Influence of radiogenic heating on mid-ocean ridge depths and seafloor subsidence

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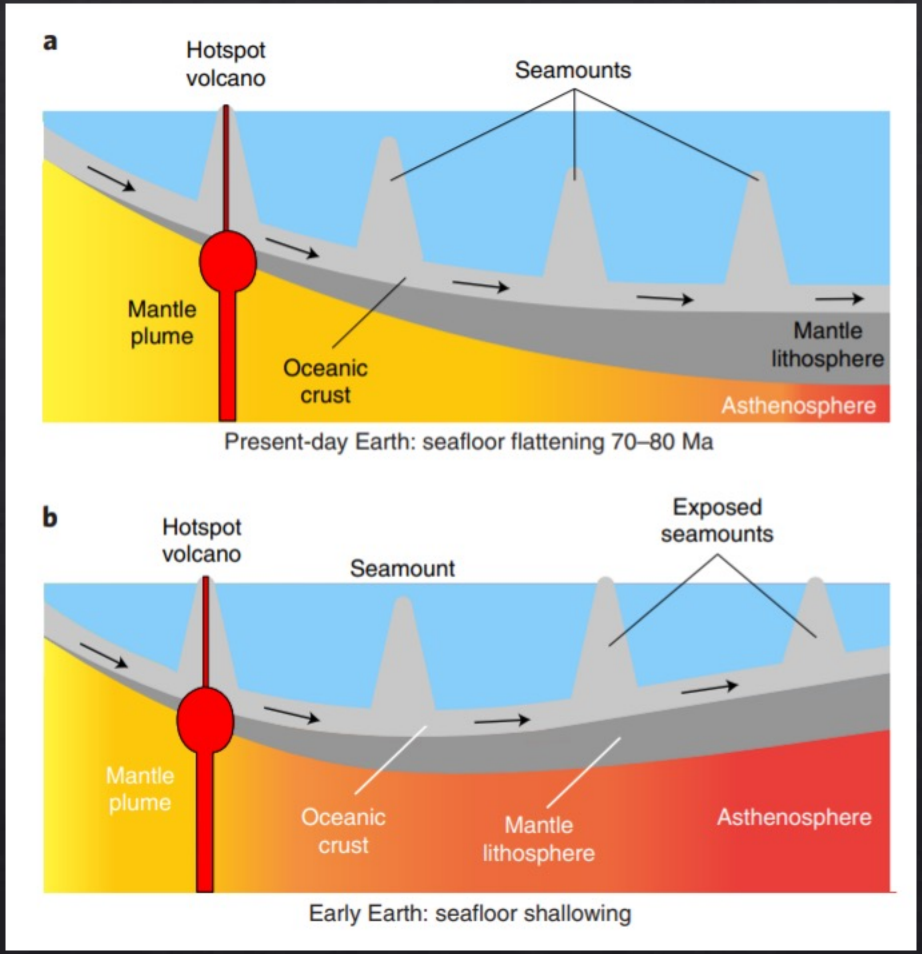
CIG SMOREs

Background and Motivations

- Mantle convection was more vigorous in Early Earth indicated by a higher Rayleigh number (Sim et al., 2016)
- Vibrant deep-sea biosphere mostly likely the origin of life
  - Possible other location is warm pools of water most likely near volcanoes
  - Needs exposed land or seamounts (Rosas and Korenaga, 2021)
  - Radiogenic materials may have made early exposed seamounts possible (Rosas and Korenaga, 2021)



Rosas and Korenaga 2021 Plate Cooling Model

- H* (referred to as H) : Heat generation unit per unit mass
- Surface velocity: Average meters per year mid-ocean ridges are spreading
- All other variables kept constant

Subsidence without radiogenic heating

Plate Age (myr)

