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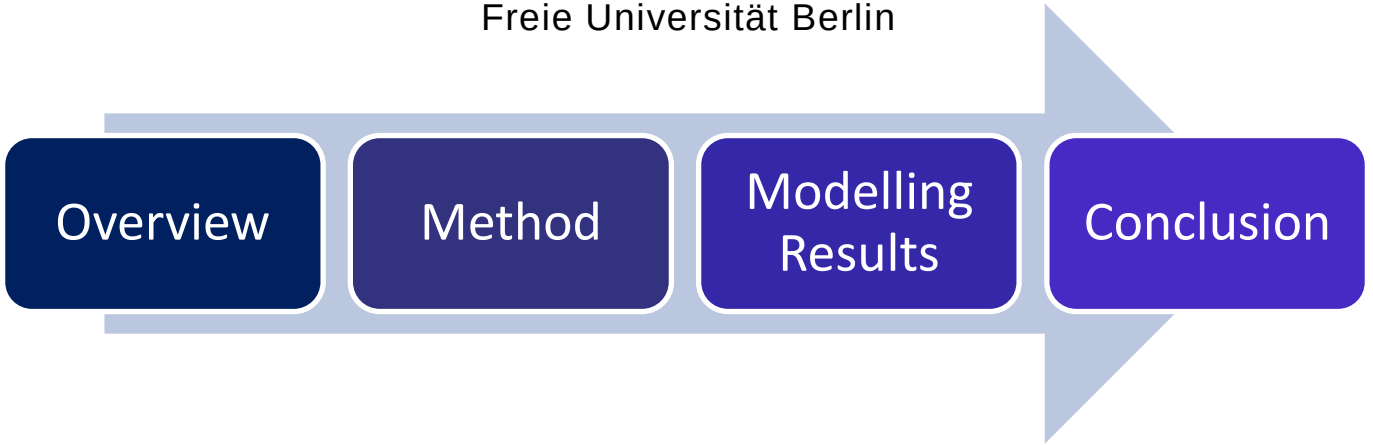
LATE ACCRETION
ONTO TERRESTRIAL PLANETS

Overview

Modelling clinopyroxene/melt partition coefficients for higher upper mantle pressures

Julia M. Schmidt, Lena Noack

Freie Universität Berlin



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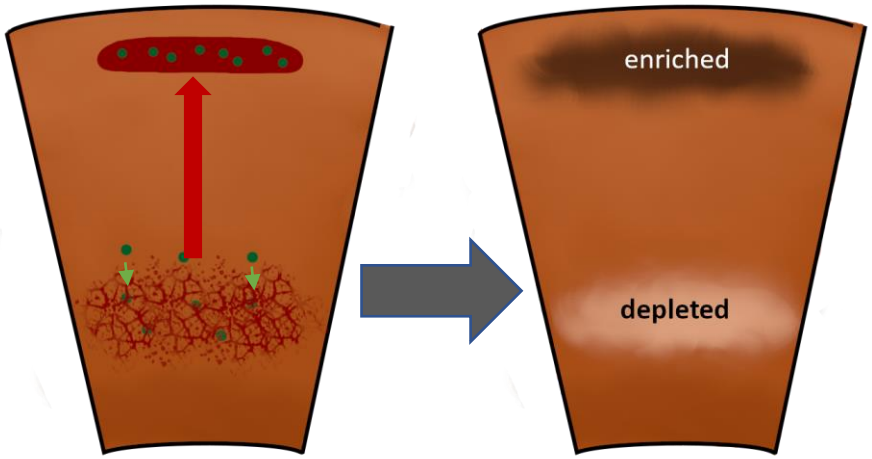
Overview

Partition coefficients are:

- important to comprehend redistribution of trace elements,
- pressure and temperature dependent,
- crucial for mantle evolution models.
  - But are neglected or set constant in partial melt simulations due to **lack of high pressure models**



