Scale of local magnitudes ML for earthquakes in the Terek–Caspian trough

© 2023 R.A. Dyagilev, I.P. Gabsatarova, E.A. Selivanova

GS RAS, Obninsk, Russia

Received February 28, 2023

Abstract A scale (calibration function) to determine the local magnitude ML of earthquakes with epicenters in the central part of the Terek-Caspian trough has been developed. The scale is based on a formula that takes into account attenuation and geometric divergence with distance for the maximum amplitudes of the simulated recordings of the short-period Wood-Anderson instrument. To calculate it, a sample of 64 earthquakes that occurred in 2020–2022, during the period of activation in the Black Mountains in the Chechen Republic, was compiled. Earthquakes were recorded by 58 stations in the distance range of 25–526 km, located around the epicenters in various geological and tectonic area. The *Magscale* program developed at the GS RAS based on methodological recommendations set out in the New Manual for Observatory Practice (NMSOP) was used for the calculation. The values of the coefficients of the equation, which characterize the attenuation in the crust and upper mantle, are obtained. The station corrections are calculated. Their use made it possible to reduce the scale deviations from ±0.26 to ±0.15. The areal distribution of residuals probably reflects the geological features of the area.

Keywords Local magnitude, calibration function, earthquakes, Terek-Caspian trough.

For citation Dyagilev, R.A., Gabsatarova, I.P., & Selivanova, E.A. (2023). [Scale of local magnitudes ML for earthquakes in the Terek-Caspian trough]. *Rossiiskii seismologicheskii zhurnal* [Russian Journal of Seismology], *5*(2), 19-31. (In Russ.). DOI: https://doi.org/10.35540/2686-7907.2023.2.02. EDN: FEJGPK

References

Akimov, A.P., & Krasilov, S.A. (2020). [WSG software package "Seismic data processing system"]. Certificate of state registration of a computer program No. 2020664678. (In Russ.). EDN: IJOVUE

Alyeshina, E.I., Kurtkin, S.V., & Karpenko, L.I. (2021). [Seismicity of the North-East of Russia in 2015]. *Zemletriaseniia Severnoi Evrazii* [Earthquakes in Northern Eurasia], *24*(2015), 164-172. (In Russ.). DOI: *10.35540/1818-6254.2021.24.15*. EDN: AORKRT

Bormann, P. (2012). Magnitude calibration formulas and tables, comments on their use and complementary data. Datasheet DS 3.1. In *Bormann*, *P.* (*Ed.*), *New Manual of Seismological Observatory Practice* (*NMSOP*), *V. 1*, *Ch. 3* (pp. 1-19). Potsdam, Germany: GeoForschungsZentrum Publ. DOI: *10.2312/GFZ.NMSOP-2_DS_3.1*

Bormann, P., & Dewey, J.W. (2012). The new IASPEI standards for determining magnitudes from digital data and their relation to classical magnitudes. Information Sheet IS 3.3. In *Bormann*, *P.* (*Ed.*), *New Manual of Seismological Observatory Practice* (*NMSOP*) (pp. 16-49). Potsdam, Germany: GeoForschungsZentrum. DOI: *10.2312/GFZ.NMSOP-2_IS_3.3*

Bormann, P., Wendt, S., & Di Giacomo, D. (2013). Seismic sources and source parameters. In *Bormann*, *P.* (*Ed.*), *New Manual of Seismological Observatory Practice 2* (*NMSOP2*) (pp. 1-259). Potsdam, Germany: Deutsches GeoForschungsZentrum GFZ. DOI: *10.2312/GFZ.NMSOP-2_ch3*

Chebrov, D.V., Saltykov, V.A., Matveenko, E.A., Droznina, S.Ya., Romasheva, E.I., Mityushkina, S.V., Ababakirov, I.R., & Pavlov, V.M. (2021). [Seismicity of Kamchatka and Commander Islands in 2015]. *Zemletriaseniia Severnoi Evrazii* [Earthquakes in Northern Eurasia], *24*(2015), 153-163. (In Russ.). DOI: *10.35540/1818-6254.2021.24.14*. EDN: FZNZSB

Di Giacomo, D., & Storchak, D.A. (2016). A scheme to set preferred magnitudes in the ISC Bulletin. *Journal of Seismology*, *20*(2), 555-567. DOI: *10.1007/s10950-015-9543-7*

Di Giacomo, D., Harris, J., & Storchak, D.A. (2021). Complementing regional moment magnitudes to GCMT: A perspective from the rebuilt International Seismological Centre Bulletin. *Earth System Science Data*, *13*(5), 1957-1985. DOI: *10.5194/essd-13-1957-2021*

