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Supporting Information for

Compartmentalization of Axial Seamount's magma reservoir inferred by analytical and numerical deformation modeling with realistic geometry

S.R. Slead[1], M. Wei[1], S.L. Nooner[2], W.W. Chadwick[3], D.W. Caress[4], and J. Beeson[3,5]

[1]Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, USA.

[2]Department of Earth and Ocean Sciences, University of North Carolina Wilmington, Wilmington, NC, USA

[3]Oregon State University, Cooperative Institute for Marine Resources Studies, Hatfield Marine Science Center, Newport, OR, USA

[4]Monterey Bay Aquarium Research Institute, Moss Landing, CA, USA

[5]National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory, Newport, OR, USA

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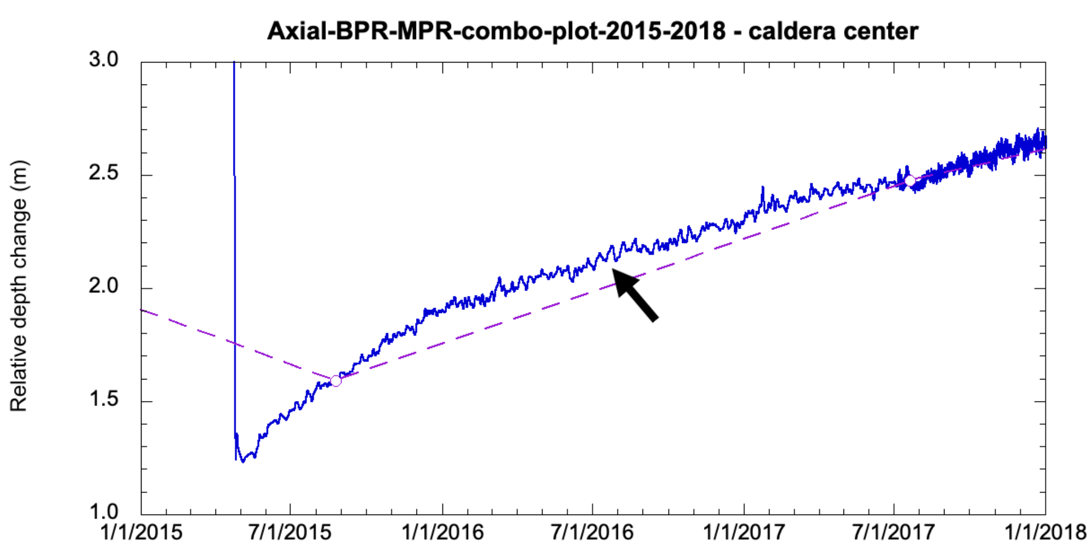

Figure S1. Pressure data from a single BPR at the center of the caldera (blue line, converted to relative depth) and 2 MPR surveys (purple dots in the summers of 2015 and 2017). The "true" MPR relative depth value in August 2016 when the AUV survey was conducted (arrow) is about 10cm higher than linear interpolation would predict (purple dashed line).

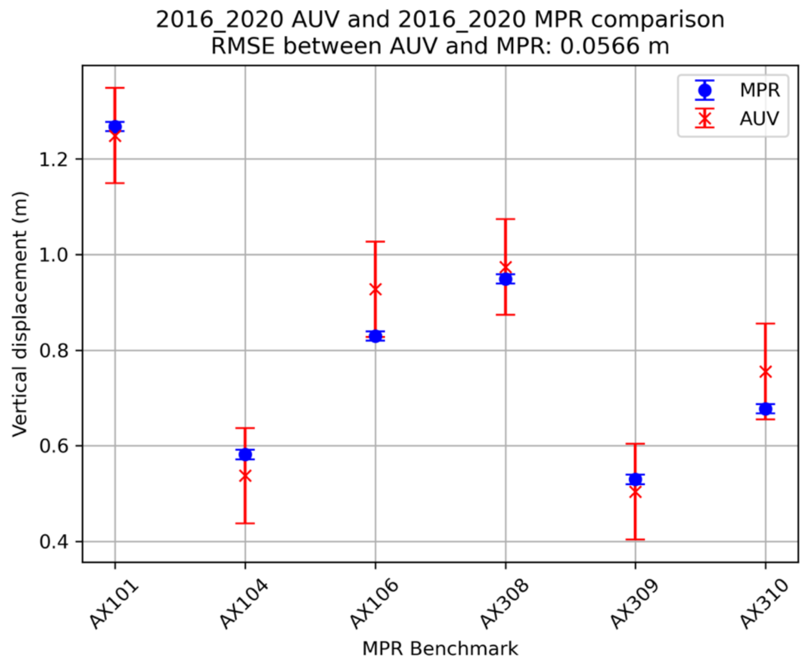

Figure S2. Comparison between the 2016-2020 AUV repeat bathymetry data and the 2016-2020 MPR data at the locations of six MPR benchmarks (see Figure 1 for locations). The uplift at the MPR benchmarks in mid-02016 was estimated by interpolating between the measured values from the 2015 and 2017 MPR surveys (no MPR survey was made in 2016). The error bars are uncertainties of 20 cm for the AUV data (Caress et al., 2020) and 1 cm for the MPR data (Chadwick et al., 2006). In general, the 2016-2020 MPR uplift values (using the estimated 2016 value) agree reasonably well with the 2016-2020 AUV depth change results.

