Antarctic lithosphere density heterogeneity provides new insights for solid-earth and cryosphere interactions

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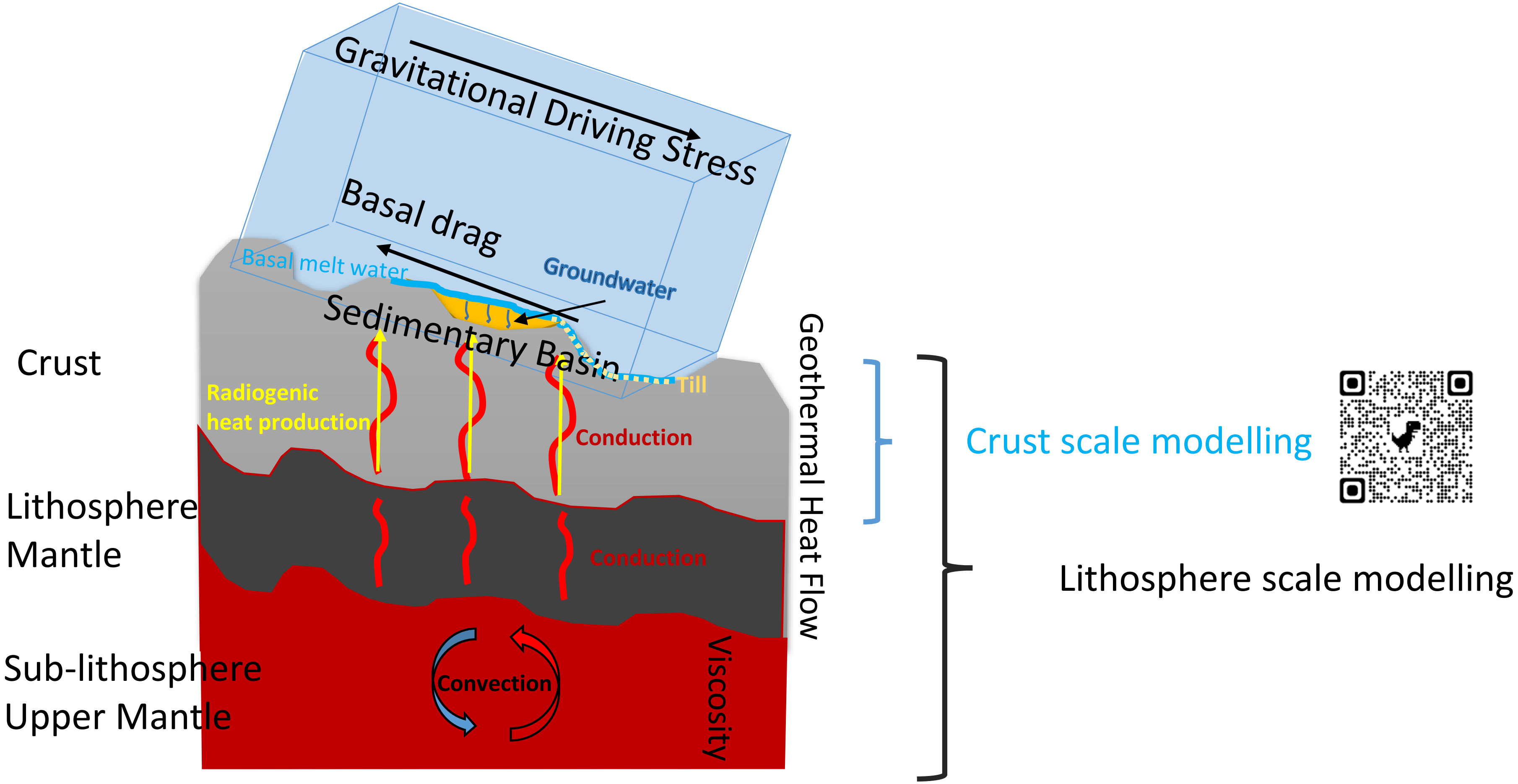
Solid-earth structure influence ice sheet

