Supporting Information for "Could Kīlauea's 2020 post caldera-forming eruption have been anticipated?"

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Introduction

Derivation of Minimum Dike Height

The surge model assumes non-deforming conduits. When a conduit is sufficiently narrow (dike-like) that pressure-induced displacements are significant, conduit pressure follows a nonlinear diffusion equation (Montagna & Gonnermann, 2013). For the 2018 eruption, the dike would also need to have sufficiently high transmissivity to explain the average volume flux of ~ 300 m^3/s (the average of the Patrick et al. (2019) values). For laminar flow, the volume flux for a dike with average dike thickness δ is

$$q \simeq \frac{\delta^3 h}{12\eta}\frac{dP}{dx}, \tag{1}$$

where h is dike height, η is viscosity (100 Pa-s), and dP/dx the down-rift pressure gradient in excess of magmastatic. We estimate the latter as 2.8 MPa (the excess pressure at the start of collapse) over the 40 km distance between the summit and Fissure 8, or 70 Pa/m. The elastic displacements u for a long crack of height h scale with

$$u \simeq \frac{2(1-\nu)h\Delta P}{\mu}, \tag{2}$$

where μ, ν are shear modulus and Poisson's ratio, and ΔP the pressure change. Define ϵ as ratio of displacement to aperture; $u = \epsilon\delta$. Montagna and Gonnermann (2013) show that non linear effects are significant when $\epsilon \sim 0.25$. Solving for h as a function of ϵ yields

$$h = \left[\frac{12\eta q}{\alpha^3(dP/dx)}\right]^{1/4} \qquad \alpha \equiv \frac{2(1-\nu)\Delta P}{\mu\epsilon}. \tag{3}$$

References

Montagna, C. P., & Gonnermann, H. M. (2013). Magma flow between summit and Pu ʻu ʻō ʻō at Kīlauea volcano, Hawai ʻi. *Geochemistry, Geophysics, Geosystems*, *14*(7), 2232–2246.

Patrick, M., Dietterich, H., Lyons, J., Diefenbach, A., Parcheta, C., Anderson, K., ... Kauahikaua, J. (2019). Cyclic lava effusion during the 2018 eruption of Kīlauea volcano. *Science*, *366*(6470).

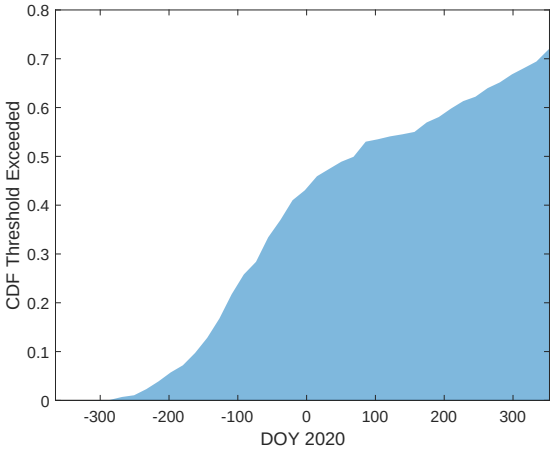

Figure S1. Cumulative probability that pressure within the HMM reservoir reached the estimated 11.5 MPa threshold as a function of Day of Year (DOY) in 2020.