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— Layered composite fluids are sometimes observed in confined systems of rather chaotic initial states, for example, layered lattes formed by pouring espresso into a glass of warm milk. In such configurations, pouring forces a lower density liquid (espresso) into a higher density ambient, which is similar to the fountain effects that characterize a wide range of flows driven by injecting a fluid into a second miscible phase. Although the initial state of the mixture is complex and chaotic, there are conditions where the mixture cools at room temperature and exhibits an organized layered pattern. Here we report controlled experiments injecting a fluid into a miscible phase and show that, above a critical injection velocity, layering naturally emerges over the time scale of minutes. We perform experimental and numerical analyses of the time-dependent flows to observe and understand the convective circulation in the layers. We identify critical conditions to produce the layering and relate the results quantitatively to the critical Rayleigh number in double-diffusive convection, which indicates the competition between the horizontal thermal gradient and the vertical density gradient generated by the fluid injection. Based on this understanding, we show how to employ this single-step process to produce layered structures in soft materials, where the local elastic properties as well as the local material concentration vary step-wise along the length of the material.

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