

The stressed state of the Earth's crust in the Altai-Sayan mountain region: reconstruction based on the modified algorithms of the cataclastic method

@Rebetsky, Yuri L. (<https://orcid.org/0000-0003-3492-2452>), reb@ifz.ru

Sycheva, Naylya A. (<https://orcid.org/0000-0003-0386-3752>), ivtran@mail.ru

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

[Abstract](#) [PDF ENG](#) [PDF RUS](#) [Full text](#) [PDF RUS](#)

Abstract. The article presents the results of a new reconstruction of stress in the Earth's crust in the Altai-Sayan mountain region and their adjacent territories based on seismological data, and using a new modification of the method of cataclastic analysis (MCA) of fault displacements by Yu.L. Rebetsky. The reconstruction is based on the catalog of earthquake focal mechanisms collected from various sources and comprising 584 events. In earlier works by Yu.L. Rebetsky et al. (2012, 2013), the data on focal mechanisms of 308 events obtained in the studies of N.D. Zhalkovsky et al. (1995) were used for studying the Altai-Sayan mountain region. This paper discusses the modified algorithms implemented in the latest version of the STRESSseism program, on the basis of which the stress reconstruction was performed. The extended data on focal mechanisms provided the stress inversion with a smaller averaging scale and allowed obtaining data for a larger number of time intervals of the quasi-homogeneous stress state in each node. Distribution maps of the directions of the maximum compression axis and the geodynamic type of the stress state, as well as the value of the Lode–Nadai coefficient were constructed and compared with the results of the previously performed reconstruction. Based on the modification of the MCA algorithm, stable orientations of the axes of the principal stresses were obtained. The results of the stress reconstruction can be used for tectonophysical zoning of dangerous segments of active faults.

Keywords:

tectonophysics, stress, earthquake, focal mechanisms

For citation: Rebetsky Yu.L., Sycheva N.A. The stressed state of the Earth's crust in the Altai-Sayan mountain region: reconstruction based on the modified algorithms of the cataclastic method. *Geosistemy perehodnykh zon = Geosystems of Transition Zones*, 2024, vol. 8, No. 4, pp. 261–276. (In Russ., abstr. in Engl.). <https://doi.org/10.30730/gtr.2024.8.4.261-276>; <https://www.elibrary.ru/poihsb>

Для цитирования: Ребетский Ю.Л., Сычева Н.А. Напряженное состояние земной коры Алтае-Саянской горной области: реконструкция на основе модифицированных алгоритмов катакластического метода. *Геосистемы переходных зон*, 2024, т. 8, № 4, с. 261–276. <https://doi.org/10.30730/gtr.2024.8.4.261-276>; <https://www.elibrary.ru/poihsb>

References

1. Kuchai O.A. **2012**. Specific features of fields of stresses associated with aftershock processes in the Altai-Sayan mountainous region. *Geodynamics & Tectonophysics*, 3(1): 59–68. (In Russ.). <https://doi.org/10.5800/gt-2012-3-1-0062>
2. Tsubulchik I.D. **1975**. Some results of the study of the stress state in the earthquake foci of Altai and Sayan. In: Gaisky A.V. (Ed.) *Seismicity of the Altai-Sayan region*: Collection of scientific papers. Novosibirsk: IGIG SO AN SSSR, p. 48–56.
3. Zhalkovsky N.D., Kuchai O.A., Muchnaya V.I. **1995**. [Seismicity and some characteristics of the stress state of the earth's crust in the Altai-Sayan region]. *Geology and Geophysics*, 36(10): 20–30. (In Russ.).
4. Kuznetsova K.I., Lukina N.V., Kuchai O.A. **1999**. Deformation of Earth crust and upper mantle: the problem of interdependence (Altai-Sayany area). *Volcanology and seismology*, 4-5: 41–49. (In Russ.).
5. Gol'din S.V., Kuchai O.A. **2007**. Seismic strain in the Altai-Sayan active seismic area and elements of collisional geodynamics. *Russian Geology and Geophysics*, 48(7): 536–557. <https://doi.org/10.1016/j.rgg.2007.06.005>
6. Gol'din S.V., Kuchai O.A. **2008**. Seismotectonic strains in the vicinity of severe Altai earthquakes. *Physical mesomechanics*, 11(1): 5–13. (In Russ.).
7. Sycheva N.A. **2023**. Study of seismotectonic deformations of the Earth's crust in the Altai-Sayan mountain region. Pt I. *Geosistemy perehodnykh zon = Geosystems of Transition Zones*, 7(3): 223–242. (In Russ., abstr. in Engl.). <https://doi.org/10.30730/gtr.2023.7.3.223-242>; <https://www.elibrary.ru/ktttdq>
8. Rebetsky Yu.L., Kuchai O.A., Marinin A.V. **2013**. Stress state and deformations of the Earth's crust in the Altai-Sayan mountain region. *Russian Geology and Geophysics*, 54(2): 206–222. <https://doi.org/10.1016/j.rgg.2013.01.011>

