Convection in a silica colloidal dispersion dried from above: the importance of skin formation and foundering

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The rheological behavior of silica colloidal dispersions varies from purely viscous to elasto-visco-plastic to brittle when their water content decreases. We have studied the onset and evolution of convection when a layer of such fluid is dryed from above. This system is characterized by the formation of a dense and visco-elasto-plastic skin at the drying surface. At the scales of a few mm, two populations of wrinkles are seen to develop in turn, due to the elastic and the viscous behaviors of the skin. On the other hand, its visco-plasticity allows the occurence of strong sheer localization. So on large scales (cm to 30 cm), several regimes have been observed. The skin can wrinkle, buckle, break and founder, henceforth participating to the large-scale convective motions, or on the contrary remain stagnant at the surface with convection developing underneath. Episodicity or coexistence of the two end-member regimes have also been observed. When heating the system from below as well, such as to create active upwellings, we observed that a hot plume impinging under the skin could break it and induce foundering. This can trigger a complete resurfacing of the tank, or on the contrary it can remain localized. Using a simple 1D model of skin formation, we can predict the occurence of the different regimes, which strongly depend on the skin rheology. Scaling laws derived from a physical understanding of the experiments, show that the convective regimes encountered here could occur on the rocky planets of the solar system, such as continuous plate tectonics on Earth, stagnant lid convection on Mars, or episodic resurfacing and plume-induced subduction on Venus.