Understanding chemical order/disorder transformations and their effects on structural and magnetic properties of ferrous L1₀ intermetallic systems has been a longstanding problem in materials science and solid state chemistry. Herein, the kinetics of ordering and disordering of the L1₀ structure in the FePd and FeNi systems will be explored in correlation with their magnetic and structural properties. In many systems, the chemically ordered L1₀ structure forms through a ordering transformation from a chemically disordered parent phase, which is often a face-centered cubic (fcc, A1) solid solution of the two elements (see unit cells of both structures in Figure 1). L1₀ FeNi (a.k.a. tetrataenite) is only found naturally in meteorites that form over 4.5 billion years; to date, it has not been produced in bulk by laboratory methods. The challenge for manufacturing L1₀ FeNi is that it has a critical temperature of 320 °C, below which the fcc chemically disordered phase transforms into the L1₀ chemically ordered phase [1]. Below this critical temperature, the atomic mobilities of Fe and Ni are extremely low (1 atomic jump per 2,600 years [2]) therefore the atomic movement necessary for chemical ordering is limited. On the other hand, the L1₀ structure forms readily in FePd making it a useful model system in which to study the order/disorder transformation [3] (it is noted, however, that the high cost of palladium makes FePd an impractical material for bulk industrial applications). In this dissertation, laboratory-synthesized L1₀ FePd was used as a test-bed system while a variety of meteorites were used as natural sources of L1₀-structured FeNi. The effect of the cooling rate on the A1→L1₀ chemical ordering transformation in FePd is investigated to elucidate the mechanism of chemical ordering. The effect of the heating rate on the L1₀→A1 chemical disordering transformation in FeNi is investigated to gain understanding of the phase’s stability and order/disorder transformation mechanism. Analysis of the magnetic properties of L1₀ FeNi and L1₀ FePd indicates that the materials have theoretical magnetic energy products comparable to those of today’s best permanent magnets; thus, results from this work may aid future synthesis efforts for advanced permanent magnet applications.

![Figure 1: Unit cells of binary alloy AB with (a) the chemically disordered fcc (A1) structure and (b) the chemically ordered L1₀ structure.](image)