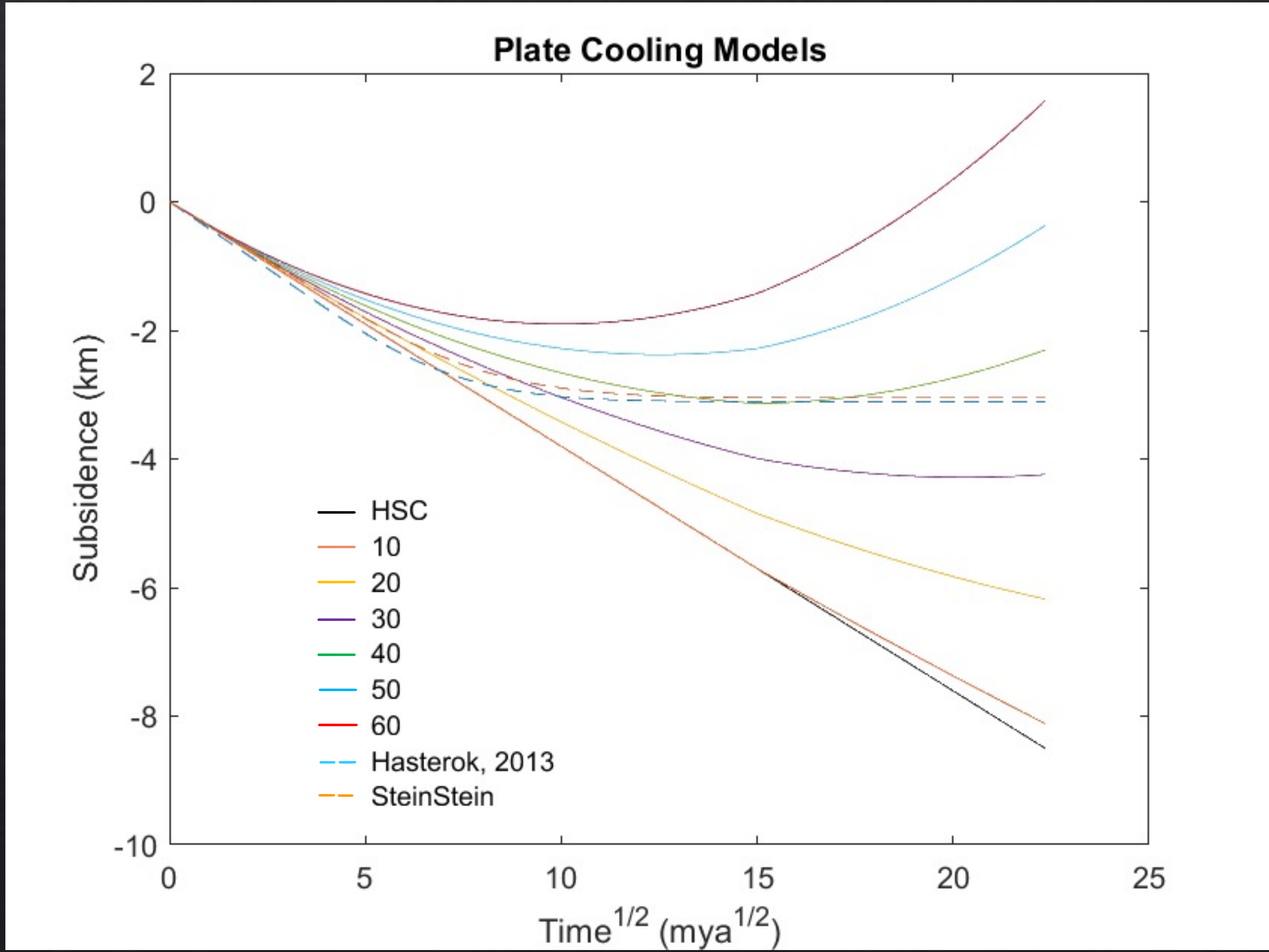
$$w_{\mathrm{s}} = w_{\mathrm{hs}} \times \begin{cases} 1 - a_1 H^* (t^{1/2} - t_i^{1/2}), & t < t_{\mathrm{c}} \\ 1 - a_1 H^* (t_{\mathrm{c}}^{1/2} - t_i^{1/2}) + \dfrac{H^*[a_1(t_{\mathrm{c}}^{1/2} - t_i^{1/2}) - a_2] - b_2}{t_{\mathrm{max}}^{1/2} - t_{\mathrm{c}}^{1/2}} (t^{1/2} - t_{\mathrm{c}}^{1/2}), & t_{\mathrm{c}} \le t \le t_{\mathrm{ma}} \end{cases}$$

