S-Se-Te sequestration into Earth's core suggests a volatile-poor late veneer composition

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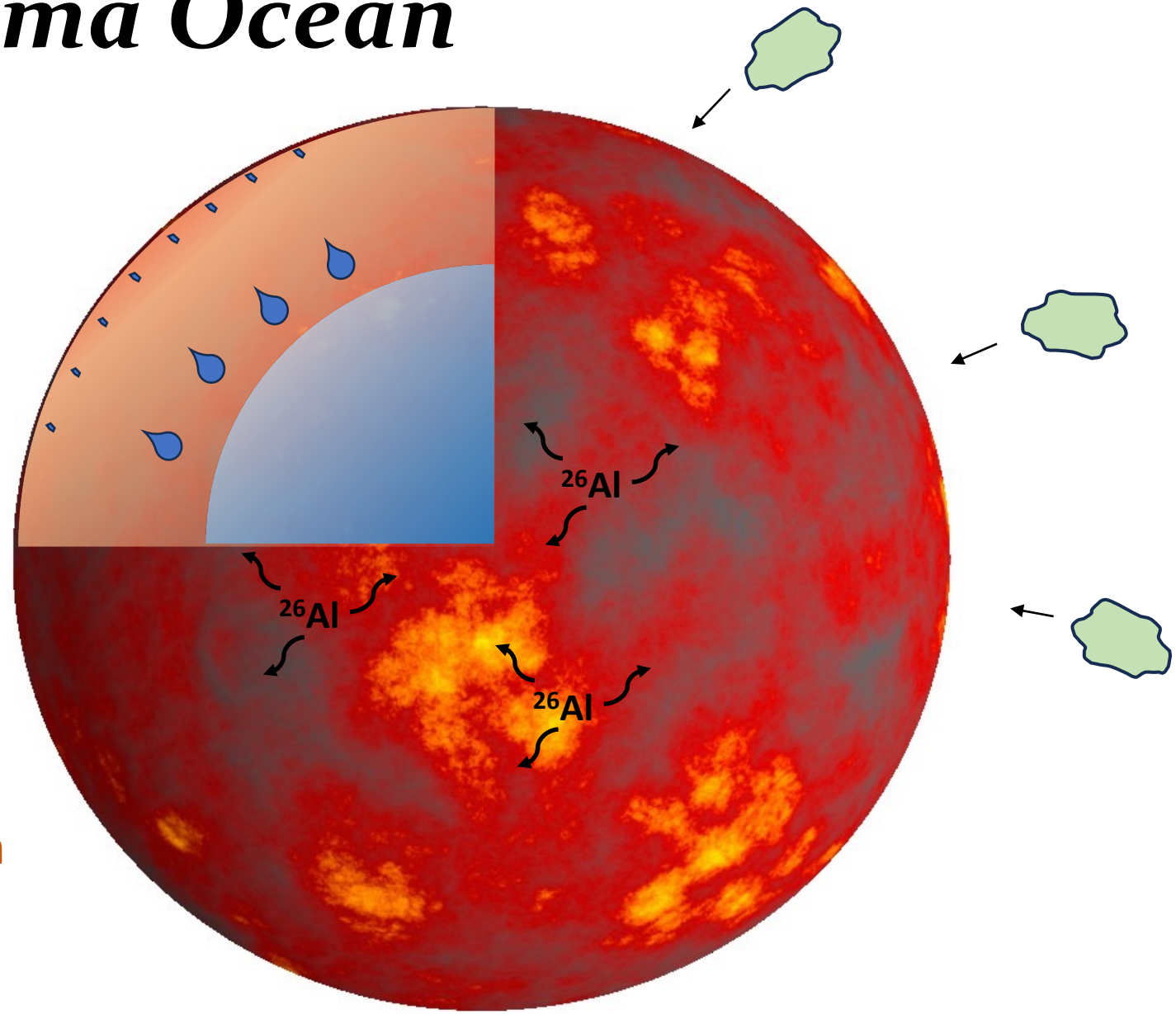
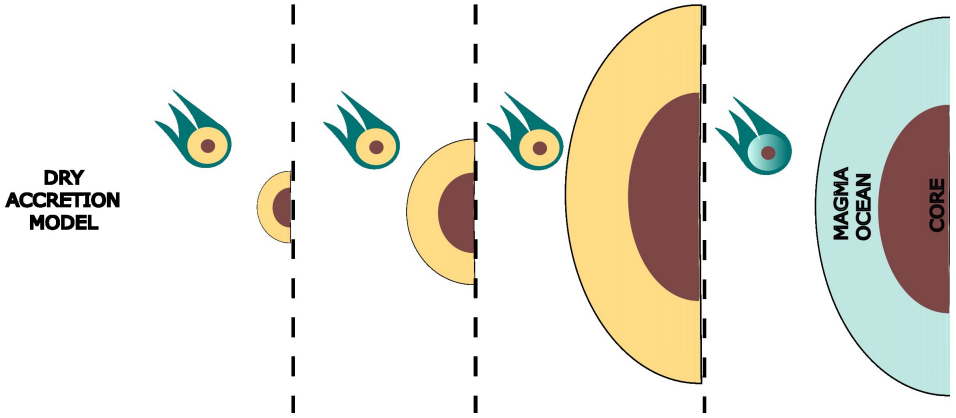
The Magma Ocean