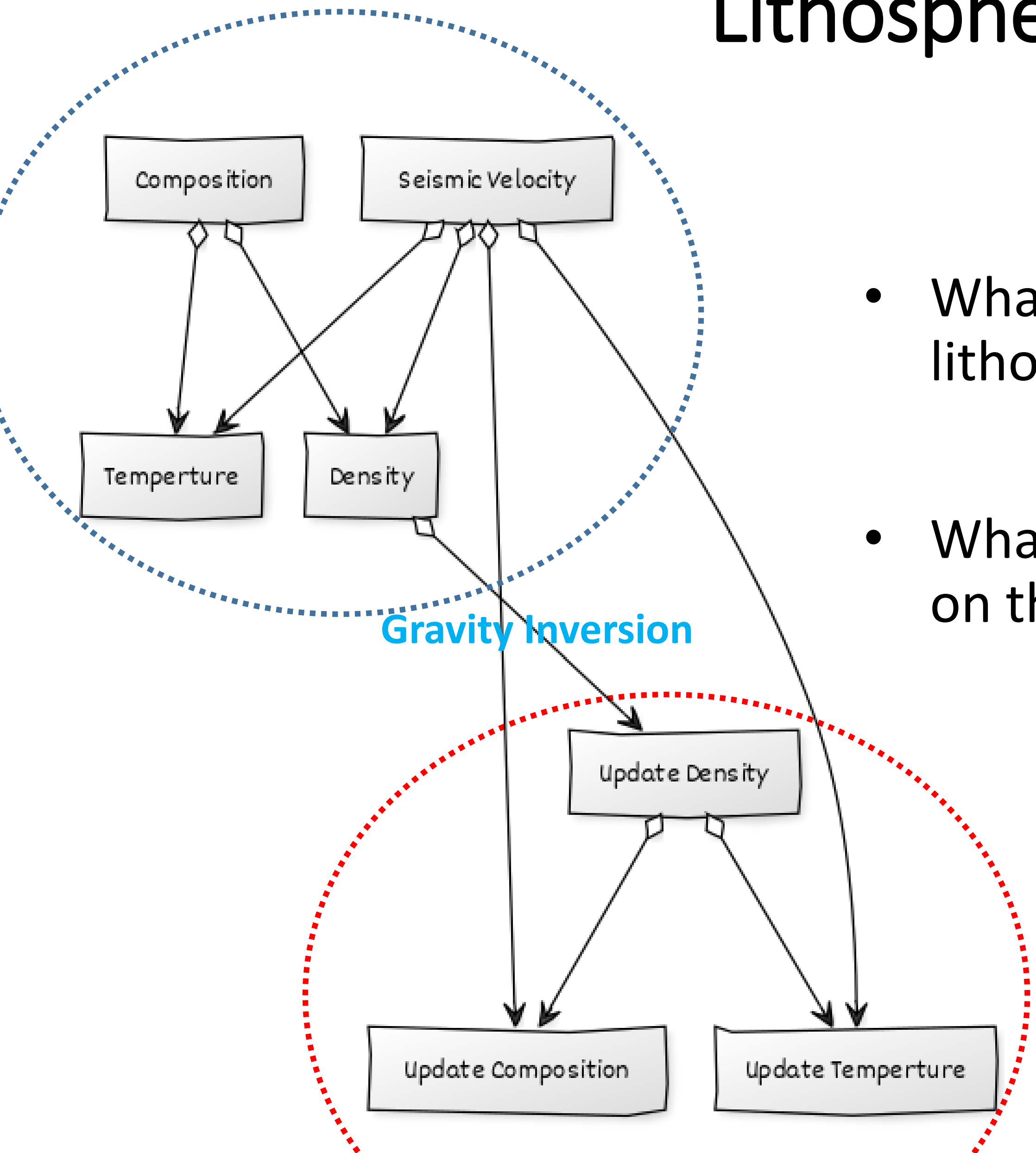
Density structure

Thermal mechanical structure

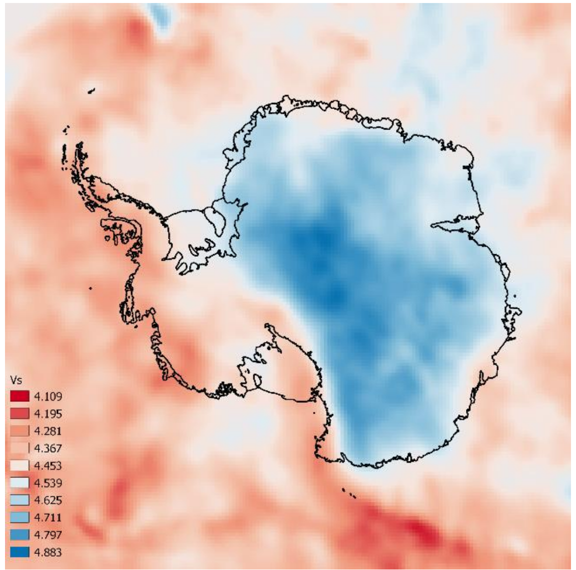


Physics + Boundary Conditions

Lithosphere scale modelling

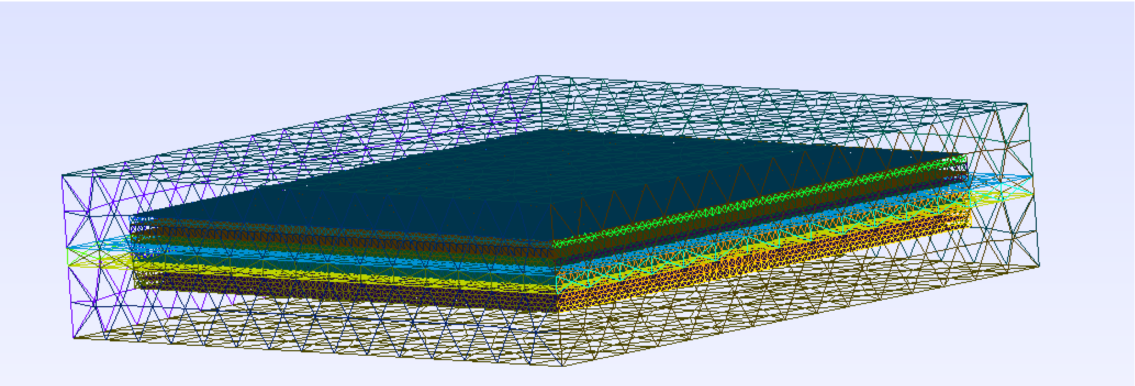


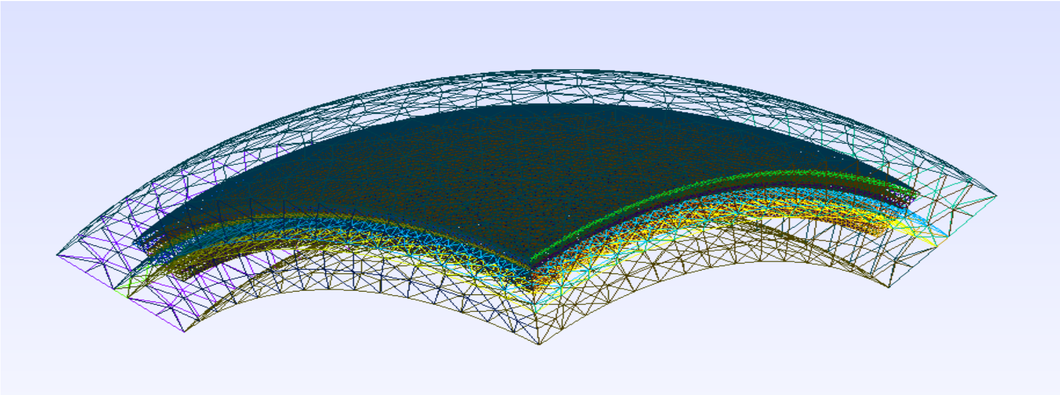
- What's the thermal mechanical structure of Antarctic lithosphere?
- What's the impact of compositional change (iron content) on thermal mechanical structure?



