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Cherkes S., Poliachenko I., Hlavatskyi D., Melnyk G., Bakhmutov V.

Subbotin Institute of Geophysics of the National Academy of Sciences of Ukraine, Akademika Palladina Ave. 32, 03142 Kyiv, Ukraine. E-mail: semyoncherkes@gmail.com, poliachenkoib@gmail.com, hlavatskyi@gmail.com, melnykgv@gmail.com, bakhmutovvg@gmail.com

PALAEOGEOGRAPHY OF UKRAINE FROM THE PRECAMBRIAN TO THE QUATERNARY: RECENT ACHIEVEMENTS OF THE KYIV PALAEOMAGNETIC SCHOOL

Introduction. Among modern fundamental problems of geology – the problem of geodynamic evolution of the Earth (continental drift, supercontinental cycles, mantle convection and processes in the Earth's core), the problem of geomagnetic field evolution (its genesis, configuration, and generation modes), and contradictions in the correlation and dating of continental and marine sediments, which complicates the solution of palaeoclimatology problems (determination of spatial and amplitude features of climate change, climate rhythmicity, development of forecast global and regional climate models, etc.) – can be highlighted.

One of the main tools for solving the abovementioned problems is the palaeomagnetic method, which is used to reconstruct palaeogeographical conditions and behavior of the geomagnetic field during ancient geological epochs. Palaeomagnetic data allow to interpret the movement of individual blocks of the Earth's crust at a quantitative level, to assess the geometry of the geomagnetic field and modes of its generation, and to correlate distant geological cross-sections. Furthermore, magnetic minerals in rocks reflect not only the peculiarities of the geomagnetic field at the place and time of their origin, but are also extremely sensitive indicators of environmental conditions (and changes), which makes it possible to successfully use the rock magnetic method in palaeoclimatology and ecology. The advantage of the palaeomagnetic (and rock magnetic) method is the relative ease of specimen preparation and its expressiveness (compared to classical methods), which determines its high productivity and efficiency, especially when combined with other geological, geochemical and geographical methods.

Activities of the Kyiv Palaeomagnetic School (KPS). The territory of Ukraine is geologically diverse and generally well studied. There is a full range of specific geological structures and formations that store information about the key stages of the Earth's evolution from ancient times to the present. Based on the palaeomagnetic method, the use of a modern integrated approach to the study of geological formations in Ukraine allows to obtain unique fundamental and applied valuable knowledge. Taking into account the development of rock magnetic techniques, the availability of new equipment (see Table 1 in [1]) and publication activity, the activities of the KPS in the study of various rocks of Ukraine can be divided into several stages, which marked the key works.

The first (1962–1994) stage began in 1962 and ended with the publication of the generalised Pleistocene magnetostratigraphic scale of Ukraine in 1994 [2]. At this time, the KPS was formed on the basis of the Subbotin Institute of Geophysics of the National Academy of Sciences of Ukraine. The school was founded by such distinguished scientists as Z.A. Kurtykhovska, N.P. Mykhailova, A.M. Glevaska, V.N. Tsykora, S.V. Kravchenko, A.Y. Karzanova, O.N. Tretiak, O.M. Rusakov, G.F. Zagniy, V.N. Kovalenko-Zavoisky, M.I. Orlova, and others. This stage was characterised by the development of the basic principles of palaeomagnetic stratigraphy, the beginning of the study of the "fine structure" of the geomagnetic field, the construction of the first regional magnetostratigraphic scales of the Cenozoic and the rise of the problem of palaeomagnetic stratification of loess-soil strata [1]. In addition, a significant work was performed on the study of Precambrian rocks, and palaeomagnetic characteristics of various rocks of the territory of Ukraine were obtained, among which palaeomagnetically informative varieties were identified [3].

At the second stage (1995–2012), extensive studies of the subaerial sediments of the reference cross-sections were carried out, and the boundaries of the Matuyama/Brunes and Gauss/Matuyama were defined. Particular attention was paid on the stratigraphic correlation of Ukrainian subaerial sediments with loess-soil records from other regions and with the MIS marine scale [1]. During this phase, palaeomagnetic and magnetostratigraphic studies of the Ediacaran rocks of the Volyn Large Igneous Province and terrigenous sediments of Podillia were carried out, the results of which were rather ambiguous [3, 4]. The main researchers of the KPS at this stage were O.N. Tretiak, A.M. Glevaska, S.V. Kravchenko, L.I. Vigilianska, V.G. Bakhmutov and G.V. Slyvinska.

