Exo-geodynamics

Simulating dynamical and thermal evolution of rocky exoplanets with various mantle mineralogy

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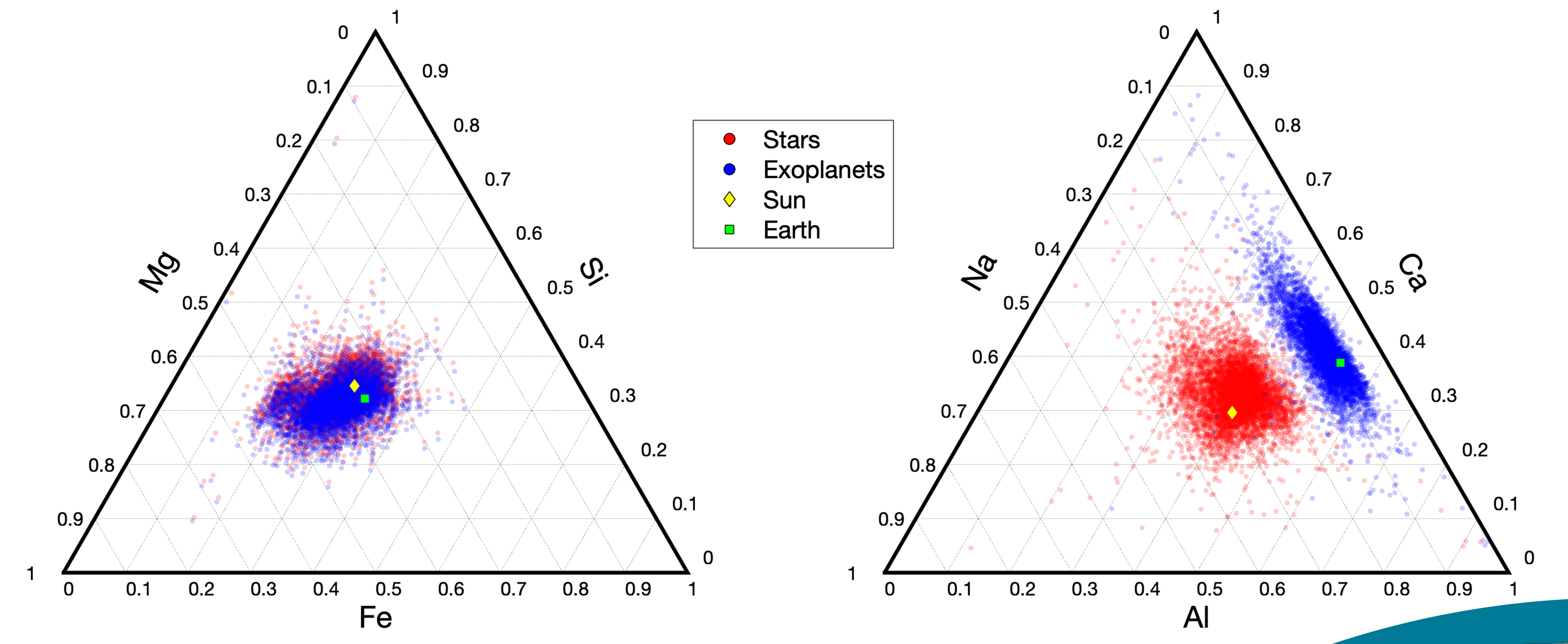
Using available observables in stellar abundances…



Use **stellar abundances** to constrain rocky planet composition

Abundances readily available from catalogues [1,2].

