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Concerning the theory of LURR based deterministic earthquake prediction

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Abstract. This paper considers theoretical aspects of a trigger effect of earth tides on earthquake initiation under the LURR approach. The growth of Coulomb stress, which appears resulting from this phenomenon, is shown to occur not for all regimes of stress state acting in the studied region. Its greatest increase corresponds to the regime of the horizontal extension and shear associated with the faults with kinematics of the normal and strike-slip faults. The low level of additional Coulomb stress for the horizontal compression regime allows asserting the low probability of the trigger effect for the faults with kinematics of the reverse faults. It is noted, that there is also an indirect factor in the form of additional pressure caused by the sea tides in addition to the main factor of the earth tides effect on deformations in the solid earth for island arcs and coastal areas of the continental crust. This is an additional vertical pressure for the ocean floor, and a lateral pressure for the crust of island arcs and coastal areas of the continents. Indirect factors significantly complicate the effect of earth tides on the Earth's crust, completely neutralizing the influence of the direct factor in some cases.

Keywords:
earth tides, trigger, earthquakes, Coulomb stress

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References

1. Avsyuk Yu.N. **1996.** *Prilivnye sily i prirodnye protsessy* [*Tidal forces and natural processes*]. Moscow: OIFZ RAN, 188 p.
2. Baranov A.A., Shebalin P.N., Baranov S.V. **2019.** A quantitative estimate of the effects of sea tides on aftershock activity: Kamchatka. *J. of Volcanology and Seismology*, 13(1): 56–69. https://doi.org/10.1134/s0742046319010020
3. Bowman D.D., Ouillon G., Sammis C.G., Sornette A., Sornette D. **1998.** An observational test of the critical earthquake concept. *J. of Geophysical Research: Solid Earth*, 103: 24359–24372. https://doi.org/10.1029/98jb00792
4. Bufe C.G., Varnes D.J. **1993.** Predictive modeling of the seismic cycle of the Greater San Francisco Bay region. *J. of Geophysical Research*, 98(B6): 9871–9883. https://doi.org/10.1029/93jb00357
5. Byerlee J.D. **1978.** Friction of rocks. *Pure and Applied Geophysics*, 116: 615–626. https://doi.org/10.1007/bf00876528
6. Cochran E.S., Vidale J.E., Tanaka S. **2004.** Earth tides can trigger shallow thrust fault earthquakes. *Science*, 306: 1164–1166. https://doi.org/10.1126/science.1103961
7. Desherevskii A.V., Sidorin A.Ya. Search for tidal seismicity in Greece using different techniques: Part 1. Analysis of spectra and periodograms. *Seismicheskie pribory = Seismic Instruments*, 48(4): 5–26. (In Russ.).
8. Emter D. **1997.** Tidal triggering of earthquakes and volcanic events. In: *Tidal Phenomena: Lect. Notes Earth Sci.* Berlin, Springer-Verlag, 66: 293–310. https://doi.org/10.1007/bfb0011468
9. Gao H., Schmidt D.A., Weldon R.J. **2012.** Scaling relationships of source parameters for slow slip events. *Bull. of the Seismological Society of America*, 102(1): 352–360. http://dx.doi.org/10.1785/0120110096
10. Jaum´e S.C., Sykes L.R. **1999.** Evolving towards a critical point: a review of accelerating seismic moment/energy release prior to large and great earthquakes. *Pure and Applied Geophysics*, 155: 279–306. https://doi.org/10.1007/s000240050266
11. Klein F.W. **1976.** Earthquake swarms and the semidiurnal solid earth tide. *Geophysical J. International*, 45: 245–295. https://doi.org/10.1111/j.1365-246x.1976.tb00326.x
12. Kocharyan G.G., Kishkina S.B., Novikov V.A., Ostapchuk A.A. Slow slip events: parameters, conditions of occurrence, and future research prospects. *Geodynamics & Tectonophysics*, 5(4): 863–891. (In Russ.). https://doi.org/10.5800/GT-2014-5-4-0160
13. Kossobokov V.G., Healy J.H., Dewey J.W. Testing an earthquake prediction algorithm. *Pure and Applied Geophysics*, 149: 219–232. https://doi.org/10.1007/bf00945168
14. Linde A.T., Gladwin M.T., Johnston M.J.S., Gwyther R.L., Bilham R.G. **1996.** A slow earthquake sequence on the San Andreas Fault. *Nature*, 383(6595): 65–68. http://dx.doi.org/10.1038/383065a0
15. Métivier L., de Viron O., Conrad C.P., Renault S., Diament M., Patau G. **2009.** Evidence of earthquake triggering by the solid earth tides. *Earth and Planetary Science Letters*, 278: 370–375. https://doi.org/10.1016/j.epsl.2008.12.024
16. Mel'khior P. **1968.** *Zemnye prilivy* [*Earth tides*]. M.: Mir, 482 p. (In Russ.).
17. Nikolaev V.A. **1994a.** [Spatio-temporal features of the strong earthquakes relationship with tidal phases]. In: *Navedionnaia seismichnost'* [*Induced seismicity*]. Moscow: Nauka, 103–114. (In Russ.).

