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Shake, rupture and flow: hydraulic constraints on the formation of Europa's chaos

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Europa's chaos terrains may have formed above shallow water lenses formed by melting of the upper ice shell with ascending thermo-compositional plumes. A key factor in the creation of chaos terrain may be dramatic disruption and collapse of the ice lid above the forming melt lens along with potentially violent mixing upon its rupture; this is analogous to the collapse of terrestrial ice shelves in which massive ice bodies disintegrate in a few days. At Thera Macula, there is evidence for modification by water immediately external to the scarp that bounds the collapsed region. Since water runs either subaerially down hill or sub- or englacially from high pressure to low, the swollen appearance of bands entering Thera Macula, which are uphill in terms of hydraulic and topographic gradients, raises the possibility that this steep scarp represents the place where the lens initially broke. As the ice lid ruptures, the overpressure within the lens may create sufficient pressure within the fracture to drive water through it, allowing water to escape into and modify surrounding terrain. Similar effects are seen when aquifers or subglacial water sources are tapped: water flows up the pipe until the pressure in the water body is relieved and the hydraulic "pressure head" in the pipe is lowered. We have modeled the hydraulic potential associated with a rupturing lens in order to investigate the range of parameters for overpressure, fracture width, and lid thickness that could produce such modification as is observed at Thera Macula. These place important constraints on the pressure within the lens and the energetics of a collapse event. These estimates may explain how ice masses within chaos are initially disrupted and provide a means for quantifying the vigor of surface-subsurface mixing critical to Europa's putative habitability.

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