How Can Analog Experiments Help Understand Core Segregation in Small Planetary Bodies?

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Core formation in small planetary bodies likely involves immiscible liquids (e.g. S- and C- rich iron alloys) percolation through pore spaces in a silicate medium. The manner in which this phenomenon occurs is not fully understood. Furthermore, it is unknown whether the metallic melts can physically segregate during percolation. To improve our understanding of core formation in small planetesimals, we performed analog experiments. We used an emulsion of oil and water to simulate an emulsion of S-rich and C-rich iron alloys, respectively. The experiments were performed in a Hele-Shaw cell, a thin "channel" made of two acrylic plates (51 cm x 1.3 cm x 15 cm) kept apart with a thin aluminum plate (0.27 mm). A U-shaped cut out of the aluminum plate forms the channel. We used a syringe pump to inject the emulsion into the channel through a hole in the top plate. We investigated the effect of injection rate and droplet size on the percolation behavior of the emulsion. We observed that droplet velocity was size dependent. The smallest droplet size detected was 0.0133 mm^2 with a velocity of 0.67 mm/s. Medium size droplets ranged from 0.03mm^2 – ~10 mm^2 with average velocity of ~0.43 mm/s. Furthermore, we observed that the larger droplets moved even faster: the largest droplet, with an area of 91.4 mm^2, had a velocity of 7.95 mm/s. We also tested the effects of percolation through a channel filled with polydisperse acrylic particles of diameter < 50 µm. When injected into the granular matrix, the oil formed a wetting front while the water advanced in "pulses". In conclusion, the size of the droplets affects their velocity and likely their ability to migrate through pore networks. The results suggest that immiscible liquids could potentially segregate due to different percolation efficiencies of the non-wetting/wetting phases. Consequently, this would affect the distribution of the metallic components within differentiated planetesimals.