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Mantle flow in planets: lessons from sugar syrup, hair gel, milk skin and marble cake.

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Even in the eon of supercomputers, I would claim that laboratory experiments remain an invaluable tool to investigate new phenomena and old problems, for at least 6 reasons: (1) Since they let nature solve the equations, they can explore new phenomena for which such equations do not yet exist. (2) You usually can turn around them and have a good look at their three-dimensional structure. (3) You can observe their evolution through time. (4) you can simplify the system until you understand something ! (5) On the other hand, experiments can explore ranges of parameters, or geometries, where the equations are too challenging to be solved analytically or even numerically. (6) They are at the same time fun and thought-provoking. So yes, laboratory experiments are crucial for exploring new physics, testing theories and computer codes, and show your students, colleagues and family « how it works ».
Mantle dynamics, and thermal convection, is a good example. The emergence of mantle convection models was dictated by the failure of static, conductive, and/or radiative thermal history models to account for the mantle temperature regime, the Earth's energy budget, and the Earth's lateral surface motions. Convection, which transports heat by material flow, is the only other physical mechanism capable of explaining these observations. The force driving flow is gravity, whereby material lighter than its environment rises, while denser material sinks. Such density anomalies can be produced by differences in composition and/or temperature. Then, the flow patterns produced by convection also strongly depend on the way the material deforms when submitted to a force: cold surface rocks break (typical of a solid) on short time scale and distances, while hot mantle rocks creep (typical of a liquid !) on geological time scales. This dual nature of a solid and a liquid is the main source of complexity, and debate, in mantle dynamics. Modern physics calls these solid-liquid materials « soft matter », and we use plenty of them in the everyday life and in the kitchen. I will show how differently mantle plumes and lithospheric plates form in honey syrup, hair gel, milk and cake. And how marble cake can help us understand mantle mixing.