Supporting Information for

Flexural Modeling of the Colville Foreland Basin, Northern Alaska

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Introduction

The following supporting information includes **Text S1**, which discusses the equations to calculate deflection parameters. **Text S2**, provides information for calculating free-air anomalies from the flexural model and Moho boundary data. **Figure S1**, shows Root mean square error (RMSE) between the observed and predicted FAA. **Figure S2** shows location of sections for Figure S2 and S3. **Figure S3** and **Figure S4** shows cross sections of flexural deflection model and FAA calculation, respectively. **Figure S5** shows density distribution versus depth in the Colville foreland basin for calculation of vertical density variation. **Figure S6** shows the misfit map of flexural deflection model.

Text S1. Deflection Calculation:

The flexure (ω) of a thin elastic plate is calculated by following three distinct solutions (Wienecke et al., 2007):

$$1.\ \omega = \frac{P}{8(\rho mantle - \ \rho crust) g \beta^2}$$

$$2.\ \omega(x,y) = \frac{P}{2\pi\beta^2(\rho mantle - \rho crust) g} \times \left\{ \begin{array}{c} \frac{(r_{x,y})^2}{2^2} \times ln(r_{x,y}) - \frac{(r_{x,y})^6}{2^2.4^2.6^2} \times \left(ln(r_{x,y}) - \frac{5}{6}\right) + \cdots \\ + \frac{\pi}{4}\left(1 - \frac{(r_{x,y})^2}{2^2.4^2} + \frac{(r_{x,y})^8}{2^2.4^2.6^2.8^2}\right) \\ \ldots - 1.1159 \times \left(\frac{(r_{x,y})^2}{2^2} - \frac{(r_{x,y})^6}{2^2.4^2.6^2} + \cdots\right) \end{array} \right\}$$

$$3. \omega(x,y) = \frac{P}{2\pi\beta^2(\rho mantle - \rho crust)g} \times \sqrt{\frac{\pi}{2}} \frac{e^{-(x,y)\sqrt{1/2}}}{\sqrt{(r_{x,y})}}$$

$$\times \left\{ sin\left[(r_{x,y}) \sqrt{\frac{1}{2} + \frac{\pi}{8}} \right] - \frac{1}{8(r_{x,y})} sin\left[(r_{x,y}) \sqrt{\frac{1}{2} + \frac{3\pi}{8}} \right] + \cdots \right\}$$

Here β is the flexural parameter, P is the applied load and $r_{x,y}$ is the radial distance from the point of origin. The first solution calculates the maximum depth of deflection; the second solution accounts for log-function where $r_{x,y} \leq 2\beta$ and the third solution accounts for sine-function where $r_{x,y} \geq 2\beta$. The log-function is only valid for small values of the radius $r_{x,y}$, whereas the deflection values produced by the sine-function are underestimated for smaller values of the radius $r_{x,y}$. The analytical solution is derived by using all three methods by using the expression $r_{x,y} = 2\beta$ for the change in the function from log to sine. To consider point load distribution, the Green's function is used which is simply given by dividing P by the ω. The Green's function for a point load represents a two-dimensional (2-D) radial cross section in the *r-z* plane (*r* is the radial coordinate position) across a radially symmetric flexural basin, normalized by the magnitude of the load. By convolving the Green's function with P, the deflection due to the distributed loads can be calculated (Pirouz et.al., 2017).

Text S2. Free Air Anomaly (FAA) calculation

FAA calculation is done for (1) flexure modeling results and (2) Moho data, which is described by following equations.

$$\Delta g_{(x,y)} = 0.0419(\rho_c - \rho_m)(Moho_{(x,y)} - T_c)$$

$$\delta gB_{(x,y)} = 0.0419\left[(\rho_c - \rho_{air})\left(Topo_{(x,y)} - T_c\right) + (\rho_b - \rho_c)\left(Basin_{(x,y)}\right)\right]$$

$$\Delta g_{elev_{(x,y)}} = \Delta g_{(x,y)} + \delta gB_{(x,y)}$$

Here equations 1, 2, and 3 calculate Bouguer anomaly ($\Delta g_{(x,y)}$), Bouguer Correction ($\delta gB_{(x,y)}$) and Free-air Anomaly ($\Delta g_{elev_{(x,y)}}$), where ρ_b, ρ_c and ρ_m are basin, crust and mantle density, respectively. The depth of basin and Moho is given by $Basin_{(x,y)}$ and $Moho_{(x,y)}$, topography is $Topo_{(x,y)}$, and undeformed crustal thickness is given by T_c (Pirouz et al., 2017).