150 km depth from ANT-20 (Lloyd et al., 2020)

Gravity inversion





Esys-escript with a new solver (AMG-PCG matrix solver) using unstructured mesh (Codd et al., 2021) in Geodetic coordinate.

Preserve topography, mass of ice sheet, and earth curvature in the model.

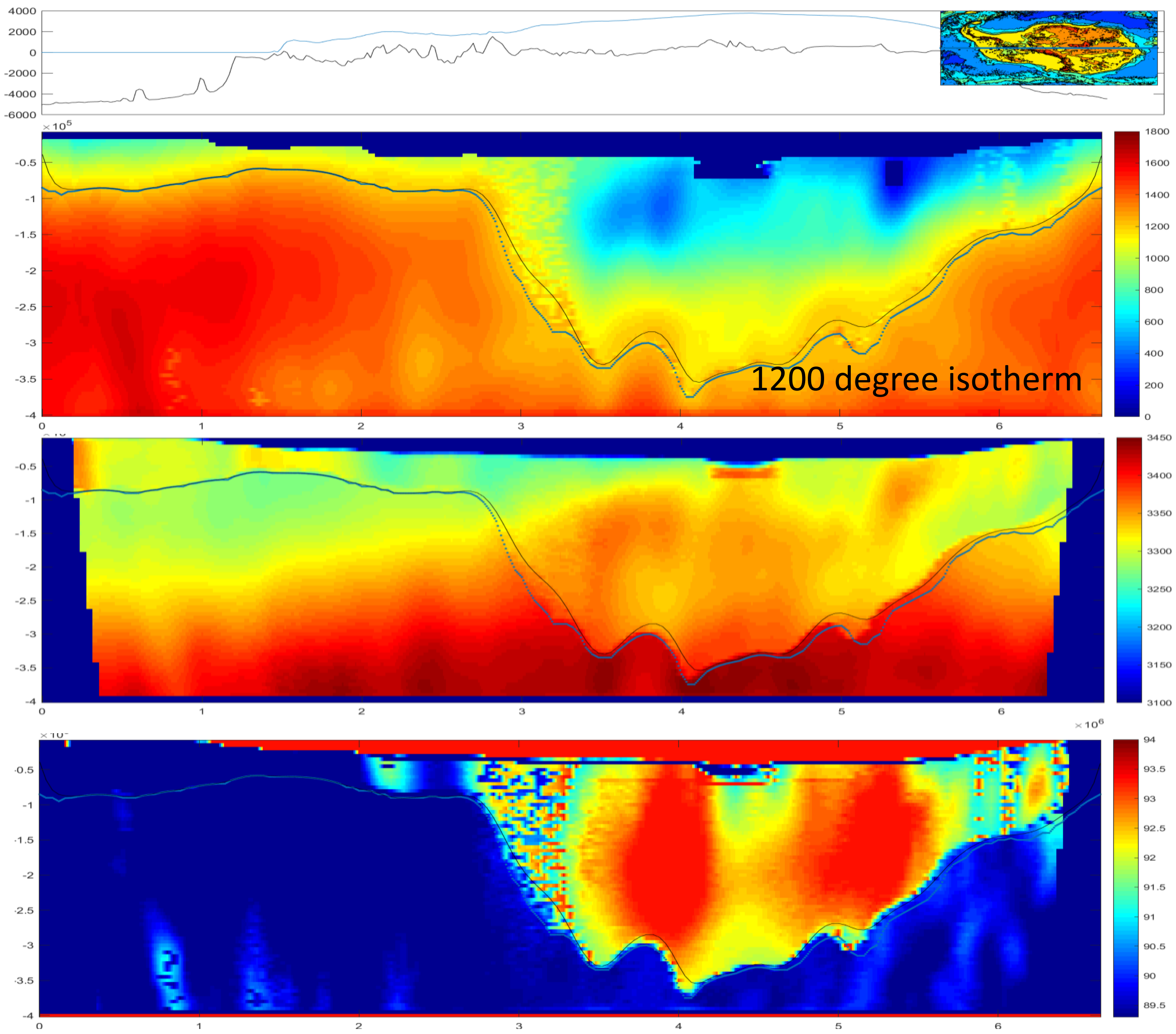
Support parallel super computing

Vertical slice after inversion

Temperature

Density

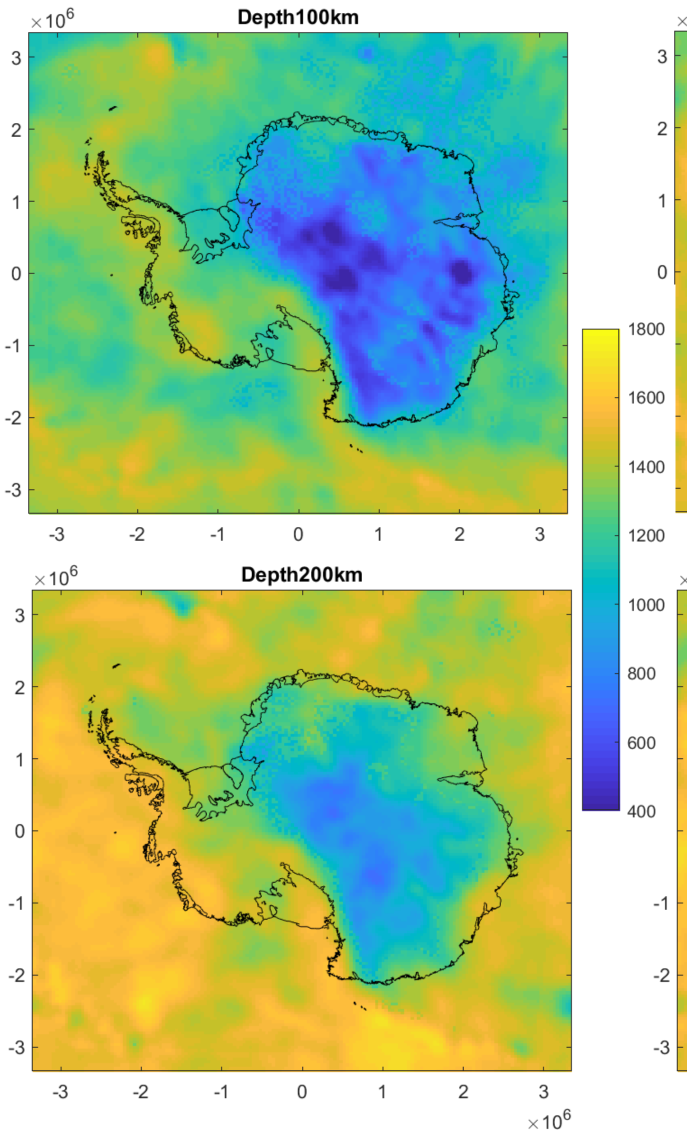
Composition

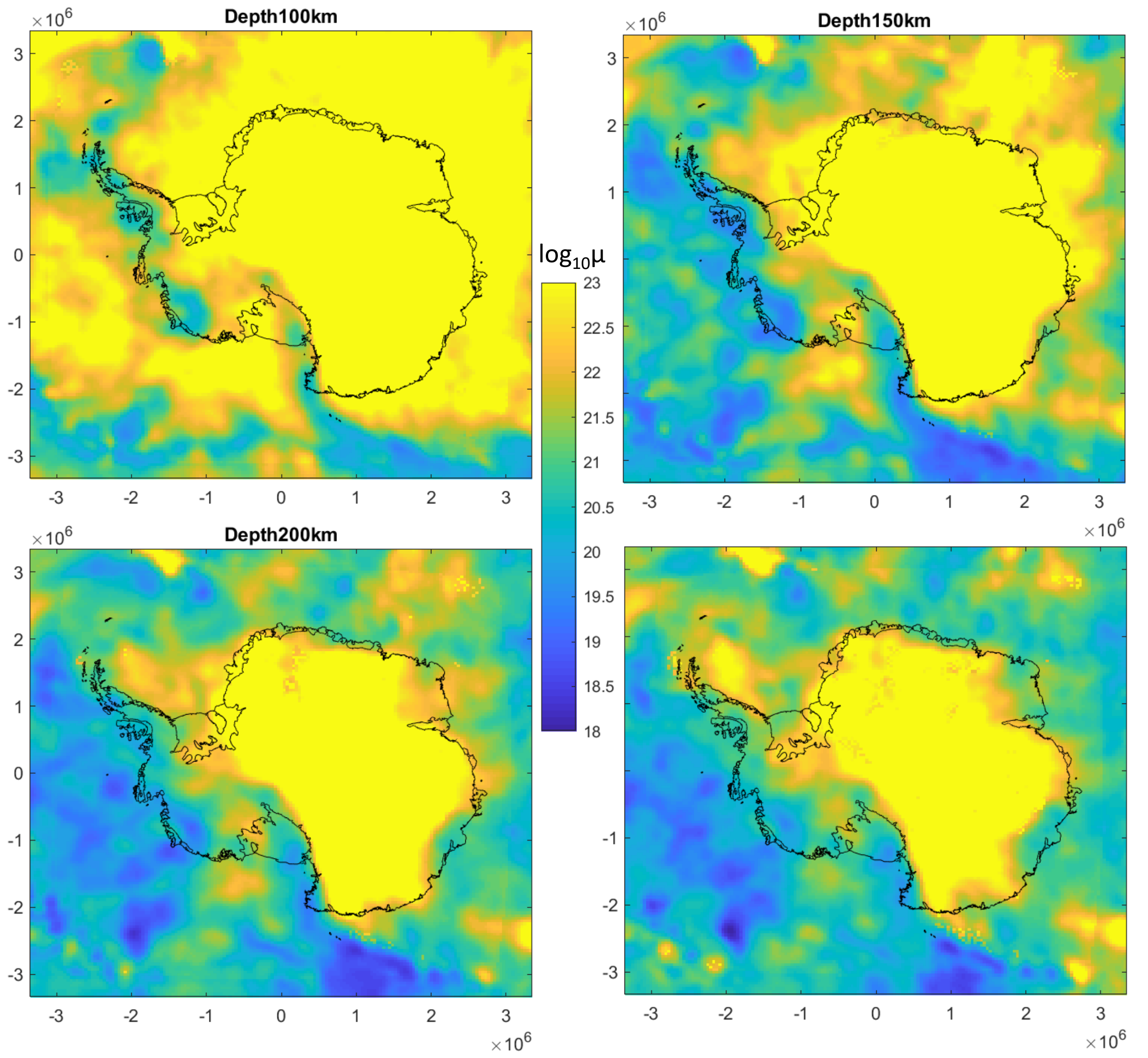


