Influence of pressure on diffusion in iron sulfides

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Cosmochemical arguments and seismic observations coupled with mineral physics experiments indicate that sulfur may be present as a light alloying element in Earth's iron-nickel core. The presence of sulfur may have a significant influence on the core's deformation behavior, which is likely controlled by diffusion. Understanding the effects of high pressure on diffusion in iron-sulfide minerals is critical to interpreting geophysical data and modeling deformation in order to better understand the core's structure and dynamics. In this study, we made measurements of iron self-diffusion in FeS (troilite) and Fe_3S_2 at high pressure. Diffusion couples consisting of either Fe and FeS_2 (pyrite) or Fe and FeS were compressed in a Walker-type multi-anvil press to pressures of 7-20 GPa, and annealed at 1073 K for 1 – 6 hours to form FeS and Fe_3S_2 layers, respectively. Electron probe microanalysis (EPMA) was used to obtain diffusion profiles by measuring iron and sulfur concentrations through the reactant sulfide phase. The width of the reaction layer at a given pressure was found to be proportional to the square root of time, consistent with diffusion-controlled growth. We modeled the measured growth rates to determine the concentration-dependent Fe diffusion coefficient, and we find that the logarithm of the diffusion coefficient decreases linearly with pressure. We find no obvious effect of the pressure-induced Fe^{2+} spin transition at 6-7 GPa on the diffusivity.