Magmatic Plumbing in Analog Extensional Tectonic Settings

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Sills, horizontal magma-driven fractures, are a common mechanism for shallow magma storage, crucial to the dynamics of volcanic unrest and noneruptive magmatic effects such as gas release. Additionally, sill and dike intrusions play a fundamental role in continental rifting. Extensional tectonic settings, which have a horizontal minimum principal stress, should favor diking; however, sills are found in this tectonic setting frequently. A recent 2D model shows that diking can reorient the stress field sufficiently to make sill formation favorable, provided that there is enough time between diking events, lithospheric density is close to magmatic density, and the axial valley is shallow (Liu and Buck 2021). Previous analog experiments also highlight the importance of rheological boundaries for sill formation in non-extensional settings (Sili et al. 2019). We used analog experiments to provide physical grounding for the 2D model and address how extensional stresses impact the conditions for sill formation in the presence of rheological contrast. Acrylic tanks filled with two layers of gelatin of varying concentration and pour temperatures, acting as analog crust, were injected with analog magma, red-dyed water, from various heights to model magma body formation. We were therefore able to observe the effects of lithological rigidity differences, interface strength, and pressure of the magma body source on magma intrusion morphology by proxy. Dikes, sills, and dike-sill hybrids all formed, indicating that the factors studied are sufficient to promote sill formation in extensional tectonic settings where rheological layering is present. The experiments performed also serve as a basis for future exploration of the mechanics of sill formation in extensional settings when strong lithological layering is not present.