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Seismotectonic deformations and stress drop of earthquakes of Central Tien Shan

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Abstract. Based on the seismic moment tensor (SMT) data of 270 earthquakes in the Central Tien Shan, which occurred from 1978 to 2021 and include 63 events from the Global Centroid Moment Tensor catalog and 207 events from the works of Aleksander D. Kostyuk and Naylya A. Sycheva, the focal parameters (seismotectonic deformations (STD), kinematic and dynamic parameters, source radius, and stress drop) were calculated. The STD calculation was based on the approaches proposed in the studies of Yuriy V. Riznichenko and Sergei L. Yunga. The area under consideration is characterized by such deformation modes as thrust, transpression, underpression, and oblique. The distribution of the Lode–Nadai coefficient was calculated and plotted. A significant part of the study area is characterized by simple compression deformation, dominated by simple compression and simple shear. To calculate the stress drop $\Delta\sigma$, the values of the scalar seismic moment M_0, which are determined in the SMT calculation, and the source radii r, which are calculated on the basis of theoretical and experimental models of the dependence of the source radius on the moment magnitude, were used. The radii r and stress drops $\Delta\sigma$ were calculated for two models of earthquake sources: the Brune model and the Madariaga–Kaneko–Shearer model. A catalog of dynamic parameters was compiled. The comparison of the kinematic and dynamic parameters of earthquakes was carried out, and the relationship of the dropped stresses with the type of movement in the source, as well as with the Lode–Nadai coefficient, was established. The results obtained in the study can be useful for specialists in other fields of knowledge – geodesy, geology, and geophysics.

Keywords:

seismicity, earthquake, focal mechanism, seismotectonic deformation, Lode–Nadai coefficient, seismic moment tensor, scalar seismic moment, source radius, stress drop

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References

Recent geodynamics of intracontinental areas of collision mountain building (Central Asia)

1. Molnar P., Tapponnier P. **1975.** Cenozoic tectonics of Asia: Effects of a continental collision: Features of recent continental tectonics in Asia can be interpreted as results of the India-Eurasia collision. *Science. New Series*, 189(4201): 419–426. https://doi.org/10.1126/science.189.4201.419
2. Omuralieva A., Nakajima J., Hasegawa A. **2009.** Three-dimensional seismic velocity structure of the crust beneath the central Tien Shan, Kyrgyzstan: Implications for large- and small-scale mountain building. *Tectonophysics*, 465(1): 30–44. https://doi.org/10.1016/j.tecto.2008.10.010
3. Makarov V.I. **1977.** *Recent tectonic structure of the Central Tien Shan*. Moscow: Nauka, 172 p. (In Russ.).
4. *Sadybakasov I.S.* ***1990.*** *Neotectonics of High Asia*. Moscow: Nauka, 176 p. (In Russ.).
5. Laverov N.P., Makarov V.I. (Eds) *Recent geodynamics of intracontinental areas of collision mountain building (Central Asia).* **2005.** Moscow: Nauchnyi Mir [Scientific world], 400 p.
6. Trifonov V.G., Soboleva O.V., Trifonov R.V., Vostrikov G.A. **2002.** [*Modern geodynamics of the Alpine-Himalayan collision belt*]. Moscow: GEOS, 224 p. (In Russ.).
7. Trofimov A.K., Udalov N.F., Utkina N.G., Fortuna A.B., Chediya O.K., Yazovskii V.M. **1976.** *Geologiya kainozoya Chuiskoi vpadiny i ee gornogo obramleniya* [*Geology of Cenozoic of the Chuy basin and its mountainous frame*]. Leningrad: Nauka, 128 p. (In Russ.).
8. Chediya O.K. **1986.** [*Morphostructures and recent tectogenesis of the Tien Shan*]. Frunze: Ilim, 315 p. (In Russ.).
9. Shul'ts S.S. **1948.** [*Analysis of recent tectonics and relief of the Tien Shan*]. Moscow: Geographgiz, 224 p. (In Russ.).