The third stage (2013 to the present) is characterised by the use of new magnetometric equipment by Ukrainian scientists and the intensification of palaeomagnetic and rock magnetic research. The research is aimed at solving the problem of correlation of key sections in the glacial and non-glacial zones and reliable determination of palaeomagnetic inversions [1]. A significant part of the research was carried out to clarify the model of development of the East European Platform in the Middle Palaeozoic [5] and Palaeoproterozoic

[4]. The study of the Ediacaran rocks of Volyn-Podillia was continued to determine the features of the geomagnetic field anomalous behaviour in the Ediacaran [3, 4]. This phase also covered studies of the relationship between the geomagnetic field and climate [6]. The active members of the KPS at the third stage of its development are V.G. Bakhmutov (the head of the School), I.B. Poliachenko, D.V. Hlavatskyi, G.V. Melnyk, S.I. Cherkes and V.V. Shpyra.

Studied objects. The research within the third stage of KPS development covers several geological intervals – from the Palaeo- and Neoproterozoic, Lower Devonian, Silurian, Jurassic/Cretaceous boundary to the Quaternary. The research focused on the full range of rocks (sedimentary, plutonic, volcanic) sampled from different parts of Ukraine (Fig. 1), mainly within the structures of the Ukrainian Shield and its slopes, the Volyn-Podillia plate, as well as the Black Sea Lowland and Crimean Mountains.

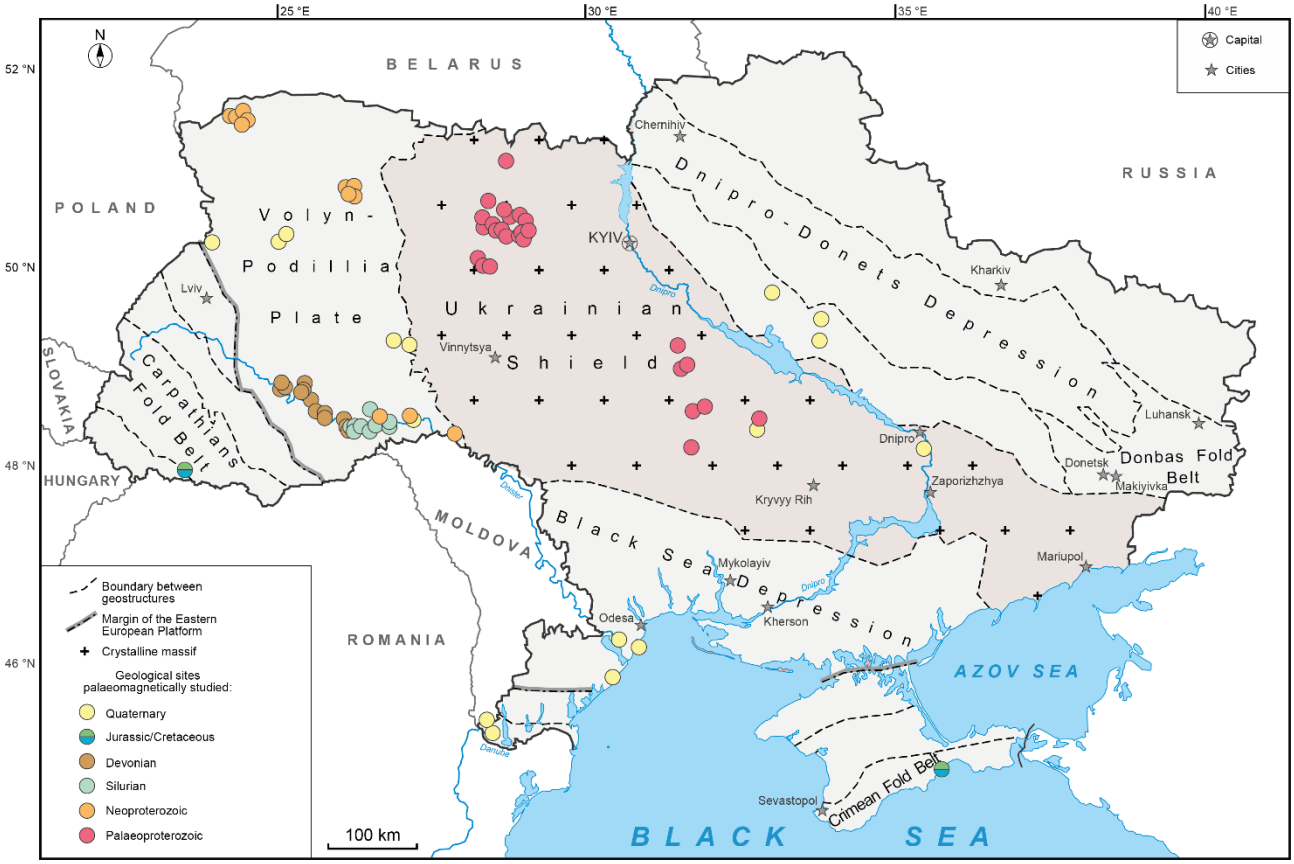

Fig. 1. Location of the studied sections/sites on the schematic map of the main geostructures of Ukraine

