Caldera Collapse Geometry Revealed by Near-field GPS Displacements at Kīlauea Volcano in 2018: Supplemental Information

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1 Geometry

Taking median values from *Anderson et al.* (2019) we specify:

a	b	d	μ	ν
1.11 km	0.92 km	1.9 km	3 GPa	0.25

2 Scaling of the deformation

The pre-collapse displacements can be written as

$$u_{\rm pre}(\mathbf{x}) = \frac{\Delta p_{\rm pre} V}{\mu} f(\mathbf{x}; \mathbf{m}) \tag{1}$$

where $f(\mathbf{x}; \mathbf{m})$ is function of the model parameters $\mathbf{m}$ that characterize the chamber, and has units of $1/l^2$) (for example for Mogi source is proportional $1/d^2$). Independent constraint on the pressure reduction from the retreating lava lake allowed the pre-collapse data to resolve the ratio V/μ and the chamber geometry.

The co-collapse displacements depend on fault slip and the slip-induced pressurization of the magma chamber,

$$u_{\rm co}(\mathbf{x}) = \frac{\Delta p_{\rm co} V}{\mu} f(\mathbf{x}; \mathbf{m}) + s g(\mathbf{x}; \mathbf{m}, \delta), \tag{2}$$

where $g(\mathbf{x}; \mathbf{m}, \delta)$ is a dimensionless function that maps fault slip to displacement at constant chamber pressure, and δ is fault dip. Following notation in *Segall et al.* (2019) the co-collapse pressure increase at constant mass is

$$\Delta p_{\rm co} = \frac{-\Phi s}{V\left(\beta_m + \beta_c\right)}, \tag{3}$$

where $\Phi \equiv \partial V/\partial s$ at constant p, and has units of l^2. β_m is magma compressibility and β_c is the chamber compressibility, defined by $\beta_c \equiv (1/V)\partial V/\partial p$.

Combining (2) and (3)

$$u_{\rm co}(\mathbf{x}) = s\left[\frac{-\Phi(\mathbf{m},\delta) f(\mathbf{x};\mathbf{m})}{\mu\left(\beta_m + \beta_c\right)} + g(\mathbf{x};\mathbf{m},\delta)\right]. \tag{4}$$

Note that Φf is dimensionless. Thus, by fixing the geometry (including V and μ, which also determines β_c, Φ) to that estimated from the pre-collapse data, we can search over the space (δ, β_m) to optimize fit to the co-collapse data.

3 Different Compressibility

Figure 1 shows observed and predicted displacements with different compressibilities.

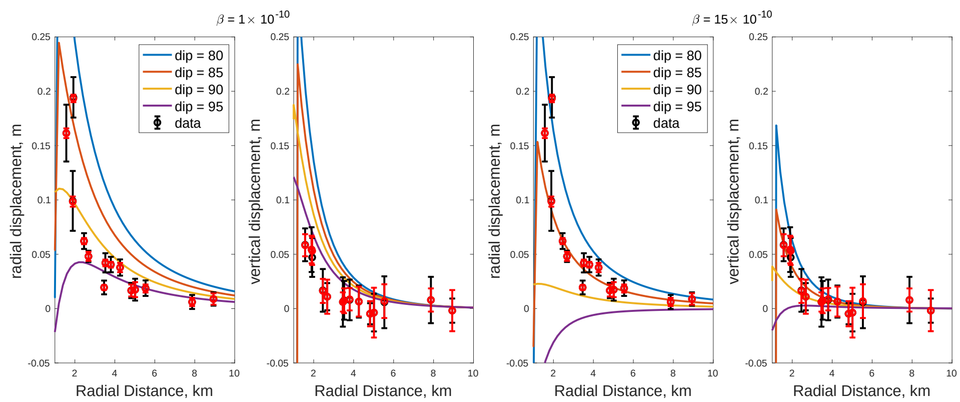

Figure 1: Predicted and observed radial and vertical displacements during a collapse event. 1-sigma error bars. Predictions are shown for a range of dips and compressibility in title.

4 Uncertainty in Chamber Geometry

Figure 2 illustrates the range of pressure change for a range of magma chamber geometries consistent with pre-collapse deformation. These models are restricted to vertical ring fault.