Subsidence in km

Heat generation unit per unit mass (nondimensionalized)

the time it takes for sublithospheric convection affects subsidence

Significance of H* on subsidence



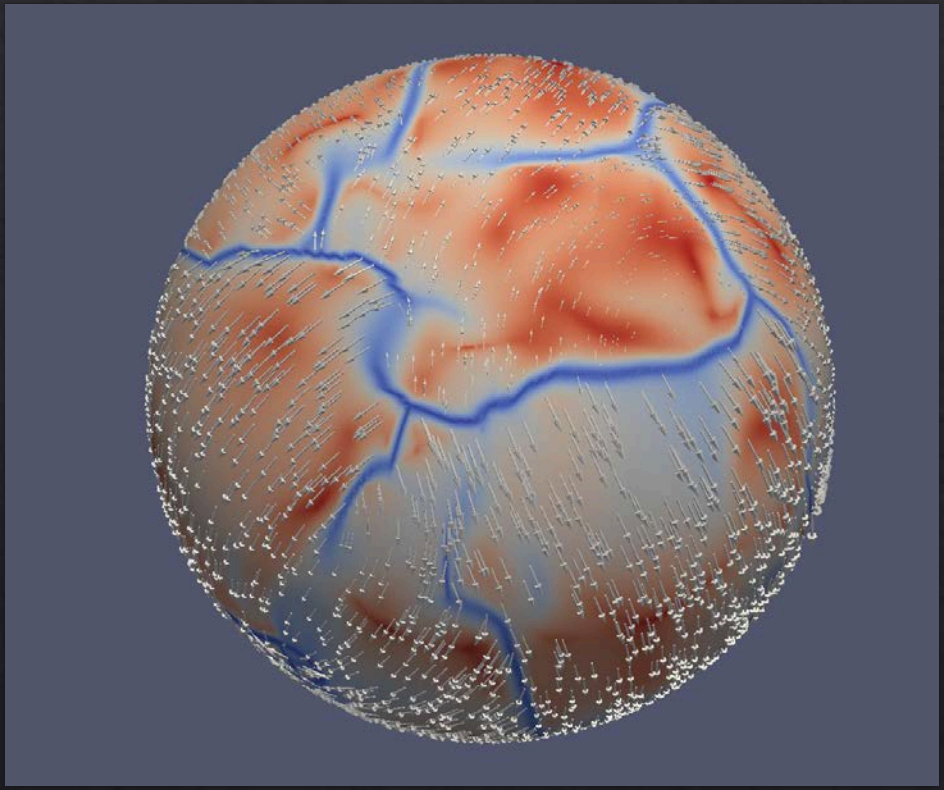
- Increasing the H* value decreases the time for radiogenic heating to affect subsidence
- Higher H values associated with Early Earth – constrains the possibility of exposed seamounts to Early Earth