Core Segregation

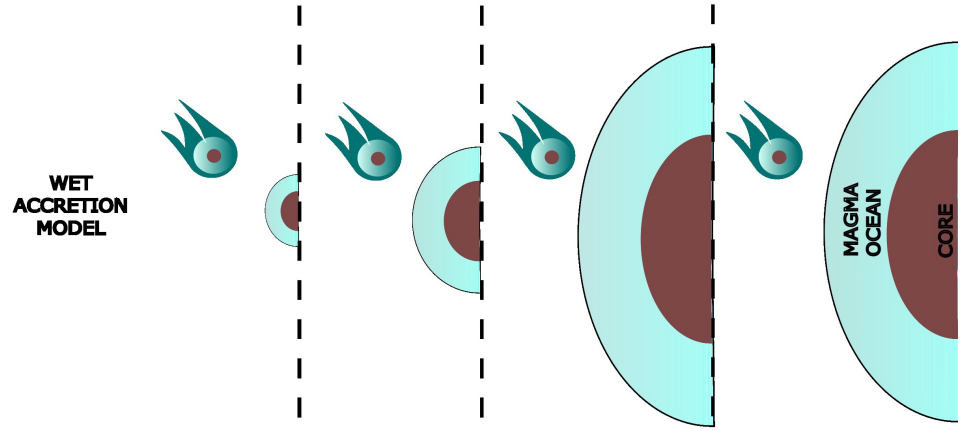


Magma Ocean

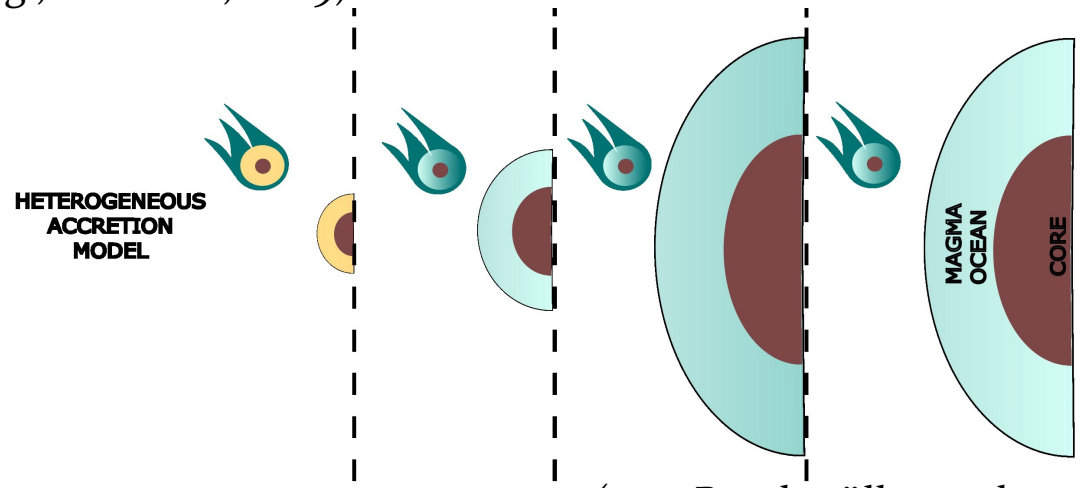
Accretion models



(e.g., Albarède, 2009)



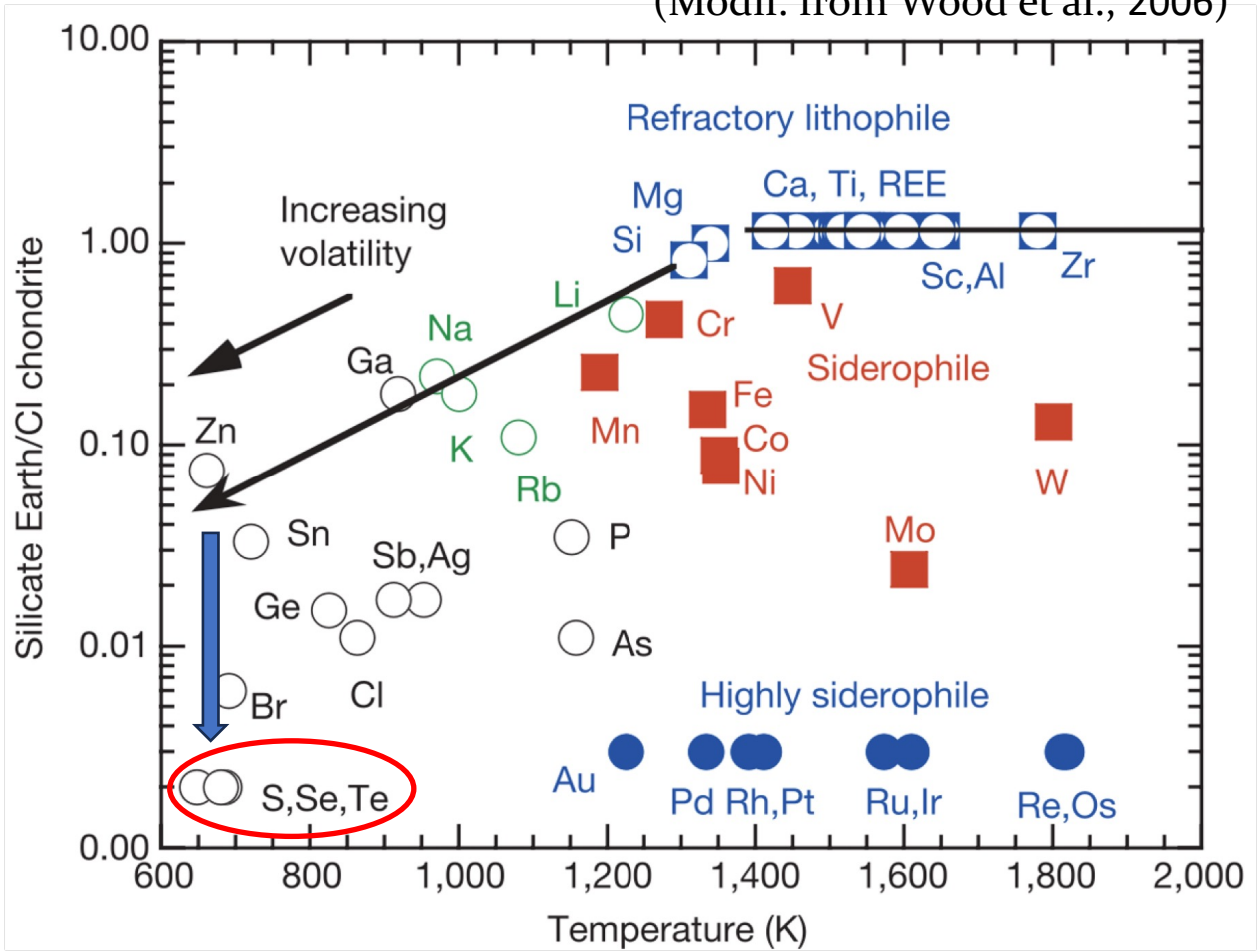
(e.g., Righter et al., 2017)



(e.g., Braukmüller et al., 2019)

Sulfur, selenium and tellurium

(Modif. from Wood et al., 2006)



- Similar volatility
- Similar abundance in BSE
- Similar geochimical behavior
  - Volatile-Siderophile elements

