Ring–shaped seismicity structures in the region of Kamchatka: possible preparation for great earthquake

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Abstract We have been studying some seismicity characteristics in the region of Kamchatka region. It was established that two pairs of ring-shaped seismicity structures at depths of 0-33 and 34-70 km have been formed here in 1973-2018 prior to large earthquakes (05.12.1997 г., *Mw*=7.8 and 20.12.2018, *Mw*=7.3). Ring-shaped structures are characterized by threshold magnitude values (*Mt*1 and *Mt*2 correspondingly) and also big axes length (*L*1 and *L*2). Ring-shaped structures were identified in the area to the east and northeast of Petropavlovsk-Kamchatskiy city, where no great earthquakes have occurred during more than 60 years (ring-shaped structure was identified also in the depth range of 71-110 km here). Earlier, correlation dependences of *Mt*1 and *Mt*2 parameters on *Mw* values of major earthquakes for the west of Pacific were creating. Using these dependencies, the magnitude of possible great earthquake in this area was estimated as *Mw*=8.6±0.2. Besides that, a conclusion on the source depth of such event was drawing on the base of the analysis of three ring-shaped structures. The reasons for ring-shaped structures formation in different depth ranges of the subduction zones are discussing.

Keywords Lithosphere, ring-shaped seismicity structures, large earthquakes, deep-seated fluids.

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References

Bürgmann R., Kogan M., Steblov M., Hilley G., Levin V., & Apel E. (2005). Interseismic coupling and asperity distribution along the Kamchatka subduction zone. *Journal of Geophysical Research*: *Solid Earth*, *110*, B07405. DOI: *10.1029/2005JB003648*

Engdahl, E.R., & Villasenor, A. (2002). Global Seismicity: 1900-1999. In: *Lee*, *H.K.*, *Kanamori*, *H.*, *Jennings*, *P.C.*, *et al.* (*Eds.*). *International Handbook of Earthquake and Engineering Seismology*, *Part A* (pp. 665-690). Amsterdam, Netherlands: Academic Press.

Fedotov, S.A., Solomatin, A.V., & Chernyshev, S.D. (2007). A long-term earthquake forecast for the Kuril-Kamchatka island arc for the period 2006-2011 and a successful forecast of the MS=8.2 Middle Kuril Earthquake of November 15, 2006. *Journal of Volcanology and Seismology*, *1*(3), 143-163. DOI: *10.1134/S0742046307030013*. EDN: LKMVEL

Gold, T., & Soter, S. (1984). Fluid ascent through the solid lithosphere and its relation to earthquakes. *Pure and Applied Geophysics*, *122*, 492-530. DOI: *10.1007/BF00874614*

Husen, S., & Kissling, E. (2001). Postseismic fluid flow after the large subduction earthquake of Antofagasta, Chile. *Geology*, *29*(9), 847-850. DOI: *10.1130/0091-7613(2001)029<0847:PFFATL>2.0.CO;2*

Karakin, A.V., & Lobkovsky, L.I. (1983). [Hydrodynamics and structure of the two-phase asthenosphere]. *Doklady Akademii nauk SSSR* [Transactions (Doklady) of the USSR Academy of Sciences. Earth Science Sections], *268*(2), 324-329. (In Russ.).

Kopnichev, Y.F., & Sokolova, I.N. (2018). Ring-shaped seismicity structures forming before large earthquakes and the great earthquakes in the Western and Eastern Pacific. *Izvestiya*. *Atmospheric and Oceanic Physics*, *54*(8), 848-858. DOI: *10.1134/S0001433818080054*. EDN: DQTVRS

Kopnichev, Y.F., & Sokolova, I.N. (2022). Ring-shaped seismicity structures in the region of Southwestern Alaska: A Justified forecast of the location and magnitude of the Chignik earthquake of July 29, 2021 (Mw=8.2). *Izvestiya*. *Atmospheric and Ocean Physics*, *58*(7), 713-723. DOI: *10.1134/S0001433822070052*

Kopnichev, Yu.F., & Sokolova, I.N. (2003). Spatio-temporal variations of the S wave attenuation field in the source zones of large earthquakes in the Tien Shan. *Izvestiya*. *Physics of the Solid Earth*, *39*(7), 568-579.

Kopnichev, Yu.F., & Sokolova, I.N. (2005). [Mantle fluids ascent in the regions of strong earthquake sources

and large deep fault zones: Geochemical evidences]. *Vestnik NIaTs RK* [NNC RK Bulletin], *2*, 147-155. (In Russ.).