Early Earth Mantle Convection Model

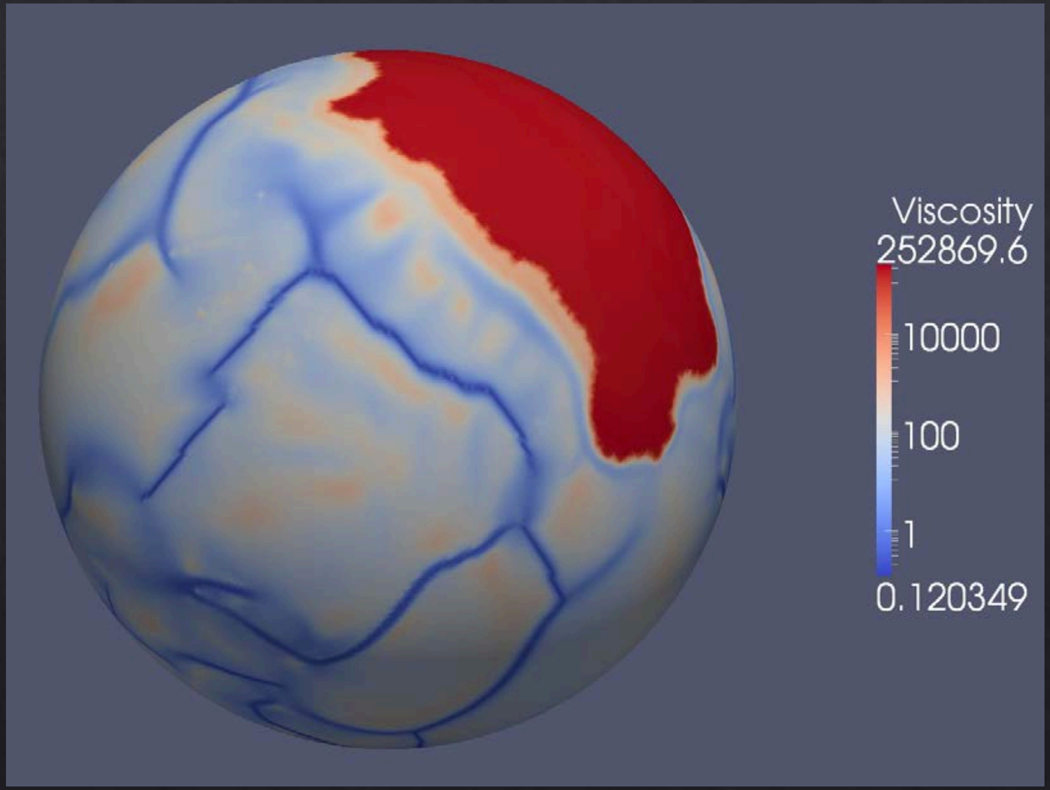
(Coltice et. al, 2014)

3 models in total: Hadean (0% continents), Archean (10%), and Modern (30%)