g/cm^3

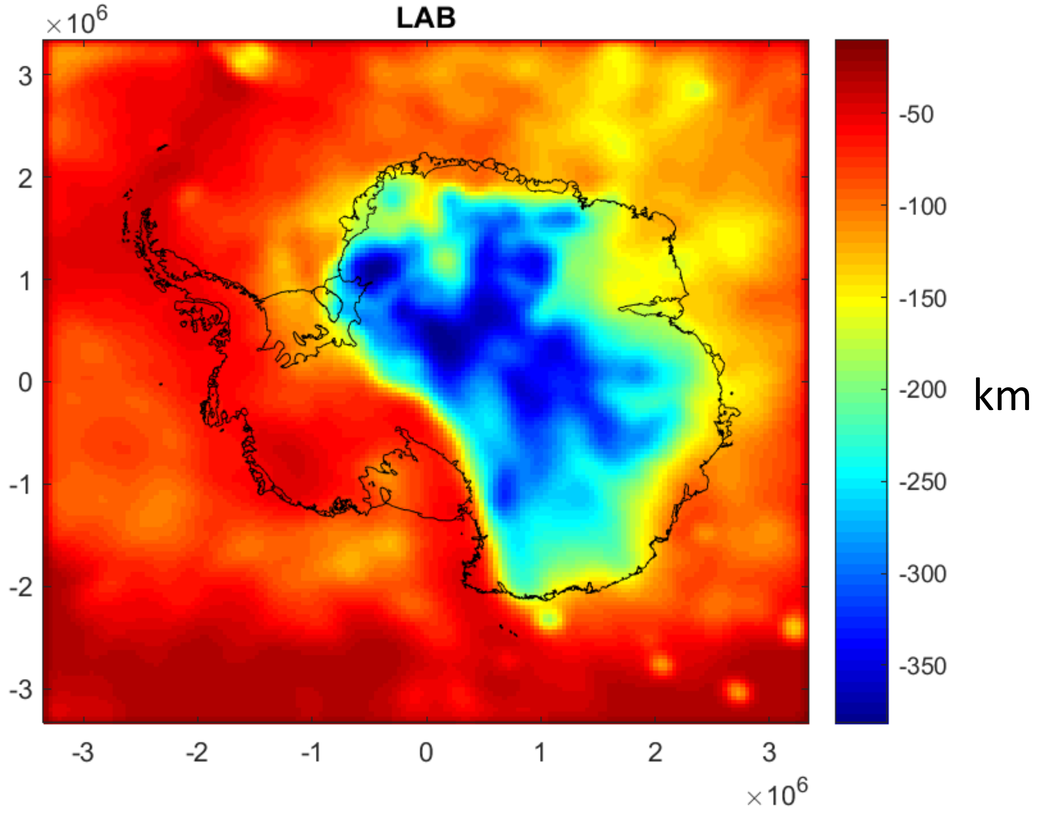
#Mg

Temperature & Viscosity



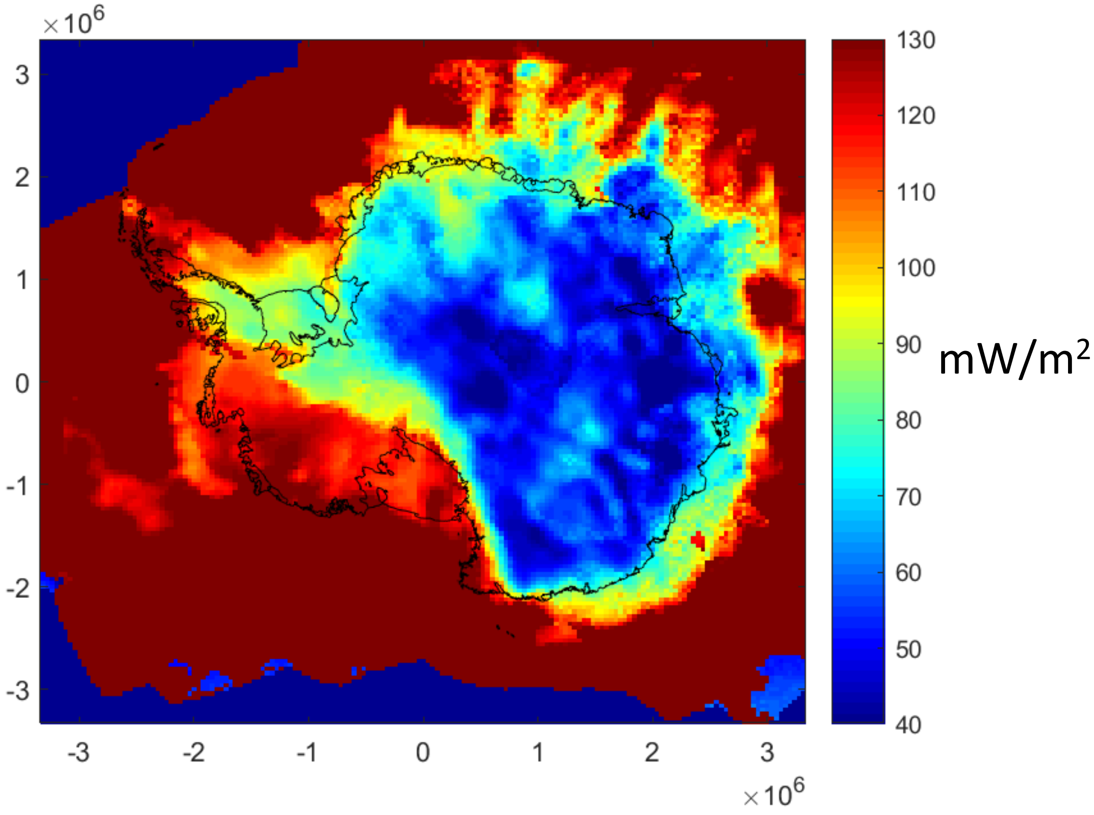


Lithosphere thickness



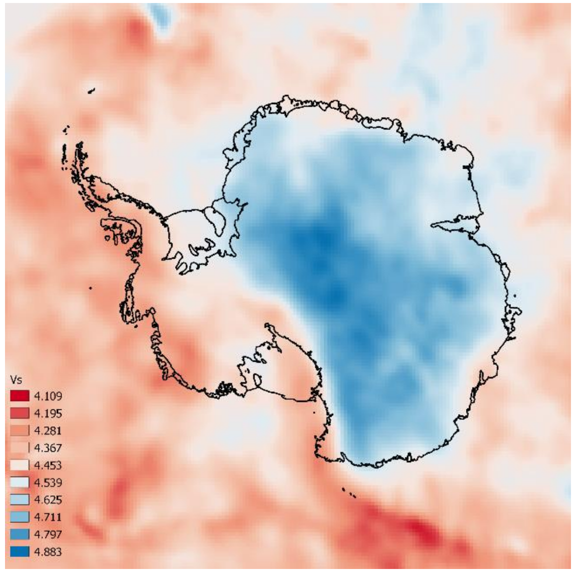
1200 degree isotherm