18. Nikolaev V.A. **1994b.** [Strong earthquake response to the Earth tide phases]. *Fizika Zemli = Izvestiya, Physics of the Solid Earth*, 11: 49–58. (In Russ.).
19. Peng Z., Gomberg J. **2010.** An integrated perspective of the continuum between earthquakes and slow-slip phenomena. *Nature Geosciences*, 3(9): 599–607. http://dx.doi.org/10.1038/ngeo940
20. Rebetsky Yu.L. **2015.** On the specific state of crustal stresses in intracontinental orogens. *Geodynamics & Tectonophysics*, 6(4): 437–466. (In Russ.). https://doi.org/10.5800/GT-2015-6-4-0189
21. Rebetsky Yu.L. **2020.** Pattern of Global crustal stresses of the Earth. *Geotectonics*, 54(6): 723–740. doi:10.1134/S0016852120060114
22. Rebetsky Yu.L., Kuzikov S.I. **2016.** Active faults of the northern Tien Shan: tectonophysical zoning of seismic risk. *Russian Geology and Geophysics*, 57: 967–983. http://dx.doi.org/10.1016/ j.rgg.2016.05.004
23. Rebetsky Yu.L., Polets A.Yu. **2014.** The state of stresses of the lithosphere in Japan before the catastrophic Tohoku earthquake of 11 march 2011. *Geodynamics & Tectonophysics*, 5(1): 469–506. http://dx.doi.org/10.5800/GT-2014-5-2-0137
24. Rebetsky Yu.L., Polets A.Yu., Zlobin T.K. **2016.** The state of stress in the Earth's crust along the northwestern flank of the Pacific seismic focal zone before the Tohoku earthquake of 11 March 2011. *Tectonophysics*, 685: 60–76. http://dx.doi.org/10.1016/j.tecto.2016.07.016
25. Rebetskiy Yu.L., Sim L.A., Marinin A.V. **2017.** *Ot zerkal skol'zheniya k tektonicheskim napryazheniyam. Metodiki i algoritmy* [*From slickensides to tectonic stresses. Methods and algorithms*]. M.: GEOS, 234 p.
26. Sacks I.S., Suyehiro S., Linde A.T., Snoke J.A. **1978.** Slow earthquakes and stress redistribution. *Nature*, 275(5681): 599–602. http://dx.doi.org/10.1038/275599a0
27. Sekine S., Hirose H., Obara K. **2010.** Short-term slow slip events correlated with non-volcanic tremor episodes in southwest Japan. *J. of Geophysical Research*, 115(B9): B00A27. http://dx.doi.org/10.1029/2008JB006059
28. Sim L.A. **1996.** *Neotektonicheskie napryazheniya Vostochno-Evropeyskoy platformy i struktur obramleniya* [*Neotectonic stresses of the East European Plain and frame structures*]: [extended abstract of diss. … doctor of Geol. and Miner.]. Moscow, Lomonosov Moscow State University, 41 p.
29. Smith M.L. **1974.** The scalar equations of infinitesimal elastic-gravitational motion for a rotating, slightly elliptical Earth. *Geophysical J. International*, 37(3): 491–526. https://doi.org/10.1111/j.1365-246x.1974.tb04099.x
30. Sornette D., Sammis C.G. **1995.** Complex critical exponents from renormalization group theory of earthquake prediction. *J. de Physique I (France)*, 5: 607–619. https://doi.org/10.1051/jp1:1995154