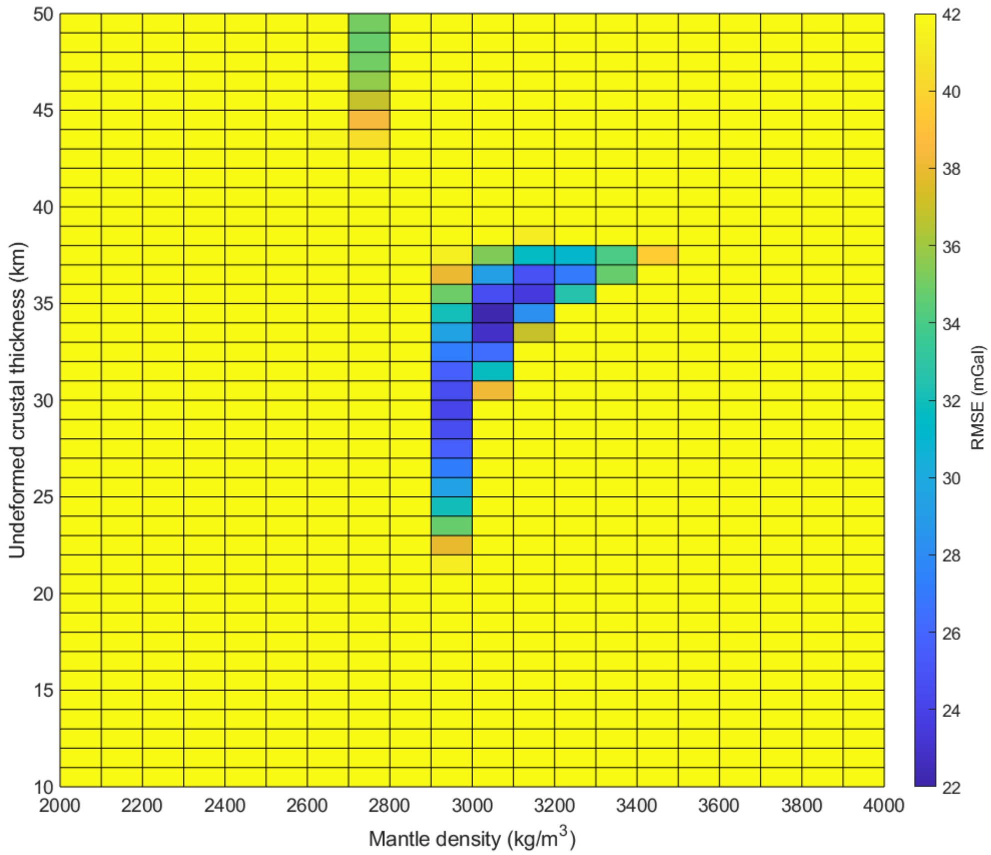

Figure S1. Root mean square error (RMSE) between the observed and predicted FAA to obtain best non-deformed crustal thickness and density variation between Mantle and Crust. Moho data constrained from (Torne et al., 2020) and FAA from WGM2012 (Bonvalot et al., 2012). The predicted model assumes constant crustal density of 2800 kg/m^3. RMSE of best fit is 22 mGal at $\Delta\rho = 500$ kg/m^3.

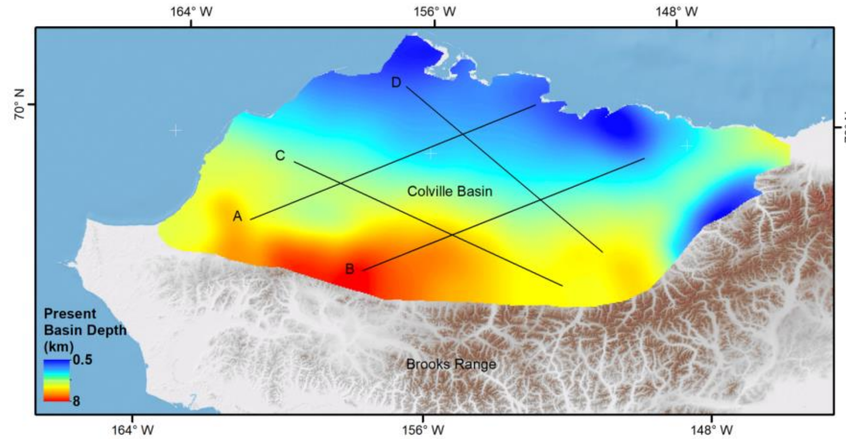

Figure S2. Location of sections for Figure S2 and S3.