Results and conclusion. The results of the study of the most ancient rocks sampled within the Buky and Novoukrainka massifs are presented in [3, 7]. Based on the temperature demagnetisation data, a high-temperature characteristic component of magnetisation was identified for the gabbro-monzonites of the Novoukrainka massif (2035 ± 10 Ma) and the monzonites of the Buky massif (1987 ± 14 Ma). The calculated corresponding palaeomagnetic determinations of the massifs are in good agreement with the data obtained for the Proterozoic dikes of the northwestern Volyn megablock with an age of ~2 Ga. According to the new palaeomagnetic data, the Volyn and Ingul domains did not experience significant movements relative to each other after ~2 Gya and since then may have developed within a single structure of the Ukrainian Shield. At the same time, the Ukrainian shield occupied palaeolatitudes of about 20–25°.

Based on the results of studies of rocks with an age of about 1.76–1.75 Ga from the Korosten and Korsun-Novomyrhorod plutons [8], a characteristic component of magnetisation was identified for anorthosites, gabbro-anorthosites, gabbro, and monzonites. The characteristic component is bipolar, and rock magnetic and microscopic data indicate its primary nature. The new results are in good agreement with data obtained earlier for other rocks of similar age within the Volyn and Inhul domains of the Ukrainian Shield, indicating that these domains have been developing as a single tectonic unit since at least 1.76 Gya. According to palaeomagnetic data for Fennoscandia and Volga-Sarmatia, ~1.76 Ga. Fennoscandia occupied a sub-equatorial position within palaeolatitudes of 5–20°, and Volgo-Sarmatia was located near the equator and rotated counterclockwise relative to Fennoscandia by ~40° compared to its present position within the East European Platform. Thus, the final formation of the East European Platform occurred no earlier than 1.76 Gya.

The results of studies of volcanogenic rocks of the Volyn series of the Volyn Large Igneous Province (580–560 Ma) [4] and red tuffites of the Grushka suite (Volyn series) of Podillia support the hypothesis of

anomalous behaviour of the geomagnetic field in the Ediacaran. The anomaly is reflected in an increased frequency of reversals and a different from dipole configuration of the Earth's magnetic field. This indicates significant transformations of the geodynamo mechanism in Ediacaran and reflects one of the key moments in its evolution. It is concluded that there is no clear palaeotectonic interpretation of palaeomagnetic determinations for the Ediacaran.

According to the results of palaeomagnetic studies of Silurian and Lower Devonian sedimentary sequences of Podillia [5], a characteristic component of magnetisation was identified. According to the data obtained, in the Ludlow epoch, the East European Platform was located in the near-equatorial latitudes of the Southern Hemisphere and moved north to the equatorial latitudes of the Southern Hemisphere in the Pridoli epoch. Then the drift pattern changes – the platform moves southward, and in the Lochkovian and Pragian times its position stabilises in the equatorial latitudes of the Southern Hemisphere. The latitudinal drift velocity was ~3–5 cm/year.

Based on the new data and the most reliable palaeomagnetic determinations from palaeomagnetic databases, we calculated kinematic parameters of the East European Platform and its segments in the Proterozoic and Palaeozoic intervals.

In addition, our new results on comprehensive rock magnetic and terrestrial-climatic reconstruction of the conditions of Quaternary sedimentary environment in different parts of Ukraine allows for their perfect stratification and correlation, which is the basis for reliable regional and global palaeoclimatic reconstructions. The proposed stratigraphic correlations indicate the outstanding completeness of continental subaerial deposits in Ukraine, which is a unique region for determining Quaternary palaeoclimatic changes in Europe. The new scheme of climatostratigraphic correlation of the reference loess-palaeosol sequences of the glacial and periglacial parts of Ukraine is proposed as a basis for further forecasting of climatic changes of a higher (thousand-year) rank.

Consequently, the results of the palaeomagnetic studies of the geological formation of Ukraine in different age ranges were synthesized for the first time. In view of newly obtained data, it is possible to trace the change in the palaeogeographical situation from the Precambrian to the Quaternary period.

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