Hadean



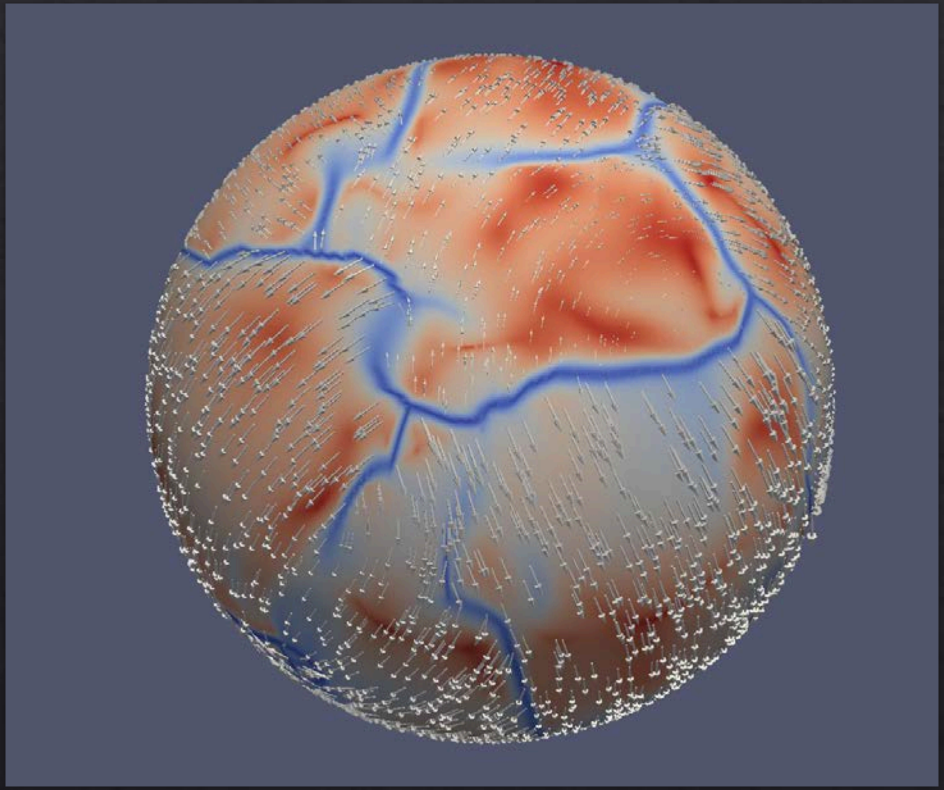
Archean



Early Earth Mantle Convection Model

(Coltice et. al, 2014)

