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Thermomagnetic analysis of native iron from the upper sedimentary horizons of Lake Baikal, section GC-99 (*Posolskaya Bank*)

D.M. Pechersky [a], D.M. Kuzina [b], E.V. Ivanov [c,*], M.I. Kuz'min [c], D.K. Nurgaliev [b], V.A. Tsel'movich [a]

[a] *Shmidt Institute of Physics of the Earth, Russian Academy of Sciences, ul. Bol'shaya Gruzinskaya 10, Moscow, 123995, Russia*
[b] *Kazan Federal University, ul. Kremlevskaya 18, Kazan, 420008, Russia*
[c] *Vinogradov Institute of Geochemistry, ul. Favorskogo 1a, Irkutsk, 664033, Russia*

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Abstract

We present results of a thermomagnetic analysis of Late Pleistocene–Holocene bottom sediments from the gravity core GC-99 of the borehole BDP-99 drilled at Posolskaya Bank of Lake Baikal in the framework of the Baikal Drilling Project. The results are compared with the earlier analytical data on the samples from the lower (Miocene) section of the BDP-98 drilled on the Akademichesky Ridge. Native-iron particles were found in only 14 of 61 samples. Their content varies from ~10^{-5} to 10^{-4}%, and their distribution is near-bimodal, with a distinct "zero" mode. The results of the thermomagnetic analysis are confirmed by a probe microanalysis: Only occasional native-iron particles were found. Nickel was detected in only one sample. The samples have a large number of magnetite and titanomagnetite grains. It is shown that the distribution of native-iron particles in the Baikal sediments depends on the rate of sedimentation: The rate increase is accompanied by the increase in the number of the "zero" group samples (free of iron particles). The conclusion is drawn that the native-iron particles in the studied sediments are predominantly of cosmic origin.

Keywords: native iron; magnetic minerals; thermomagnetic analysis; probe microanalysis; Late Pleistocene–Holocene sediments; Lake Baikal

Introduction

In recent years, we have collected voluminous data on native iron present in epicontinental sediments of different ages (from Cenozoic to Cambrian) in different regions of Eurasia, in the Northwest Atlantic sediments, and in the lacustrine sediments of Baikal (East Siberia) and the Darhad Basin (Mongolia). The content and composition of native-iron particles in the sediments were studied by thermomagnetic analysis (TMA) (up to 800 ºC) and probe microanalysis (PMA) (Grachev et al., 2009; Pechersky et al., 2008, 2011, 2013a,b,c). The main results of the previous studies are as follows. In epicontinental and oceanic sediments, native-iron microparticles are present in low contents (seldom exceeding 0.001%). Usually, these contents show no correlation with the sediment lithology and with the content of terrestrial Fe-minerals (magnetite, iron hydroxides, etc.). This argues for the predominantly cosmic origin of native-iron particles, and their ubiquitous occurrence testifies to their relationship with cosmic dust. The results of TMA (Pechersky et al., 2013a) and PMA of the Upper Miocene Baikal sediments revealed the main regularity: a bimodal distribution of native-iron particles and a predominance of the "zero" group samples, i.e., lacking iron particles. The "zero" group samples amount to 30–40% in the earlier studied epicontinental and oceanic sediments (Pechersky et al., 2011, 2012, 2013c) and 93% in the lower section of the Baikal sediments (Pechersky et al., 2013a). This can be explained by the high rate of sedimentation and, correspondingly, the inverse dependence of accumulation of metallic iron on it, which testifies to the cosmic origin of the native-iron particles in the studied Baikal sediments (Pechersky and Sharonova, 2013). The above regularity is due to the limited amount of cosmic dust settling on the Earth's surface. According to PMA, the Baikal sediments of the Akademichesky Ridge contain both pure native-iron particles and ones with Si and Cr impurities but free of Ni impurity.

In this work we study native-iron particles in the Quaternary sediments at Posolskaya Bank of Lake Baikal. They accumulated in a deep-water basin, in contrast to the earlier

* Corresponding author.
E-mail address: eivanov@igc.irk.ru (E.V. Ivanov)