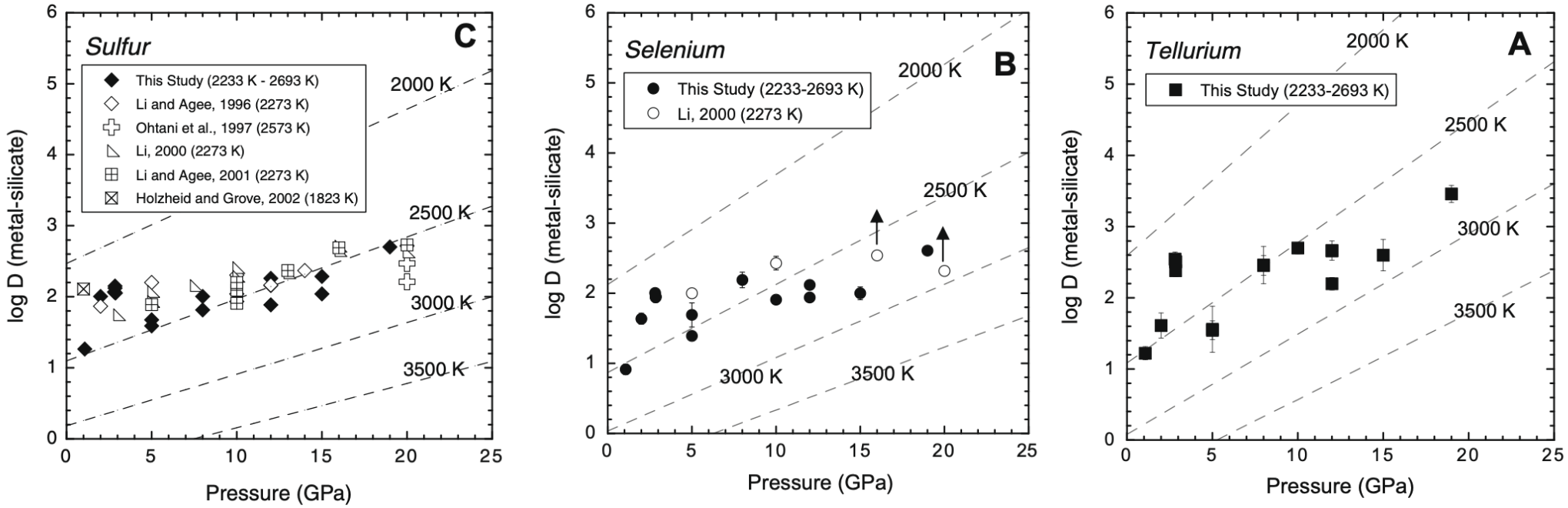
Relevant trackers for Timing & Model of volatile elements arrival to Earth!

Did they arrive during or after Earth's core formed?

Experimental studies at low pressure

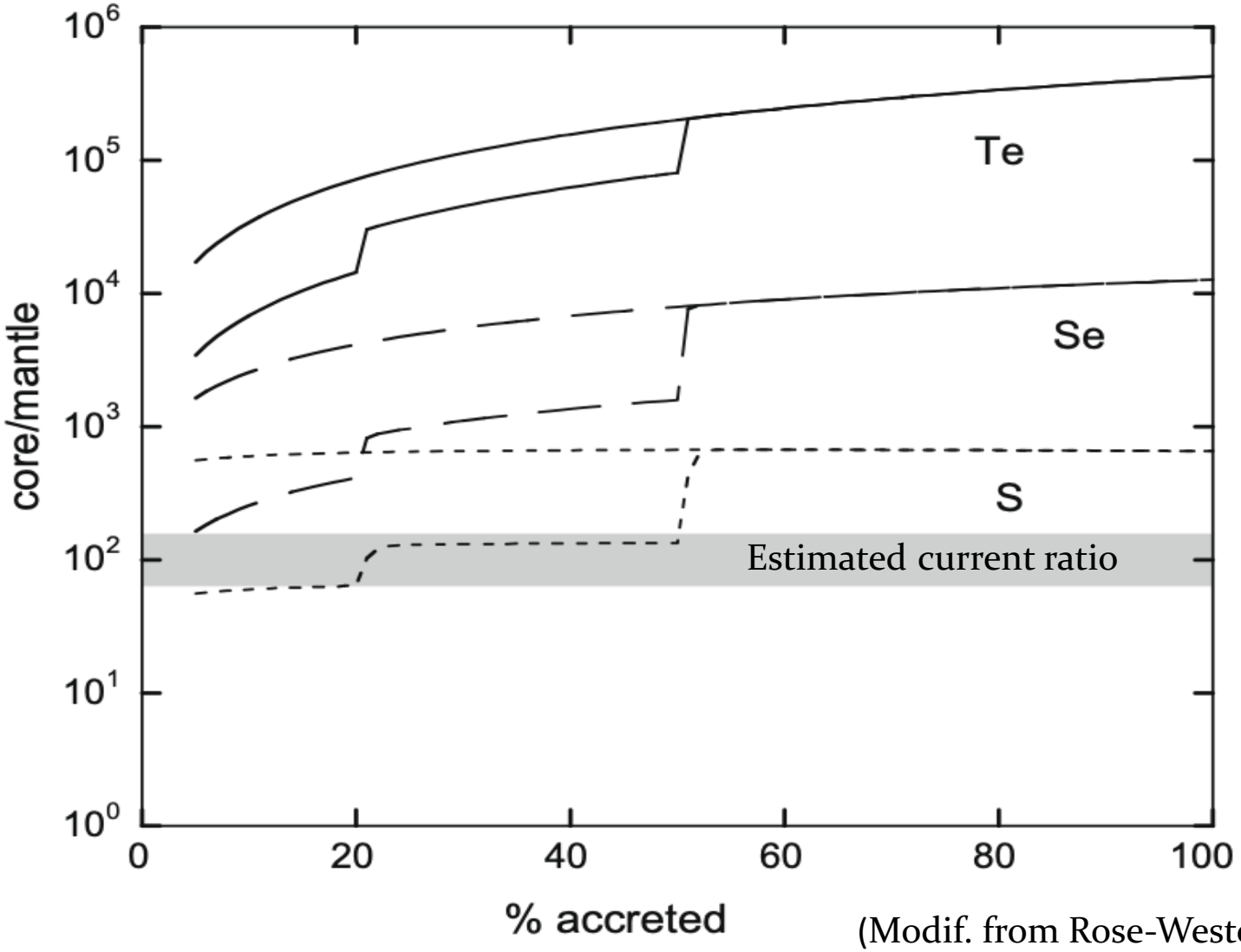
$$D_i^{\text{met-sil}} = \frac{X_i^{\text{met}}}{X_i^{\text{sil}}}$$

If $D_i^{\text{met-sil}} > 1$ Element into the metal (core)!