Hadean



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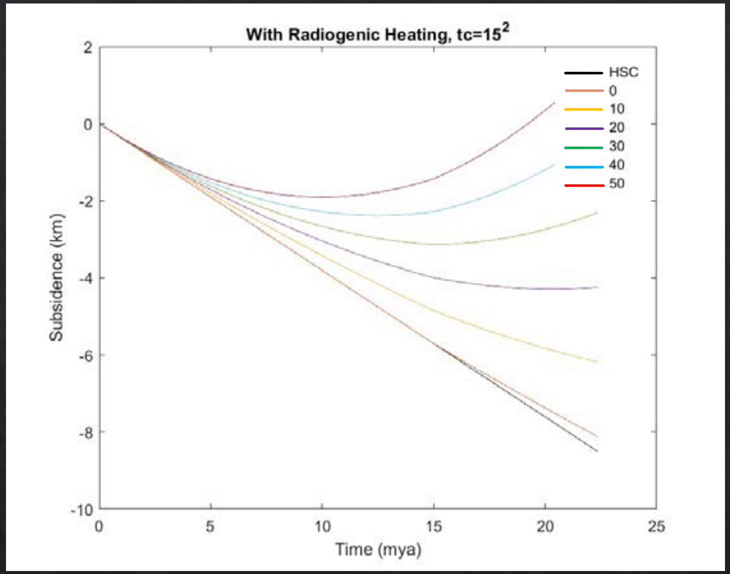