Diagilev, R.A. (2022). [Calculation of the parameters of the local magnitude scale, MagScale]. Certificate of state registration of the computer program No. 2022666504. (In Russ.). EDN: KDVZVH

Emanov, A.F., Emanov, A.A., Fateev, A.V., Shevkunova, E.V., & Podkorytova, V.G. (2021). [Seismicity of the Altai and Sayan region in 2015]. *Zemletriaseniia Severnoi Evrazii* [Earthquakes in Northern Eurasia], *24*(2015), 122-128. (In Russ.). DOI: *10.35540/1818-6254.2021.24.11*. EDN: GGVHYE

Fokina, T.A., Safonov, D.A., Kostylev, D.V., & Mikhailov, V.I. (2021). [Seismicity of the Amur and Primorye, Sakhalin and the Kuril-Okhotsk region in 2015]. *Zemletriaseniia Severnoi Evrazii* [Earthquakes in Northern Eurasia], *24*(2015), 139-152. (In Russ.). DOI: *10.35540/1818-6254.2021.24.13*. EDN: OHBBDR

Gabsatarova, I.P. (2006). [Introduction into the routine practice of subdivisions of the GS RAS of the procedure for calculating the local magnitude]. In *Sovremennye metody obrabotki i interpretatsii seismologicheskikh dannykh*. *Materialy Mezhdunarodnoi seismologicheskoi shkoly* [Modern methods of processing and interpretation of seismological data. Materials from International seismological school] (pp. 50-54). Obninsk, Russia: GS RAS Publ. (In Russ.). EDN: TPPJQZ

Gabsatarova, I.P., Assinovskaya, B.A., Baranov, S.V., Karpinsky, V.V., Konechnaya, Ya.V., Munirova, L.M., Nadezhka, L.I., Nikulin, V.G., Noskova, N.N., Petrov, S.I., Pivovarov, S.P., & Sanina, I.A. (2021). [Seismicity of the Russian part of East European platform and adjacent territories in 2015]. *Zemletriaseniia Severnoi Evrazii* [Earthquakes in Northern Eurasia], *24*(2015), 182-191. (In Russ.). DOI: *10.35540/1818-6254.2021.24.17*. EDN: TDOJDR

Gabsatarova, I.P., Koroletski, L.N., Ivanova, L.E., Sayapina, A.A., Bagaeva, S.S., Adilov, Z.M., & Asmanov, O.A. (2021). [Seismicity of the Northern Caucasus in 2015]. *Zemletriaseniia Severnoi Evrazii* [Earthquakes in Northern Eurasia], *24*(2015), 69-83. (In Russ.). DOI: *10.35540/1818-6254.2021.24.06*. EDN: ORCRZJ

Godzikovskaia, A.A. (2023). *Baza dannykh "Katalog zemletriasenii Kavkaza s M≥4.0 (K≥11.0) s drevneishikh vremen po 2000 g."* [Database "Catalogue of earthquakes in the Caucasus with M≥4.0 (K≥11.0) from ancient times to 2000"]. Retrieved from *http://zeus.wdcb.ru/wdcb/sep/caucasus/catrudat.html* (In Russ.).

Grünthal, G., & Wahlström, R. (2012). The European Mediterranean Earthquake Catalogue (EMEC) for the last millennium. *Journal of Seismology*, *16*(3), 535-570. DOI: *10.1007/s10950-012-9302-y*

Herak, M. (2020). Conversion between the local magnitude (ML) and the moment magnitude (Mw) for earthquakes in the Croatian Earthquake Catalogue. *Geofizika*, *37*(2), 197-211.

Hutton, L.K., & Boore, D.M. (1987). The ML scale in Southern California. *Bulletin of the Seismological Society of America*, *77*(6), 2074-2094. DOI: *10.1785/BSSA0770062074*

IASPEI Seismic Format (ISF) Version 2.0. (2022). Available at: *http://www.isc.ac.uk/standards/isf/download/isf2.pdf*

International Seismological Centre. (2023). On-line Bulletin. DOI: *10.31905/D808B830*

Kanamori, H. (1983). Magnitude scale and quantification of earthquakes. *Tectonophysics*, *93*(3-4), 185-199.

Kondorskaya, N.V., Aranovich, Z.I., Solov'yeva, O.N., & Shebalin, N.V. (Eds.). (1981). *Instruktsiia o poriadke proizvodstva i obrabotki nabliudenii na seismicheskikh stantsiiakh Edinoi sistemy seismicheskikh nabliudenii SSSR* [Instructions on the production and processing of observations procedure at seismic stations of a Unified system of seismic observations of the USSR]. Moscow, Russia: Nauka Publ., 272 p. (In Russ.).

