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Native iron in Quaternary deposits of the Darhad Basin (*northern Mongolia*)

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Abstract

Quaternary sediments from the borehole DBC-1 drilled in the Darhad Basin, northern Mongolia, have been studied by thermomagnetic analysis (248 samples) and probe microanalysis (9 samples) to determine the origin (cosmic or terrestrial) of native iron. Most of the samples showed extremely low contents of native iron. Only 26 samples have iron in contents sufficient for its reliable identification (10^{-5}–10^{-3}%). The negligible content of native iron in the Darhad Basin sediments distinguishes them from the earlier studied sediments of different geologic associations of Eurasia and the Atlantic, which we explain by the high sedimentation rate in this basin. However, the bimodal distribution of native-iron contents in the samples with a distinct "zero" mode, similar to that in the objects of Eurasia and the Atlantic, testifies to the predominantly cosmic origin of the native iron.

Keywords: native iron; magnetic minerals; thermomagnetic analysis; probe microanalysis; Quaternary deposits; Darhad Basin

Introduction

Particles of native iron are often found in sedimentary rocks. Native iron in deep-water ocean sediments and manganese concretions is usually considered to be of cosmic origin (Brownlee, 1985; Fredriksson and Martin, 1963; Murray and Renard, 1891; Parkin et al., 1980). However, many sediments contain iron particles related to volcanic activity, bacterial activity, and metamorphism (Frost, 1985; Lukin, 2006; Novgorodova, 1994; Shterenberg and Vasil'eva, 1979). Therefore, it is important to find signs of difference between native iron of cosmic and terrestrial origin.

In recent years, we have studied the abundance and composition of native iron particles in epicontinental sediments of different ages (Miocene, Oligocene, Eocene, Cretaceous, Late Jurassic, and Early Cambrian) in different regions of Eurasia, in the Atlantic sediments, and in the Upper Miocene sediments of Lake Baikal (Grachev et al., 2009; Pechersky et al., 2008a,b, 2011, 2013a,b; Pechersky and Sharonova, 2012).

The content and composition of native iron particles were studied by thermomagnetic analysis (TMA) with heating to 800 ºC and by probe microanalysis (PMA). The goal of this work was to perform TMA and PMA of such particles in the lacustrine sediments of the Darhad Basin, northern Mongolia (Fig. 1), in order to find signs of their cosmic or terrestrial origin.

The object of study

The highland Darhad Basin is located in northern Mongolia, in the southwest of the Baikal Rift Zone (Fig. 1). In contrast to nearby deep-water Lake Baikal and Lake Hövsgöl, the Darhad Basin is totally filled with sediments up to 500 m in thickness (Zorin et al., 1989). This is due to the active removal of clastics from the surrounding mountains. Moreover, the Darhad Basin repeatedly became a lake as a result

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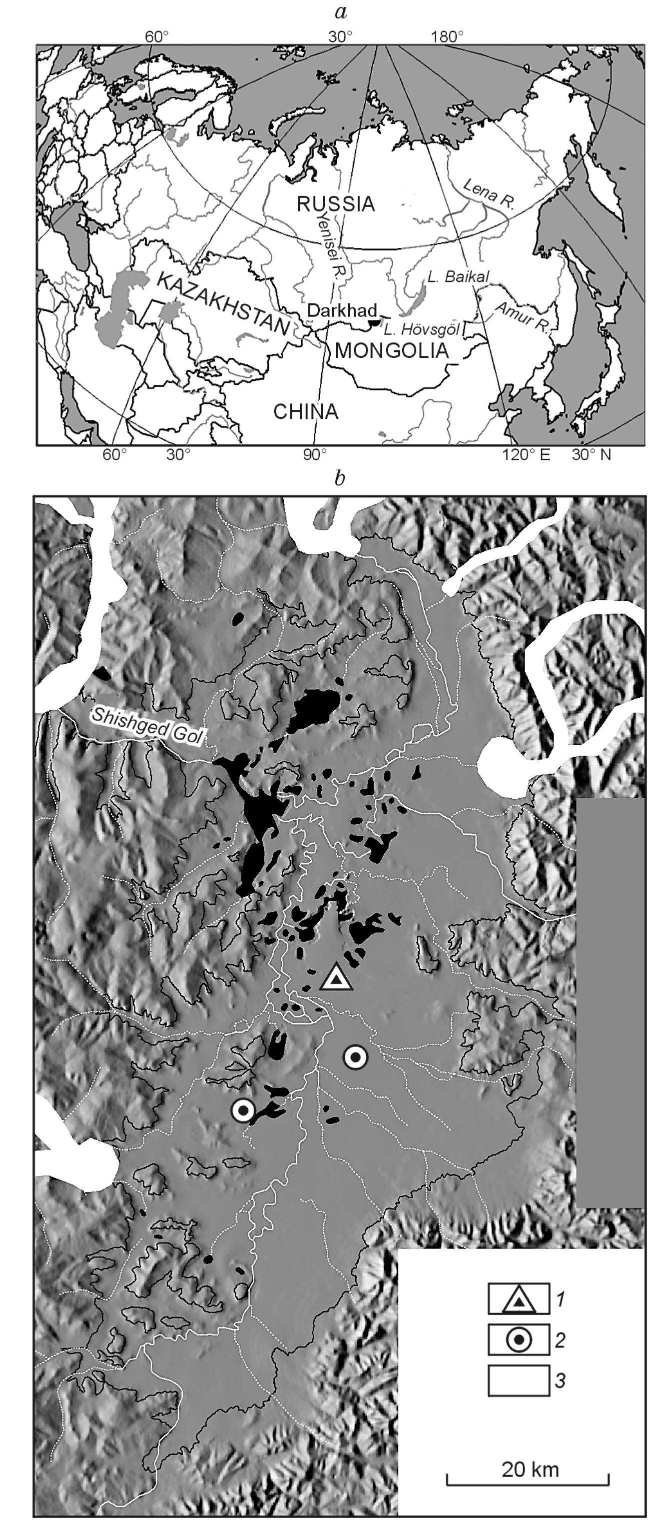

