Geosistemy perehodnykh zon = Geosystems of Transition Zones / Геосистемы переходных зон
2026, vol. 10, No. 1, p. 5–22
http://journal.imgg.ru/archive.htm; https://elibrary.ru/title_about.asp?id=64191
https://doi.org/10.30730/gtrz.2026.10.1.005-022 ; https://www.elibrary.ru/fkahve

Analysis of dynamic parameters of earthquakes in the Crimean-Black Sea region. Stress drop distribution

Sycheva, Nailya A. (https://orcid.org/0000-0003-0386-3752), nelya@ifz.ru

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

Abstract PDF RUS PDF ENG **Full text** PDF RUS

Abstract. The information on the dynamic parameters (DP) of 261 earthquakes with K_P = 5.2–13.1 (K_P, earthquake class according to Pustovitenko and Kulchitsky) that occurred from 1990 to 2022 was collected for the Crimean-Black Sea region from various sources. These parameters include scalar seismic moment of M_0, source radius r, stress drop $\Delta\sigma$, etc. The distributions of the DP depending on the magnitude and scalar seismic moment were constructed and approximated by a linear function; in some cases, a power function was additionally considered. The determination coefficient R^2 was calculated. The dependence of the logarithm of the scalar seismic moment for the Crimean-Black Sea region is $\lg(M_0) = 0.87M + 11.4$ ($R^2 = 0.84$). The areal distribution of the average annual rate of seismotectonic deformations (STD intensity) was constructed based on the earthquake catalog (1993–2022). The STD intensity was compared with the stress drop level. Based on the data on the stress drop for the Crimean-Black Sea region, the areal distribution of the weighted average of the stress drop was constructed.

Keywords:
earthquake, seismicity, scalar seismic moment, moment magnitude, source radius, stress drop, coefficient of determination, seismotectonic deformations, Crimean-Black Sea region

For citation: Sycheva N.A. Analysis of dynamic parameters of earthquakes in the Crimean-Black Sea region. Stress drop distribution. *Geosistemy perehodnykh zon = Geosystems of Transition Zones*, 2026, vol. 10, No. 1, pp. 5–22. (In Russ.). https://doi.org/10.30730/gtrz.2026.10.1.005-022 ; https://www.elibrary.ru/fkahve

Для цитирования: Сычева Н.А. Анализ динамических параметров землетрясений Крымско-Черноморского региона. Распределение сброса напряжений. *Геосистемы переходных зон*, 2026, т. 10, № 1, с. 5–22. https://doi.org/10.30730/gtrz.2026.10.1.005-022 ; https://www.elibrary.ru/fkahve

References

1. DeMets C., Gordon R.G., Argus D.F., Stein S. Current plate motions. *Geophysical Journal International*. 1990,101:425–478. https://doi.org/10.1111/j.1365-246x.1990.tb06579.x
2. DeMets C., Gordon R.G., Argus D.F., Stein S. Effects of recent revisions to the geomagnetic reversal time scale on estimates of current plate motions. *Geophysical Research Letters*. 1994,21:2191–2194. https://doi.org/10.1029/94gl02118
3. Smith D.E., Kolenkiewics R., Robbins J.W., Dunn P.J., Torrence M.H. Horizontal crustal motion in the central and eastern Mediterranean inferred from satellite laser ranging measurements. *Geophysical Research Letters*. 1994,21:1979–1982. https://doi.org/10.1029/94gl01612
4. Reilinger R. et al. Global Positioning System measurements of present-day crustal movements in the Arabia-Africa-Eurasiaplate collision zone. *Journal of Geophysical Research*. 1997,102:9983–9999. https://doi.org/10.1029/96jb03736
5. Tari E., Sahin M., Barka A., Reilinger R., King R., McClusky S., Prilepin M. Active tectonics of the Black Sea with GPS. *Earth Planets Space*. 2000,52:747–751. https://doi.org/10.1186/bf03352276
6. Segall P., Davis J.L. GPS application for geodynamics and earthquake studies. *Annual Review of Earth and Planetary Sciences*. 1997,25:301–336. https://doi.org/10.1146/annurev.earth.25.1.301
7. Herring T.A. Geodetic applications of GPS. *Proceedings of the IEEE*. 1999,87:92–110. https://doi.org/10.1109/5.736344
8. McClusky S., Balassanian S., Barka A., Demir C., Ergintav S., Georgiev I., Gurkan O., Hamburger M., Hurst K., Kahle H., et al. Global Positioning System constraints on plate kinematics and dynamics in the eastern Mediterranean and Caucasus. *Journal of Geophysical Research*. 2000,105(B3):5695–5719. doi:10.1029/1996JB900351