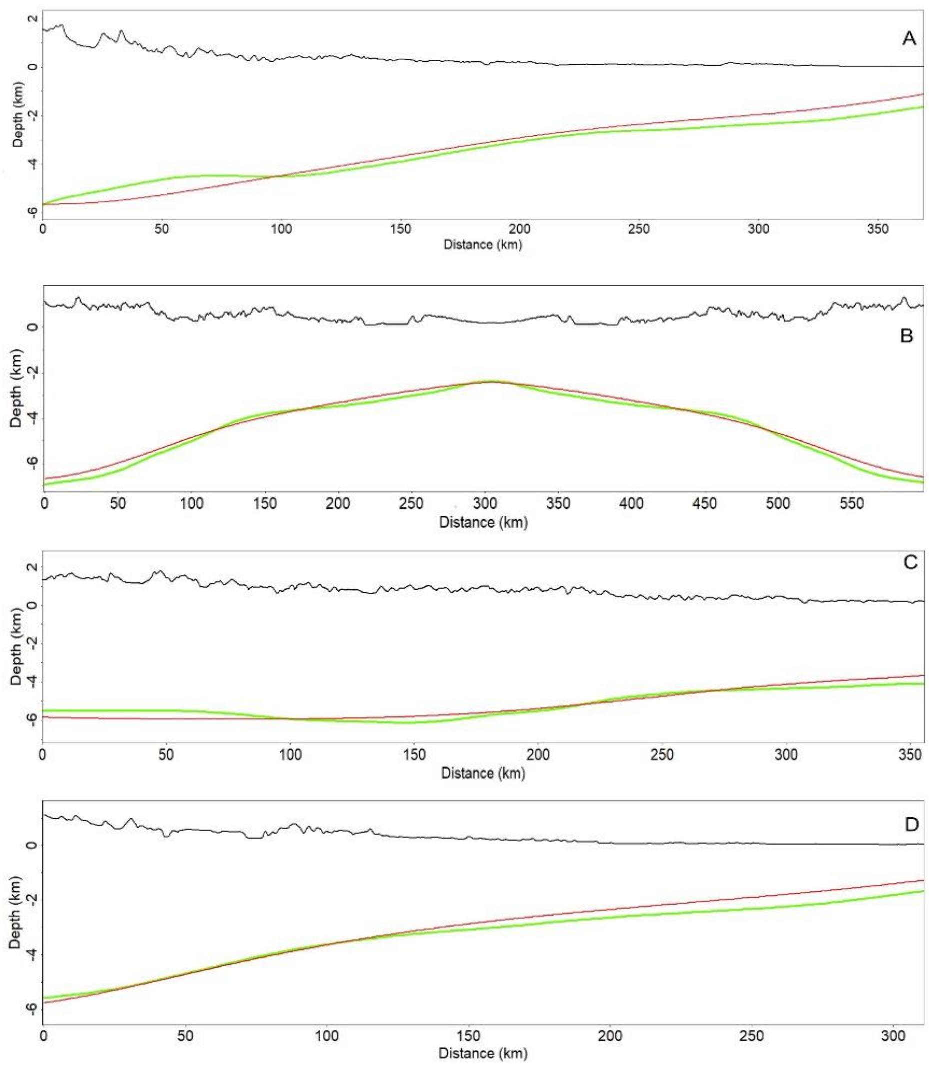

Figure S3. Best fit cross-sections (red curve) compared to observed data (green) in the Colville foredeep. Topography (black) is 3x exaggerated. Location of sections shown in Figure S1.

Figure S4. Calculated FAA from flexure model (red) and Moho data (yellow) compared with observed FAA (black) in the Colville foredeep. FAA from flexure model fits well to the observed anomalies and FAA calculated with Moho data shows some mismatch. Location of sections shown in Figure S1.