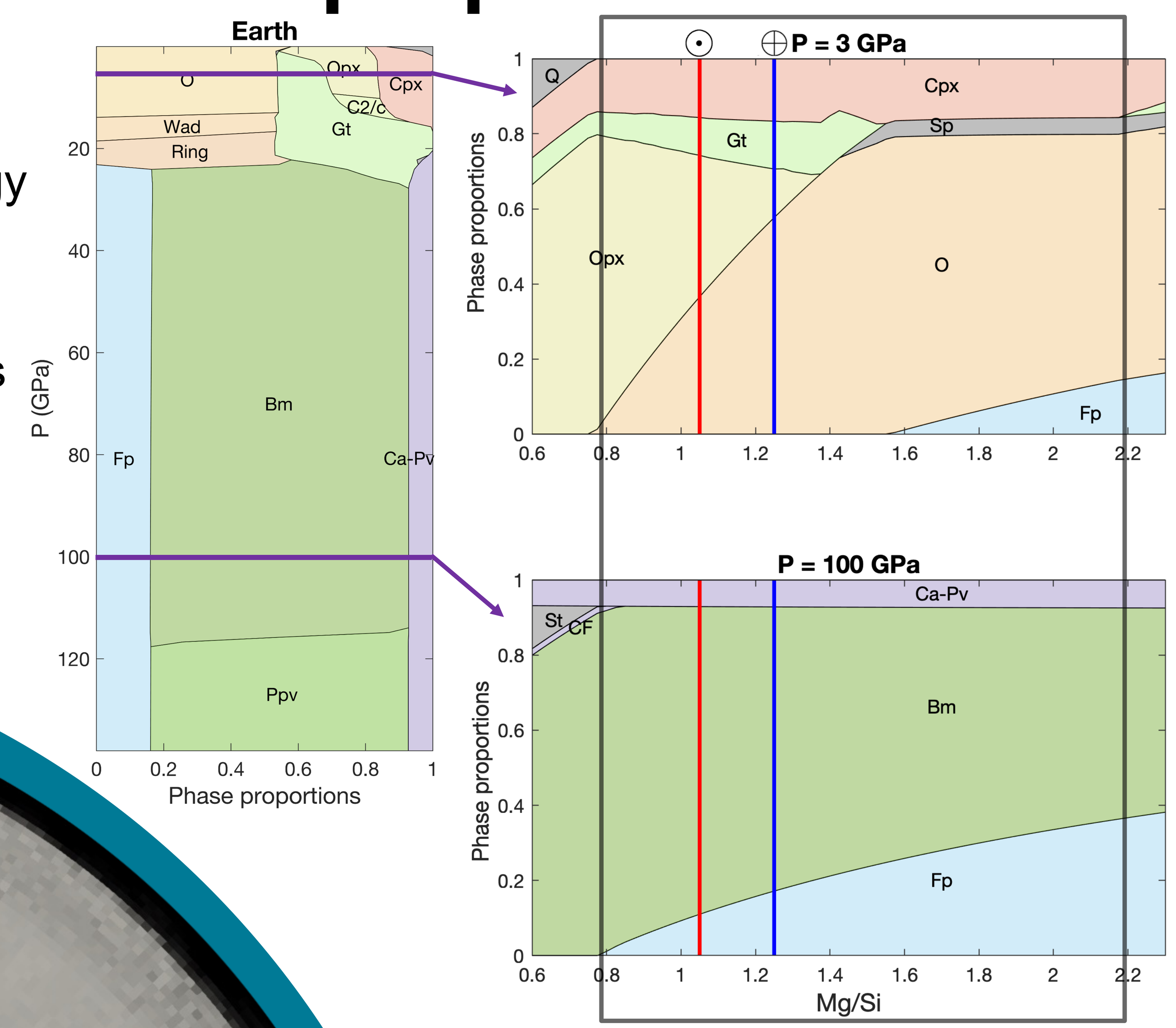
Apply **volatile depletion** [3] to simulate formation process

Simulate range of rocky exoplanet compositions for Fe, Mg, Si, Ca, Al, Na, S, and Ni

… To investigate rocky planet interior properties…

Bulk composition used to model mantle mineralogy (e.g., [4])