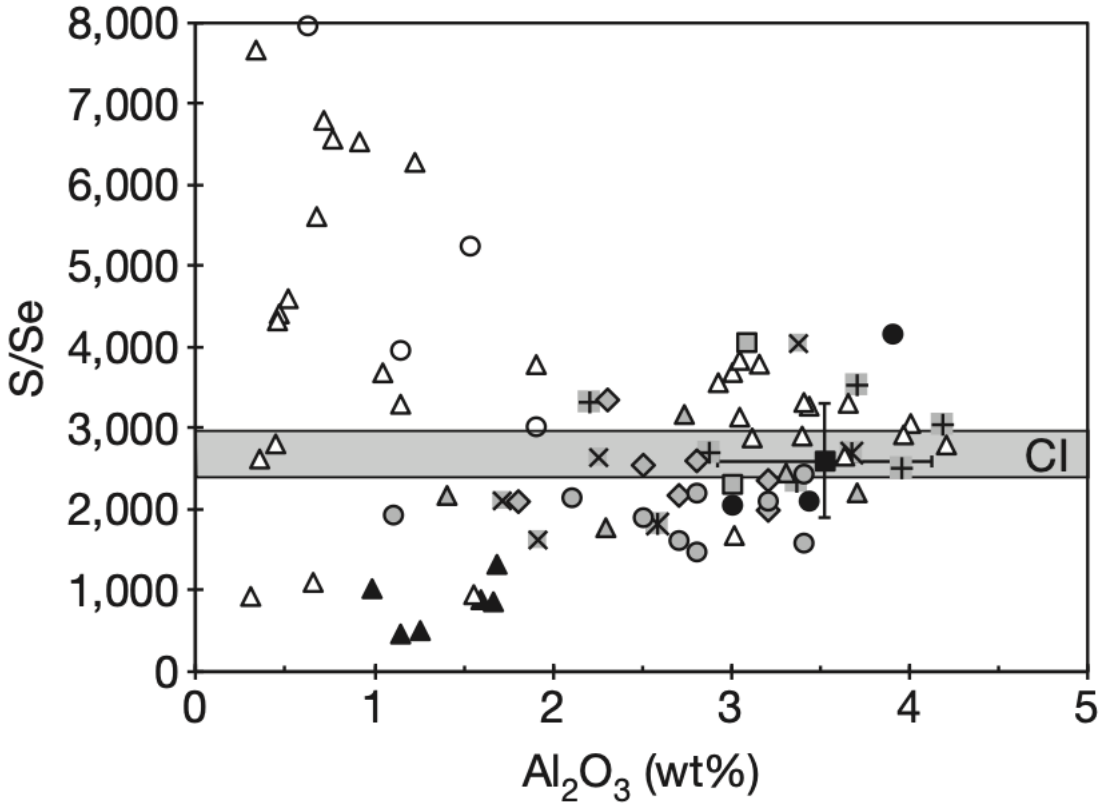
(Rose-Weston et al., 2009)

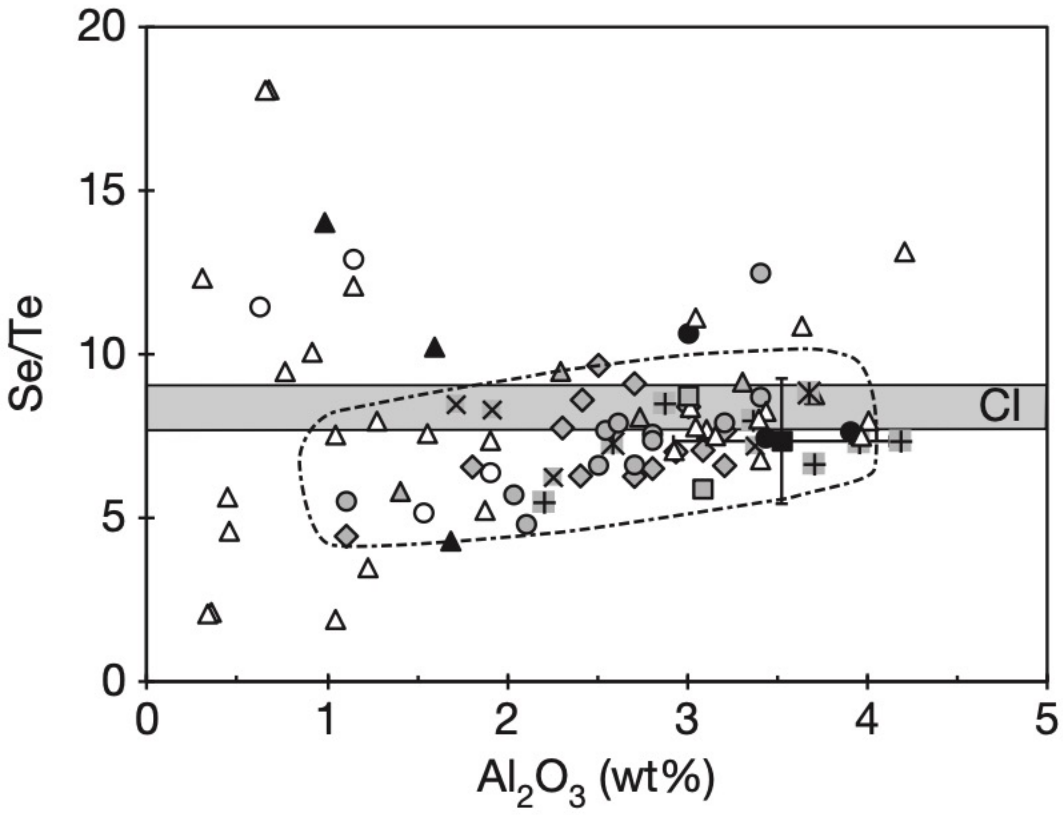
Experimental studies at low pressure



(Modif. from Rose-Weston et al., 2009)

