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MODERN GEOTHERMOCHRONOLOGIC AND PALEOMAGNETIC POTENTIAL IN DEPOSITS EXPLORATION

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Abstract. The paleomagnetic and geochronologic methods, described in the article, are successfully used in international practice for solving current applied and fundamental challenges of geology, geophysics and related sciences. On the basis of our consideration, we conclude that only the use of a combination of modern methods and advanced equipment makes it possible to obtain results comparable to the world level. As an example, we present the results of multidisciplinary studies of the Kola Peninsula, on the basis of which a unique model of the tectonic-thermal evolution of northeastern Fennoscandia and the Barents Sea shelf has been created. The available analytical resources are described and the basic technical specifications of the equipment, operated in the leading scientific centers of the Russian Federation, such as Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences (IPE RAS), Kazan Federal University (KFU), Saint Petersburg State University (SPBU), are presented.

Keywords: paleomagnetism, thermochronology, geochronology, magnetostratigraphy, drill core orientation, correlation, sedimentary basins.

References (Translation)

- Burov B.V., Balabanov Yu.P., Yasonov P.G., Khramov A.N., Rzhnevsky Yu.S.*, 1978. "A way to orient the core of wells in space". Description of the invention, patent No. 606151.
- Pavlov V.E., Fluto F., Veselovsky R.V., Fetisova A.M., Latyshev A.V.* Centennial variations of the geomagnetic field and volcanic pulses in the permo-Triassic traps of the Noril'sk and Maimecha-Kotui provinces, *Physics of the Earth*. 2011. No. 5. pp. 35-50. (In Russian).
- Paleomagnetology*, Editor A.N. Hramov. Leningrad, Nedra. 1982. 312 pages. (In Russian).
- Popov V.V., Hramov A.N.* A new method of orienting the core of wells in space, *Oil and Gas Geology. Theory and practice*. 2007. No. 2. (In Russian).
- Soloviev A.V.* Study of tectonic processes in the field of convergence of lithospheric plates. *Methods of track and structural analysis*. Moscow, Science. 2008. 320 pages. (In Russian).
- Fetisova A.M., Veselovsky R.V., Latyshev A.V., Radko V.A., Pavlov V.E.* Magnetic stratigraphy of permo-Triassic traps in the Kotui River valley (Siberian platform) in the light of new paleomagnetic data, *Stratigraphy. Geological correlation*. Vol. 22. No. 4. 2014. Stranitsy 36-51. DOI: 10.7868 / S0869592X1404005X (In Russian).

- Burgess S.D., Bowring S.A.* High-precision geochronology confirms voluminous magmatism before, during, and after Earth's most severe extinction, *Science Advances*. 2015. Vol. 1. No. 7. DOI: 10.1126/sciadv.1500470
- Hounslow M., Muttoni G.* The geomagnetic polarity timescale for the Triassic: linkage to stage boundary definitions, Geological Society, London, Special Publications. 2010. Vol. 334. pp. 61–102.
- Ketcham R.A.* Forward and Inverse Modeling of Low-Temperature Thermochronometry Data, *Reviews in Mineralogy and Geochemistry*. 2005. Vol. 58. pp. 275–314. DOI:10.2138/rmg.2005.58.11
- Laslett G.M., Green P.F., Duddy I.R., Gleadow A.J.W.* Thermal annealing of fission tracks in apatite 2. A quantitative analysis, *Chemical Geology: Isotope Geoscience*. 1987. Section 65. pp. 1–13. DOI:10.1016/0168-9622(87)90057-1
- Lisker F., Ventura B., Glasmacher U.* Apatite thermochronology in modern geology, Geological Society, London, Special Publications. 2009. Vol. 324. pp. 1–23.
- Manning E.B., Elmore R.D.* An integrated paleomagnetic, rock magnetic, and geochemical study of the Marcellus shale in the Valley and Ridge province in Pennsylvania and West Virginia, *J. Geophys. Res. Solid Earth*. 2015. Vol. 120. pp. 705–724. DOI: 10.1002/2014JB011418.
- Symons D.T.A., Arne D.C.* Paleomagnetic constraints on Zn–Pb ore genesis of the Pillara Mine, Lennard Shelf, Western Australia, *Miner Deposita*. 2005. Vol. 39. pp. 944–959. DOI: 10.1007/s00126-004-0446-8
- Van Alstine D.R., Butterworth J.E.* Paleomagnetic core orientation helps determine the sedimentological, paleostress, and fluid-migration history in the Maracaibo Basin, Venezuela, *Core Workshop for I Congreso Virtual de Sedimentología*, 11 de Febrero al 08 de Marzo de 2002.
- Veselovskiy R.V., Thomson S.N., Arzamastsev A.A., Zakharov V.S.* Apatite fission track thermochronology of Khibina Massif (Kola Peninsula, Russia): Implications for post-Devonian Tectonics of the NE Fennoscandia, *Tectonophysics*. 2015. Vol. 665. P. 157–163. DOI: <http://dx.doi.org/10.1016/j.tecto.2015.10.003>

