Rapid seeding, core segregation, and volatile loss of planetesimal belts isolated in space and time

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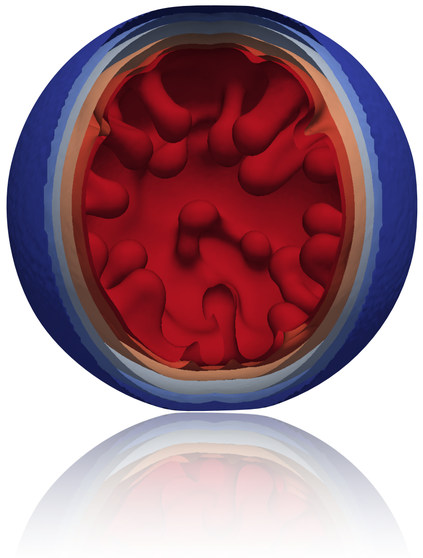
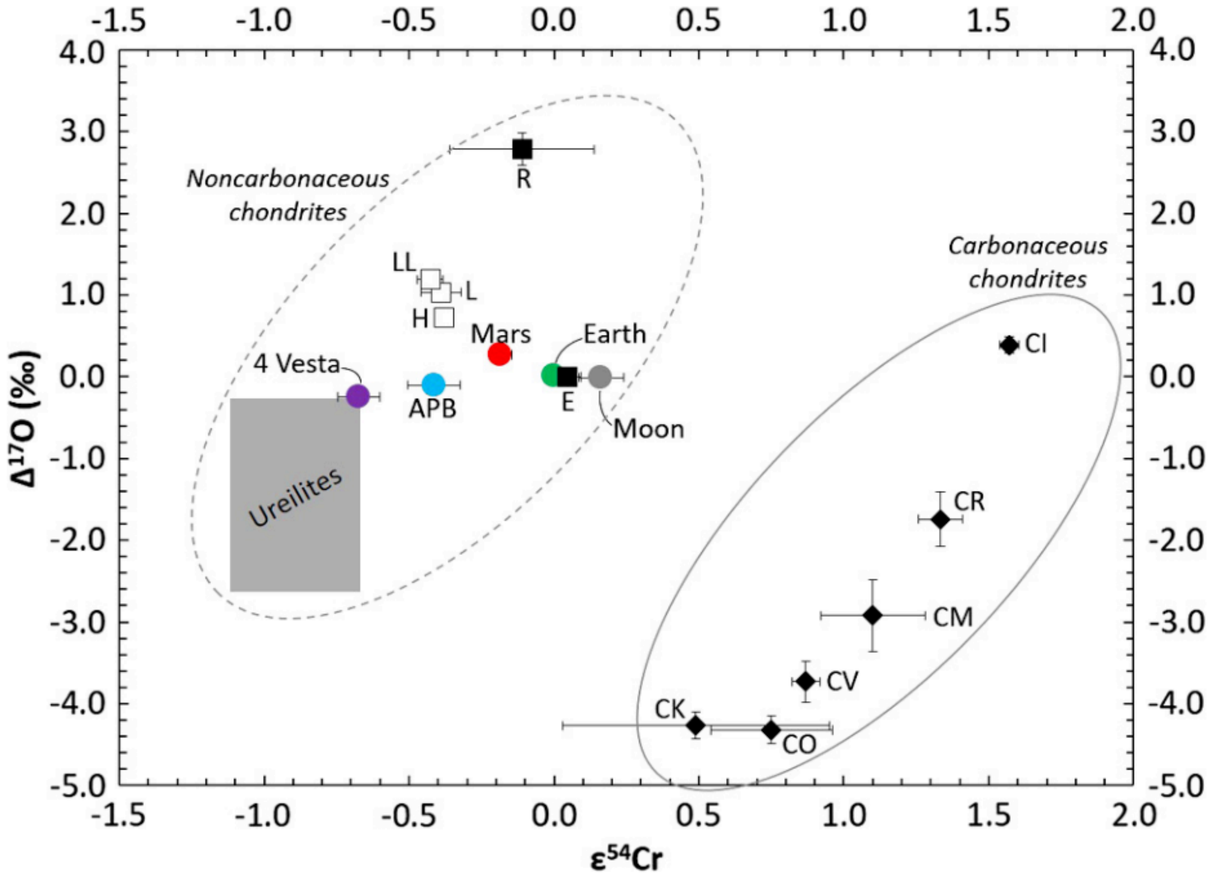
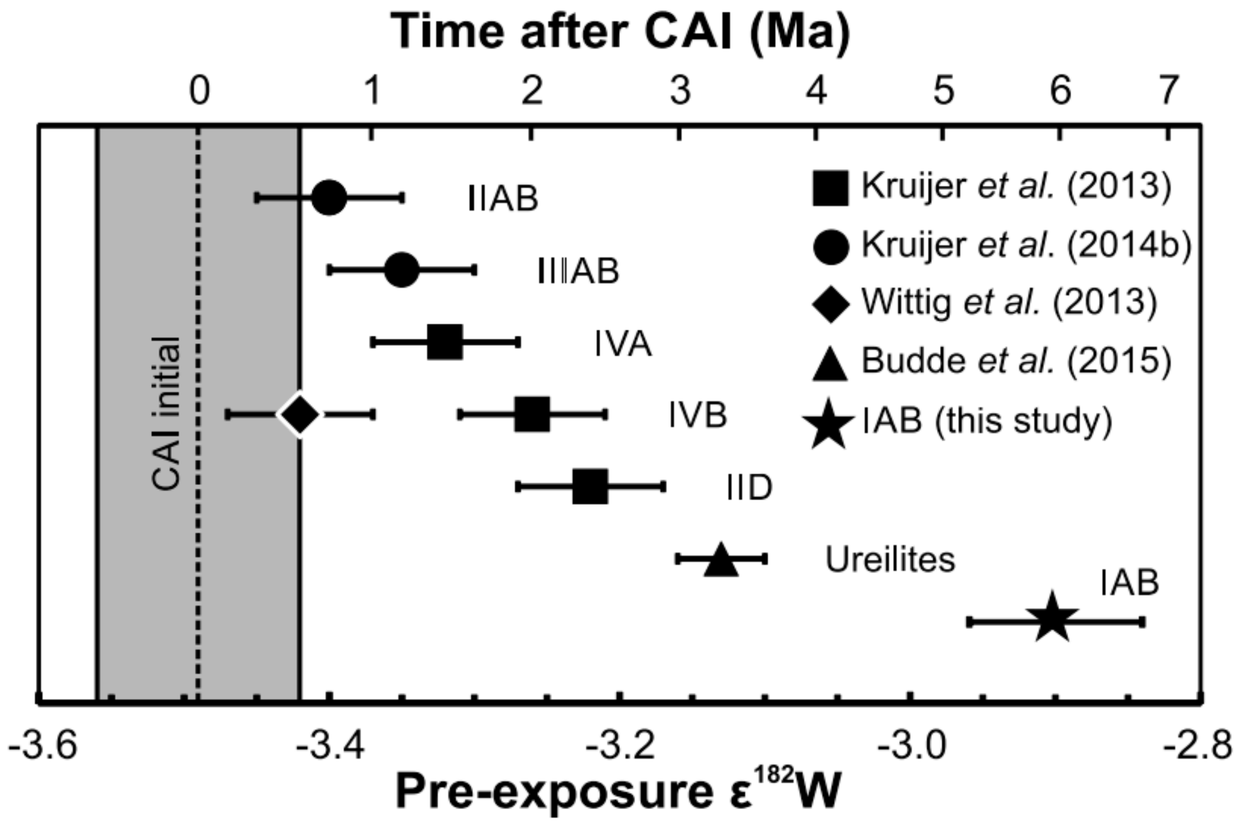