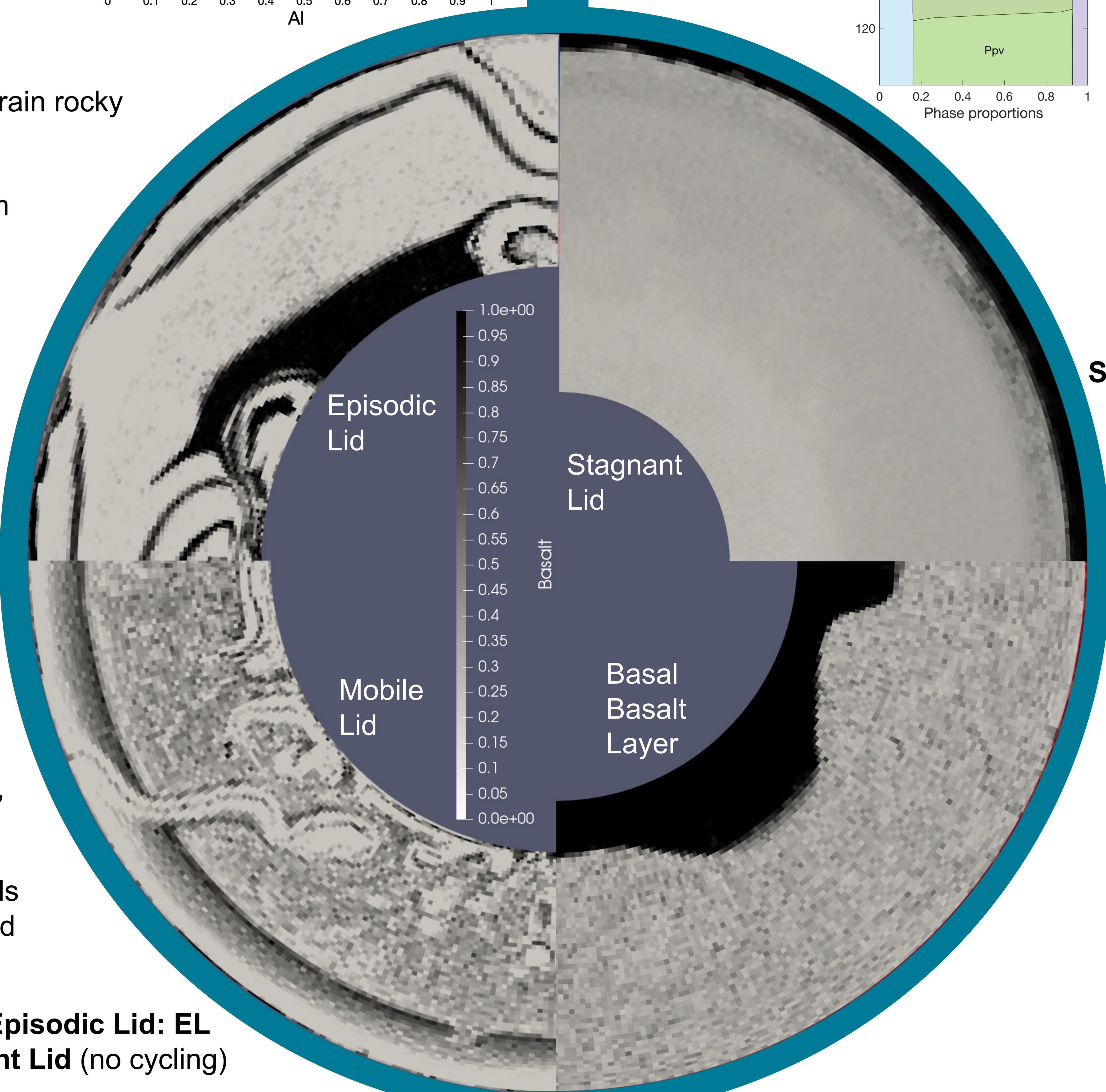
Mantle properties depend on the **mineralogy**



Mineralogy calculated with Gibbs energy minimization [5,6]