9. Leskova E.V., Emanov A.A. **2014**. Some properties of the hierarchical model reproducing the stress state of the epicentral area of the 2003 Chuya earthquake. *Izv., Physics of the Solid Earth*, 50(3): 393–402. <https://doi.org/10.1134/S1069351314030057>
10. Leskova E.V., Emanov A.A. **2013**. [Change in tectonic stress field with depth and time (according to 2003–2012 seismological monitoring data)]. In: *Materialy tret'ei molodezhnoi shkoly-seminara*. Vol. 1. *Modern tectonophysics. Methods and results*, p. 187–193. (In Russ.).
11. Kuchay O.A., Bushenkova N.A. **2009**. Earthquake focal mechanisms in Central Asia. *Physical mesomechanics*, 12(1): 17–24. (In Russ.).
12. Sankov V.A., Parfeevets A.V. **2020**. The Cenozoic crustal stress state of Mongolia according to geological and structural data (Review). *Geodynamics & Tectonophysics*, 11(4): 722–742. (In Russ.). <https://doi.org/10.5800/GT-2020-11-4-0503>
13. Karagianni I., Papazachos C.B., Scordilis E.M., Karakaisis G.F. **2015**. Reviewing the active stress field in Central Asia by using a modified stress tensor approach. *Journal of Seismology*, 19(2): 541–565. <https://doi.org/10.1007/s10950-015-9481-4>
14. Heidbach O., Rajabi M., Cui X., Fuchs K., Müller B., Reinecker J., Reiter K., Tingay M., Wenzel F., Xie F., Ziegler M.O., Zoback M., Zoback M. **2018**. The World Stress Map database release 2016. Crustal stress pattern across scales. *Tectonophysics*, 744: 484–498. <https://doi.org/10.1016/j.tecto.2018.07.007>
15. Rebetsky Yu.L. **1997**. Reconstruction of tectonic stresses and seismotectonic strains: Methodical fundamentals, current stress field of Southeastern Asia and Oceania. *Doklady AN = Proceedings of the Academy of Sciences*, 354(4): 560–563.
16. *Earthquakes of Northern Eurasia*. URL: <http://www.gsras.ru/zse/contents.html>
17. *Earthquakes of Russia: Yearbook*. URL: <http://www.gsras.ru/zr/>
18. Kuchai O.A. **2013**. Parameters of earthquake focal mechanisms in the Altai-Sayan region: Certificate of state registration of the database: Certificate of program RU 2013620060. No. 20126211, declared 01.11.2012, publ. 09.01.2013. (In Russ.).
19. Radziminovich N.A. **2021**. Focal mechanisms of earthquakes of Southern Baikal Region and Northern Mongolia. *Geodynamics & Tectonophysics*, 12(4): 902–908. (In Russ.). <https://doi.org/10.5800/GT-2021-12-4-0562>
20. Emanov A.F., Emanov A.A., Leskova E.V., Kolesnikov Y.I., Yankaitis V.V., Filina A.G. **2012**. The $M_s = 7.0$ Uureg Nuur earthquake of 15.05.1970 (Mongolian Altai): The aftershock process and current seismicity in the epicentral area. *Russian Geology and Geophysics*, 53(10): 1090–1099. <https://doi.org/10.1016/j.rgg.2012.08.009>
21. Rebetsky Yu.L. **1996**. I. Stress-monitoring: Issues of reconstruction methods of tectonic stresses and seismotectonic deformations. *Journal of Earthquake Prediction Research*, Beijing (China), 5(4): 557–573.
22. Rebetsky Yu.L., Mikhailova A.V., Rosanova G.V., Fursova E.V. **1997**. II. Stress-monitoring: The modern field of regional stresses in South-East Asia and Oceania. Principles of quasiplastic deforming of fractured media. *Journal of Earthquake Prediction Research*, Beijing (China), 6(1): 11–36.
23. Rebetsky Yu.L., Lermontova A.S. **2016**. Registration of supercritical conditions of geologic environment and challenges in earthquake source remote sensing. *Vestnik KRAUNTS. Nauki o Zemle = Earth Sciences Bulletin of KRAESC*, 4(32): 115–123. (In Russ.).
24. Rebetsky Yu.L., Lermontova A.S. **2018**. On the long-range influence of earthquake rupture zones. *Journal of Volcanology and Seismology*, 12: 341–352. <https://doi.org/10.1134/s0742046318050068>
25. Rebetskii Yu.L. **2003**. Development of the method of cataclastic analysis of shear fractures for tectonic stress estimation. *Doklady Earth Sciences*, 388(1): 72–76.
26. Rebetsky Yu.L., Polets A.Yu. **2018**. The method of cataclastic analysis of discontinuous displacements. In: *Moment tensor solutions – A useful tool for seismotectonics*. Ed. Sebastiano D'Amico. Springer, p. 111–162. https://doi.org/10.1007/978-3-319-77359-9_6
27. Makarov P.V., M.O. Eremin M.O. **2013**. Fracture model of brittle and quasi-brittle materials and geomechanics. *Physical mesomechanics*, 16: 207–226. <https://doi.org/10.1134/s1029959913030041>
28. Stefanov Yu.P., Chertov M.A., Aidagulov G.R., Myasnikov A.V. **2011**. Dynamics of inelastic deformation of porous rocks and formation of localized compaction zones studied by numerical modeling. *Journal of the Mechanics and Physics of Solids*, 59(11): 2323–2340. <https://doi.org/10.1016/j.jmps.2011.08.002>
29. Tikhotsky S.A., Tatevosyan R.E., Rebetsky Yu.L., Ovsyuchenko A.N., Larkov A.S. **2023**. The 2023 Kahramanmaraş earthquakes in Turkey: Seismic movements along conjugated faults. *Doklady Earth Sciences*, 511: 703–709. <https://doi.org/10.1134/s1028334x23600974>
30. Rebetsky Yu.L., Dobrynina A.A., Sankov V.A. **2024**. Tectonophysical zoning of active faults of the Baikal Rift System. *Geodynamics & Tectonophysics*, 15(4): 0775. (In Russ.). <https://doi.org/10.5800/gt-2024-15-4-0775>; EDN: [LSSFVG](https://www.edn.ru/LSSFVG)