EPSC-DPS Joint Meeting 2019, session TP14, Geneva, 18 September 2019

Rapid core formation & distinct reservoirs

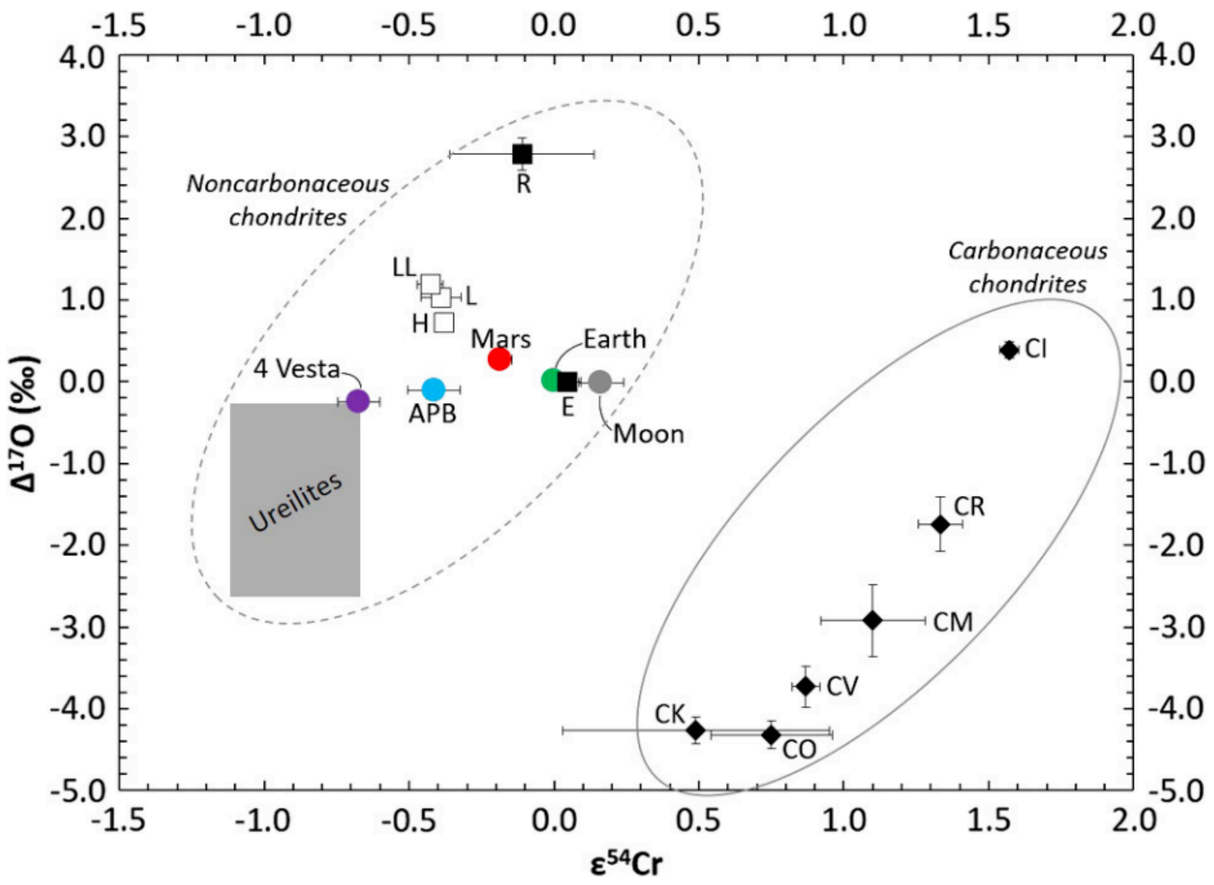


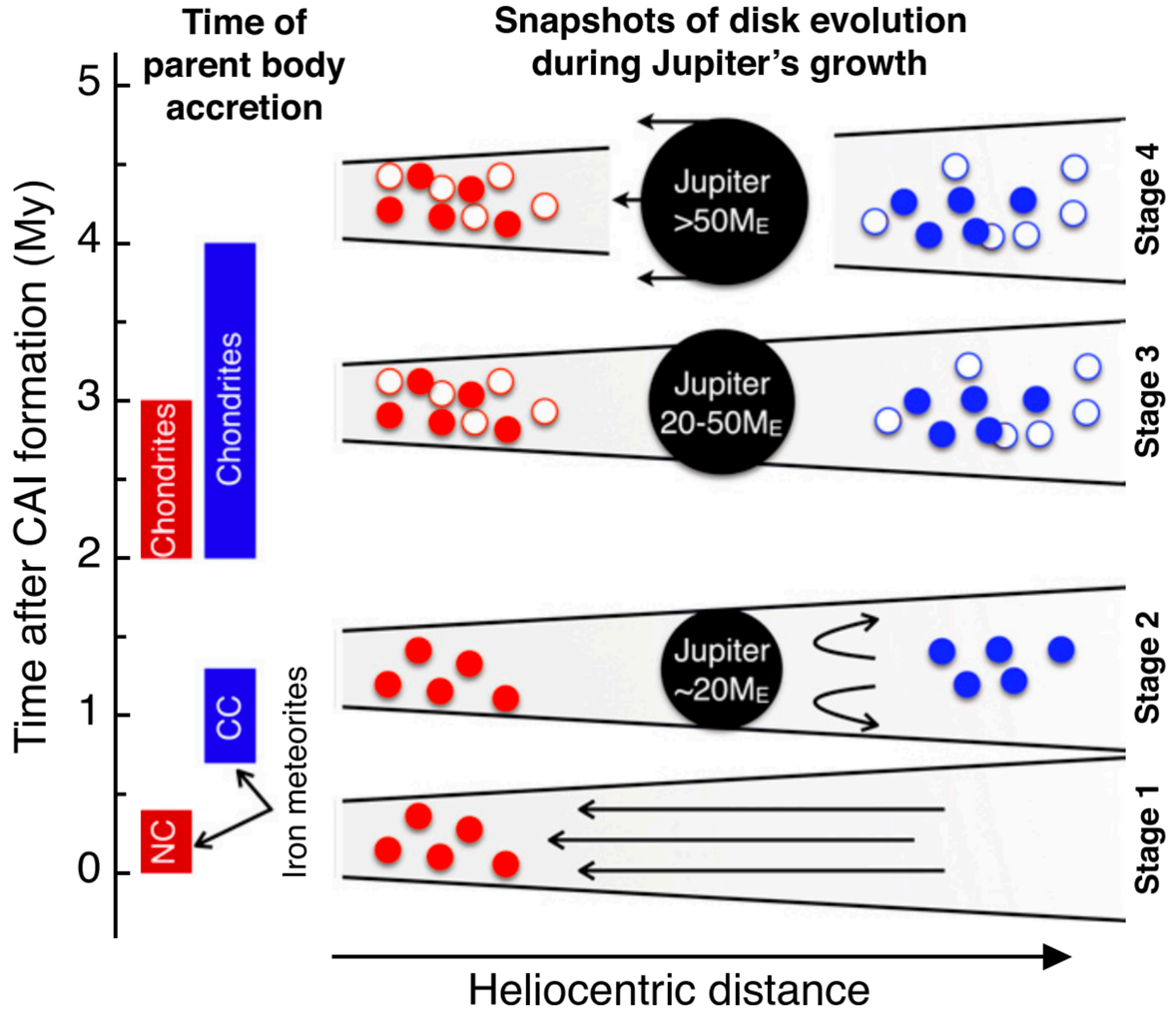


Trinquier+ 07, 09; Warren 11

Hunt, Cook, Lichtenberg+ 18

Cause for reservoir separation?