10. Burtman V.S. **2012.** *Tian Shan and High Asia: Geodinamics in the Cenozoic*. Moscow: GEOS, 188 p. (In Russ.).
11. Yudakhin F.N. **1983.** [*Geophysical fields, deep structure, and seismicity of the Tien Shan*]. Frunze: Ilim, 246 p. (In Russ.).
12. Sycheva N.A., Bogomolov L.M. **2020**. On the stress drop in North Eurasia earthquakes source-sites versus specific seismic energy. *Geosistemy perehodnykh zon = Geosystems of Transition Zones*, 4(4): 417–446. https://doi.org/10.30730/gtrz.2020.4.4.393-416.417-446
13. Kostyuk A.D., Sycheva N.A., Yunga S.L., Bogomolov L.M., Yagi Y. **2010.** Deformation of the Earth's crust in the Northern Tien Shan according to the earthquake focal data and satellite geodesy. *Izv., Physics of the Solid Earth*, 46(3): 230–243. https://doi.org/10.1134/s1069351310030055
14. Sycheva N.A. **2020.** Seismic moment tensor and dynamic parameters of earthquakes in the Central Tien Shan. *Geosistemy perekhodnykh zon = Geosystems of Transition Zones*, 4(2): 192–209. (In Engl.). https://doi.org/10.30730/gtrz.2020.4.2.178-191.192-209
15. Yagi Y. **2004.** *Determination of focal mechanism by moment tensor inversion*. Tsukuba: IISEE Lecture Note. 51 p.
16. Sycheva N.A., Bogomolov L.M., Kuzikov S.I. **2020.** *Computational technologies in seismological studies (on the example of KNET, Northern Tian Shan)*. Yuzhno-Sakhalinsk: IMGG DVO RAN, 358 p. (In Russ.). https://dx.doi.org/10.30730/978-5-6040621-6-6.2020-2
17. Sycheva N.A., Mansurov A.N. **2020**. Seismotectonic deformation of the lithosphere in the Pamir and adjacent territories. *Geodynamics & Tectonophysics*, 11(4): 785–805. (In Russ.). https://doi.org/10.5800/gt-2020-11-4-0507
18. Yunga S.L. **1990.** [*Methods and results of study of seismotectonic deformations*]. Moscow: Nauka, 191 p. (In Russ.).
19. Aki K., Richards P. **1983.** *Quantitative seismology: Theory and methods*. Vol. 1–2. Moscow: Mir, 880 p.
20. Riznichenko Yu.V. **1985.** [*Problems of seismology*]. Moscow: Nauka, 408 p. ([Selected works]). (In Russ.).
21. Scholz C.H. **2002.** *The Mechanics of earthquakes and faulting*. Cambridge: Cambridge University Press, 496 p.
22. Abercrombie R.E., Rice J.R. **2005.** Can observations of earthquake scaling constrain slip weakening? *Geophysical Journal International*, 162: 406–424. https://doi.org/10.1111/j.1365-246x.2005.02579.x
23. Scuderi M.M., Marone C., Tinti E., Di Stefano G., Collettini C. **2016.** Precursory changes in seismic velocity for the spectrum of earthquake failure modes. *Nature Geoscience*, 9(9): 695–700. https://doi.org/10.1038/ngeo2775
24. Brune J.N. **1971.** Corrections. *J. of Geophysical Research*, 76: 5002.
25. Brune J.N. **1970.** Tectonic stress and the spectra of seismic shear waves from earthquakes. *J. of Geophysical Research*, 75(26): 4997–5009. https://doi.org/10.1029/jb075i026p04997
26. Madariaga R. **1976.** Dynamics of an expanding circular fault. *Bull. of the Seismological Society of America*, 66: 639–666.
27. Madariaga R. **1979.** On the relation between seismic moment and stress drop in the presence of stress and strength heterogeneity. *J. of Geophysical Research*, 84: 2243–2250. https://doi.org/10.1029/jb084ib05p02243
28. Eshelby J.D. **1957.** The determination of elastic field of an ellipsoidal inclusion and related problems. *Proceedings of the Royal Society of London*, A241(1226): 376–396. https://doi.org/10.1098/rspa.1957.0133
29. Sycheva N.A., Bogomolov L.M. **2024.** [Dynamic parameters of earthquakes in Altai-Sayan mountain region]. In: *Problems of geodynamics and geoecology of intracontinental orogens: IX Intern. Symp., 24–28 June, Bishkek*: Abstracts. Bishkek, p. 123.
30. Boore D. **2003.** Simulation of ground motion using the stochastic method. *Pure and Applied Geophysics*, 160: 635–676. https://doi.org/10.1007/pl00012553
31. Bormann P., Liu R., Xu Z., Ren K, Zhang L., Wendt S. **2009.** First application of the New IASPEI teleseismic magnitude standards to data of the China National Seismographic Network. *Bulletin of the Seismological Society of America*, 99(3): 1868–1891. https://doi.org/10.1785/0120080010
32. Yunga S.L. **1997.** On the classification of seismic moment tensors based on their isometric mapping onto a sphere. *Doklady Akademii Nauk*, 352(2): 253–255. (In Russ.).
33. Sycheva N.A., Bogomolov L.M. **2016.** Patterns of stress drop in earthquakes of the Northern Tien Shan. *Russian Geology and Geophysics*, 57(11): 1635–1645. https://doi.org/10.1016/j.rgg.2016.10.009