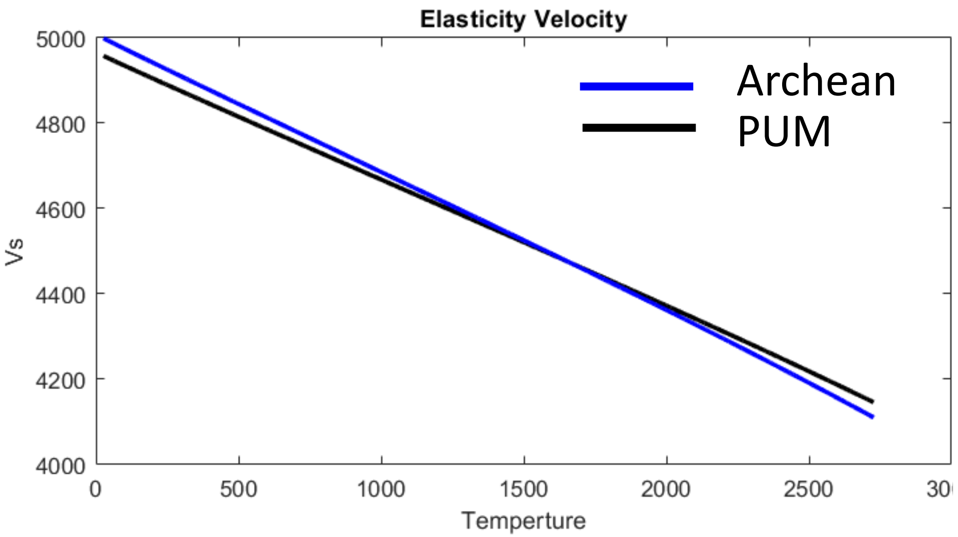
Heat flow

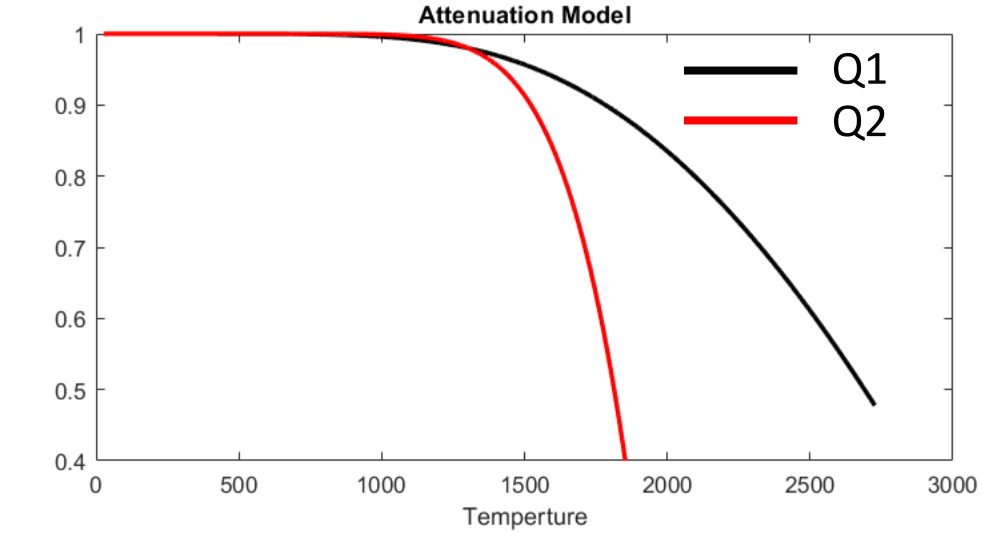


Convert Seismic velocity to temperature and density

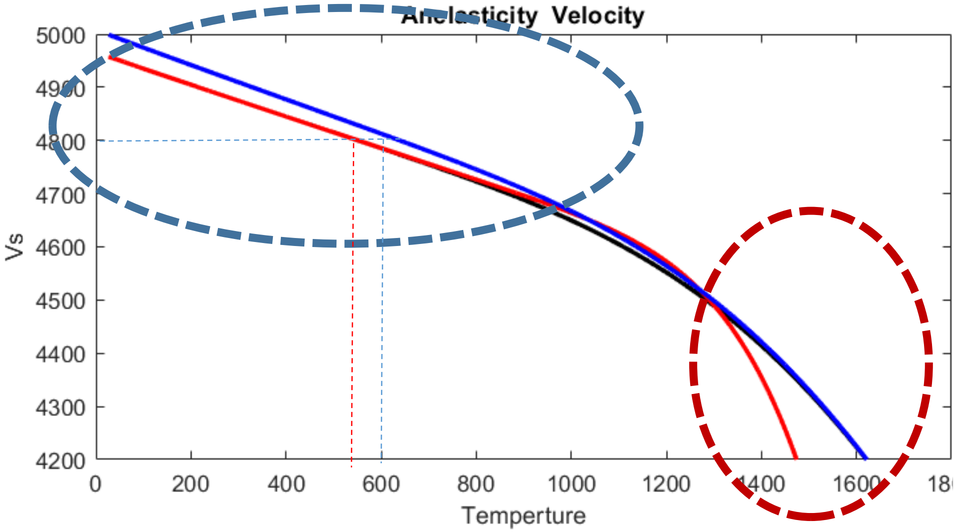
(Goes et al., 2000)



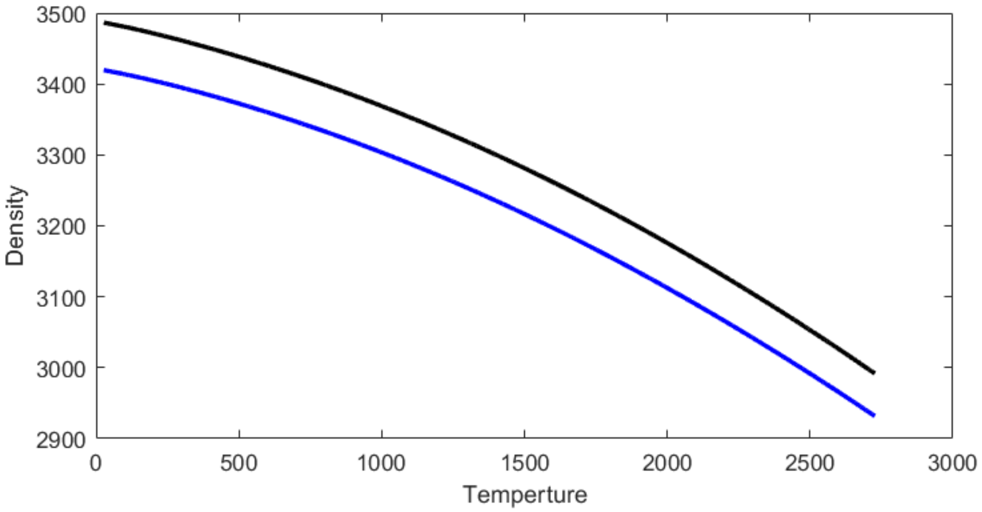