Text S1.

To validate our FEM methodology, we compared an analytical prolate spheroid model (Yang et al., 1988) to an FEM with a pressurized cavity of the same dimensions. The reason we chose a prolate spheroid was to replicate the deformation model proposed by Nooner & Chadwick, 2016 in order to validate all modeling methods, including the analytical model. The prolate spheroid proposed by Nooner & Chadwick (2016) for the 2015 co-eruptive deformation has a centroid depth of 3.81 km, major/minor axes of 2.2/0.38 km, and has a strike/dip of 286°/77°. For the FEM and analytical models, we fixed all geometrical parameters and iterated over volume change values to optimize fit the 2015-2020 MPR data. The models produced results with acceptably small difference (<3%) such that the FEM physics and boundary conditions can be considered valid (Figure S3a,b).

We also tested the effect of bathymetry in an FEM using GMRT bathymetry data (Ryan et al., 2009). To increase computational efficiency, we progressively down sampled the bathymetry to find the coarsest resolution that does not impact results (100 m resolution). We found that inclusion of bathymetry fit the MPR data better by 40% and the source's best-fit volume change increased by 27% over that of the models with a flat seafloor (Figure S3). This result was surprising since Axial has relatively low bathymetric relief. We suspect that the large depression to the northeast of the caldera (Helium Basin, which is the is the southern-most part of the CoAxial segment of the Juan de Fuca Ridge) could exert some influence. This region has a sharp slope where the depth decreases about 800 m over 4 km and its influence may be enhanced by shallowness of the pressure source, since the effect of topography on deformation increases with decreasing magma chamber depth (Williams & Wadge, 1998). More work must be done to verify that the signal is real and not just numerical artifact.

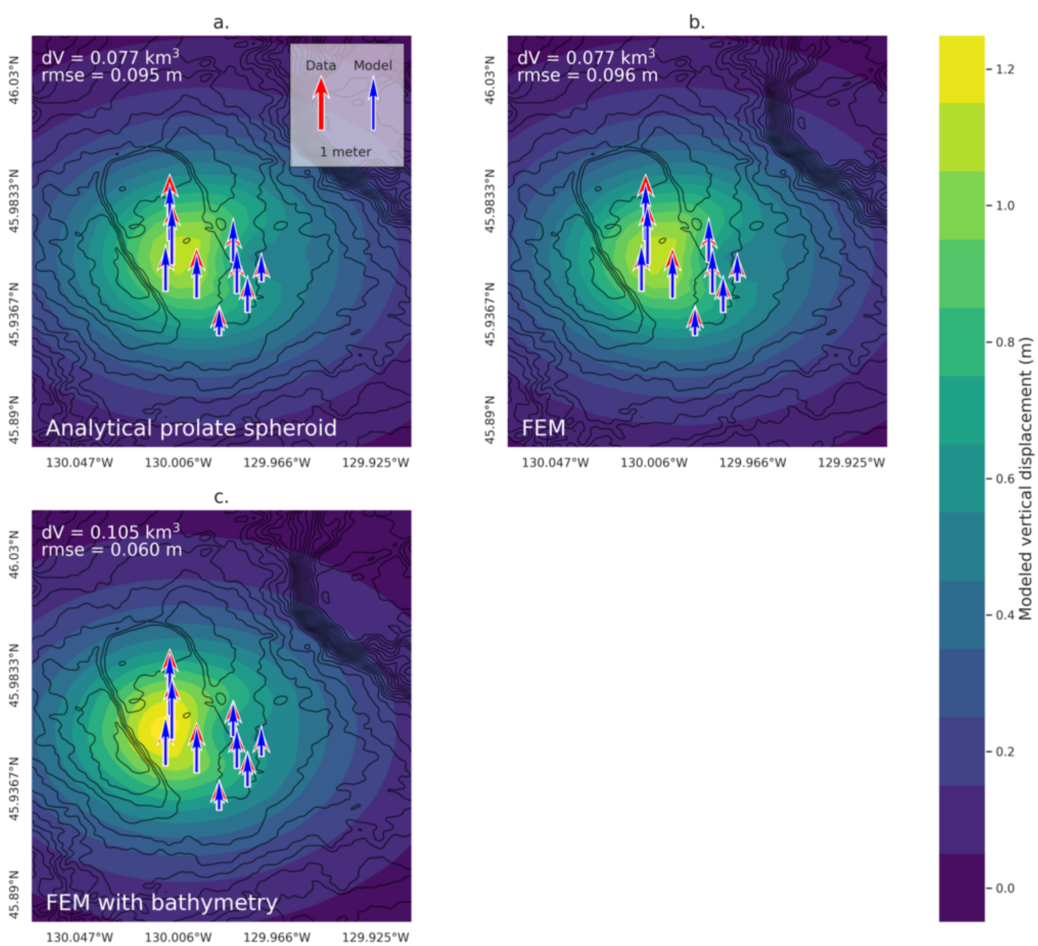

Figure S3. a) Analytical prolate spheroid model (best-fit solution from Nooner & Chadwick, 2016), b) FEM using the same prolate spheroid geometry as in (a), c) FEM using the same prolate spheroid geometry as in (a) and (b) but with bathymetry instead of flat seafloor. For all plots, the MPR displacement data are the red arrows, and the modeled displacements are the blue arrows. Reported RMSE values are between the model and the data.