31. Stroup D.F., Bohnenstiehl D.R., Tolstoy M. et al. **2007.** Pulse of the seafloor: Tidal triggering of microearthquakes at 9°50′ N East Pacific Rise. *Geophysical Research Letters*, 34: L15301.
32. Tanaka S., Ohtake M., Sato H. **2004.** Tidal triggering of earthquakes in Japan related to the regional tectonic stress. *Earth, Planets and Space*, 56(5): 511–515. https://doi.org/10.1186/bf03352510
33. Wahr J.M. **1981a.** A normal mode expansion for the forced response of a rotating Earth. *Geophysical J. of the Royal Astronomical Society*, 64: 651–675. https://doi.org/10.1111/j.1365-246x.1981.tb02689.x
34. Wahr J.M. **1981b.** Body tides on an elliptical, rotating, elastic and ocean less earth. *Geophysical J. of the Royal Astronomical Society*, 64: 677–703. https://doi.org/10.1111/j.1365-246x.1981.tb02690.x
35. Wei M., McGuire J.J., Richardson E. **2012.** A slow slip event in the south central Alaska subduction zone and related seismicity anomaly. *Geophysical Research Letters*, 39(15): L15309. http://dx.doi.org/10.1029/2012GL05235
36. Yin X.C. et al. **1995.** A new approach to earthquake prediction: The Load/Unload Response Ratio (LURR) theory. *Pure and Applied Geophysics*, 145(3-4): 701–715. https://doi.org/10.1007/bf00879596
37. Yin X.C., Wang Y.C., Peng K.Y., Bai Y.L., Wang H.T., Yin X.F. **2001.** Development of a new approach to earthquake prediction: The Load/Unload Response Ratio (LURR) theory. *Pure and Applied Geophysics*, 157(11-12): 2365–2383. https://doi.org/10.1007/978-3-0348-7695-7_29
38. Zakupin A.S. **2016.** Program complex for the analysis of instability of seismic process. *Geoinformatika*, 1: 34–43. (In Russ.). (In Russ.).
39. Zakupin A.S., Kamenev P.A. **2017.** Space-time localization probability of enhanced seismic hazard in LURR medium-term prediction technique as applied to New Zealand territory. *Geosistemy perekhodnykh zon = Geosystems of Transition Zones*, (3): 40–49. (In Russ.). doi.org/10.30730/2541-8912.2017.1.3.040-049
40. Zakupin A.S., Semenova E.P. **2018.** Study of the process of preparation of strong earthquakes (Mw > 5) on Sakhalin using the LURR method. *Vestnik KRAUNTs. Fiz.-mat. nauki = Bulletin KRASEC. Physical and Mathematical Sciences*, 5: 83–98. (In Russ.). https://doi.org/10.18454/2079-6641-2018-25-5-83-98
41. Zakupin A.S., Zherdeva O.A. **2017.** Retrospective evaluation of applicability for medium-range prediction of earthquakes within the Northern Sakhalin region. *Vestnik DVO RAN = Vestnik of the Far East Branch of RAS*, 1: 18–25. (In Russ.).
42. Zakupin A.S., Bogomolov L.M., Boginskaya N.V. **2020.** Application of methods of analysis of seismic sequences SDP and LURR for earthquake prediction on Sakhalin. *Geophysical Processes and Biosphere*, 19(1): 66–78. (In Russ.). https://doi.org/10.21455/GPB2020.1-4