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The link between circumferential dikes and eruptive fissures around calderas: insights from numerical and analog models

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Active calderas are seldom associated with circumferential eruptive fissures along their rim, but eroded portions of extinct magmatic complexes reveal widespread evidence of circumferential dikes. This discrepancy suggests that, while the conditions to emplace circumferential dikes below volcanoes are easily met, mechanisms must exist to arrest the dikes before they reach the surface.
Here we explain this discrepancy with laboratory experiments of air injection into a gelatin medium shaped to mimic a volcanic edifice with caldera. Our models show that the ascending dikes experience a variable degree of deflection, depending on the competition between dike overpressure, Pe, and the forcing induced by the topographic load, Pl. When Pl/Pe = 4.3 – 4.5 the analog dikes proceed almost insensitive to the stress rotation and erupt within the caldera. When Pl/Pe = 4.8 – 5.3 the analog dikes closely propagate orthogonal to the least compressive stress $\sigma 3$ and stall below the caldera rim in a circumferential arrangement. Progressive buoyancy increase through repeated supply of fluid is fundamental for the occurrence of circumferential fissures. Complementary numerical models explain the observed circumferential arrangement and validate the experiments. These results contribute defining the shallow magma transfer and related hazard assessment within calderas.