected [14]. The fit of these models to regional and global earthquake statistics is an additional test of the productivity law.

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