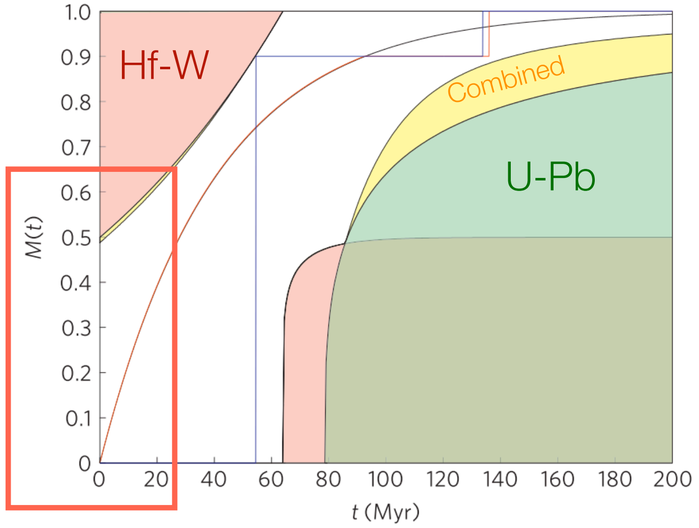


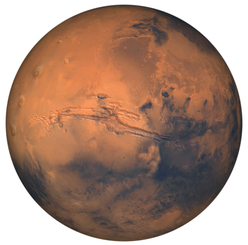


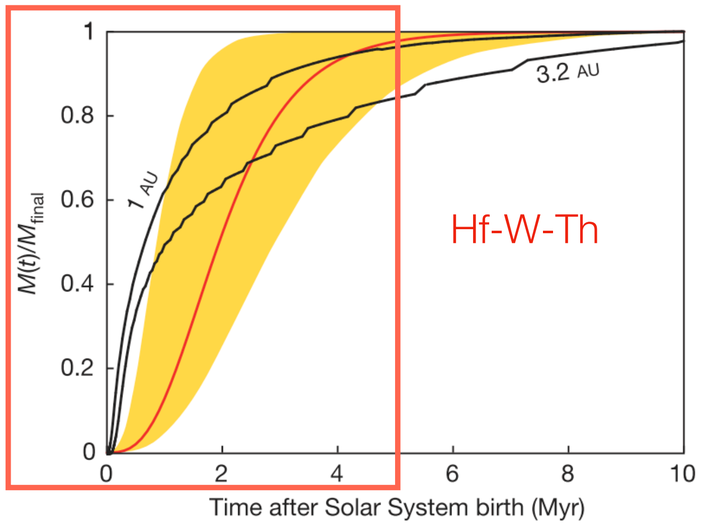
Trinquier+ 07, 09; Warren 11

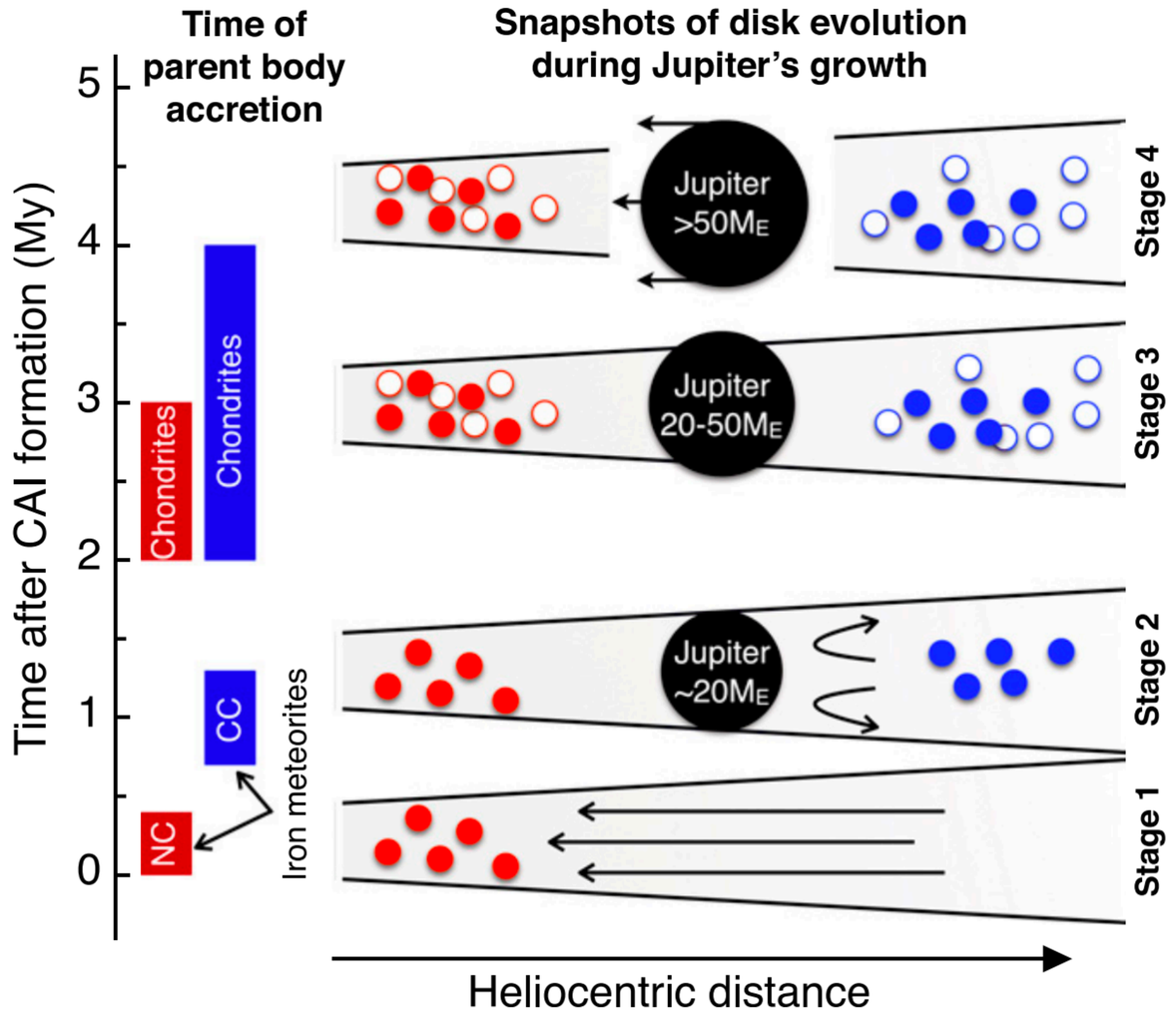
Kruijer+17

But protracted growth for the inner planets?









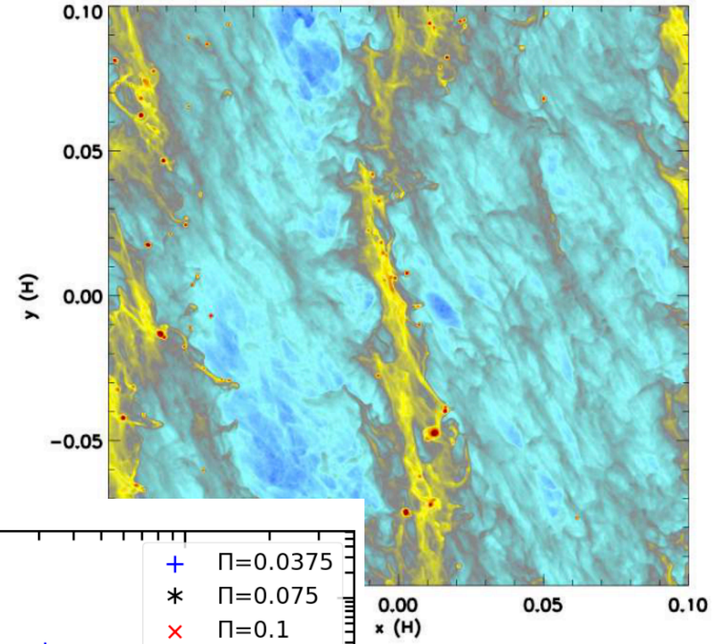
Rudge+ 10; Dauphas & Pourmand 11

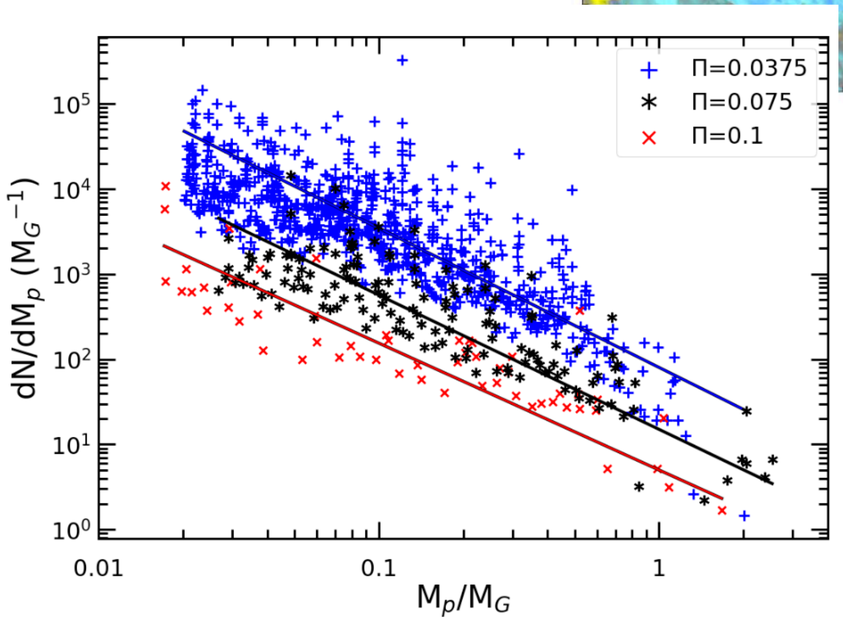
Kruijer+17

Both combined is a challenge

- Hard to form a 20 M_{Earth} planet in ≈ 1 Myr
  - Streaming instability (*SI*) requires favourable local conditions ≈ 10^5-10^6 yrs
  - *SI*-generated size-frequency distribution (R_{max} ≈ 250 km) limits efficacy of pebble accretion
- Optimistic models of pebble accretion rapid (≈ 10^4 yr); migration-constrained
- Jupiter is a porous ‘filter’

➡ Early-formed Jupiter scatters >> $M_{\text{ast.-belt}}$ into inner Solar System





Johansen+ 15, Simon+ 16, Abod+ 19

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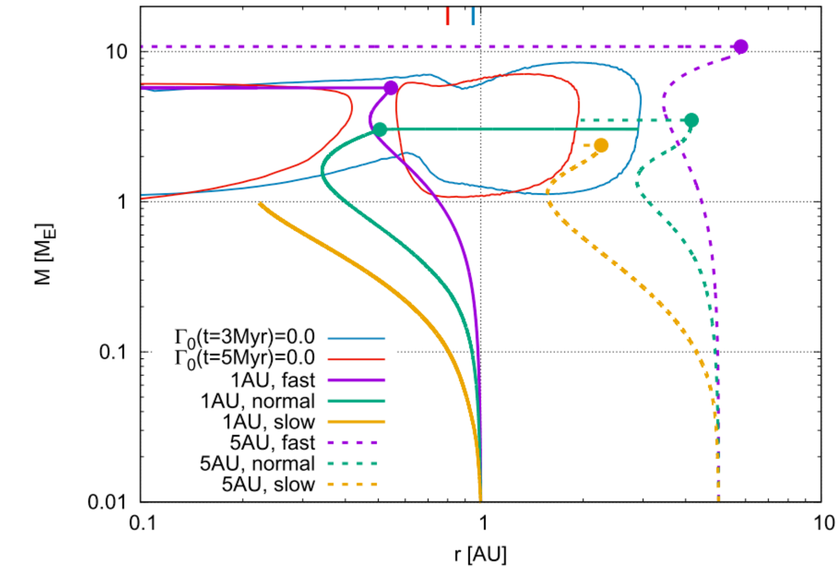