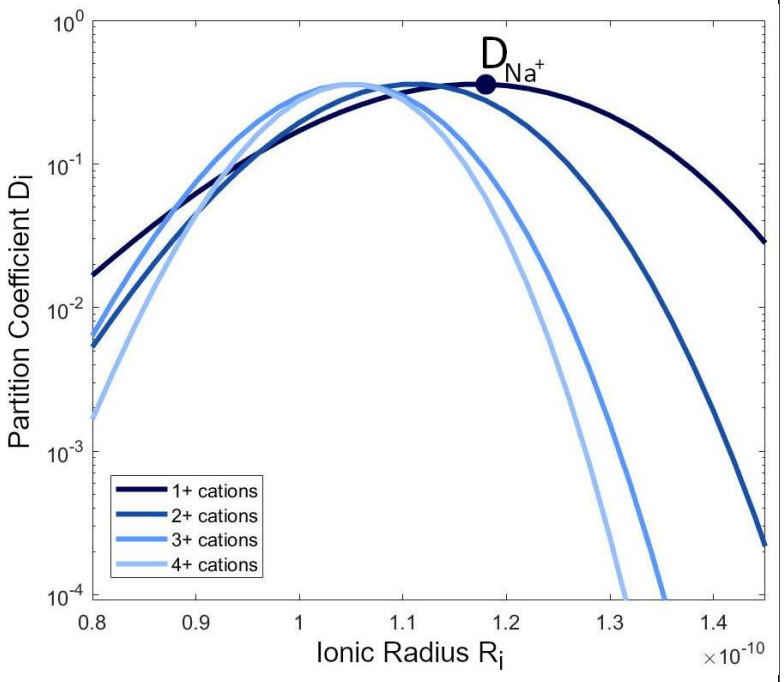
Incompatible elements are redistributed into partial melt and transported upwards.

- This results in an enriched suface and depleted upper mantle

Overview

Sodium clinopyroxene/melt partition coefficients can be used as a „reference“ coefficients for other trace elements:

- ❖ Sodium is the best fitting element in the M2 crystal lattice site of clinopyroxene and has therefore the highest partition coefficients
- ❖ The elements of one charge have a logarithmic relationship
- ❖ Curves of different charges shift depending on E-Modulus and lattice site radius



Clinopyroxene takes up most incompatible trace elements in all mantle materials

- ➢ Cpx/melt partition coefficients are crucial for mantle evolution models

Method

Approach by Wood and Blundy (1997):

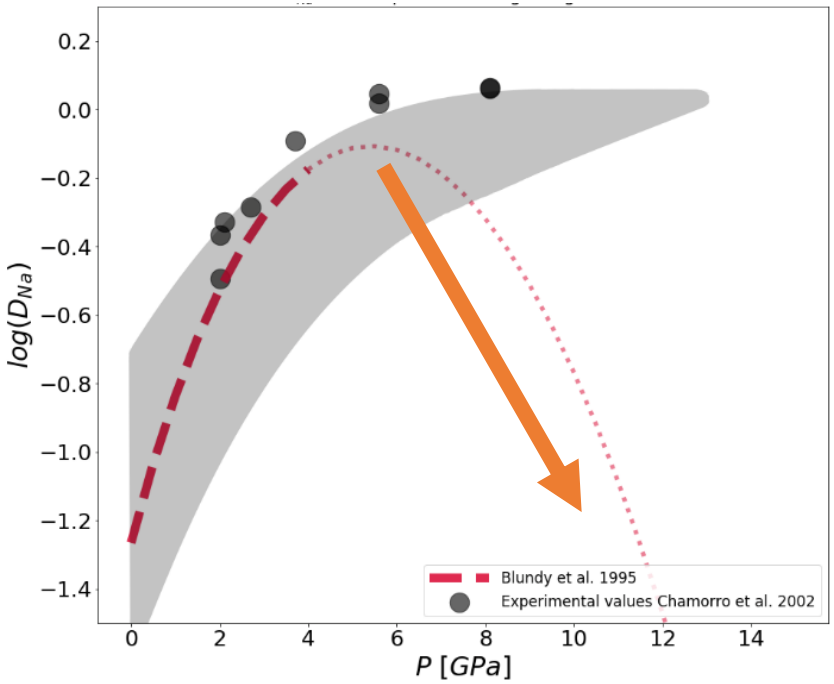
Best fit for $D_i^{cpx/melt}$:

$$D_i = D_0 * exp\left[\frac{-4\pi E N_A\left[\frac{r_0}{2}(r_i - r_0)^2 + \frac{1}{3}(r_i - r_0)^3\right]}{RT}\right]$$

Where:

$$D_0 = D_{Na} = exp\left(\frac{10367 + 2100P - 165P^2}{T} - 10.27 + 0.358P - 0.0184P^2\right)$$

D_{Na} scaling law, T rising along the solidus (derived from de Smet (1999))



Experiments show that $\boldsymbol{D_{Na}}$ partition coefficients **increase until they become constant**

Scaling law only applicable up to 4 GPa!

We develop a thermodynamic model after Blundy et al. (1995) and parameterize it to higher upper mantle pressures

Thermodynamic Moodel Results

Between liquidus and solidus:

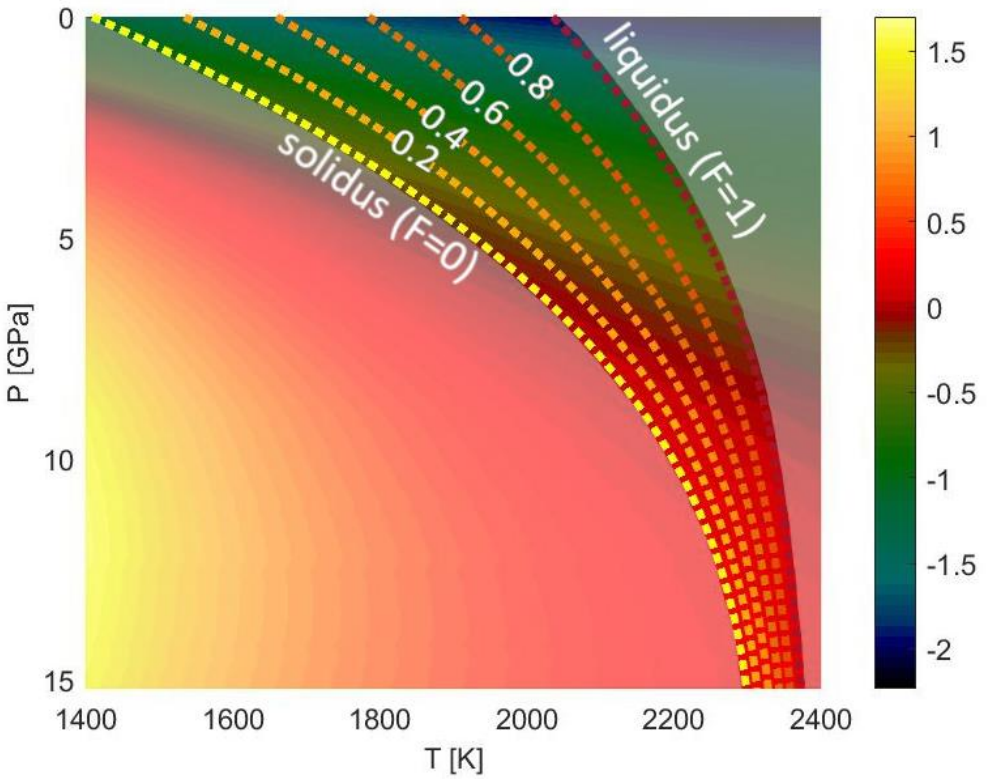
- ❖ Increasing partition coefficients with pressure
- ❖ Decreasing partition coefficients with temperature
- ➢ agrees with literature!

Parameterized a new scaling law from the model with the intervals steps:

F = 0.2 and

P = 0.1 GPa.

