Paleogeographic causes of the formation of mineral deposits on the east of the East European platform in the Permian period

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Abstract. There took place cardinal paleo- and zoogeographic changes in the second half of the Permian period and the beginning of the Triassic on the east of the East European Platform. These changes have been reflected in the geochemical features and magnetic properties of the rocks, the isotopic composition of chemical elements, the characteristics of the fauna, as well as the nature of the sediments. Permian sediments complete an extremely complex geological structure, are characterized by a diversity of lithologic-facies composition and occurring of specific minerals, which are considered indicators of various types of lithogenesis (sulfate-carbonate rocks, coals, copper sandstones, schists, etc.). Based on lithological and paleomagnetic studies, paleogeographic reconstructions were performed. They showed that one of the factors of Perm sedimentation and related processes of the formation of ore and nonmetallic minerals are global climatic changes caused by Carboniferous-Permian glaciation.

1. Introduction

There took place cardinal paleo- and zoogeographic changes in the second half of the Permian period and the beginning of the Triassic on the east of the East European Platform. They culminated in a biotic catastrophe at the boundary of the Permian and Triassic. These changes have been reflected in the geochemical features and magnetic properties of the rocks, the isotopic composition of chemical elements, the characteristics of the fauna, as well as the nature of the sediments.

Permian sediments complete the Paleozoic section. They have an extremely complex geological structure, are characterized by a diversity of lithologic-facies composition and occurring of specific minerals, which are considered indicators of various types of lithogenesis (sulfate-carbonate rocks, coals, copper sandstones, schists, etc.). One of the most important geological tasks is to find out the causes of the frequent changes in sedimentation conditions in the territory under consideration. This can serve as a basis for forecasting and searching for mineral deposits. The combination of features allows considering that the main factors of the change in paleogeographic conditions are climate and tectonics.
2. Object and methodology

The object of research is the Late Paleozoic sediments in the territory between the Volga River and Ural mountains in Permian. In the Late Carboniferous–Permian the paleogeographic situation was determined by the meridional drift of the East European Plate in a northerly direction across the planetary climatic zones [2]. In the Permian period the considering territory was located in the low latitudes (20–25°) of the northern hemisphere [2, 7], moving from the humid tropical zone to the zone of dry subtropics. According to the laws of atmospheric circulation they are located at the level of parallels 20-30° on both sides of the equator. For this reason, there were reigned a generally dry and hot (arid) climate in the Permian period on the plains of the Volga-Ural region and in the foothills of the Urals. The tectonic restructuring of the territory, caused by the Permian collision, led in the Permian to the degradation and complete disappearance of the inland continental seas, widespread in the Carboniferous. Tectonic changes occurred against the background of another planetary phenomenon - the Permian–Carboniferous glaciation [3, 6], which covered mainly the southern hemisphere. For this reason, it is often called the Great Gondwana glaciation. Carbon-Permian glaciation reached its top approximately 280-300 million years ago, i.e. in the early Permian time. During periods of maximum development, the total area of continental glaciers reached 35-45 million km². That led to significant fluctuations in sea level. The result of that was the transgressive-regressive movements of epicontinental seas in Permian.

There were performed lithological and paleomagnetic studies to clarify the primary factors of sedimentation and patterns of a location of mineral deposits.

3. Results and Discussions

As a result of the studies, it was found that the climate in the considering era was generally arid, but unstable and often changed. The glaciation did not occur directly in this region. But meanwhile, it had a strong effect on the entire paleogeographic and climatic conditions of the east part of the East European Platform [4]. First of all, that was expressed in enhancing the contrast of local climatic conditions, both in space and in time. The main factor in the regional climatic zonality was the mountain system of the Ural Range. In this regard, it is important to note that during the Carboniferous-Permian glaciation the mountain glaciers were predominated. Information on the high mountain humid climate and mountain glaciers in the Urals in Permian time is given in the monograph Strakhova N.M. et al. [8] with reference to the works of Khabakov A.V. according to the height of mountain ranges. Based on the analysis of pebbles of the Ufa plateau and Artin conglomerates of the Orenburg region, the height of the mountain peaks is estimated at around 1.5-2 km. Based on this, it is assumed that if the foot of the mountains was located in an arid or humid subtropical climate, then the climate could be wetter and colder in the top parts. In the same place [8] it is directly indicated that traces of the removal of glacial boulders from the Ural mountains are noted in the Artin deposits of the Orenburg region. Foci of a humid climate existed on the coast of the inland sea and in the highlands of the Ural mountains also in the Late Permian. That is confirmed by the occurrence of brown coal and numerous finds of fragments of fossil woods in the alluvium of ancient rivers.