S-Se-Te in the mantle



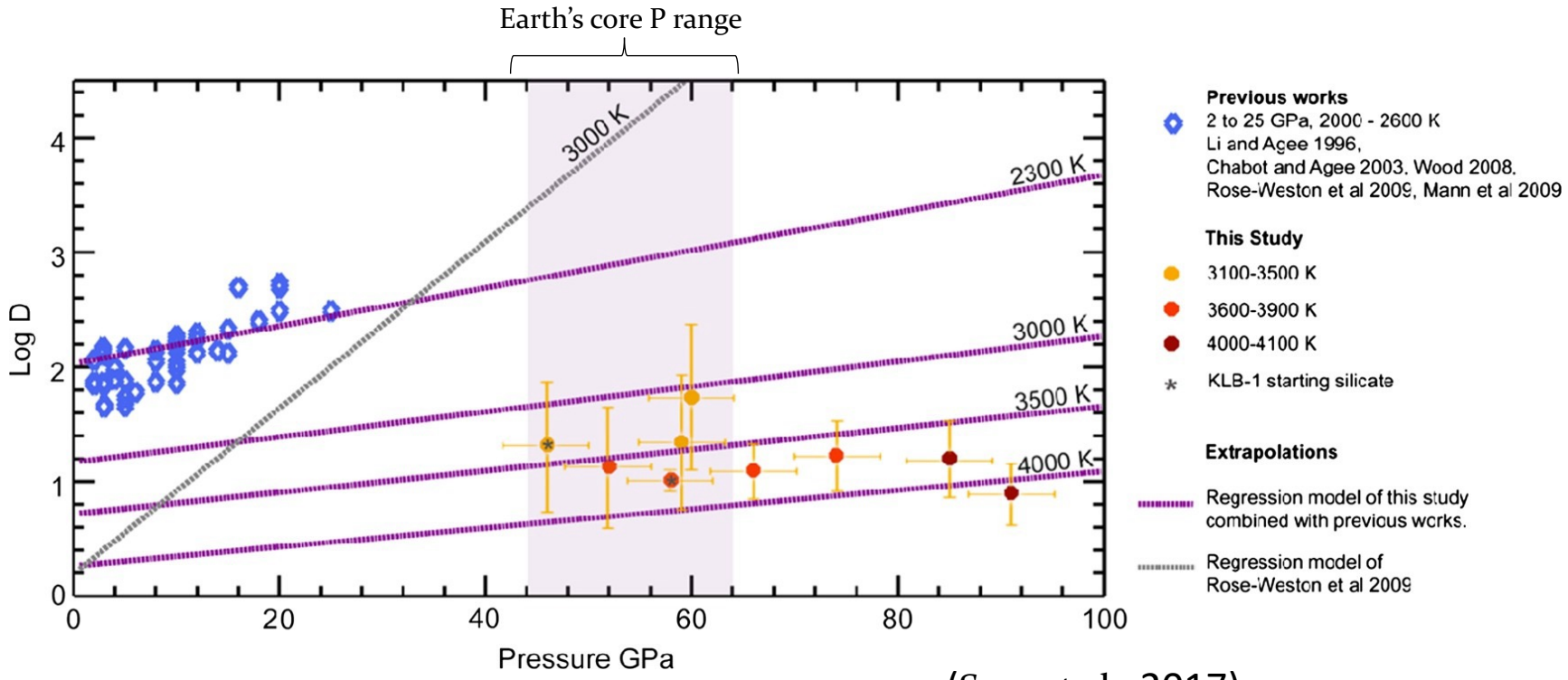


(Wang & Becker, 2013)

A (S, Se, Te)-carrying *late veneer* seems like a plausible answer

But…

Sulfur behaviour at core conditions



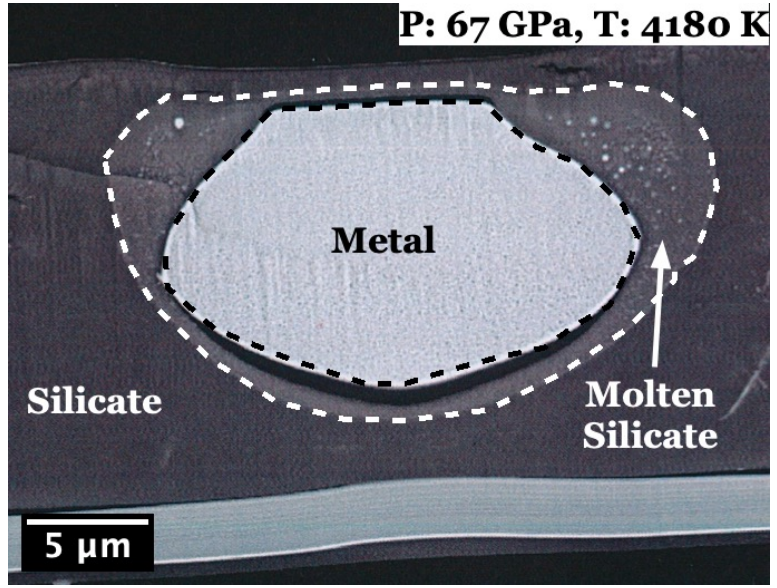
(Suer et al., 2017)

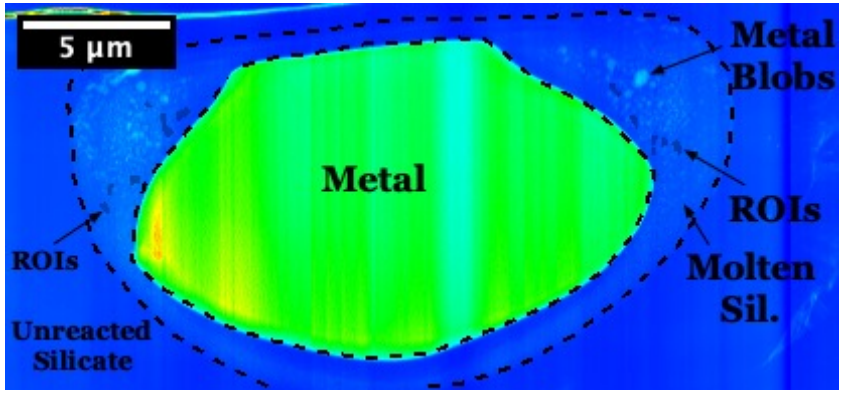
Sulfur shows lower partition coeficient (≈ more S partitions into the mantle than previously thought)…
How do Se and Te behave at core conditions?

Our study

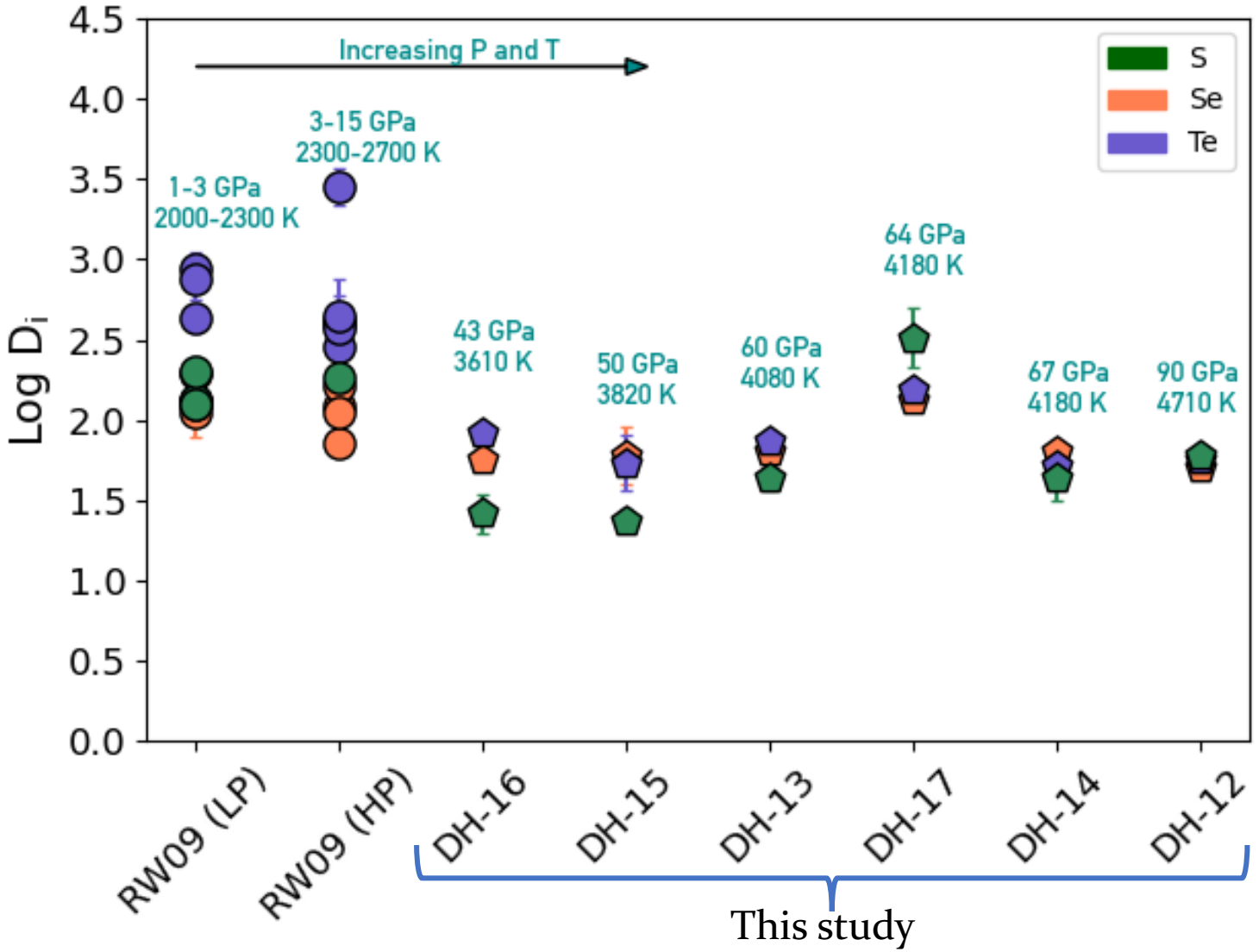
- Experimental approach:
  - Laser Heated-Diamond anvil cell experiments at core PT conditions (43-90 GPa, 3600-4700 K)
  - Peridotite-Fe(S,Se,Te) alloy-Peridotite