9. Gorur N. Cretaceous syn- to post-rift sedimentation on the Southern Continental Margin of the Western Black Sea Basin. In: *Regional and petroleum geology of the Black Sea and surrounding region* (ed. by A.G. Robinson). American Association of Petroleum Geologists (AAPG), AAPG Memoir. 1997,68:227–240.
10. Spadini G., Robinson A., Cloetingh S. Western versus Eastern Black Sea tectonic evolution: Pre-rift lithospheric controls on basin formation. *Tectonophysics*. 1996,266(1–4):139–154. https://doi.org/10.1016/s0040-1951(96)00187-4
11. Mironov A.P., Milyukov V.K., Steblov G.M. [Modern movements of the Northern Caucasus and Crimea based on GPS observations]. In: *Chetvertaya tektonofizicheskaya konferentsiya v IFZ RAN. Tectonophysics and current issues of Earth sciences*: Materialy dokladov, 2016, 1, p. 168–170. (In Russ.).
12. Gobarenko V.S., Murovskaya A.V., Yegorova T.P., Sheremet E.E. Collision processes at the northern margin of the Black Sea. *Geotectonics*. 2016, 50(4):407–424. https://doi.org/10.1134/s0016852116040026
13. Pustovitenko B.G., Eredzhepov E.E., Bondar' M.N. [Spectral and focal parameters of the 2022 Crimean earthquakes]. *Uchenyye zapiski Krymskogo federal'nogo universiteta imeni V.I. Vernadskogo. Geografiya. Geologiya*. 2023,9(4):139–156. (In Russ.).
14. Rebetsky Yu.L., Sycheva N.A. Tectonophysical zoning of active faultin the Altai-Western Sayan region: Identification of locationsfor preparation of strong earthquakes. *Geotectonics*. 2025,59(6):518–546. https://doi.org/10.1134/s0016852125700402
15. Rebetskiy Yu.L. [Current state of earthquake prediction theories. Results of the estimation of natural stresses and a new earthquake source model]. In: *Problemy tektonofiziki: K sorokaletiyu sozdaniya M.V. Gzovskim laboratorii tektonofiziki v IFZ RAN*. Moscow: IFZ RAN, 2008, p. 359–395. (In Russ.).
16. Pevnev A.K. Earthquake forecasting is possible (On the place of geodetic research in solving the problem of earthquake forecasting). Pt 1. Grigory A. Gamburtsev and possibility of earthquake prediction. *Prostranstvo i Vremya = Space and Time*. 2015,4(22):195–201. (In Russ.).
17. Pevnev A.K. Earthquake forecasting is possible: (On the place of geodetic research in solving the problem of earthquake forecasting). Pt 2. Back to Grigory A. Gamburtsev's theory: Deformation model for preparation of crustal earthquake source. *Prostranstvo i Vremya = Space and Time*. 2016,1-2(23-24):227–238. (In Russ.). URL: https://space-time.ru/space-time/article/view/2226-7271provr_st1_2-23_24.2016.91 (accessed 02.02.2026).
18. Panteleev I.A., Naimark O.B. Modern trends in mechanics of tectonic earthquakes. *Perm Federal Research Center J.* 2014,3:44–62. (In Russ.). EDN: TDURFP
19. Pustovitenko B.G., Panteleyeva T.A. [Spectral and focal parameters of the Crimean earthquakes]. Kyiv: Naukova dumka, 1990, 249 p. (In Russ.).
20. Pustovitenko B.G., Pustovitenko A.A., Kapitanova S.A., Porechnova E.I. [Spatial features of source parameters of the Crimean earthquakes]. *Seysmichnost' Severnoy Yevrazii:* Materialy Mezhdunar. konf. Obninsk: GS RAN, 2008, p. 238–242. (In Russ.).
21. Pustovitenko B.G., Merzhey E.A., Pustovitenko A.A. [Dynamic parameters of the earthquake source in Crimea based on the data from digital seismic stations]. *Geofizicheskiy zhurnal*. 2013,35(5):172–186. (In Russ.).
22. Pustovitenko B.G. [Refined source parameters of the 1990 Crimean earthquakes]. *Uchenyye zapiski Tavricheskogo natsional'nogo universiteta imeni V.I. Vernadskogo. Seriya Geografiya*. 2014,27(2):169–178. (In Russ.).
23. Brune J.N. Tectonic stress and the spectra of seismic shear waves from earthquake. *Journal Geophysical Research*. 1970,75(26):4997–5009. https://doi.org/10.1029/jb075i026p04997
24. Brune J.N. Corrections [to "Tectonic stress and the spectra of seismic shear waves from earthquakes"]. *Journal of Geophysical Research*. 1971,76(5002). http://dx.doi.org/10.1029/JB076i020p05002
25. Aptekman Zh.Ya., Belavina Yu.F., Zakharova A.I., Zobin V.M., Kogan S.Ya., Korchagina O.A., Moskvina A.G., Polikarpova L.A., Chepkunas L.S. [*P*-wave spectra in the problem concerning determination of dynamic parameters of earthquake focuses: transition from station-obtained spectrum to the focal one and the calculation of dynamic focal parameters]. *Volcanology and Seismology*. 1989,2: 66–79. (In Russ.).
26. Kostrov B.V. [*Focal mechanics of a tectonic earthquake*]. Moscow: Nauka, 1975. (In Russ.).
27. Hanks T.C., Kanamori H. A moment magnitude scale. *Journal of Geophysical Research*. 1979,84(35):2348–2350. https://doi.org/10.1029/jb084ib05p02348
28. Pustovitenko B.G., Kalinyuk I.V., Merzhey E.A. [Dynamic parameters of earthquake sources in the Crimean-Black Sea region]. *Zemletriaseniia Severnoi Evrazii = Earthquakes in Northern Eurasia*. 2016,19(2010):296–304. (In Russ.).
29. Pustovitenko B.G., Eredzhepov E.E. [Spectral and source parameters of earthquakes in the Crimean-Black Sea region]. *Zemletriaseniia Severnoi Evrazii = Earthquakes in Northern Eurasia*. 2020,23(2014):250–262. (In Russ.).
30. Pustovitenko B.G., Kulchitsky V.E., Goryachun A.V. [*Earthquakes of the Crimean-Black Sea region (instrumental observation period 1927–1986)*]. Kyiv: Naukova Dumka, 1989. (In Russ.).

