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Conditions Leading to Sudden Release of Magma Pressure

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Abstract: Buildup of magmatic pressures in a volcanic system can arise from a variety of mechanisms. Numerical models of the response of volcanic structures to buildup of pressures in magma in dikes and conduits provide estimates of the pressures needed to reopen blocked volcanic vents. They also can bound the magnitude of sudden pressure drops in a dike or conduit due to such reopening. Three scenarios are considered: a dike that is sheared off by covolcanic normal faulting, a scoria cone over a conduit that is blocked by in-falling scoria and some length of solidified magma, and a lava flow whose feed has partially solidified due to an interruption of magma supply from below. For faulting, it is found that magma would be able to follow the fault to a new surface eruption. A small increase in magma pressure over that needed to maintain flow prior to faulting is required to open the new path, and the magma pressure needed to maintain flow is lower but still greater than for the original dike. The magma pressure needed to overcome the other types of blockages depends on the details of the blockage. For example, for a scoria cone, it depends on the depth of the slumped scoria and on the depth to which the magma has solidified in the conduit. In general, failure of the blockage is expected to occur by radial hydrofracture just below the blocked length of conduit at magma pressures of 10 MPa or less, resulting in radial dikes. However, this conclusion is based on the assumption that the fluid magma has direct access to the rock surrounding the conduit. If, on the other hand, there is a zone of solidified basalt, still hot enough to deform plastically, surrounding the molten magma in the conduit, this could prevent breakout of a hydrofracture and allow higher pressures to build up. In such cases, pressures could build high enough to deform the overlying strata (scoria cone or lava flow). Models of such deformations suggest the possibility of more violent eruptions resulting from sudden shear failure of a scoria cone with material accelerations near 100 m/s^2.