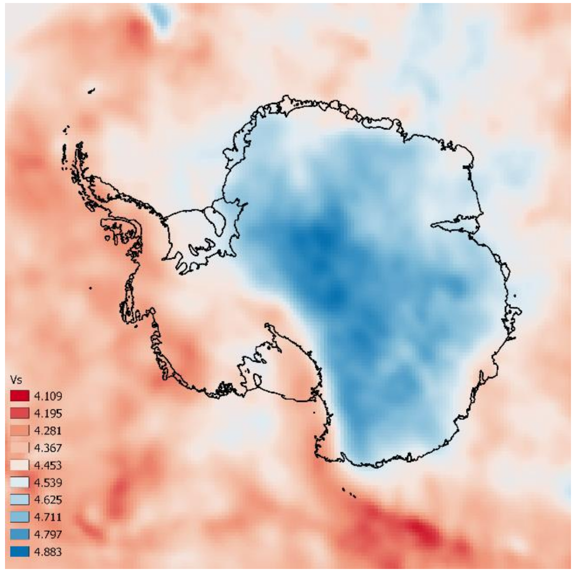
150 km depth from ANT-20 (Lloyd et al., 2020)



Archean, Q1
PUM, Q1
PUM, Q2



Moving foreword



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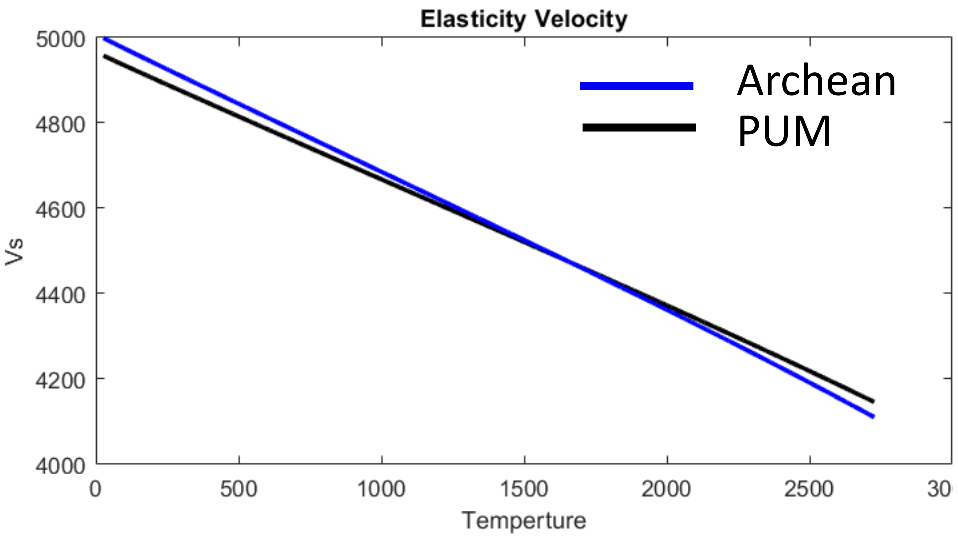

