New Properties of Aftershocks of Strong Earthquakes and Their Relation to the Focal Zone Size

Zavyalov A.D. (1), Zotov O.D. (1, 2), Guglielmi A.V. (1)

(1) Schmidt Institute of Physics of the Earth Russian Academy of Sciences, Moscow, Russia

(2) Borok Geophysical Observatory of the Institute of Physics of the Earth, Russian Academy of Sciences, Moscow, Russia

e-mail: zavyalov@ifz.ru

The data from the USGS/NEIC earthquake catalog from 1973 to 2019 are used in this study. Dependence of aftershocks number on short time intervals, not more than 24 h after the main shock, and distances from the epicenter (or hypocenter for deep focus earthquakes) of the main shock up to 5° were studied. The main methodological technique in all constructions was epoch overlay method. Both the moments of the main shocks and the coordinates of their epicenters/hypocenters played the role of a reference point for synchronizing the sequences of repeated shocks.

As a result we established two new properties of spatial distribution of aftershocks. The first property is that the maximum of the curve describing the spatial distribution of aftershocks is observed at a certain distance (approximately from 10 to 120 km) from the epicenter of the main shock. The logarithm of this distance is directly proportional to the magnitude of the main shock. The second property is that the position of the maximum is independent of time, i.e. it is a stable spatial characteristic of the origin, at least at the short time intervals after the main shock that we considered.

These properties proved to be characteristic not only for shallow main shocks, but also for deep ones with hypocenter depths of more than 300 km. We used them as a basis for determination of the focal zone size. It appeared that the relationship between the distance of maximum aftershocks spatial distribution and the main shock magnitude is well approximated by the equation LgR[km]=0.43*M–1.57 (1). If we interpret the distance from the main shock to the maximum of aftershock distribution as average radius R of the source region, then L=2*R on average, and (1) gives the empirical formula for characteristic size of source region lgL[km]=0.43*M–1.27 (2) [1]. Note, our formula (2) practically coincides with the formula of Yu.V. Riznichenko [2] lgL[km]=0.44*M–1.29 (3), but differs slightly from the formula proposed by Wells and Coppersmith in [3] lgL[km]=0.67*M–2.94 (4).

We used a similar approach when determining the characteristic size of the focal zone of deep-focus earthquakes. For these events the regression equation is lgL[km]=0.23*M+0.04 (5). It differs from relation (2). However, for deep-focus earthquakes, the statistics for the main shocks and their aftershocks decreased by more than ten times. The magnitude range of the main shocks studied also decreased.

This work was carried out with financial support from the State Assignment Programs of the Schmidt Institute of Physics of the Earth, Russian Academy of Sciences.

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