Fluid-driven granular flows in a submerged silo

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When a granular silo is submerged in fluid, the characteristics of the flow within it can be profoundly influenced by the imposition of fluid flow through the system. For instance, the granular flow rate through the outlet is no longer restricted to Beverloo's law, and the velocity field within the silo evolves as the viscous forces increase[1]. When the fluid flow is sufficient, viscous finger instabilities force their way through the granular packing, leaving little comparison with classical silo flow. In addition to these behaviours, here we also find the spontaneous emergence of straight, dilute, wormhole-like channels that accelerate towards the outlet, acting as a bypass of the wider silo. The formation of these wormholes is linked to the balance of flow above and below the top surface of the granular bed. This array of behaviours is captured in a phase diagram, illustrating a complex system that encapsulates porous flow, dilation and compaction, erosion, and granular suspension flow.

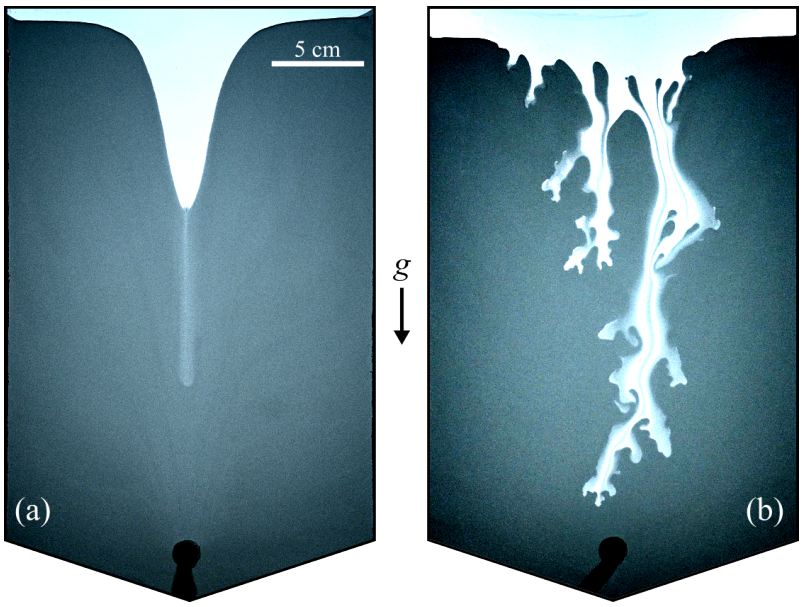

Figure 1: The formation of (a) wormholes and (b) viscous fingers in a fluid-driven silo.

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[1]Morgan et al., *PRE* **104**, 4 (2021)