Thermodynamic model

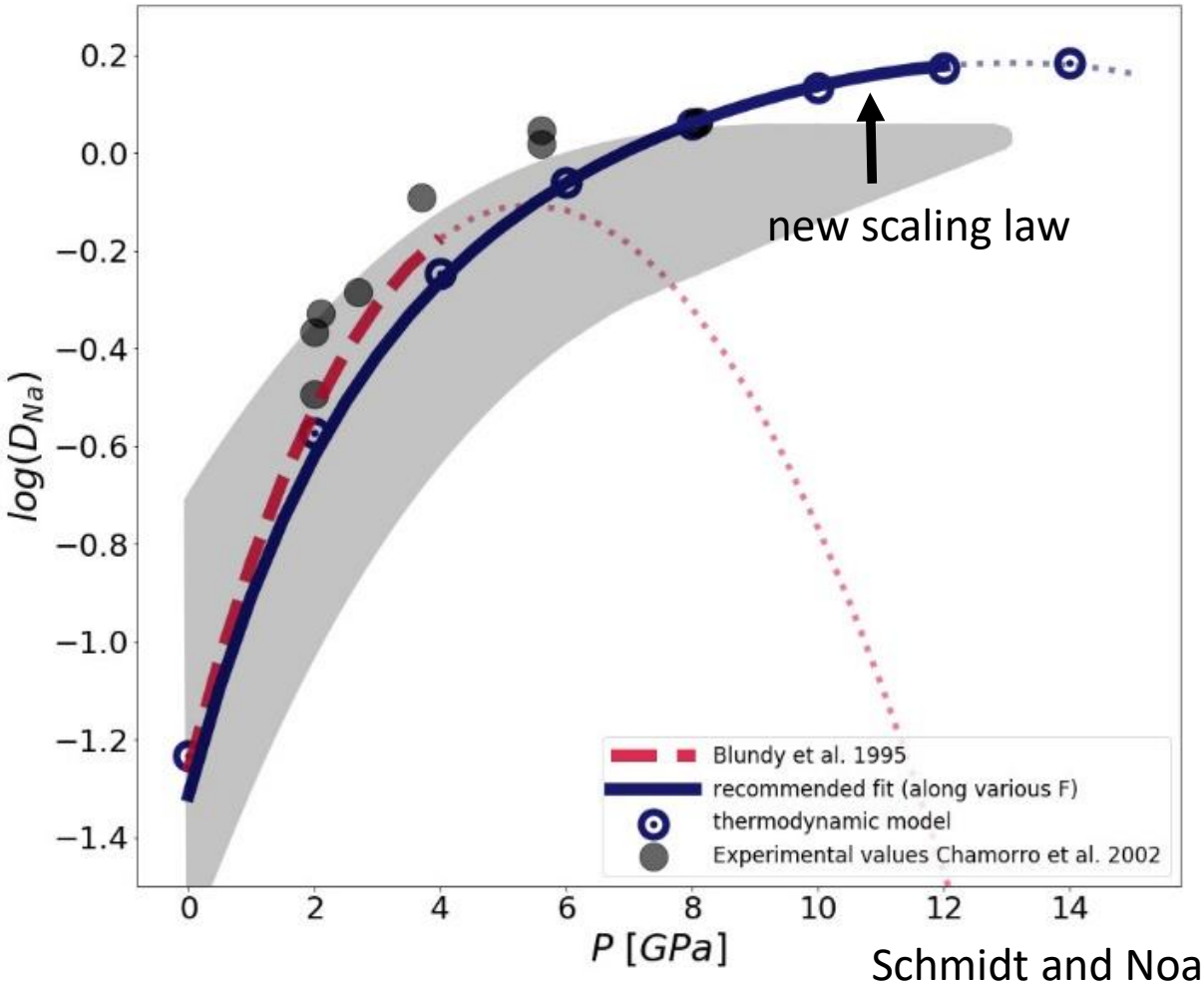


Schmidt and Noack, submitted

Liquidus and Solidus according to de Smet et al. (1999)