Malovichko, A.A., Dyagilev, R.A., Verkholantsev, F.G., Golubeva, I.V., & Zlobina, T.V. (2021). [Seismicity of the Urals and Western Siberia in 2015]. *Zemletriaseniia Severnoi Evrazii* [Earthquakes in Northern Eurasia], *24*(2015), 200–209. (In Russ.). DOI: *10.35540/1818-6254.2021.24.19*

Melnikova, V.I., Gileva, N.A., Filippova, A.I., Radziminovich, Ya.B., & Kobeleva, E.A. (2021). [Seismicity of Baikal and Transbaikalia in 2015]. *Zemletriaseniia Severnoi Evrazii* [Earthquakes in Northern Eurasia], *24*(2015), 129-138. (In Russ.). DOI: *10.35540/1818-6254.2021.24.12*. EDN: JCDDFK

Morozov, A.N., Avetisov, G.P., Antonovskaya, G.N., Asming, V.E., Baranov, S.V., Vaganova, N.V., Vinogradov, Yu.A., Jolondz, A.S., Konechnaya, Ya.V., Fedorov, A.V., & Fedorov, I.S. (2021). [Seismicity of the Arctic in 2015]. *Zemletriaseniia Severnoi Evrazii* [Earthquakes in Northern Eurasia], *24*(2015), 210-216. (In Russ.). DOI: *10.35540/1818-6254.2021.24.20*. EDN: XBTXBS

Nesmeyanov, S.A., Lutikov, A.I., Shchukin, Yu.K., & Dontsova, G.Yu. (1996). [Seismogenic structures]. In *Kompleksnaia otsenka seismicheskoi opasnosti territorii g. Groznogo* (*Utochnenie iskhodnoi seismichnosti*. *Seismicheskoe mikroraionirovanie*. *Seismicheskii risk*). *Nauch*. *red*. *S.I. Poltavtsev* [Comprehensive assessment of the seismic hazard of the territory of Grozny (Updating the initial seismicity. Seismic microzoning. Seismic risk). Sci. ed. S.I. Poltavtsev] (pp. 38-47). Moscow, Russia: Ministry of Construction of Russia Publ. (In Russ.).

Rautian, T.G. (1960). [Energy of the Earthquakes]. In *Metody detalnogo izucheniya seismichnosti*. *Trudy IFZ AN SSSR*, *9*(*176*). [Methods of Detailed Study of the Seismicity. Proceedings of the IPE AS USSR № 9(176)] (pp. 75-114). Moscow, Russia: IPE AS USSR Publ. (In Russ.).

Rautian, T.G. (1964). [On the determination of the energy of earthquakes at a distance of 3000 km]. In *Eksperimental'naia seismika*. *Trudy IFZ AN SSSR*

N 32(*199*) [Experimental seismic. Proceedings of the IPE AS USSR N 32(199)] (pp. 88-93). Moscow, Russia: Nauka Publ. (In Russ.).

Richter, C.F. (1935). An instrumental earthquake magnitude scale. *Bulletin of the Seismological Society of America*, *25*(1), 1-32. DOI: *10.1785/BSSA0250010001*

Richter, C.F. (1958). Elementary seismology. San Francisco and London: W.H. Freeman and Company, 768 p.

Shibaev, S.V., Koz'min, B.M., & Makarov, A.A. (2021). [Seismicity of Yakutia in 2015]. *Zemletriaseniia Severnoi Evrazii* [Earthquakes in Northern Eurasia], *24*(2015), 173-181. (In Russ.). DOI: *10.35540/1818-6254.2021.24.16*. EDN: TMGQEE

Solov'ev, S.L., & Solov'eva, O.N. (1967). [The relationship between the energy class and the magnitude of the Kuril earthquakes]. *Izvestiia AN SSSR*, *ser.* "*Fizika Zemli*" [Izvestiya of the Academy of Sciences of the USSR. Physics of the Solid Earth], *2*, 13-22. (In Russ.).

Information about authors

Dyagilev Ruslan Andreevich, PhD, Leading Researcher, Deputy Director of the Geophysical Survey of Russian Academy of Sciences (GS RAS), Obninsk, Russia. E-mail: dra@gsras.ru

Gabsatarova Irina Petrovna, PhD, Leading Researcher, Head Laboratory of the GS RAS, Obninsk, Russia. ORCID: 0000-0001-8998-340X. E-mail: ira@gsras.ru

Selivanova Elena Arkadievna, Leading Engineer of the GS RAS, Obninsk, Russia. E-mail: seliv@gsras.ru