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Viscosity of Fe-Ni-C Liquids at High Pressures

Bin Chen[1,2], Xiaojing Lai[1,2], Feng Zhu[3], Jiachao Liu[3], Yoshio Kono[4]

[1]Hawaii Institute of Geophysics and Planetology, University of Hawaii at Manoa, Honolulu, Hawaii, USA
[2]Department of Geology and Geophysics, University of Hawaii at Manoa, Honolulu, Hawaii, USA
[3]Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, Michigan, USA
[4]HPCAT, Advanced Photon Source, Argonne National Laboratory, Argonne, Illinois, USA

Understanding and modeling of planetary core processes such as the geodynamo and heat flow via convection in the outer core require knowledge on the viscosity of candidate liquid iron alloys. Certain light elements are found to have significant effects on the viscosity of liquid iron. *Nasch et al.* (1997) found that the viscosity of Fe-Ni-S is significantly larger than that of liquid iron, which was interpreted as due to the structural control of sulfur and formation of large, macro-molecular viscous flow units. Whether such effects are present in other Fe-light-element systems such as the Fe-Ni-C system under pressure is unclear. In this study, we performed viscosity measurements on the basis of the modified Stokes' floating sphere viscometry method for the Fe-Ni-C liquids at high pressures in a Paris-Edinburgh press at Sector 16 of the Advanced Photon Source, Argonne National Laboratory. Our results show that the addition of 3-5 wt.% carbon to iron-nickel liquids has insignificant effect on its viscosity at pressures lower than 5 GPa. But the viscosities become notably higher at 5-8 GPa, likely due to the liquid structural transition of the Fe-Ni-C liquids as revealed by our X-ray diffraction measurements. The observed correlation between structure and physical properties such as density, sound velocity, and viscosity of liquids will permit stringent benchmark test of the computational liquid models and contribute to a more comprehensive understanding of the behavior of liquids at high pressures and high temperatures. The new viscosity data of the Fe-Ni-C liquids will provide insights into the internal dynamics of planetary liquid outer cores.

References:

Nasch, P.M., Manghnani, M.H. & Secco, R.A., 1997. Anomalous Behavior of Sound Velocity and Attenuation in Liquid Fe-Ni-S. Science, 277(5323), pp.219–221.