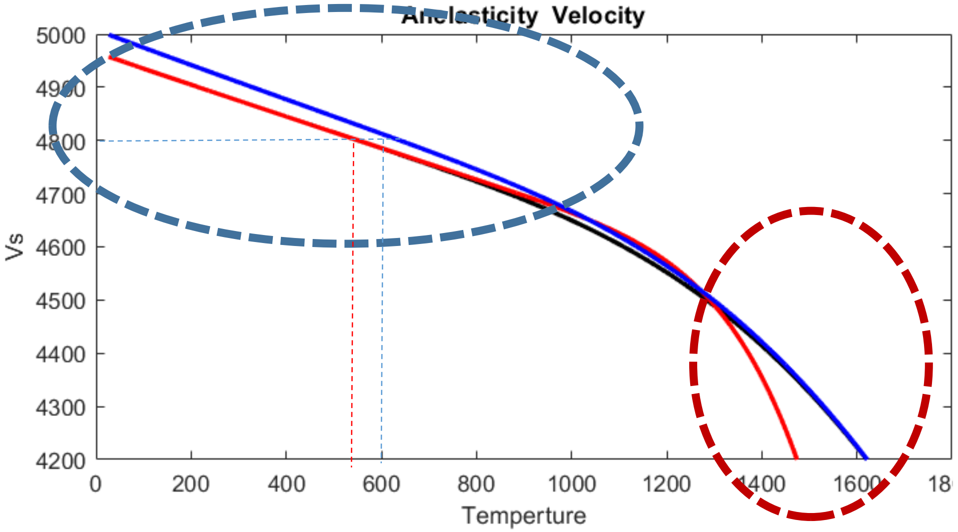

Archean, Q1
PUM, Q1
PUM, Q2

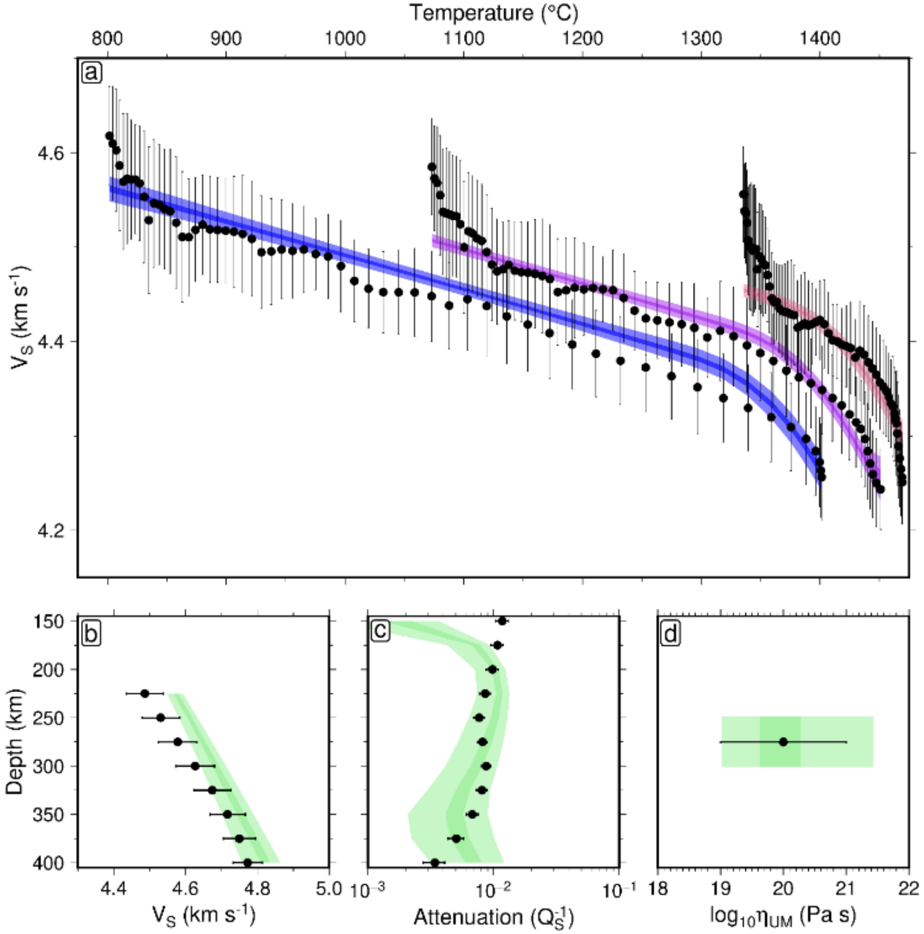

Fig 4 in Hazzard et al., 2022

Calibrate anelasticity parameter with “known” composition ?

Summary

- 1. A new thermal mechanical model in Antarctica.

- 2. Incorporate compositional change lead 100-150 degree hotter mantle in depleted region (6-10 mW/m^2), with 10 – 50 km thermal lithosphere thickness change.

- 3. Anelastic parameter remain large uncertainty to estimate thermal mechanical structure in Antarctica.

Reference

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- Goes, S., Govers, R., & Vacher, A. P. (2000). Shallow mantle temperatures under Europe from P and S wave tomography. *Journal of Geophysical Research: Solid Earth*, *105*(B5), 11153-11169.
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- Lloyd, A. J., Wiens, D. A., Zhu, H., Tromp, J., Nyblade, A. A., Aster, R. C., ... & O'Donnell, J. P. (2020). Seismic structure of the Antarctic upper mantle imaged with adjoint tomography. *Journal of Geophysical Research: Solid Earth*, *125*(3).