

## Transition of a pyrrhotites to antiferromagnetic state induced by cation vacancies

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Pyrrhotites have the NiAs crystal structure in which a fraction of cation sites is unoccupied. The temperature ( $T_0$ ) at which the total magnetic moment of the two sublattices is zero (antiferromagnetic) depends on the chemical composition. It can change from 558 K ( $\text{Fe}_{10}\text{S}_{11}$ ) to 593 K ( $\text{Fe}_7\text{S}_8$ ). Accordingly, concentration of vacancy: from 9.1% to 12.5 %.

There was studied the dependence of the magnetization on the temperature of the pyrrhotite samples after being synthesized at 1273 K. The synthetic pyrrhotites were investigated with a thermoballistic apparatus in a field of  $10^6/4\pi$  A/m. The phase and chemical composition was monitored by using the methods of X-ray diffraction (XRD).

The influence of concentration vacancies on the temperature to transition of the pyrrhotites to the antiferromagnetic state was considered on the basis of calculating the magnetic moment of the two sublattices using the molecular field method. Integral of the exchange interaction:  $J_{11} = 6.55 \cdot 10^{-21}$  joules;  $J_{22} = 5.21 \cdot 10^{-21}$  joules,  $J_{12} = J_{21} = 6.52 \cdot 10^{-21}$  joules. For pyrrhotites ( $\text{Fe}_{10}\text{S}_{11}$ -  $\text{Fe}_7\text{S}_8$ ) the Neel point  $T_N = 593$  K (pyrrhotites transition temperature to the paramagnetic state).

samples temperature	Concentration of cation vacancies, %				
	9.1	9.9	10.7	11.6	12.5
$T_0$ , K	¶548	¶568	¶578	¶588	¶593
	#558	#578	#588	#593	#593
Specific magnetization of the samples; $\sigma \cdot 10^{-7}$ , T $\cdot$ m <sup>3</sup> /kg					
T = 293 K	#13.70	#14.91	#16.26	#17.84	#19.05
¶ as calculated; # the experimental data					

**Table 1.** Temperature to transition of pyrrhotites to the antiferromagnetic state (if the inequality  $T_0 < T_N$ ).

As it is shown in the table, tendency to decreasing of temperature to transition pyrrhotites to the antiferromagnetic state with increasing concentration of cation vacancies is observed both experimental data and the theoretical calculation results.

## Zeolitization of aluminosilicate waste materials in soil as a tool for soil remediation

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Zeolites are largely used in soil remediation technologies by exploiting their well-known high cation exchange capacity. Beside this property, zeolites possess large pores and internal cavities. Such pores can be used to trap scarcely soluble heavy metal (HM) precipitates, thus chemically reducing their solubility and physically isolating the contaminant at the microscopic level.

Zeolite synthesis can be easily promoted in soil at low temperatures by adding Si- and Al-containing materials in alkaline conditions. As a consequence of this process HM are stabilized as micro or nano clusters of oxides and hydroxides trapped inside the structure of crystalline zeolites or physically and chemically immobilized by amorphous 'geopolymers' [1-4].

In this process, waste materials such as coal fly ash, blast furnace slag, building wastes, glass and aluminum refuses can be profitably employed, together with cheap alkali reagents (e.g. NaOH, KOH, lime).

The process has been successfully applied to Cu [2], Cd [4], Ni [5] and Cr(VI) polluted soils.

Promoting zeolite synthesis in soil can be a promising methodology to effectively stabilize HM in polluted sites, especially in combination with other physico-chemical or biological remediation processes.

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- [2] Terzano *et al.* (2005) *Environ Sci Technol* **39**, 6280–6287.
- [3] Terzano *et al.* (2006) *Appl. Geochem.* **21**, 993–1005.
- [4] Terzano *et al.* (2007) *Appl. Clay Sci.* **35**, 128–138.
- [5] Belviso *et al.* (2010) *Chemosphere* **78**, 1172–1176.