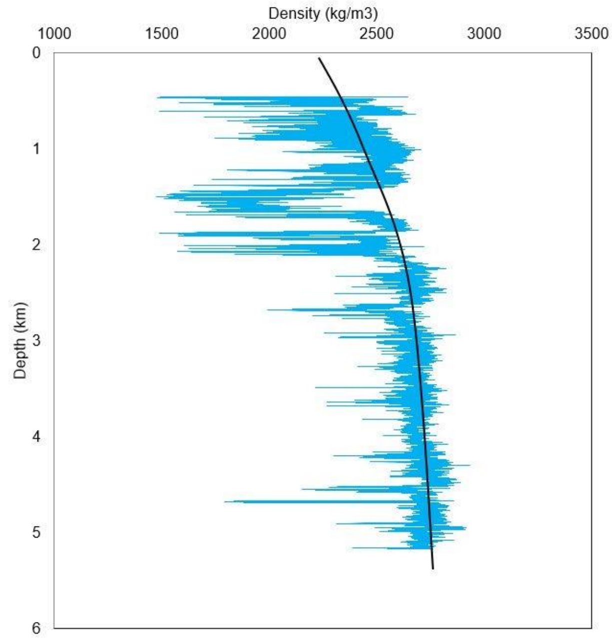

Figure S5. Vertical density variation with increasing depth in the Colville basin. The blue curve represents the measured density in the borehole. The black curve corresponds to a polynomial function that averages the depth distribution of density. The well is located at the southernmost edge of the Colville foredeep. See the green circle in (Figure 1) main text for the location of density log. Well data is available from USGS NPRA datasets at https://certmapper.cr.usgs.gov/data/apps/npra/.

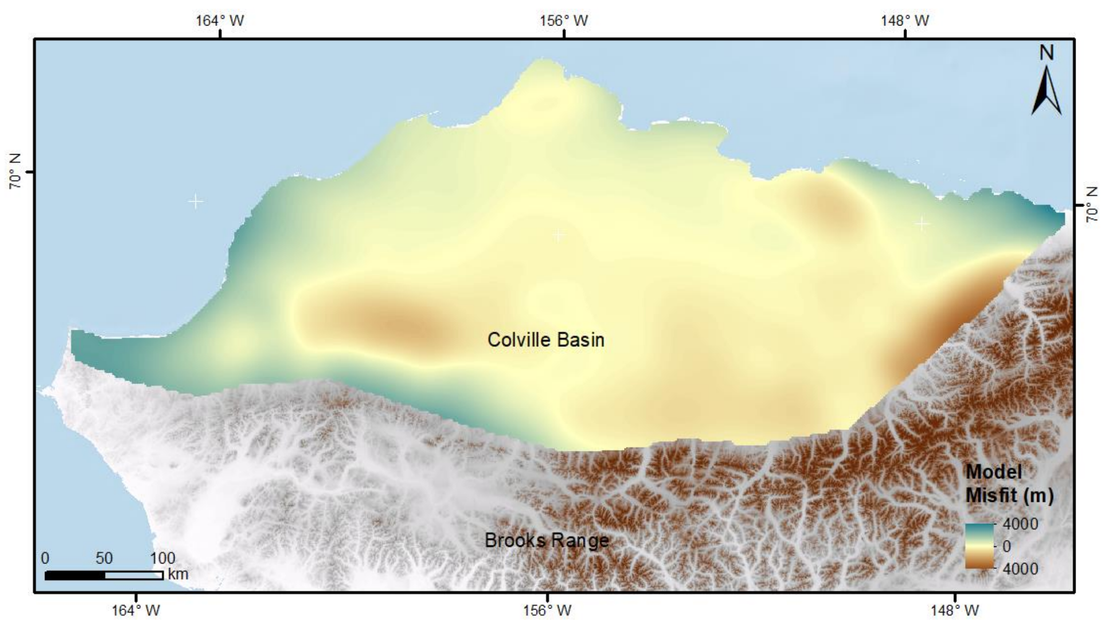

Figure S6. Misfit of flexure model shown with colormap. Yellow color characterizes the minimum misfit which covers significant part of the basin and blue and brown highlights regions of maximum misfit.