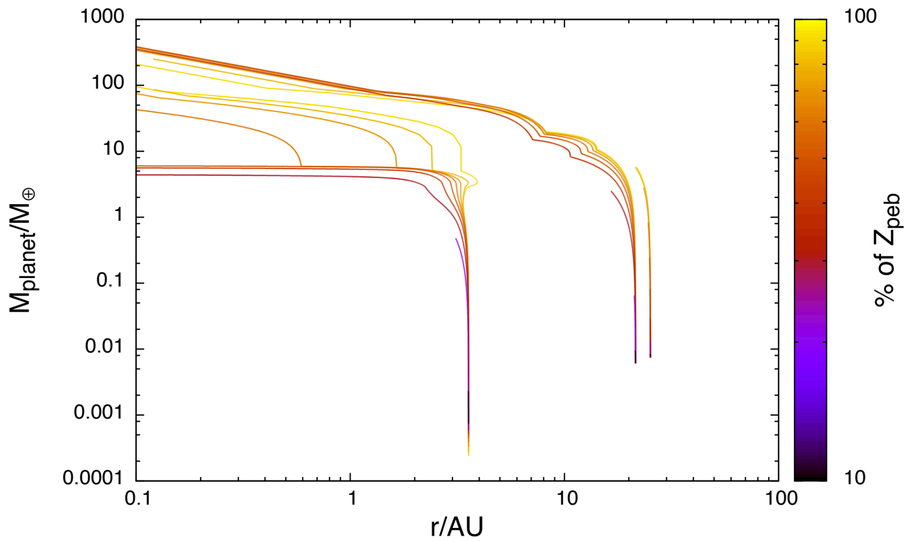

Brügger+ 18, Bitsch+ 19, McNally+ 19

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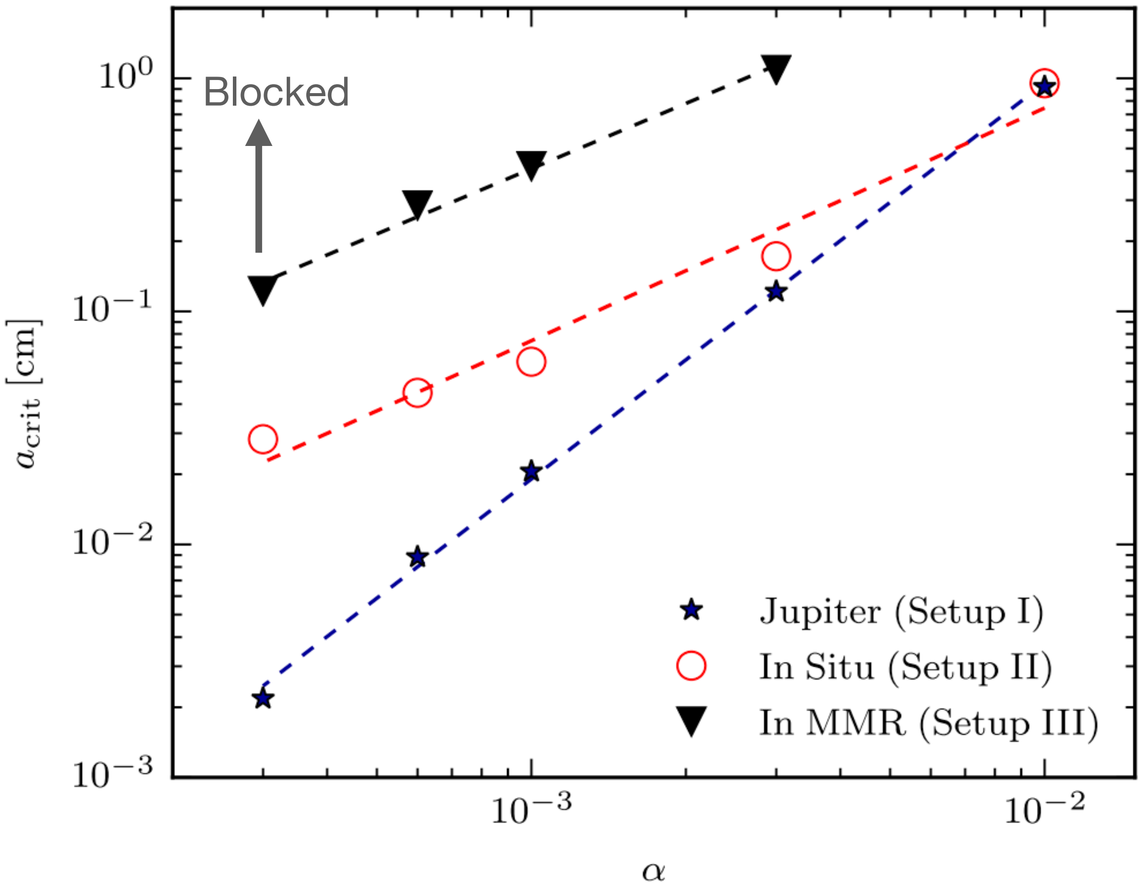
Grain size threshold to be blocked by Jupiter



Midplane turbulence

Haugbølle+ 19; see also Drążkowska+ 19 —> EPSC-DPS2019-762

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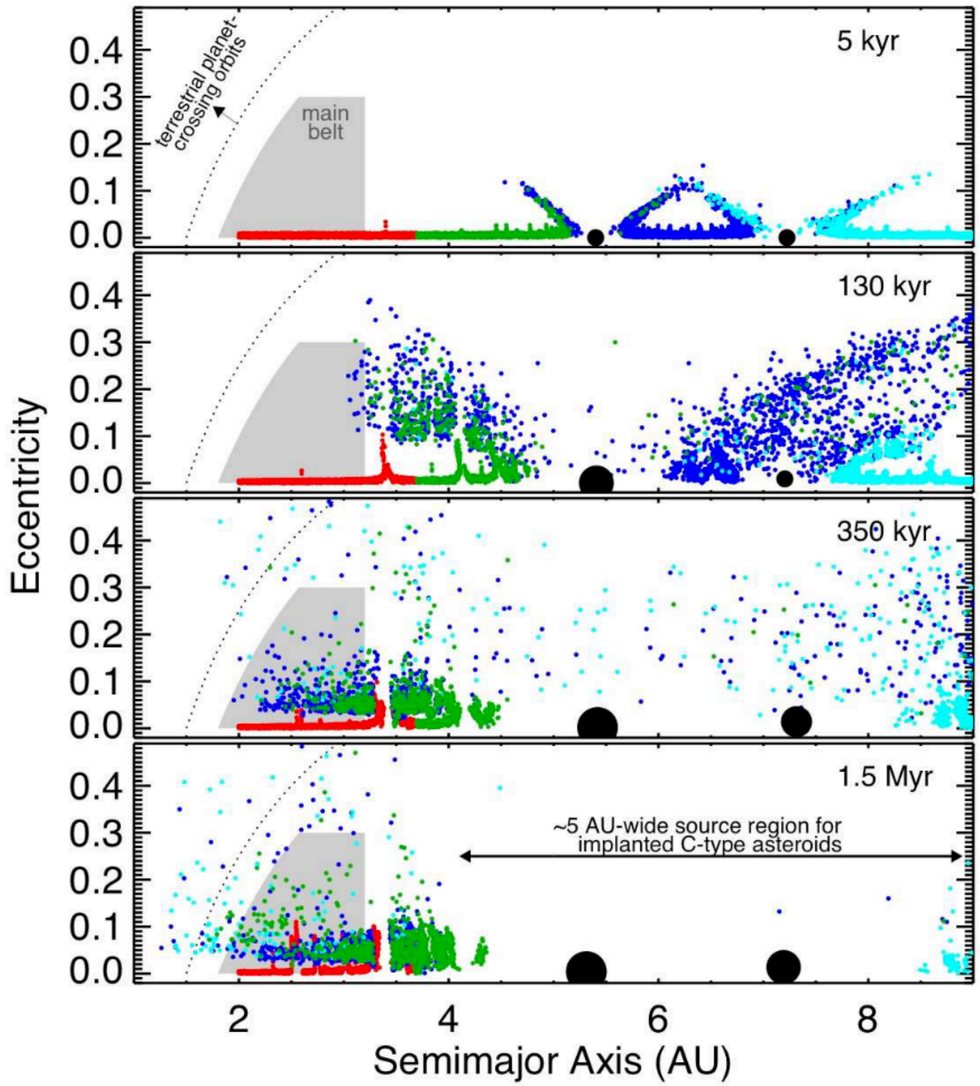
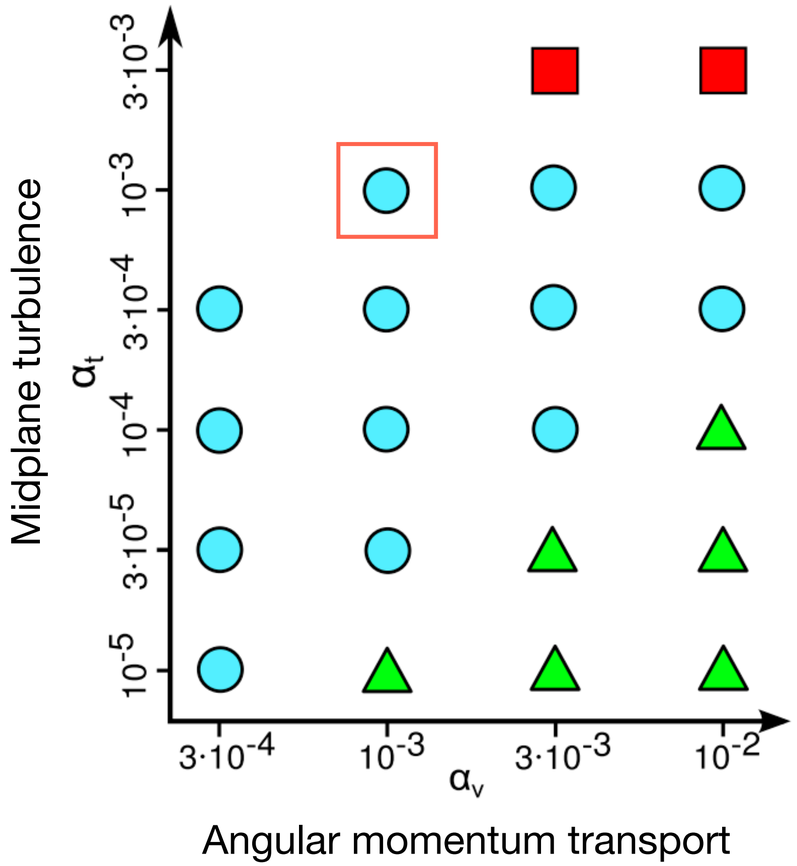


