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Magnetic Stratigraphy of the Ordovician in the Lower Reach of the Kotuy River: the Age of the Bysy-Yuryakh Stratum and the Rate of Geomagnetic Reversals on the Eve of the Superchron

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Abstract—Until recently, the existing data prevented the geophysicists from accurately dating the Bysy-Yuryakh stratum, which outcrops in the middle reach of the Kotuy River, constraining the time of its formation to a wide interval from the end of the Late Cambrian to the beginning of the Silurian. The obtained paleomagnetic data unambiguously correlate the Bysy-Yuryakh stratum to the Nyaian regional stage and constrain its formation, at least a considerable part of it, by the Tremadocian. This result perfectly agrees with the data on the Bysy-Yuryakh conodonts studied in this work and yields a spectacular example of the successful application of paleomagnetic studies in solving important tasks of stratigraphy and, correspondingly, petroleum geology. Within the Bysy-Yuryakh stratum, we revealed a large normal-polarity interval corresponding to the long (>1 Ma) period when the geomagnetic reversals were absent. This result, in combination with the data for the Tremadocian and Middle–Upper Cambrian sequences of the other regions, indicates that (1) the rate of occurrence of the geomagnetic reversals on the eve of the Ordovician Moyero superchron of reversed polarity was at most one reversal per Ma; (2) the superchron does not switch on instantaneously but is preceded by a certain gradual change in the operation conditions of the dynamo mechanism which, inter alia, manifests itself by the reduction of the frequency of geomagnetic reversals with the approach of the superchron. This finding supports the views according to which a process preparing the establishment of the superchrons takes place at the core–mantle boundary.

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INTRODUCTION

One of the most topical tasks in the studies of the evolution of the geomagnetic field lies in obtaining the information about the time changes in the rate of geomagnetic reversals with the approach of a superchron. The gradual reduction in the reversal rate is interpreted as an indication that somewhere in the Earth's interior, probably at the core–mantle boundary, a certain process takes place leading to the gradual change in the generation conditions of the magnetic field in the outer core (Courtillot and Besse, 1987; Larson and Olson, 1991; Courtillot and Olson, 2007; Olson et al., 2013; Biggin et al., 2012). In contrast, a sharp shutdown of the reversals is understood as a manifestation of the stochastic nonlinear nature of the geodynamo and as evidence that a process preparing the arrival of the superchron is absent (Hulot and Gallet, 2003; Aubert et al., 2009). The fact of a protracted reduction in the frequency of reversals on approaching (from the past) the most explored—Cretaceous—superchron had not been doubted (e.g., see (McFadden and Merril, 1996)) until this conclusion was challenged and interpreted as an artifact by (Gallet and Hulot, 1997). (Strictly speaking, they did not fully reject the possibility of the existence of a process that prepared the superchron. They only constrained the duration of this process by an order of magnitude shorter compared to the previous researchers).

In the ensuing controversy (McFadden and Merril, 2000), a certain intermediate period was chosen by the work (Constabe, 2000), where it was shown that the existing data were insufficient for selecting, with due strictness, which of the alternative standpoints was correct. It has become clear that to resolve this ques-