Strong (Opx- and Bm-dominated) to **weak** (Fp-dominated) mineralogies

Planets with **SiO_2 phases** (Q, St) fall just outside of range

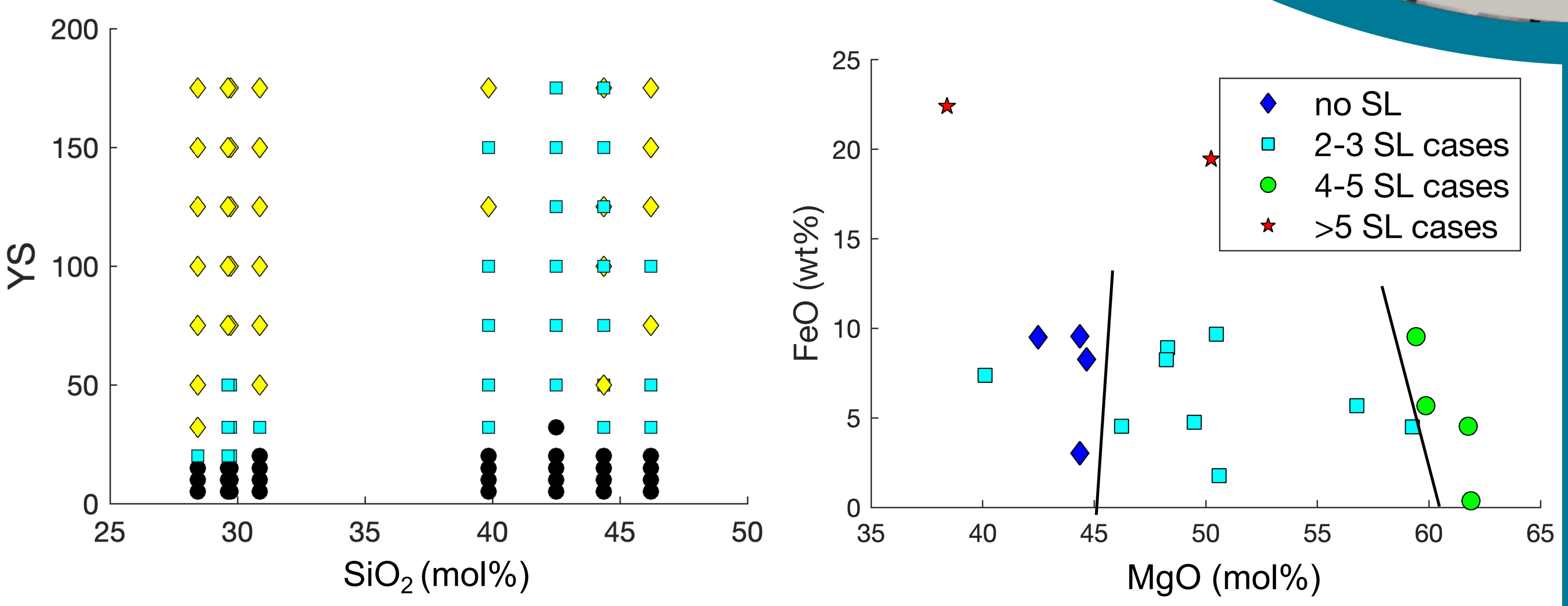


2D thermochemical convection model [7] with composition-dependent properties in lookup tables

Steady-state simulations (20 Gyr), vary crust yield strength (YS)

Surface dynamic regime: controls atmosphere-interior interaction and climate feedback loops.

Mobile Lid: ML (active cycling); **Episodic Lid: EL** (intermittent cycling); **SL: Stagnant Lid** (no cycling)



Si-poor (low mantle viscosity) planets more likely to be in SL regime, EL more common for Si-rich planets. **ML regime** constant with composition.