Raymond & Izidoro 17

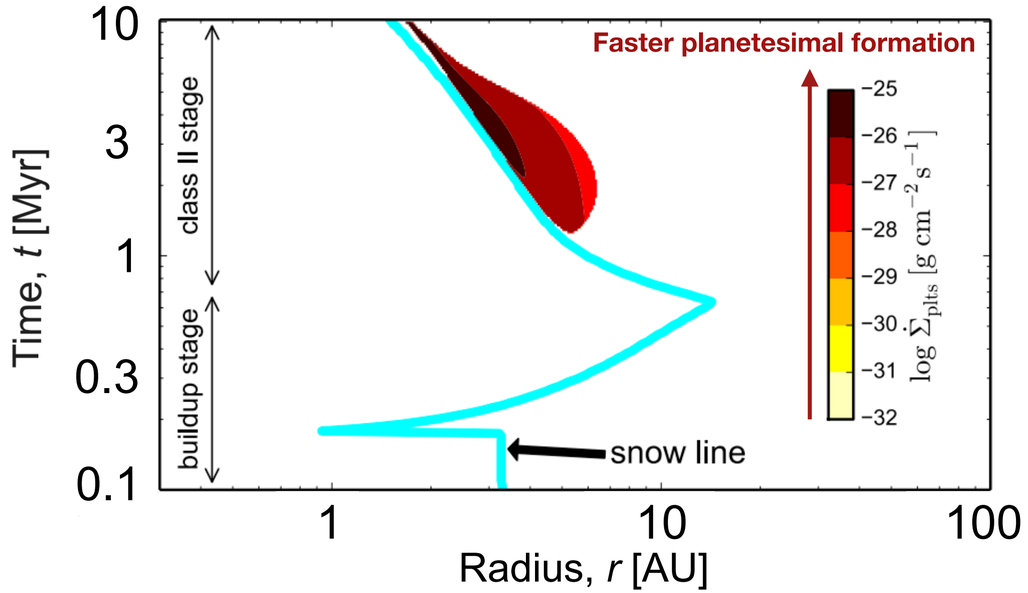
Planetesimal formation in ≈wind-driven disk



infall + disk

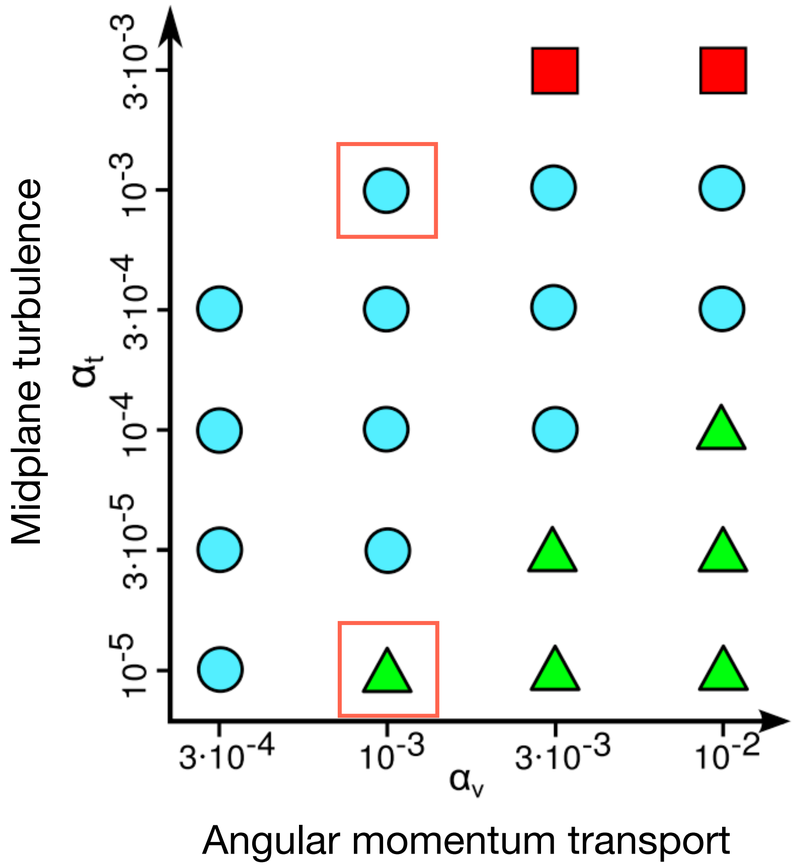
disk

no planetesimals



Drążkowska & Dullemond 18

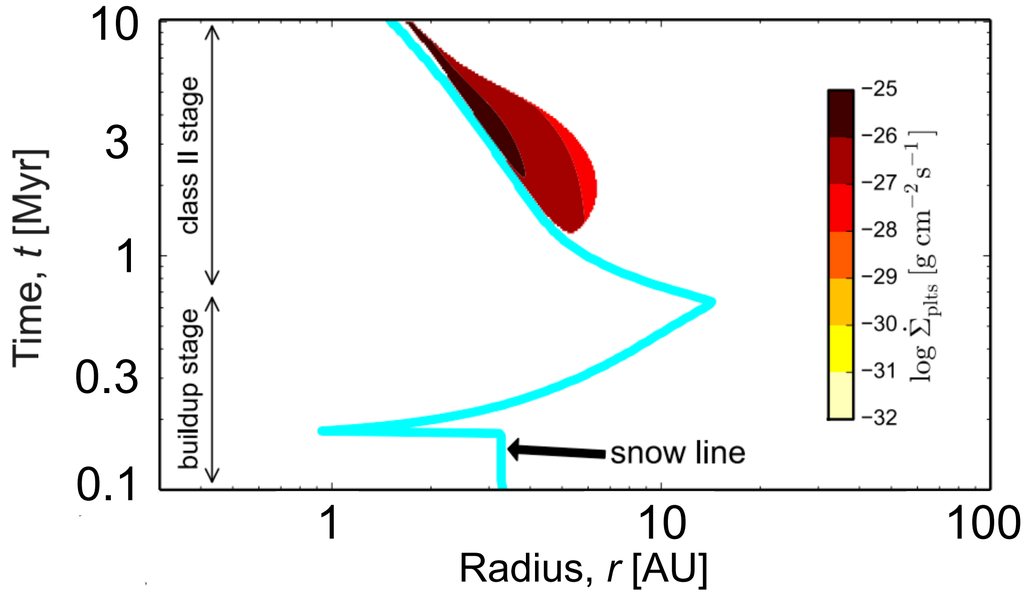
Rapid accretion in midplane-quiescent disks