Kopnichev, Yu.F., & Sokolova, I.N. (2009a). Ring seismicity in different depth ranges before large and great earthquakes in subduction zones. *Doklady Earth Sciences*, *425A*(3), 448-450. DOI: *10.1134/S1028334X09030222*

Kopnichev, Yu.F., & Sokolova, I.N. (2009b). Characteristics of ring seismicity in different depth ranges before large and great earthquakes in the Sumatra region. *Doklady Earth Sciences*, *429*(8), 1385-1388. DOI: *10.1134/S1028334X09080327*

Kopnichev, Yu.F., & Sokolova, I.N. (2010). On the correlation between seismicity characteristics and S-wave attenuation in the ring structures that appear before large earthquakes. *Journal of Volcanology and Seismology*, *4*(6), 396-411. DOI: *10.1134/S0742046310060047*. EDN: OHMPQF

Kopnichev, Yu.F., & Sokolova, I.N. (2011a). Annular seismicity structures and the March 11, 2011, earthquake (Mw=9.0) in Northeast Japan. *Doklady Earth Sciences*, *440*(1), 1324-1327. DOI: *10.1134/S1028334X11090194*. EDN: PECMHT

Kopnichev, Yu.F., & Sokolova, I.N. (2011b). [Heterogeneity of the short-period S-wave attenuation in the source zone of the Maule earthquake in Chile (27.02.2010, Mw=8.8) and its relation to seismicity and volcanism of the region]. *Geofizicheskie issledovaniia* [Geophysical Research], *12*(3), 22-32. (In Russ.). EDN: OGYNPR

Kopnichev, Yu.F., & Sokolova, I.N. (2015). [Ring-shaped seismicity structures in the region of Northern Chile and successful prediction of place and magnitude of the Iquique earthquake of 01.04.2014 (Mw=8.2)]. *Vestnik NIaTs RK* [NNC RK Bulletin], *4*, 153-159. (In Russ.).

Kopnichev, Yu.F., & Sokolova, I.N. (2021). [Ring-shaped seismicity structures, being formed in the Alaska region: Justified prediction of the place and magnitude of the Simeonof earthquake of July 22, 2020 (Mw 7.8)]. *Rossiiskii seismologicheskii zhurnal* [Russian Journal of Seismology], *3*(3), 50-60. (In Russ.). DOI: *10.35540/2686-7907.2021.3.03*. EDN: QUJNGX

Kopnichev, Yu.F., & Sokolova, I.N. (2023). [Characteristics of ring-shaped seismicity at depths up to 110 km prior to large and great earthquakes in subduction zones of the Pacific]. *Rossiiskii seismologicheskii zhurnal* [Russian Journal of Seismology], *5*(4), 41-51. (In Russ.). DOI: *10.35540/2686-7907.2023.4.03*. EDN: HDHWNE

Kopnichev, Yu.F., & Sokolova, I.N. (2024). Inhomogeneities of the absorption field of short-period S-waves in the Kuril and Kamchatka regions, and their connection with strong and strongest earthquakes. *Journal of Volcanology and Seismology*, *18* (In print).

Kopnichev, Yu.F., Gordienko, D.D., & Sokolova, I.N. (2009). Space-time variations of the shear wave attenuation field in the upper mantle of seismic and low seismicity areas. *Journal of Volcanology and Seismology*, *3*(1), 44-58. DOI: *10.1134/S0742046309010059*. EDN: LLQHEP

Letnikov, F.A. (1992). *Sinergetika geologicheskikh system* [Synergetics of geological systems]. Novosibirsk, Russia: Nauka Publ., 229 p. (In Russ.). EDN: YYUFUL

Ogawa, R., & Heki, K. (2007). Slow postseismic recovery of geoid depression formed by the 2004 Sumatra-Andaman earthquake by mantle water diffusion. *Geophysical Research Letters*, *34*, L06313. DOI: *10.1029/2007GL029340*

USGS. Search Earthquake Catalog. Earthquakes. (2019). U.S. Geological Survey National Earthquake Information Center, Federal Center Denver, Colorado. Retrieved from *https://earthquake.usgs.gov/earthquakes/search/*

Yamazaki, T., & Seno, T. (2003). Double seismic zone and dehydration embrittlement of the subducting slab. *Journal of Geophysical Research*: *Solid Earth*, *108*(B4). DOI: *10/1029/2002JB001918*

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