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Iron sulfides in the lacustrine sediments of North-East Russia

Pavel S. Minyuk[1] , Dasha K. Pozhidaeva

[1] North-Eastern Integrated Research Institute named after N.A. Shilo of the Far Eastern Branch of the Russian Academy of Sciences

minyuk@neisri.ru

Iron sulfides are widespread minerals in lake sediments. They are often indicators of anoxic environments. The formation of sulfides can occur directly in the water column, as well as during diagenesis, due to the redistribution of iron and sulfur in sediments. The most common mineral is pyrite (FeS_2). Pyrite is a paramagnetic mineral and does not significantly affect the magnetic properties of sediments. Among magnetic minerals, greigite (Fe_3S_4) is often found, pyrrhotite (Fe1-xS) is rarely noted [1, 2]. Sulfides are numerous in the sediments of glacial lakes of the North-East of Russia. They are a mineral component of the therapeutic mud of the Talaya group of lakes. Magnetic iron sulfides formed during diagenesis distort the “primary” magnetic signal of sediments, in particular, make it difficult to determine secular variations of the geomagnetic field. These minerals were studied in Gryazevoe (61°08'21" N, 152°19'57" E), Nalimnoe (61°07'41" N, 152°20'8" E), Sosednee (62°03'29" N, 149°31'22" E), Vodorazdel’noe (63°44'8" N, 148°13'4" E), Sapog (63°29'9" N, 147°50'41" E), Chernoe (59°31'56" N, 147°23'07" E) lakes. Most lakes were formed at the end of the Late Pleistocene or at the beginning of the Early Holocene. The sediments are composed mainly of detrital and/or organogenic detrital silts.

The sulfides were studied using optical, mineralogical, and thermomagnetic methods. Heavy and magnetic fractions, smear slides, and sediments were studied. Hysteresis characteristics were determined for individual samples. Studies of the elemental composition of sulfides were carried out on an EVO-50 scanning electron microscope with Bruker AXS XFlash energy dispersion spectrometers and the Quantax Esprite 1.9 X-ray microanalysis system, as well as on a Camebax microanalyzer with an X-Max energy dispersion detector.

Iron sulfides of the studied lake sediments s are mainly in the form of framboids. In transmitted light they look like opaque spheres of various sizes. Framboids are often destroyed to a dark dusty mass (individual crystals). Sometimes sulfide minerals fill the diatom valves.

The composition of sulfide formations is not homogeneous. According to energy dispersion X-ray spectroscopy (EDS), the spherules consist mainly of iron and sulfur. The framboids of pyrite composition are most numerous. The ratio of Fe (wt %)/S (wt %) is about 0.9. The size of the spheres varies from several to 48 mm. The sediments of Gryazevoe lake are dominated by framboids 20-30 mm (up to 48 mm), Nalimnoe – (10-20 mm), Sosednee (up to 20 mm), Vodorazdel’noe – 20-30 (up to 48 mm), Sapog – (20-30 mm), Chernoe – up to 35 mm.

Greigite is found in the sediments of Gryazevoe, Sapog, Vodorazdel’noe, Sosednee, Nalimnoe lakes. The magnetic particles are single domain, the ratio of Fe (wt. %)/S (wt.%) is about 1.1-1.3. On the thermomagnetic curves resulted from heating, there is a significant decrease in MS and Ji around 400°C. The characteristic growth of MS during heating, possibly associated with iron hydroxides or Hopkinson peak of greigite, begins at a temperature of about 200°C. Pyrrhotite were found in the sediments of the Sosednee, Gryazevoe, and Sapog lakes. They often have a needle-like structure. According to EDS data, the Fe/S ratio is about 1.5. Curie points according to TMA data are about 320°C.

Many grains of magnetic fractions from sediments contain high iron content, but low sulfur content. The Fe/S ratio is over 1.5, often above 2. It is difficult to diagnose iron sulfides by thermomagnetic methods, since the magnetic fractions are polymineral and even in one sample may contain the entire set of sulfides. The interlayers with magnetic sulfides show high values of MS, Jrs, Js, and a low content of the paramagnetic component.

[1] Roberts A.P., Earth-Science Reviews 151(2015) 1.

[2] Roberts A.P., Chang L.A., Rowan C.J., Horng C.S., Florindo F., Reviews of Geophysics 49(2011) RG1002.