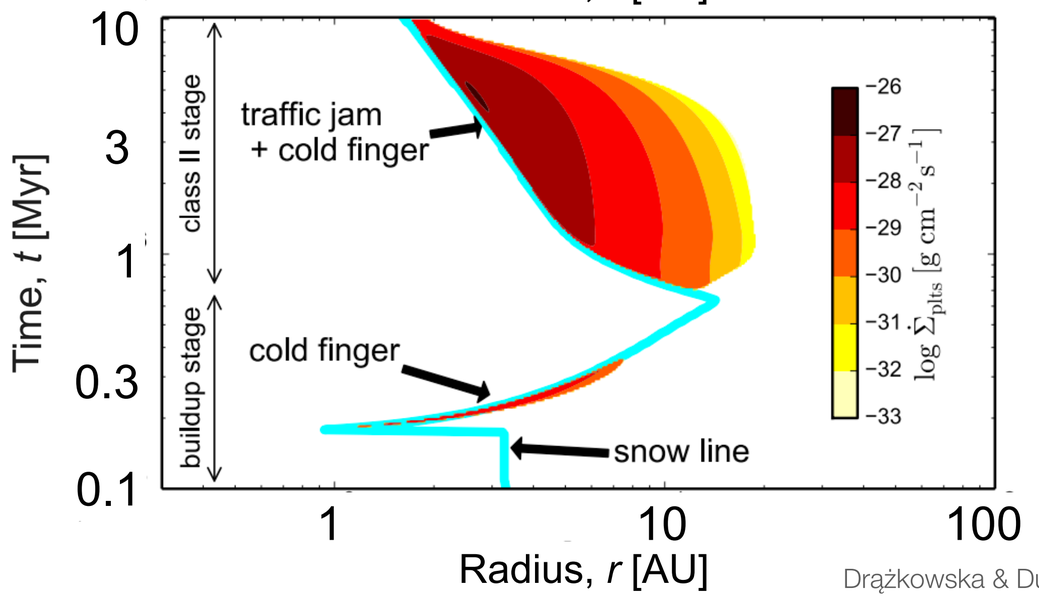


infall + disk

disk

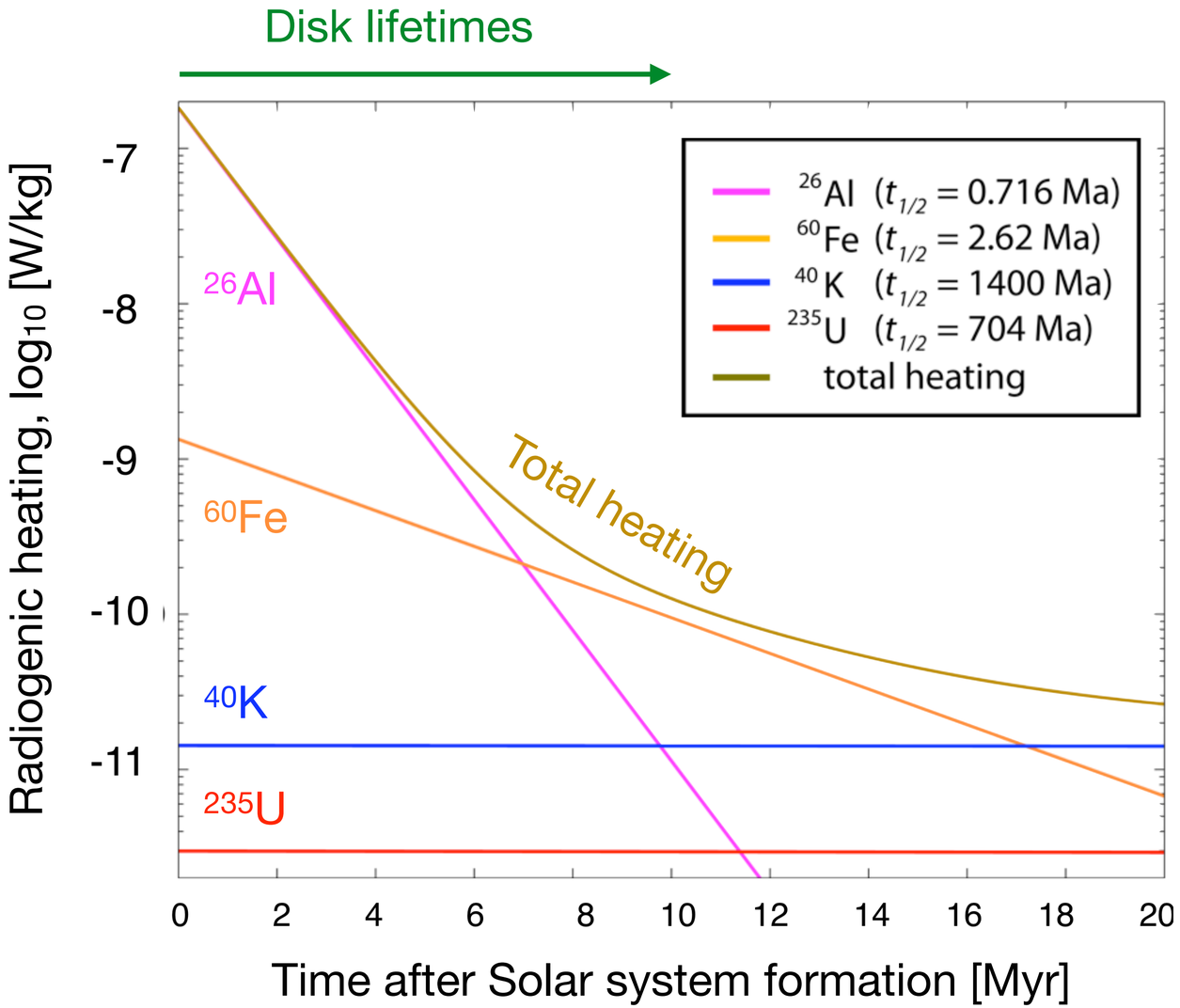
no planetesimals

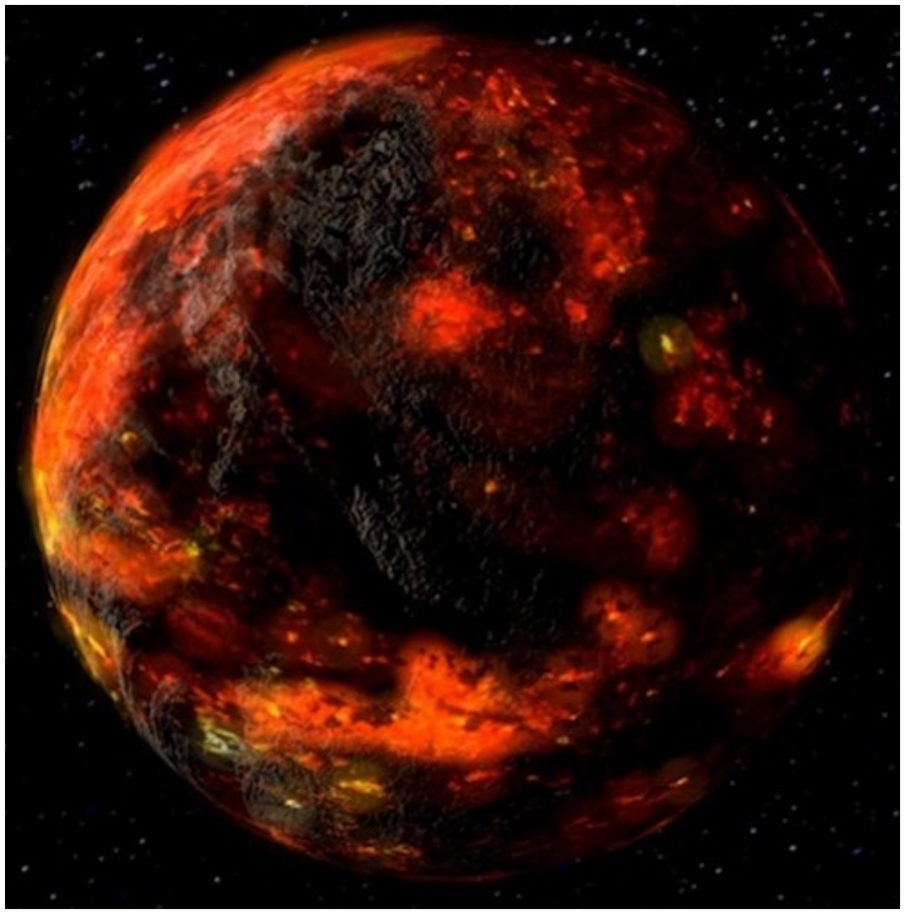




Drążkowska & Dullemond 18

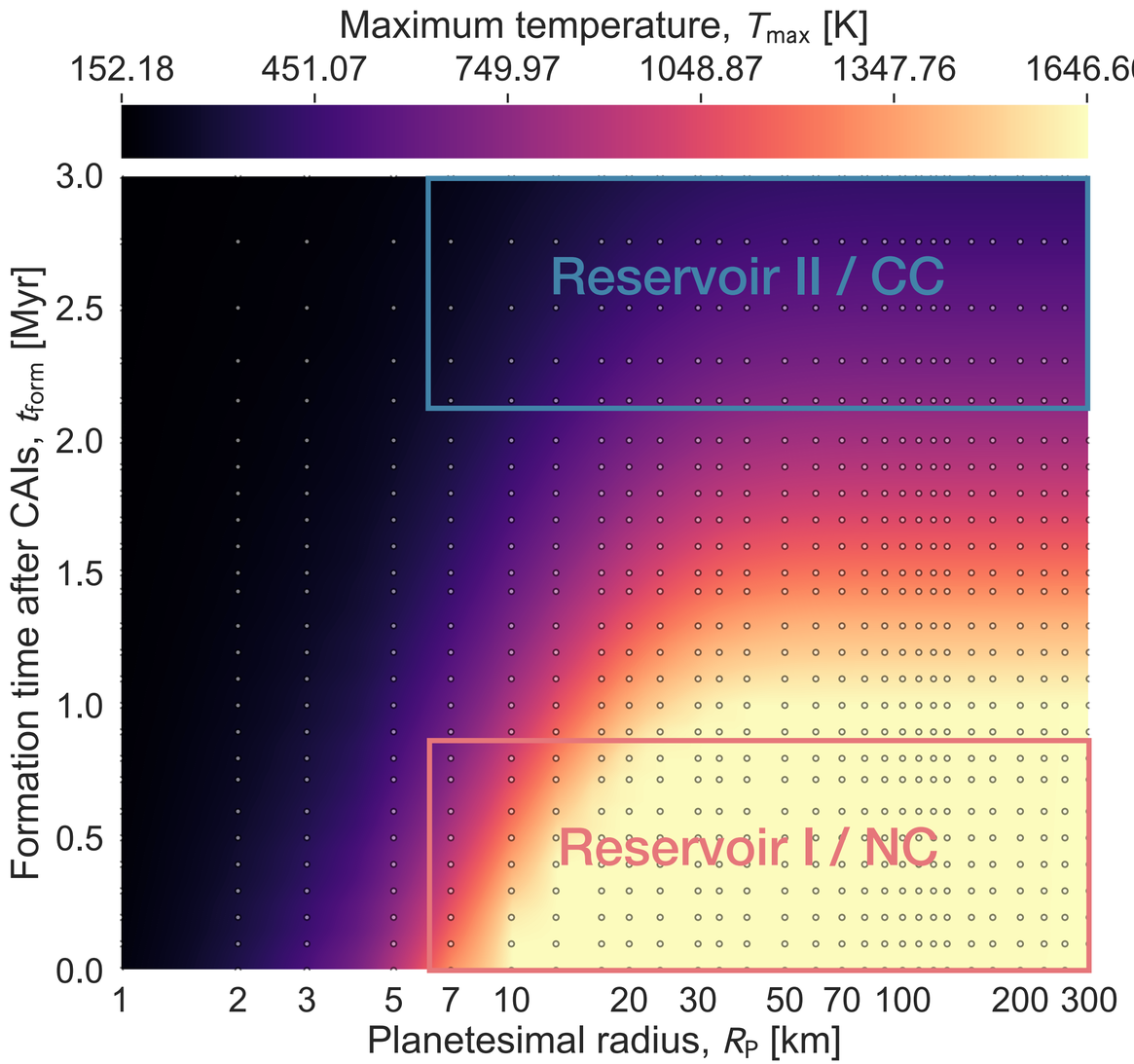
Getting rid of the water: radiogenic heating

