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Melting and phase relations in the Fe-C-S-O system at high pressure and temperature

Yingwei Fei
Carnegie Institution of Washington, Geophysical Laboratory, Washington, United States (y.fei@gl.ciw.edu)

The physical state of the core (liquid outer core and solid inner core) could provide tight constraint on the core temperature if melting temperature of core materials is precisely determined at high pressure. On the other hand, the density of the Earth's core is significantly lower than that of pure iron measured experimentally at high pressure and temperature. The density deficit in the core (both liquid outer core and solid inner core) provides inside into the chemistry of the core, suggesting that the core must contain several weight percent of one or more light elements (lighter than iron) in addition to Fe-Ni alloy. Sulfur (S), carbon (C), and oxygen (O) are the prominent candidates among the proposed light elements, because of their high solar abundance and strong chemical affinity for Fe. Determining the effect of pressure on melting relations in the Fe-S, Fe-C, and Fe-O binary systems and multi-component system is crucial for understanding the chemistry, temperature, and evolution of planetary cores. There has been significant progress in determining the melting relations in the system Fe-FeS at high pressure, using multi-anvil apparatus and laser-heating diamond-anvil cell. These studies have revealed new iron-sulfur compounds (Fe3S2, Fe2S, and Fe3S) stable at high pressures, change of melting relations, and pressure effect on eutectic temperature and composition. The behaviors of the Fe-C and Fe-O systems have also been experimentally investigated recently. Experimental data in the Fe-C-S-O system at high pressure have just emerged. In parallel, there are high-quality data on density measurements of solid and liquid phases at high pressure and temperature. In this study, I present recent advances in experimental techniques and melting relations in the Fe-C-S-O system. The emphasis will be on the need to develop thermodynamic models by synthesis of thermochemical, thermophysical, and phase equilibrium data. The systematic approach provides a better understanding of the correlation between physical state and composition with different thermal models of the planetary cores.