

## Unusually large shift in low-temperature susceptibility peak of $\text{Fe}_{2.8}\text{Ti}_{0.2}\text{O}_4$ with frequency

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**Abstract.** The temperature dependence of magnetic susceptibility,  $\chi$ , of titanomagnetites ( $\text{Fe}_{3-x}\text{Ti}_x\text{O}_4$ ,  $0 \leq x \leq 0.2$ ) at different frequencies in the range of 13 Hz to 117 kHz is reported. Whereas the position of the  $\chi$ -peak of  $\text{Fe}_3\text{O}_4$  at 120 K shows no significant shift over this frequency range, that of  $\text{Fe}_{2.8}\text{Ti}_{0.2}\text{O}_4$  shifts from 70 K at 13 Hz to 115 K at 117 kHz. This seems to be the first observation of such large shift in the position of a  $\chi$ -peak with frequency reported for any magnetic material. Generally, for ferrites, a  $\chi$ -peak observed at low-temperatures is attributed to the occurrence of an isotropic point (temperature at which first order anisotropy constant  $K_1 = 0$ ) associated with change in crystal structure. In such a case a shift in  $\chi$ -peak with frequency is not expected normally. Thus, the observed large shift in the position of  $\chi$ -peak with frequency is an unusual phenomenon and some of its repercussions are discussed.

**Keywords.** Titanomagnetites; magnetic susceptibility; anisotropy constant; isotropic point.

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### 1. Introduction

The behaviour of magnetic materials is somewhat different when studied in low and high magnetic fields. Low field parameters, such as permeability ( $\mu$ ) or susceptibility ( $\chi$ ) are usually determined using AC techniques and generally at low frequencies (11 to 350 Hz). The results at such frequencies are presumed to be the same as those from DC methods. In the present context, one of the major features seen in the low field susceptibility of ferrites, particularly in magnetite ( $\text{Fe}_3\text{O}_4$ ) is the occurrence of a peak attributed to the isotropic point of the material. Magnetite is cubic (inverse spinel) at room temperature and changes to orthorhombic structure below 119 K. The first order crystalline anisotropy constant,  $K_1$ , of magnetite is  $-1.10 \times 10^5$  erg/cc at 293 K (Bickford 1950) and it attains a value of  $+1.65 \times 10^6$  at 77 K (Bonstrom *et al* 1961), crossing zero value at 119 K, the isotropic point. At low frequencies a  $\chi$ -peak of magnetite has been observed (Radhakrishnamurty *et al* 1981) at  $\sim 120$  K, as expected. A small variation (about 10 K) in this value seems to occur with frequency, if all the reported results are carefully scrutinized and reinterpreted. For example, the  $\chi$ -peak in the present study is at 13 Hz at 120 K, while the  $\mu$ -peak has been reported to be at 130 K at 16 GHz (Bickford 1950). Such data are rare in the range from 10 Hz to 100 kHz for ferrites and rarer still are the studies on temperature dependence at low frequencies, though such investigations at frequencies  $> 1$  MHz and above reaching up to GHz ranges are more common due to application aspects or ferromagnetic