31. Bachmanov D.M., Kozhurin A.I., Trifonov V.G. The active faults of Eurasia database. *Geodynamics & Tectonophysics*. 2017**,**8(4):711–736. (In Russ.). doi.org/10.5800/gt-2017-8-4-0314
32. Pustovitenko B.G., Kul'chitskiy V.E., Sukhoruchenko S.K., Klyanchin A.I. [Organization and first results of seismic observations in the northwestern part of Crimea (1972–2020)]. *Uchenyye zapiski Krymskogo federal'nogo universiteta im. V.I. Vernadskogo. Geografiya. Geologiya*. 2020,6(4):144–169. (In Russ.).
33. Sycheva N.A., Bogomolov L.M. Distribution of reduced seismic energy and stress drop in the Altai-Sayan seismoactive region. *Geodynamics & Tectonophysics*. 2025,16(4):0835. (In Russ.). doi:10.5800/GT-2025-16-4-0835
34. Yunga S.L. [Methods and results of studying seismotectonic deformations]. Moscow: Nauka, 1990. (In Russ.).
35. Riznichenko Yu.V. [*Problems of seismology*]. Moscow: Nauka, 1985. ([Selected works]). (In Russ.).
36. Yunga S.L. *Study of surface movements and deformations of the Earth's crust on the territory of the Central Tien Shan, the Kazakh platform and Altai; creation of seismological data processing programs, processing*: Research report. Obninsk, 2002. (In Russ.).
37. Lukk A.A., Yunga S.L. Seismotectonic deformation of the Garm region. *Izv. AN SSSR, Fizika Zemli*. 1979,10:24–43. (In Russ.).
38. Rautian T.G., Khalturin V.I., Fujita K., Mackey K.G., Kendall A.D. Origins and methodology of the Russian energy K-class system and its relationship to magnitude scales. *Seismological Research Letters*. 2007,78(6):579–590. https://doi.org/10.1785/gssrl.78.6.579
39. Magnus YA.R., Katyshev P.K., Peresetskiy A.A. [*Econometrics. A beginner's course*. 6th ed., rev. and suppl.]. Moscow: Delo, 2004. (In Russ.).
40. Puzyrev N.N. [*Methods and objects of seismic research*]. Novosibirsk: SO RAN Publ.: NITsOIGGM, 1997. (In Russ.).
41. Gibowicz S.J., Kijko A. *An introduction to mining seismology*. San Diego: Academic Press, 1994. (International Geophysics). https://doi.org/10.1016/c2009-0-02348-4
42. Nikonov A.A. [Tsunami on the shores of the Black and Azov Seas]. *Fizika Zemli*. 1997,1:86–96. (In Russ.).
43. Rebetsky Yu.L. *Tectonic stresses and strength of rock massifs*. Moscow: Akademkniga, 2007. (In Russ.)..