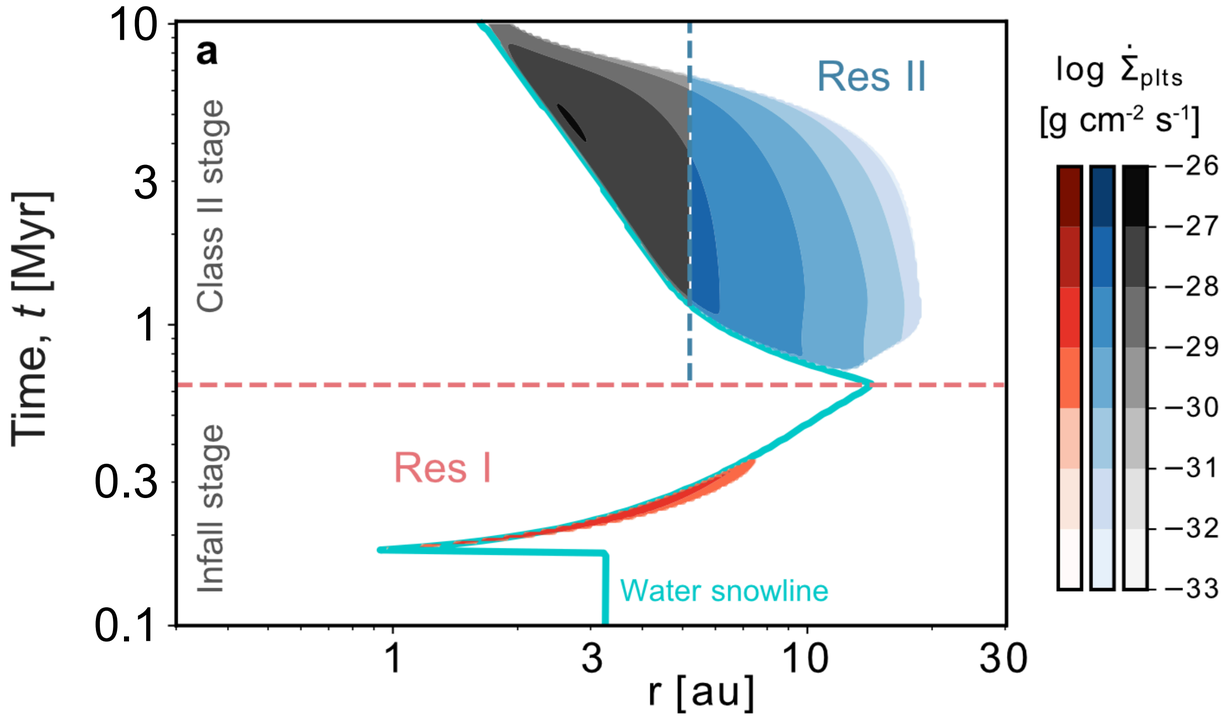




Lichtenberg+ 16a,18,19a,b

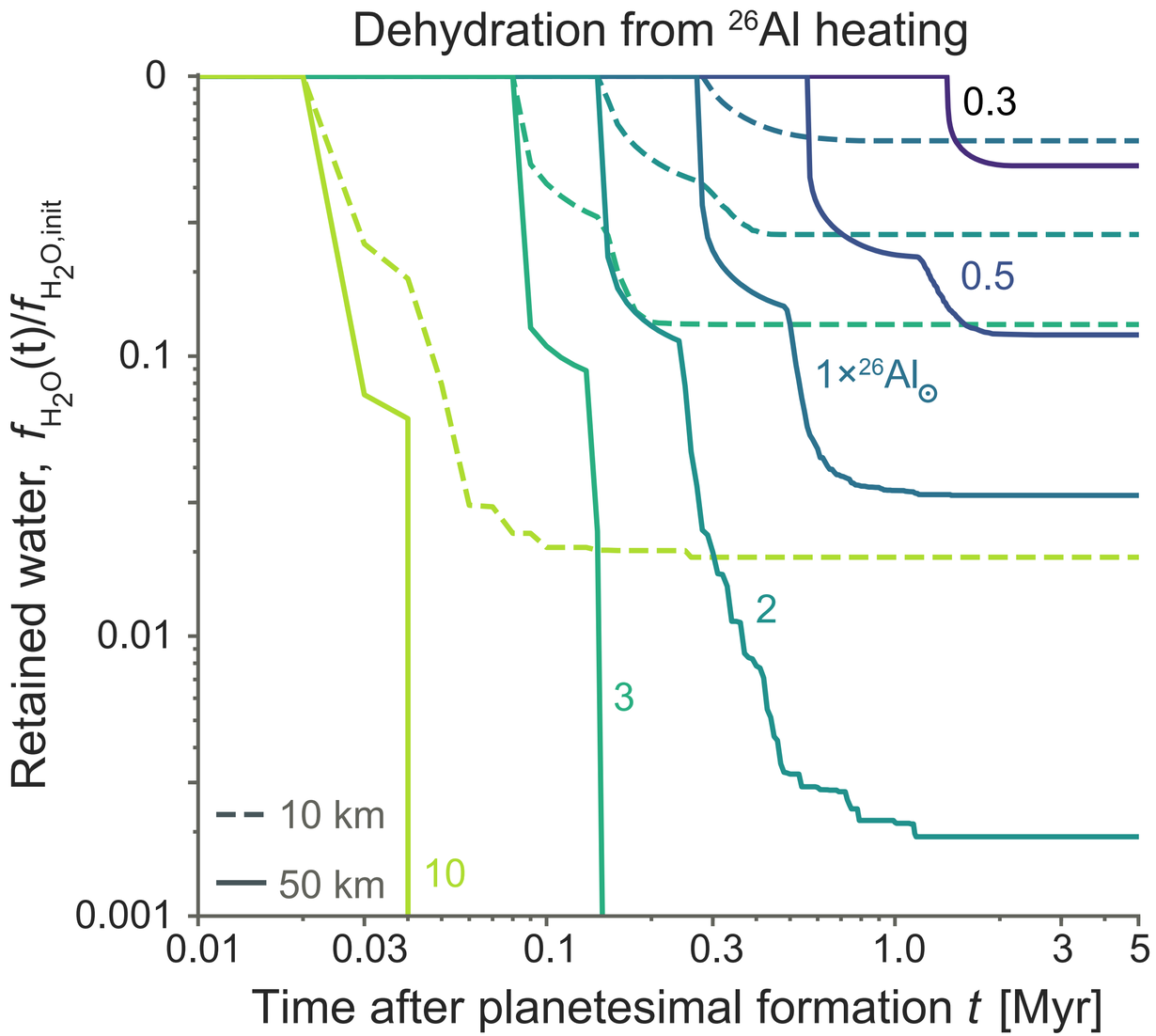
Compositional bifurcation of reservoirs



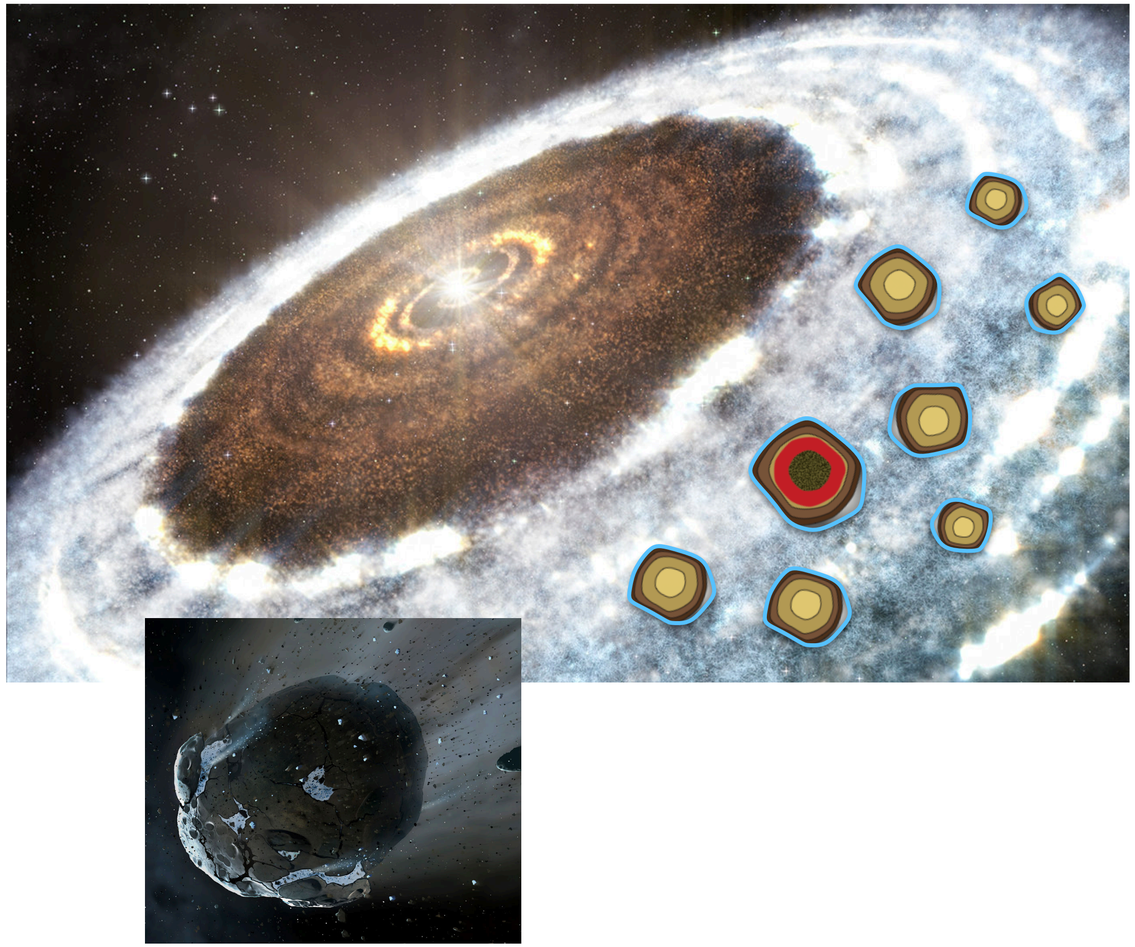


Lichtenberg, Drążkowska, Schönbächler, Golabek, Hands, in prep.