- Analytical approach:
  - EPMA analysis on metal and silicate phases
  - Nano-XRF analyses at **ID16B** – ESRF
    - Higher spatial and analytical resolution (~100 nm, ppm level)



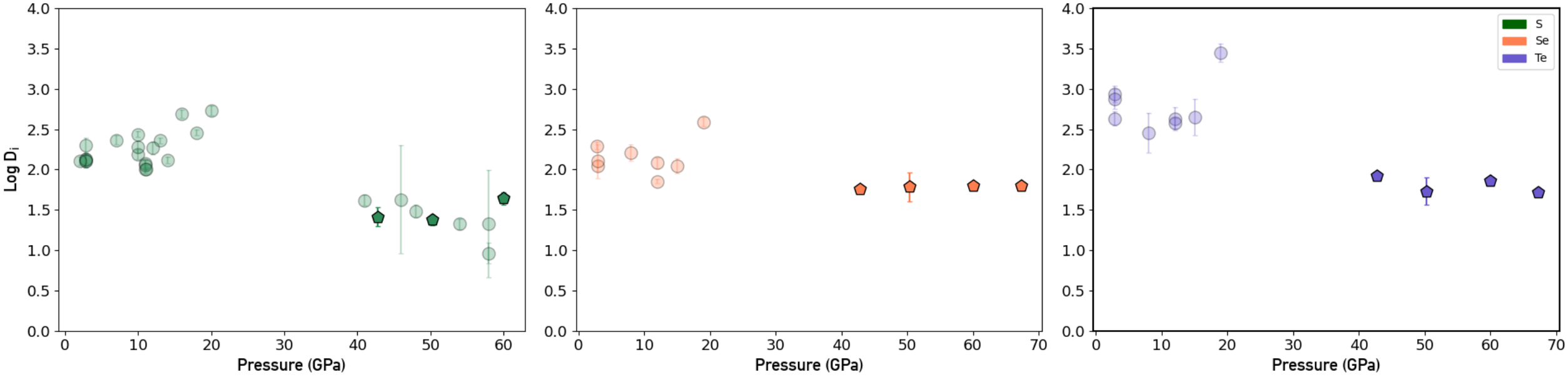


S, Se, Te at core conditions



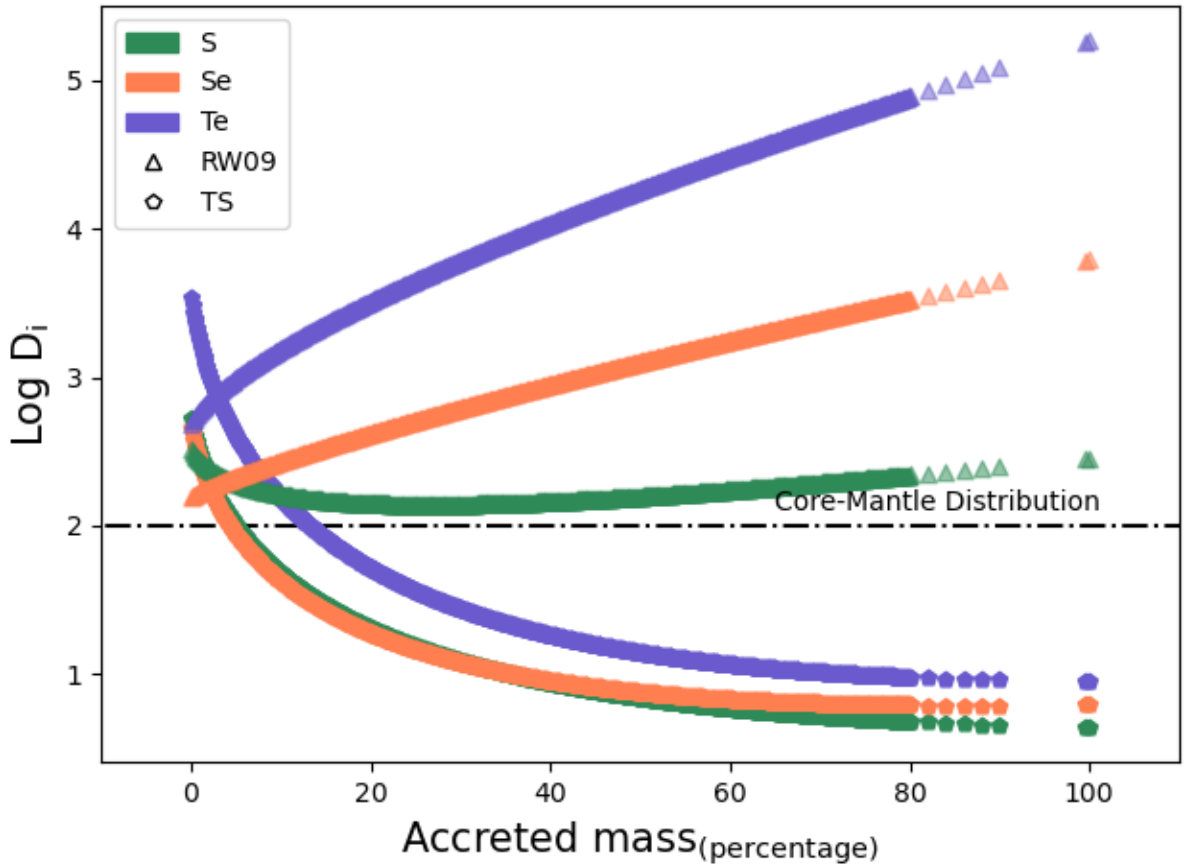
S, Se, Te at core conditions

*Semi transparent symbols: Li & Agee 2001; Chabot & Agee 2003; Rose-Weston et al., 2009; Suer et al., 2017; Vogel et al., 2018; Huang et al., 2021; Kubik et al., 2021