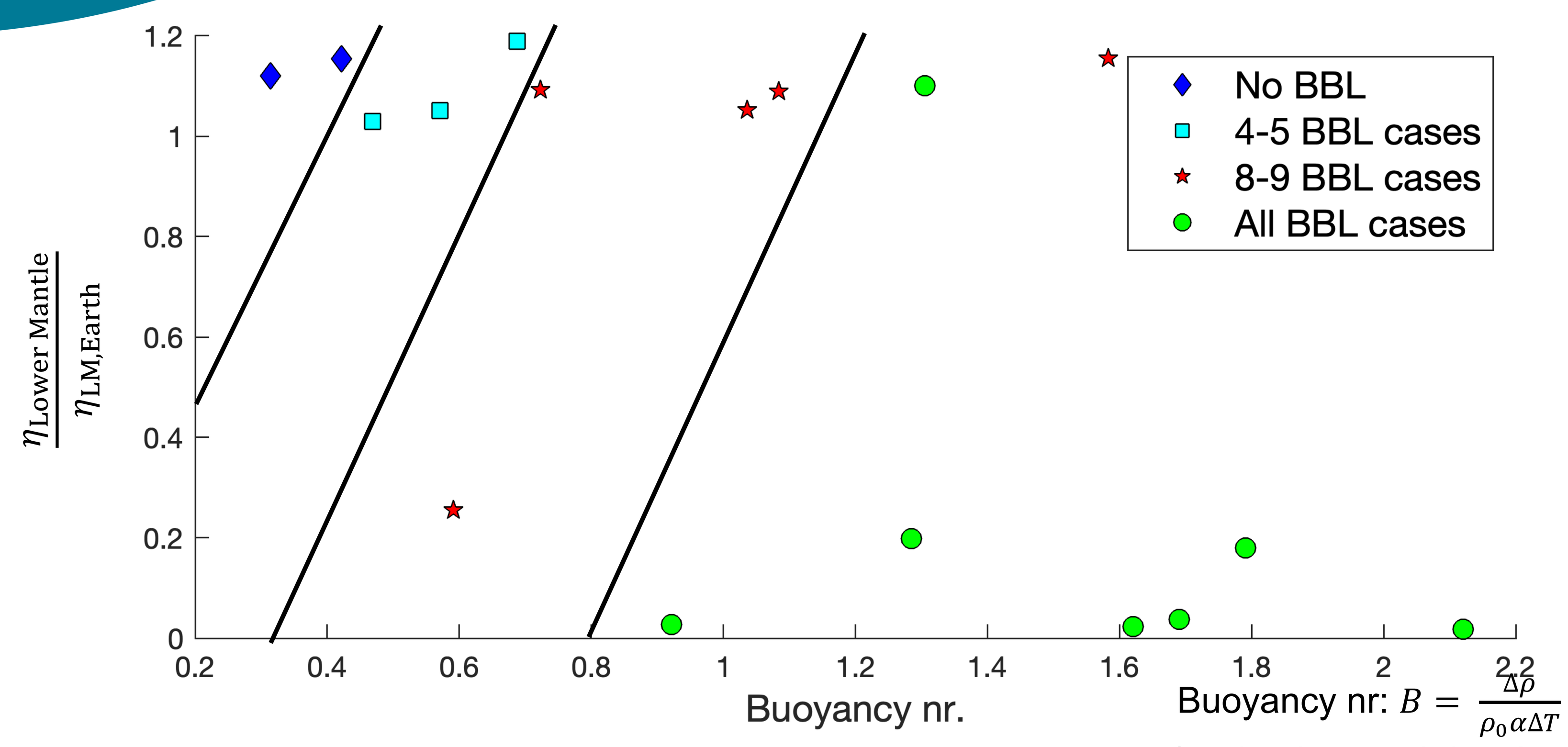
… How it changes their evolution…

Crust-mantle density contrast ($\Delta\rho$) can have major impact on long-term evolution

Dense crust collects at bottom of the mantle

Basal Basalt Layers (BBL) introduce thermal boundary layer, leave cold upper mantle

BBL present at **high YS** low mantle **viscosity** (high Mg/Si) and high **buoyancy nr** (low Fe)



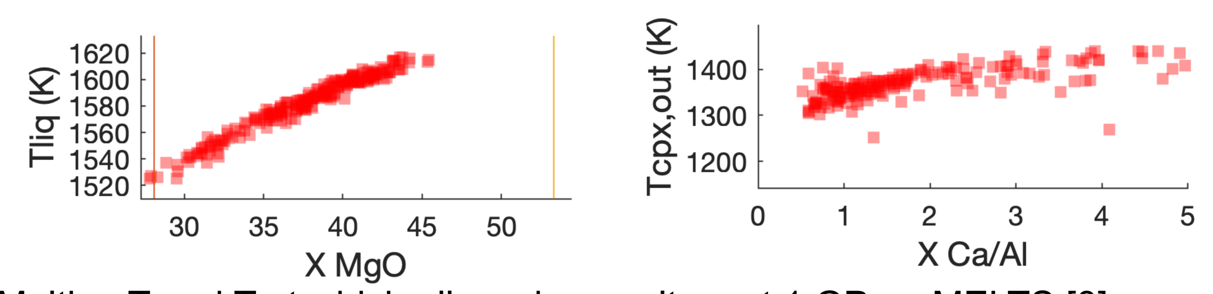
Buoyancy nr: $B = \frac{\Delta\rho}{\rho_0 \alpha \Delta T}$

(ρ_0: background density, α: thermal expansivity, ΔT: mantle thermal range)

… And their habitability

Outlook

First: Study **melting behaviour** with available software [5,8]. Melting behaviour determines **crust composition** → reflectance spectra, observing exogeology [9]



Melting T and T at which all cpx has molten, at 1 GPa, pMELTS [8]

Conclusions

- Stellar abundances constrain rocky planet mineralogy
- Planets can have much weaker upper mantle with ferropericlase when Mg/Si is high
- SiO2-phases remain rare
- Composition has limited effects on propensity for mobile lid regime
- Planet more likely in stagnant lid regime at high Mg/Si, episodic lid at low Mg/Si
- High B nr., low viscosity mantles can lead to stable stratification and cold upper mantle
- Planet interior composition is important to consider when studying habitability

Bibliography

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