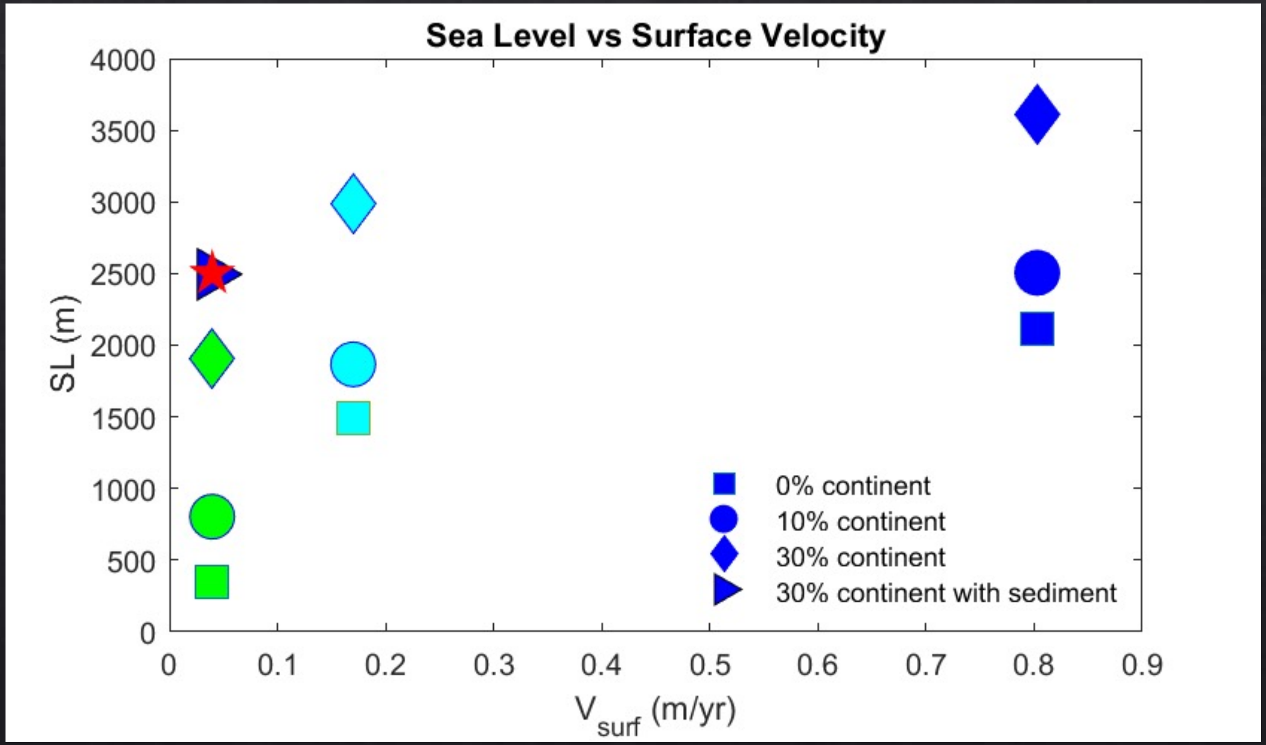
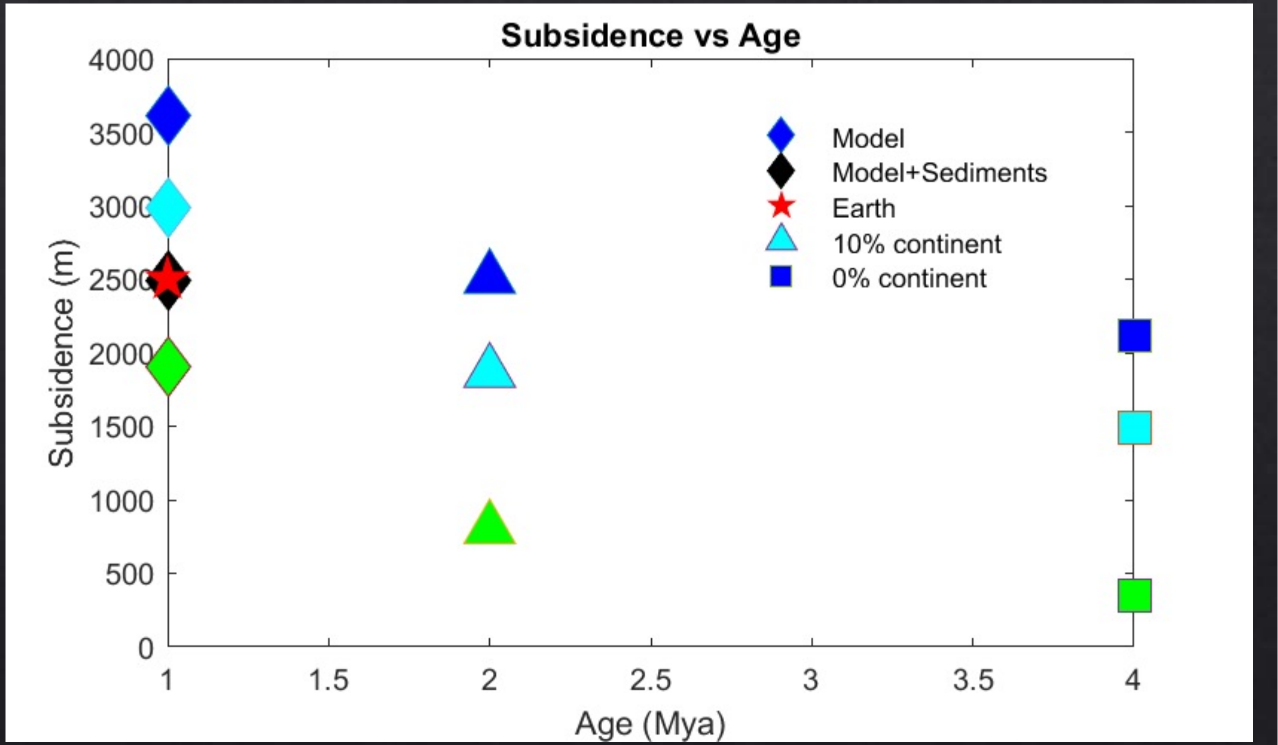