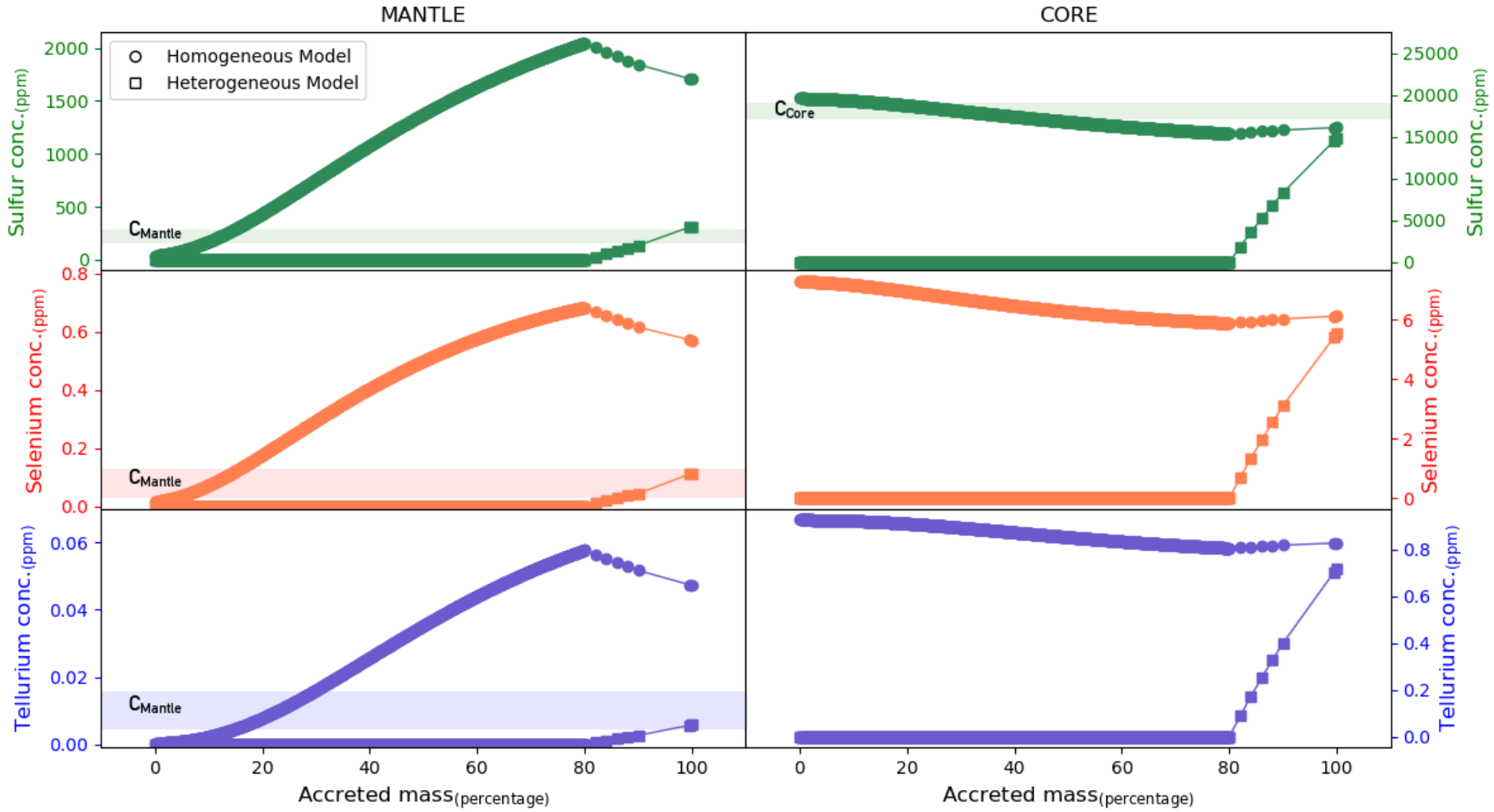


$$\text{Log } D_i^{\text{met-sil}} = \boldsymbol{a} + \boldsymbol{b}\frac{1}{\text{T}} + \boldsymbol{c}\left(\frac{\text{P}}{\text{T}}\right) + \text{Log } \text{X}_{\text{FeO}}^{\text{sil}} - \text{Log } C_S$$