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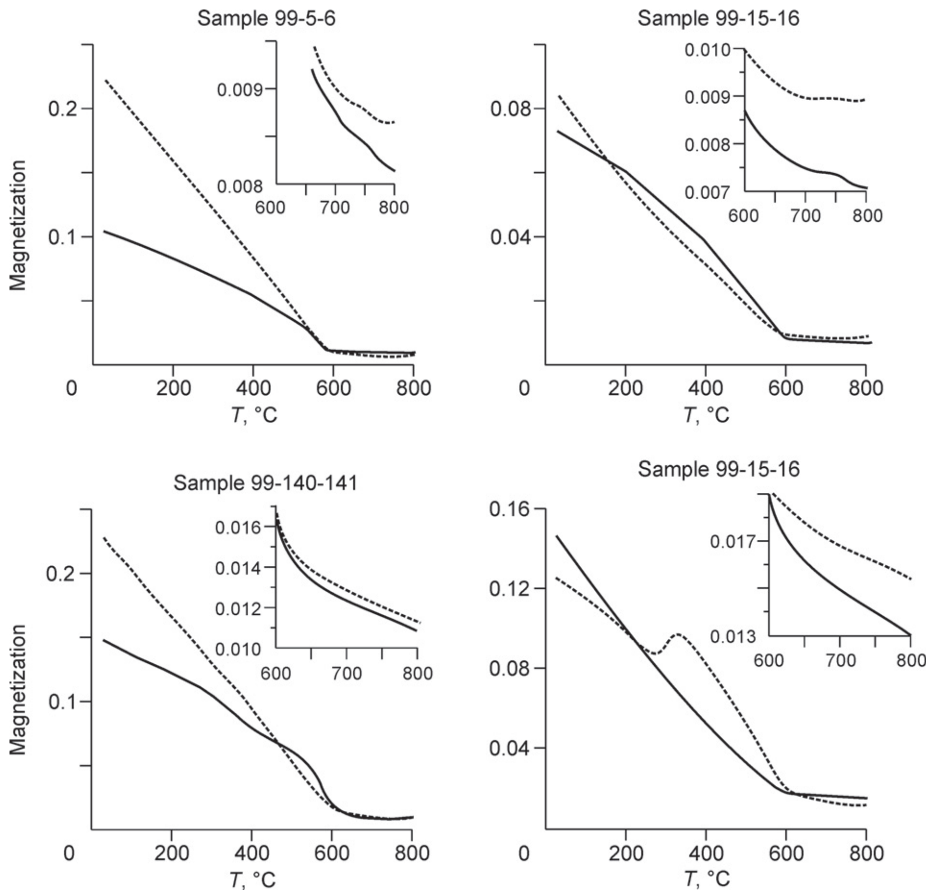

Fig. 1. Results of TMA of the samples. Insets show vertically magnified M(T) curves in the range 600–800 ºC.

studied lower (Miocene) section of BDP-98, where the sediments formed in the paleodelta of the Barguzin River.

The object of study

We studied 61 samples of Late Pleistocene–Holocene bottom sediments from the gravity core GC-99 of the deep-water borehole BDP-99 drilled at Posolskaya Bank in the framework of the Baikal Drilling International Project in 1999. Posolskaya Bank is the southern end of the Selenga–Buguldeika isthmus separating South Baikal from Central Baikal. The 3 m thick section is formed by biogenic terrigenous ooze rich in diatom remains (up to 25–27%) to a depth of 80 cm and by glacial-lake clays with minor diatoms (~3%). According to the SiO_{2bio} (biogenic silica) distribution pattern (Fig. 2), the Pleistocene–Holocene boundary passes at a distance of 80 cm from the sediment surface, because diatom ooze was deposited in warm interglacials, and clays, in cold glaciations (Baikal..., 2000; Kuz'min et al., 2001). Thus, the rate of sedimentation of the upper section is estimated at ~8 cm/kyr, which is consistent with the average rates of sedimentation in the earlier examined depth range of the BDP-98 core (Pechersky et al., 2013a). As seen from the SiO_{2bio} distribution pattern, the SiO_{2bio} content in the 100–300 cm thick clay section (especially in its lower part) does not increase (≤5%). This indicates that the section does not reach the Karginian warming level and the sediments are no older than 25 ka. The estimated rate of sedimentation in the depth range 100–300 cm is ~12 cm/kyr.

Thermomagnetic analysis and probe microanalysis

The main method of study of the samples is thermomagnetic analysis (TMA). It was carried out on a ~50 mg sample in the Laboratory of Rock Paleomagnetism and Magnetism at the Institute of Geology and Petroleum Technologies of Kazan State University, using Curie express balance (Burov et al., 1986). The TMA included measurement of the specific magnetization of the samples in the magnetic field of 500 mT at room temperature (M_{20}) and its temperature dependence. The heating rate was 100 ºC/min. The obtained thermomagnetic curves were used to determine the Curie points (T_c) of magnetic minerals in the samples and the character of the material change on heating, which permits the mineral identification. To evaluate the content of magnetic mineral in the sample, a Q-type thermomagnetic curve was constructed from each Curie point to room temperature. The difference between the magnetization at room temperature and the initial magnetization of the sample is the saturation magnetization of the