KINETICS OF TETRATAENITE DISORDERING

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Tetrataenite is a chemically ordered $L1_0$-type $Fe_{50}Ni_{50}$ alloy detected for the first time by ^{57}Fe Mössbauer studies in iron meteorites [1]. Because tetrataenite has very high coercivity compared to other FeNi metallic minerals found in meteorites, its presence has been recently shown to be a proxy to the thermal history of meteorites [2]. In particular, it is a sensitive tracer of transient secondary thermal events, like those associated with impacts, that leads to disordering of tetrataenite into taenite. However, in the absence of data about the time-temperature conditions necessary to disorder tetrataenite, it is currently impossible to interpret quantitatively such observations. Several works show that thermomagnetic curves for tetrataenite are essentially flat in a temperature range below 500 °C, and drop sharply at ~ 550 °C (*the apparent Curie point*), although no information was provided about the heating rate [3]. At the apparent Curie point disordering takes place and tetrataenite is transformed into taenite. Even works dealing with different techniques give no explicit information about time-dependence of disordering [4]. Thus, in order to gain insights related to the disordering kinetics of tetrataenite, we present preliminary results concerning time-temperature experiments for tetrataenite disordering, using Santa Catharina meteorite as a starting material, and magnetic properties as a proxy to the ordered state.

Santa Catharina meteorite is known to contain about 50% tetrataenite [5]. Samples of about 5 mg were annealed in air, at temperatures in the 300 to 600 °C range. Annealing was carried out in several cycles ranging from 3 min to more than a month, followed by cooling to room temperature. Before and after each annealing step hysteresis properties were measured. These properties, in particular the coercivity of remanence (B_{CR}) are sensitive proxies to the presence and disappearance of tetrataenite. At annealing temperatures below the chemical order-disorder transition temperature (~ 320 °C, [6]), no changes in magnetic properties were observed. Indeed, our results show that B_{CR} remains constant after annealing experiments at 300 °C for over 6 days, indicating that magnetocrystalline anisotropy responsible for the high coercivity of tetrataenite is stable. Nevertheless, ~ 30 days are necessary at 400 °C to decrease B_{CR} by about 50%, whereas annealing at 550 °C and 600 °C for ~ 10 min and ~ 3 min leads to complete disordering (B_{CR} decreases by more than 90%). This data set allows proposing a quantitative time-temperature scenario to account for the disordering of tetrataenite observed in some meteorites. We show that tetrataenite disordering may take place at any temperature above the order-disorder transition for L_{10} superstructure phase when the appropriate time-scale is considered. This result means that the "apparent Curie point" for tetrataenite estimated in previous works is not an absolute property in the sense that any estimate of this parameter should be referred to a given time-scale.

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