= Mid-ocean ridge depths

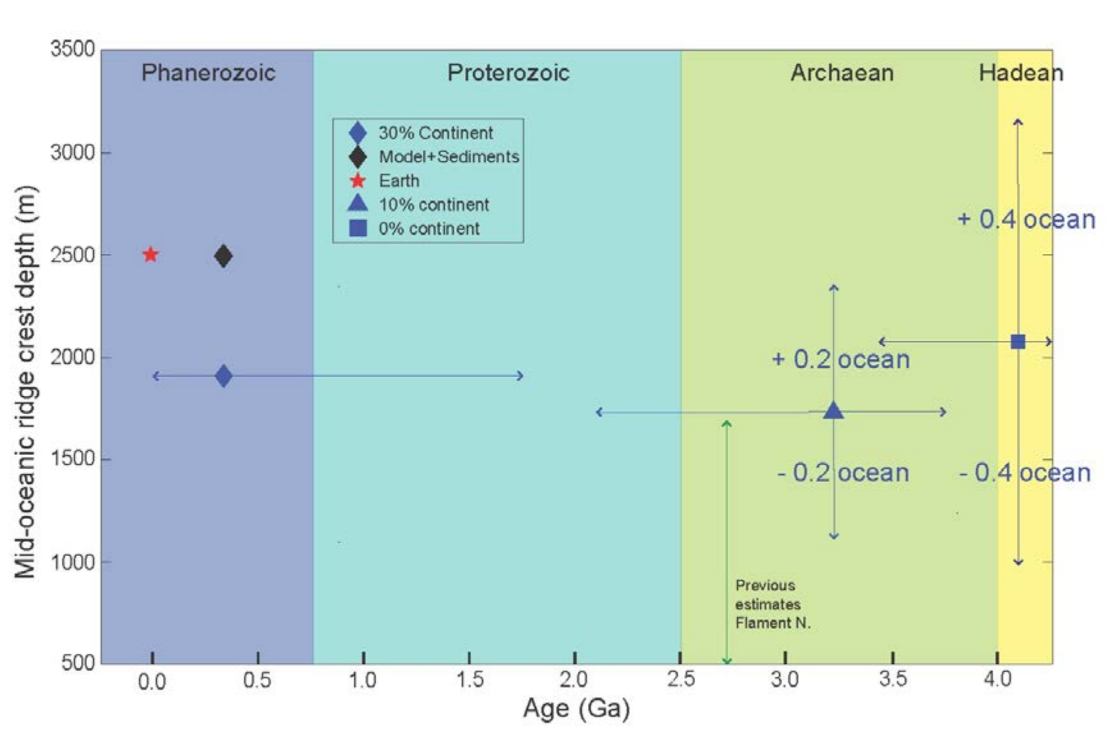
+ Modern day ocean

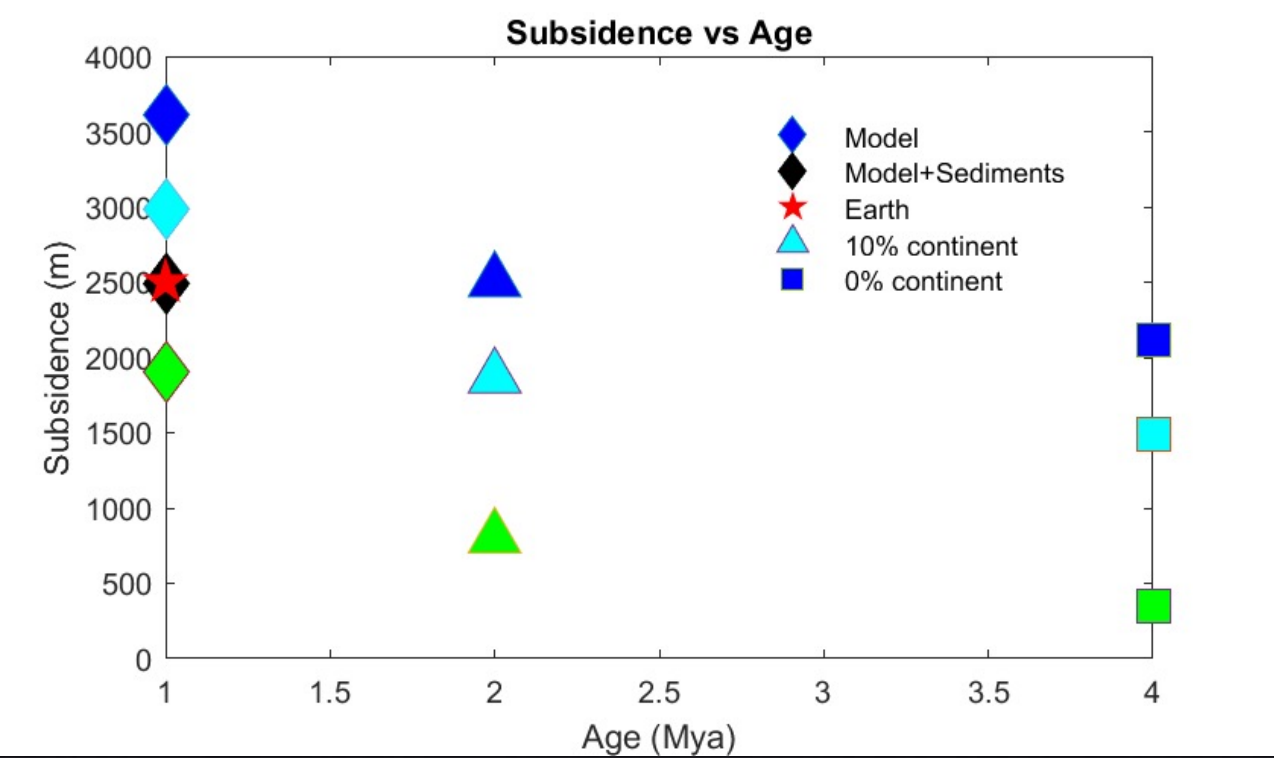
Results: Subsidence throughout time (continued)





Results: Subsidence throughout time





Conclusions

- MOR depths for Early Earth heavily depend on surface velocity
    - If surface velocity has stayed constant there is a possibility that land could have been exposed
    - If surface velocity has slowed over time, MOR depths have stayed relatively constant

Future Research

- Constrain how surface velocity functioned throughout time
- Properly indicate how different levels of radiogenic heating affected mid-ocean ridge depths
- Would want to do more research to see how radiogenic heating ebbed and flowed
    - Would help constrain when exposed land, especially in the Hadean, could have been possible

Citations

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