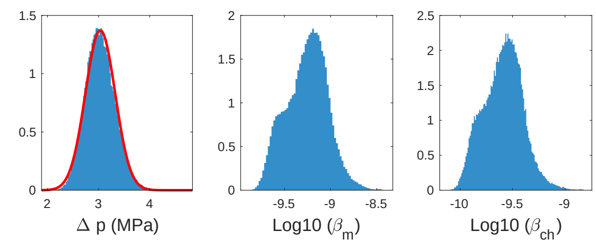

Figure 2: Range of properties for vertical ring-fault system from resampling the posterior distribution of magma chamber geometries based on pre-collapse deflation from *Anderson et al.* (2019). a) Pressure change. Red curve shows Gaussian fit; b) Magma compressibility; c) Chamber compressibility.

5 Point Source Model

Figure 3 shows posterior distribution of point source parameters, location and moment tensor components, based on MCMC analysis of the co-collapse displacement data. Figure 4 illustrates the point source on a "Hudson plot" and as three orthogonal double forces.

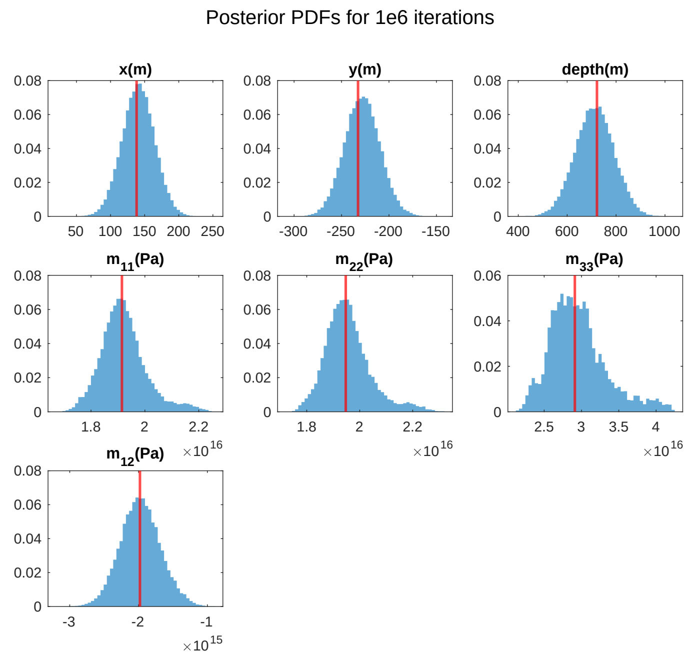

Figure 3: Posterior distribution for point source moment tensor fit to co-collapse displacements.

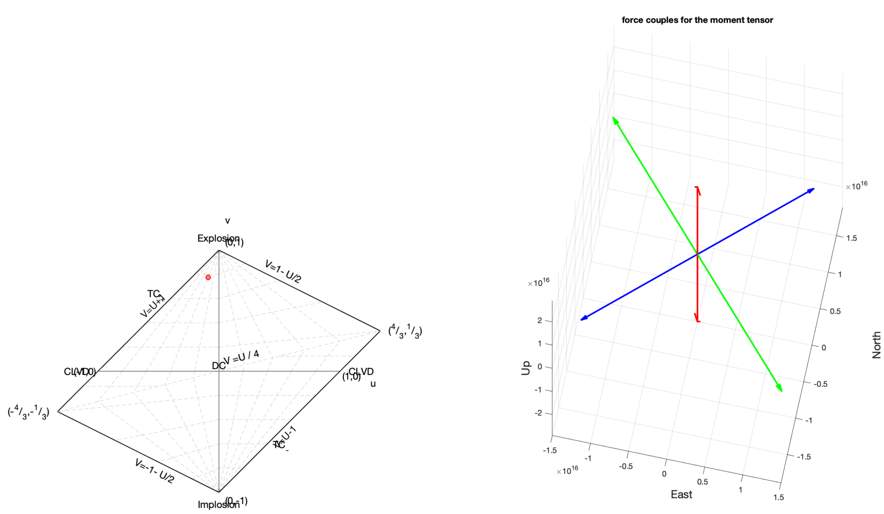

Figure 4: A) Hudson plot showing point source model is largely isotropic expansion. B) Double forces; max (red), intermediate (green) and minimum (blue).

References

Anderson, K. R., I. A. Johanson, M. R. Patrick, M. Gu, P. Segall, M. P. Poland, E. K. Montgomery-Brown, and A. Miklius (2019), Magma reservoir failure and the onset of caldera collapse at Kīlauea volcano in 2018, *Science*, *366*(6470).

Segall, P., K. R. Anderson, I. Johanson, and A. Miklius (2019), Mechanics of inflationary deformation during caldera collapse: Evidence from the 2018 Kīlauea eruption, *Geophysical Research Letters*.