References (Transliteration)

- Burov B.V., Balabanov Yu.P., Yasonov P.G., Khramov A.N., Rzhnevskiy Yu.S.*, 1978. «Sposob oriyentirovaniya kerna skvazhin v prostranstve». Opisaniye izobreteniya, patent No. 606151. (In Russian).
- Pavlov V.E., Fluto F., Veselovskiy R.V., Fetisova A.M., Latyshev A.V.* Vekovye variatsii geomagnitnogo polya i vulkanicheskiye pul'sy v permo-triasovykh trappakh Noril'skoy i Maymecha-Kotuyskoy provintsiy, *Fizika Zemli*. 2011. No. 5. Stranitsy 35–50. (In Russian).
- Paleomagnitologiya*, Redaktor A.N. Khramov. Leningrad, Nedra. 1982. 312 stranits. (In Russian).
- Popov V.V., Khramov A.N.* Novyi metod oriyentirovaniya kerna skvazhin v prostranstve, *Neftegazovaya geologiya. Teoriya i praktika*. 2007. No. 2. (In Russian).
- Solov'yev A.V.* Izucheniye tektonicheskikh protsessov v oblasti konvergentsii litosfernykh plit. *Metody trekovogo i strukturnogo analiza*. Moskva, Nauka. 2008. 320 stranits. (In Russian).
- Fetisova A.M., Veselovskiy R.V., Latyshev A.V., Rad'ko V.A., Pavlov V.E.* Magnitnaya stratigrafiya permo-triasovykh trappov doliny reki Kotuy (Sibirskaya platforma) v svete novykh paleomagnitnykh dannykh, *Stratigrafiya. Geologicheskaya korrelyatsiya*. Tom 22. №4. 2014. Stranitsy 36–51. DOI: 10.7868/S0869592X1404005X (In Russian).
- Burgess S.D., Bowring S.A.* High-precision geochronology confirms voluminous magmatism before, during, and after Earth's most severe extinction, *Science Advances*. 2015. Vol. 1. No. 7. DOI: 10.1126/sciadv.1500470

- Hounslow M., Muttoni G.* The geomagnetic polarity timescale for the Triassic: linkage to stage boundary definitions, Geological Society, London, Special Publications. 2010. Vol. 334. pp. 61–102.
- Ketcham R.A.* Forward and Inverse Modeling of Low-Temperature Thermochronometry Data, Reviews in Mineralogy and Geochemistry. 2005. Vol. 58. pp. 275–314. DOI:10.2138/rmg.2005.58.11
- Laslett G.M., Green P.F., Duddy I.R., Gleadow A.J.W.* Thermal annealing of fission tracks in apatite 2. A quantitative analysis, Chemical Geology: Isotope Geoscience. 1987. Section 65. pp. 1–13. DOI:10.1016/0168-9622(87)90057-1
- Lisker F., Ventura B., Glasmacher U.* Apatite thermochronology in modern geology, Geological Society, London, Special Publications. 2009. Vol. 324. pp. 1–23.
- Manning E.B., Elmore R.D.* An integrated paleomagnetic, rock magnetic, and geochemical study of the Marcellus shale in the Valley and Ridge province in Pennsylvania and West Virginia, J. Geophys. Res. Solid Earth. 2015. Vol. 120. pp. 705–724. DOI: 10.1002/2014JB011418.
- Symons D.T.A., Arne D.C.* Paleomagnetic constraints on Zn–Pb ore genesis of the Pillara Mine, Lennard Shelf, Western Australia, Miner Deposita. 2005. Vol. 39. pp. 944–959. DOI: 10.1007/s00126-004-0446-8
- Van Alstine D.R., Butterworth J.E.* Paleomagnetic core orientation helps determine the sedimentological, paleostress, and fluid-migration history in the Maracaibo Basin, Venezuela, Core Workshop for I Congreso Virtual de Sedimentología, 11 de Febrero al 08 de Marzo de 2002.
- Veselovskiy R.V., Thomson S.N., Arzamastsev A.A., Zakharov V.S.* Apatite fission track thermochronology of Khibina Massif (Kola Peninsula, Russia): Implications for post-Devonian Tectonics of the NE Fennoscandia, Tectonophysics. 2015. Vol. 665. pp. 157–163. DOI: <http://dx.doi.org/10.1016/j.tecto.2015.10.003>