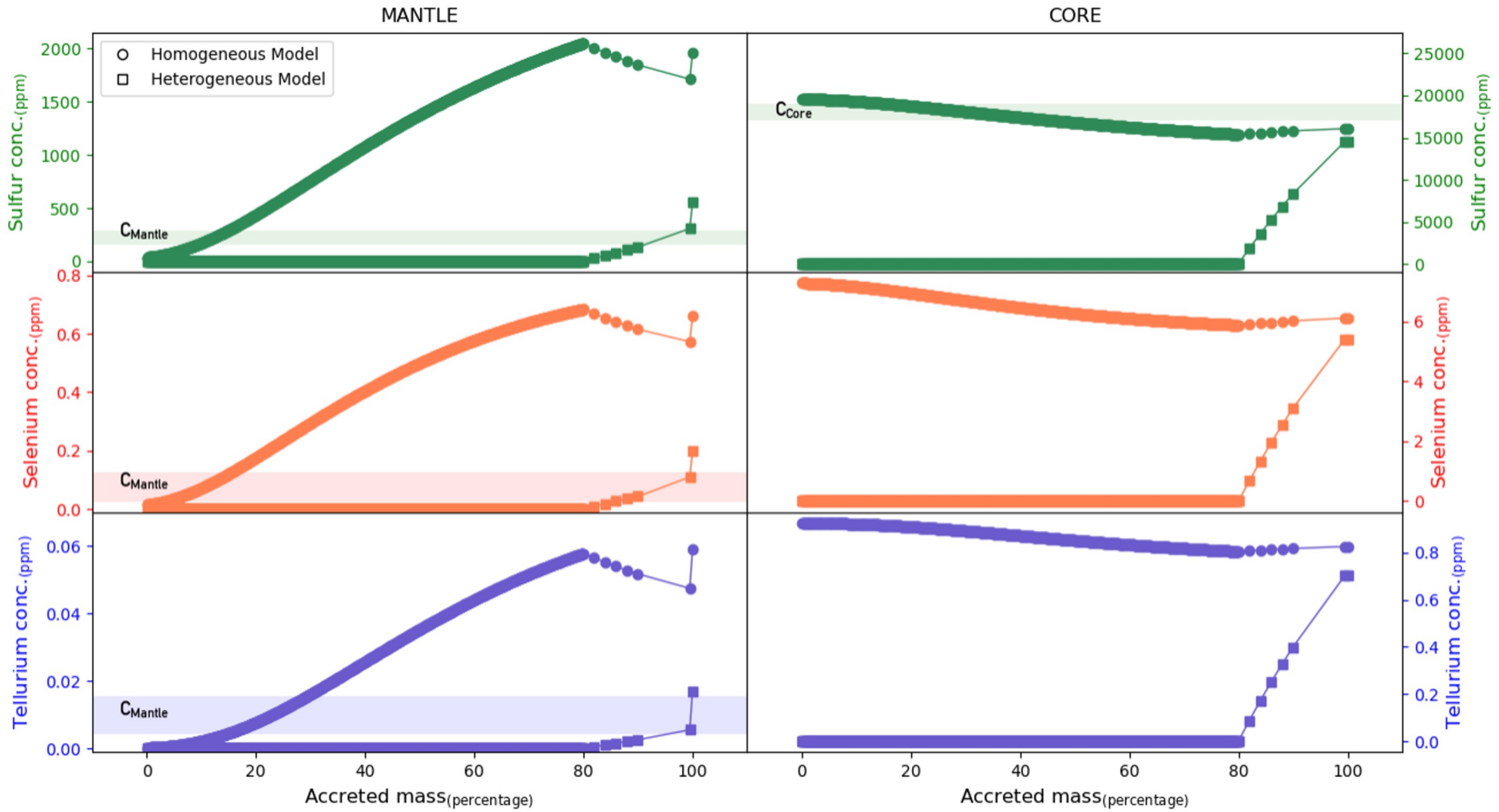
Comparison with previous (LP) studies



Modelling results (without late veneer)



Modelling results (with late veneer)

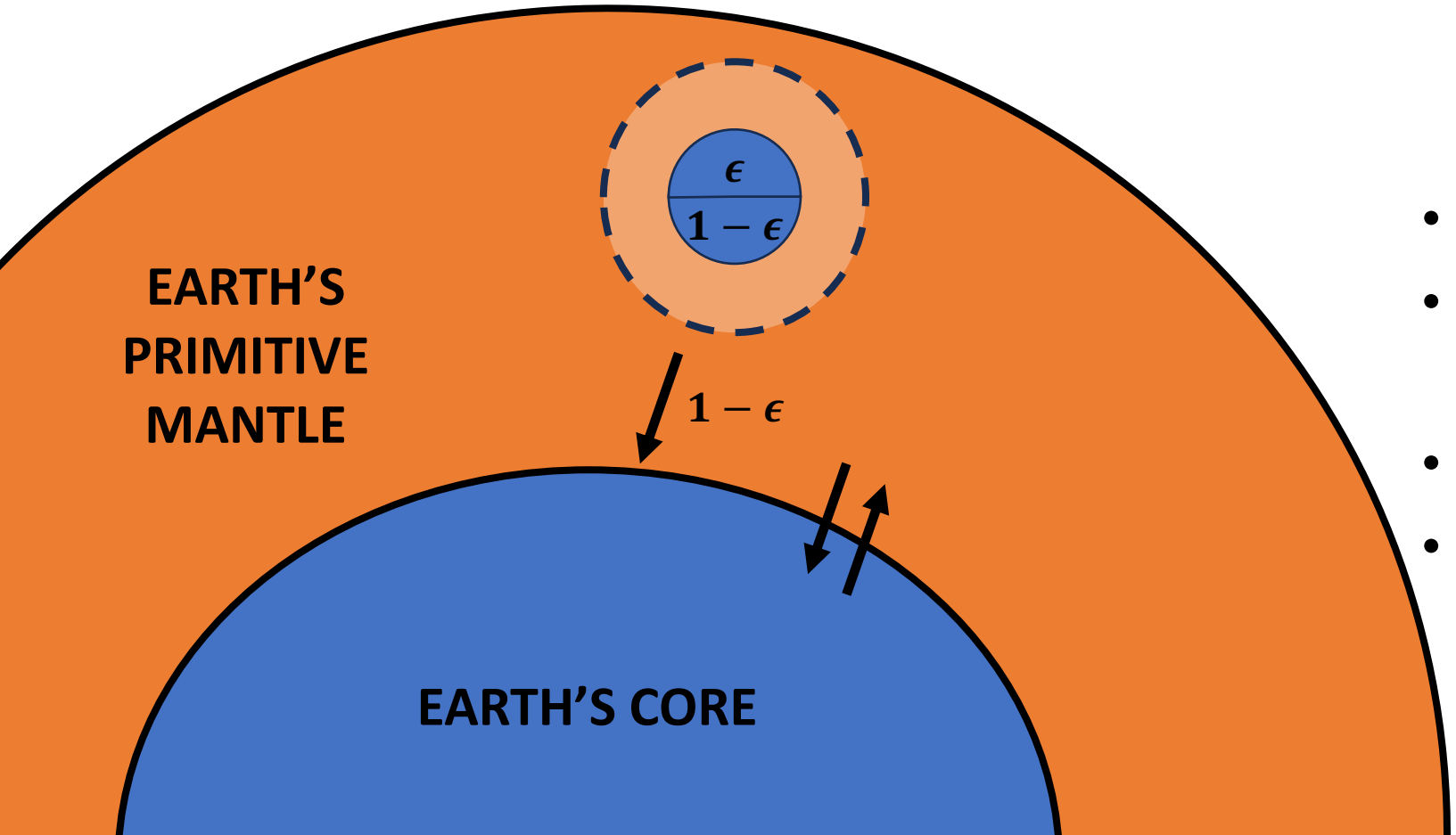


Conclusions

- Sulfur, selenium and tellurium (volatile and siderophile elements)
  - Good trackers for constraining: timing and model of accretion
- No studies have been performed with S-Se-Te at core condition. We explored their metal-silicate partitioning at HP-HT
- A first approach tells that:
  - A *late veneer* does not seem to be required to explain the concentrations in Earth's mantle.
  - A *heterogeneous accretion* process is more likely than a *homogeneous* one with a constant delivery of these elements
  - Further modelling will allow us to propose possible volatile accretting scenarios


Thank you!

Modelling



- Each step increment of mass of
  - M_E (0-80%): 0.1 % Earth mass
  - M_E(80-90%): 2 % Earth mass
  - M_E(90-99.5%): 9.5 % Earth mass
  - M_E(99.5-100%): 0.5 % Earth mass
- P^{eq} at 40% of CMB
- T^{eq} average liq-sol peridotite (Badro et al., 2015)
- Constant fO_2($X_{BSE}^{FeO} = 0.057$)
- Log Cs=-5.372 (pyrolitic mantle, Suer et al., 2017)