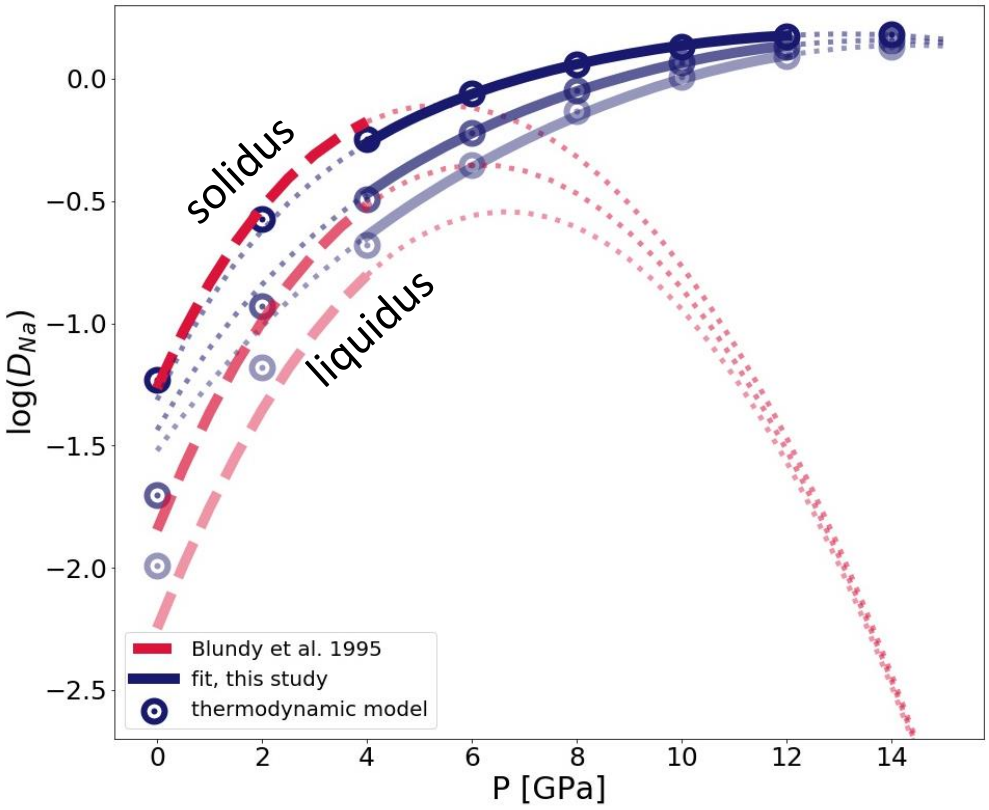
Parameterization Results

With our new scaling law, $D_{Na}^{cpx/melt}$ continues to rise with increasing pressure up to 12 Gpa. The scaling law agrees well with experimental literature values.



Schmidt and Noack, submitted

Parameterization Results



Schmidt and Noack, submitted

- The parameterization between liquidus and solidus ensures that the scaling law is applicable in a wide P-T range.
- Up to 4 GPa, the scaling law of Blundy et al. (1995) fits better to the thermodynamic model.
- From 0-4 GPa: use scaling law of Blundy et al. (1995)
- From 4-12 GPa: use new scaling law

Final equation, to be used between 4 and 12 GPa:

$$D_{Na} = exp\left(\frac{2183 + 2517P - 157P^2}{T} - 4.575 - 0.5149P + 0.0475P^2\right)$$

Conclusion

- Now it is possible to calculate P-T sensitive partition coefficients from 0-12 GPa by combining the scaling laws of Blundy et al. (1995) and our study.
- D_{Na} can serve as a „reference“ coefficient to calculate other trace elements from.
- The results enable us to calculate the redistribution of trace elements on Earth and other terrestrial planets with comparable mantle compostion.

References

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