Getting rid of the water: radiogenic heating



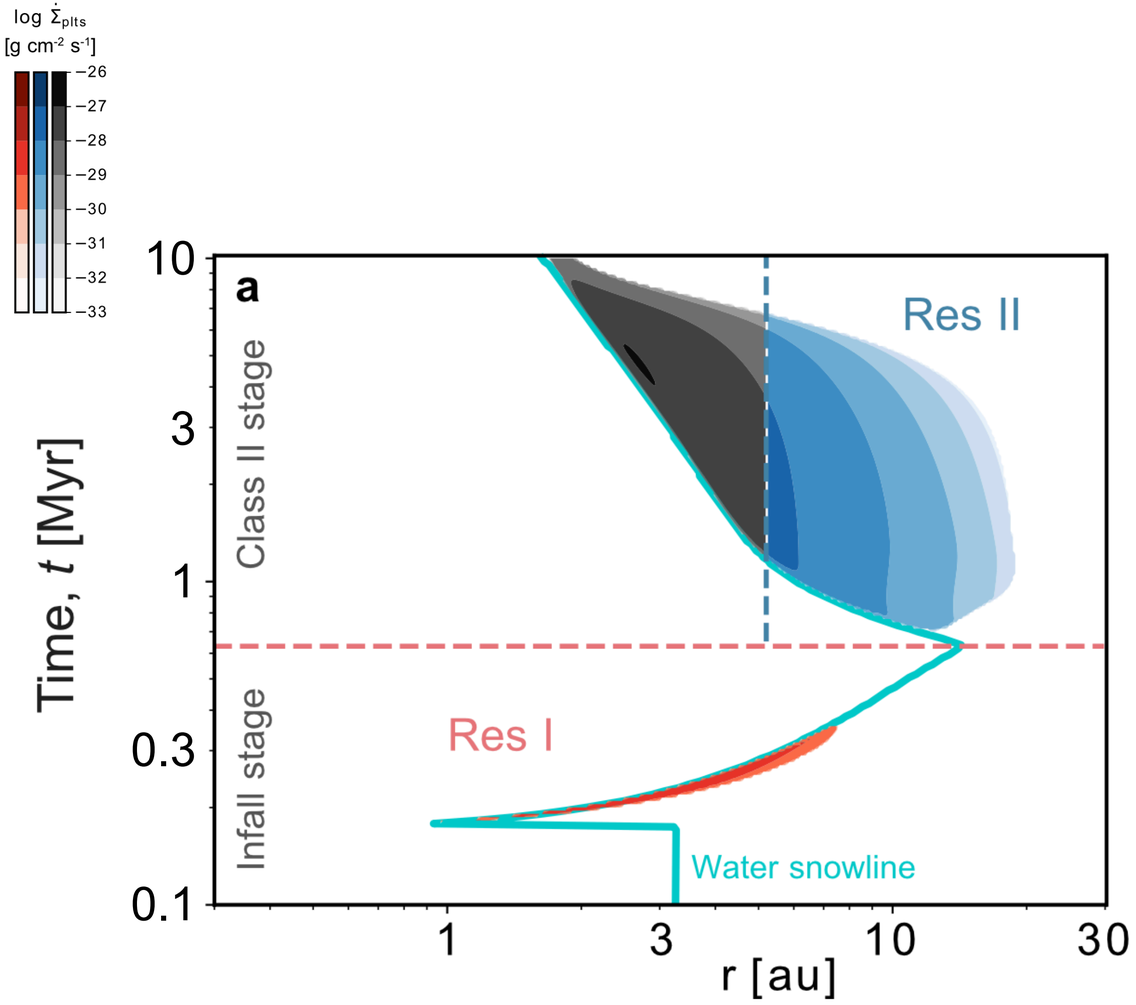
^{26}Al-heated icy planetesimals seeding the inner planets

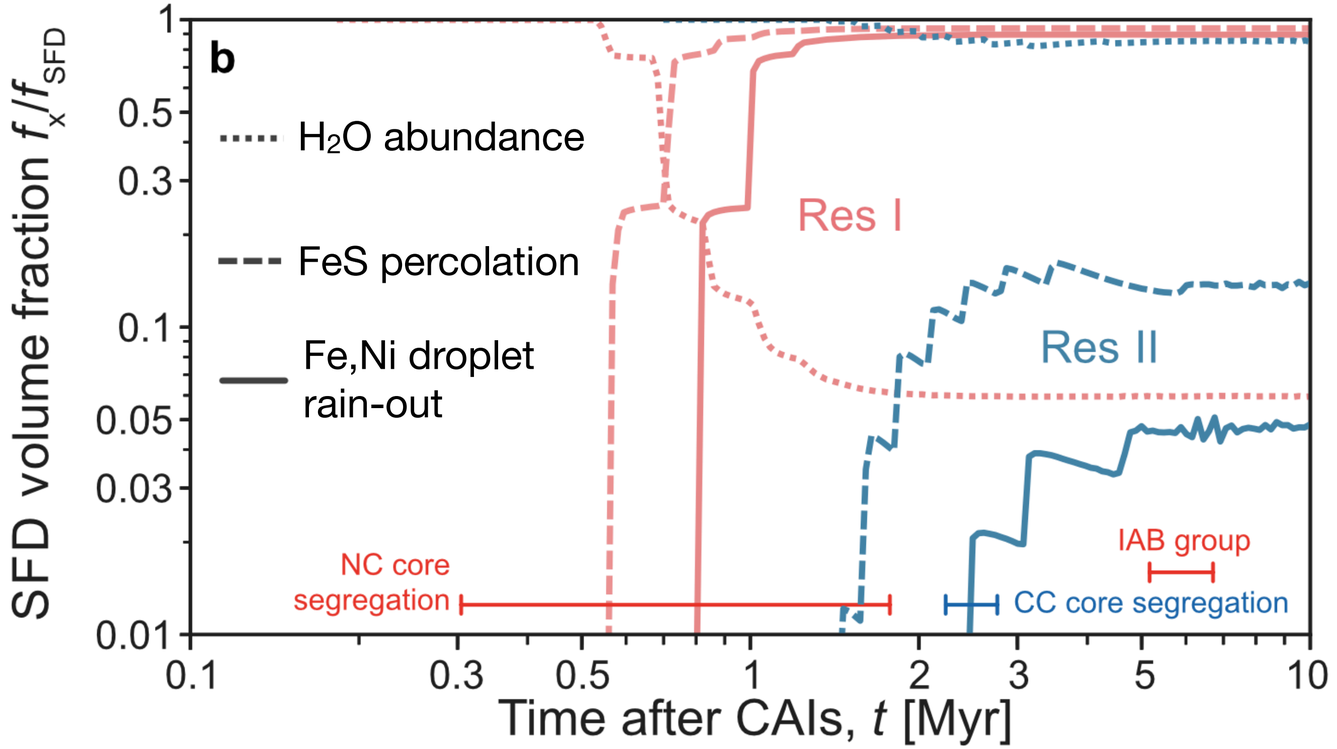


A. Angelich (NRAO/AUI/NSF)/ALMA (ESO/NAOJ/NRAO); ESA/NASA/M.A.Garlick

Lichtenberg+ 19b, Nature Astronomy

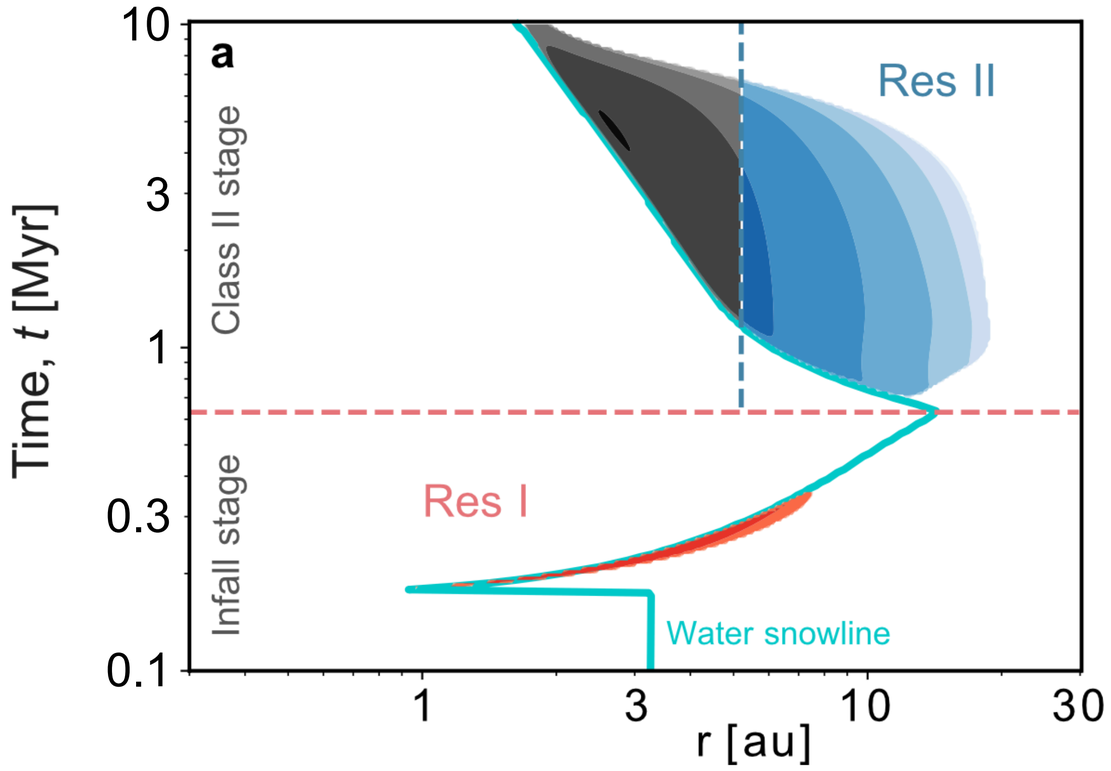
Compositional bifurcation of reservoirs





Lichtenberg, Drążkowska, Schönbächler, Golabek, Hands, in prep.

Early compositional bifurcation of planetary building blocks



- Reservoir separation induced by protoplanet seeding
  - Not dependent on the presence of Jupiter, but *causing* its nucleation and growth
- Rocky planets seeded *before* giant planets
- Water accretion sequence to inner Solar System: water-depleted ➡ dry ➡ water-rich
  - Qualitatively reproduces latest geochemical constraints < 4 Myr
    (Sarafian+17a,b; Peslier+ 17; Piani+ 17,18; McCubbin & Barnes 19)

Lichtenberg, Drążkowska, Schönbächler, Golabek, Hands, in prep.