The paleomagnetic data obtained from numerous sections of the Upper Permian of the east of East European Platform are also in full agreement with the paleoclimatic data. A group of paleomagnetologists, led by A.N. Khramov [5], have convincingly shown that at this time the shift of geographical parallels in the direction from the north-east to south-west prevailed here. Against the background of this displacement, the reverse movements of paleolatitudes were sometimes observed. A change in the position of the paleolatitudes corresponded to a certain tectonic regime of oscillatory movements on the platform. So, at the beginning of the Permian, the advance of paleolatitudes to the southwest was accompanied by the lowering of the platform. In the Kungur century, the movement of paleolatitudes reversed and coincided with a significant elevation of the territory. The beginning of the Kazan age was characterized by a shift in paleolatitudes again to the southwest, and significant
subsidence was noted in the movement of the platform. That led to the formation of a vast sea basin. At the boundary of the Kazan and Urzhum ages, the situation again reverses. The border of the arid zone moves to the northeast, and the platform is experiencing a new uplift. And finally, in the Severodvinsk age, the boundaries of the arid zone shifted to the southwest and occupy the same position. The central areas of the platform have been slightly lowered. That leads to the formation of a shallow but vast unleavened lake.

Thus, the position of paleolatitudes established by A.N. Khramov [5] for the Late Paleozoic sharply differed from the present. The virtual geomagnetic pole was located at that time in the northwestern part of the Pacific Ocean (Fig.1). And the east of the East European platform was mainly between paleomagnetic latitudes 30° and 10° (in the arid climate zone), periodically shifting relative to them by an average of 9° - 10° in the south-west and north-east directions.

**Figure 1.** Palaeomagnetic map of east Russian platform (1 - palaeomagnetic latitude and palaemagnetic longitude in the point of observation, 1a - data of A.N. Khramov [5], 1b - data of B.V. Burov and U.P. Balabanov (1998) [9]; 2 - palaeomagnetic latitude for late Permian)
Paleomagnetic studies in the east part of the East European platform were continued by researchers from Kazan University. A detailed study of the reference sections of the Upper Permian and Lower Triassic showed that over the period from Urzhum to the Early Triassic time, the virtual geomagnetic pole shifted more than 10° to the north. This shift was also reflected in the paleolatitude position of the studied territory. Paleolatitudes were directed from northwest to southeast at an angle of 50°-55° to modern parallels at the end of the Biarmian and Tatarian and about 40° in the Early Triassic time, and the territory itself was located in the late Permian time between 20° and 30° north latitude, and in the Early Triassic - between 30° and 40° [9] (Fig. 2).

Figure 2. Palaeomagnetic latitude direction and location of ancient geomagnetic pole for $P_3t$ and $T_1$ epochs

According to the results of Rb-Sr and Sm-Nd isotope dating, the age of these basalts is 250 Ma. It timed to the boundary of the Permian and Triassic [1]. At that time, the virtual geomagnetic pole was located in the western part of the Pacific Ocean, off the eastern coast of Honshu Island, and the studied basalts were located at paleolatitude 30°. Based on these data, the east of the East European platform should be located between paleolatitudes of 20° and 30°. It should also be noted that a characteristic feature of
the clay formations of the Lower Triassic and the formations of the terminal Permian, is the wide development of soil horizons in them. That indicates a significant humidization of the climate in this time in this territory.

4. Conclusions

Thus, one of the factors of Perm lithogenesis and related processes of formation of ore and nonmetallic minerals can be global climatic changes caused by Permian coal-glaciation. This led to the regular formation of monoclimatic deposits and associated minerals. The paragenesis of coal formation and mineralization of copper, due to climatic factors, can be used to predict and search for coal and some types of ore deposits. Zones of ancient paralytic coal formation near hot and arid climatic zones can be attributed to areas favorable for the search for sedimentary deposits of copper. The spatio-temporal association of monoclimatic geological formations and associated mineral complexes is the subject of special predictive mineralogical studies based on paleogeographic reconstructions.

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