Fig. 1. Sketch map (*a*); Darhad Basin (digital relief model SRTM) (*b*). *1*, borehole DBC-1 drilled in 2004; *2*, boreholes drilled in 1965–1966 (Uflyand et al., 1971); *3*, Late Pleistocene glaciers (at the top left, the glacier damming the Shishged Gol valley—glacial dam of paleolake Darhad).

of basaltic, glacial, and sedimentary dams. The lake formation stages took place in the Pliocene–Quaternary. The last dammed lake existed in the Late Pleistocene–Holocene (Gillespie et al., 2008; Krivonogov et al., 2005, 2012; Uflyand et al., 1971). The intricate history of the basin determined the complex structure of its sedimentary filling.

We studied sediments stripped by the borehole DBC-1 at a depth of 92.6 m in 2004 (Batbaatar et al., 2008; Krivonogov et al., 2007, 2008, 2012). Three lithologic units are recognized below a 1.5 m thick bed of Holocene cover mixtites in the borehole: upper, middle, and lower. The upper unit (depth 1.5–31.8 m) is composed of gray siltstones with a banded lamination, which accumulated in the glacial-dammed lake. The middle unit (31.8–51.6 m) is also gray-colored but more diverse in composition; it has many sand beds and reflects alternation of subaqueous and subaerial environments. The lower unit (51.6–92.6 m) consists of greenish layers of sandy silt with wavy lamination. These beds are enriched in fine peat organic matter and contain mollusk and ostracode shells. The core also includes three sand beds at depths of 8.2–9.4, 41.4–46.7, and 75.9–77.5 m, which accumulated in nearshore-lake or river environments. According to lithology, the upper unit might be a more or less continuous sediment sequence, and the middle and lower units might have stratigraphic gaps.

The direct magnetization of sediments and luminescence and radiocarbon dates testify to their Pleistocene age (Krivonogov et al., 2012), though the age models based on paleomagnetic and radiometric data differ considerably (Fig. 2). This contradiction is still unsolved.

Paleomagnetic data

A paleomagnetic age model of sedimentation in the Darhad Basin (Krivonogov et al., 2012) (Fig. 2) was constructed by juxtaposing the intervals with anomalous magnetic inclination with the minimum virtual dipole moment (VDM) on the reference curve (Channell et al., 2009; Petrova, 2002; Pospelova, 2004). The following paleomagnetic excursions have been identified: Mono, Kargapolovo/Lashamp, Blake II, and Blake I. We ignored the minor time gap between the true age of sediments and the record of their paleomagnetic excursion, caused by the delayed recording of orientational magnetization in the semiliquid sediment. Identification of excursions below a depth of 50 m is difficult because of assumed stratigraphic gaps; therefore, we ignored them in the age model. Thus, the used model determines the probable age of the upper unit, i.e., the sediments of paleolake Darhad, and the upper part of the middle unit (Fig. 2). On the age plot, all points are approximated by a straight line (R^2 = 0.99). This suggests that the upper 50 m of the Darhad Basin sediments accumulated in the last 120 kyr. The sedimentation proceeded mainly regularly, with a high rate, ~36 cm/kyr.

Investigation technique

Thermomagnetic analysis (TMA) was carried out in the Paleomagnetic Laboratory of the Geological Department of Kazan State University, using Curie express balance (Burov et al., 1986). It included measurement of the specific magneti-