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Sublimation-driven formation of recent mass flows on Mars: experimental tests in low-pressure environments

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Martian gullies are kilometre-scale landforms consisting of an alcove, channel and depositional fan. They are among the youngest landforms that may have formed by liquid water and are active today. Understanding their formation is thus critical for resolving Mars' most recent climatic history and potential to sustain life. Gullies on Mars have been hypothesized to have formed by either the action of liquid water and brines or the action of sublimating carbon-dioxide (CO_2) ice. They strongly resemble terrestrial systems formed by aqueous debris flows, having similar sedimentology, morphology, and morphometry. Yet, new deposits have formed within multiple gullies across Mars over the past decade, and we cannot reconcile these flows with the low availability of atmospheric water and the triple point of water under present martian conditions. These flows do, however, occur in winter when temperatures are below the CO_2 condensation point, and CO_2-ice has been observed in many gullies during time of activity. But can CO_2 sublimation support and fluidize mass flow on Mars and form deposits similar to terrestrial debris flows? Here, I present novel experiments where we operate small-scale mass-flow flumes inside Mars chambers at Aarhus University (Denmark) and the Open University (UK). In these chambers Martian atmospheric conditions can be simulated, which is crucial for fluidization of mass flows since volume expansion, and therefore gas flow rate, by CO_2-ice sublimation is much larger under the low atmospheric pressure of Mars (8 mbar) than under the atmospheric pressure of Earth (1000 mbar). These experiments reveal that CO_2 sublimation under martian atmospheric conditions can fluidize mass flows by generating elevated pore pressures reducing intergranular friction, resulting in lobate deposits with levees, as observed in martian gullies. These findings show that CO_2-sublimation processes can explain our observations in active Martian gully systems today, which has far-reaching implications for the search for potential liquid water on Mars as well as the interpretation of planetary landforms on other planetary bodies. In particular, they show that on planetary bodies unlike Earth, landforms may be created that look similar to those found on Earth but are actually produced by disparate and so-far unknown processes.