

System-level fractionation of carbon from disk and planetesimal processing

Tim Lichtenberg



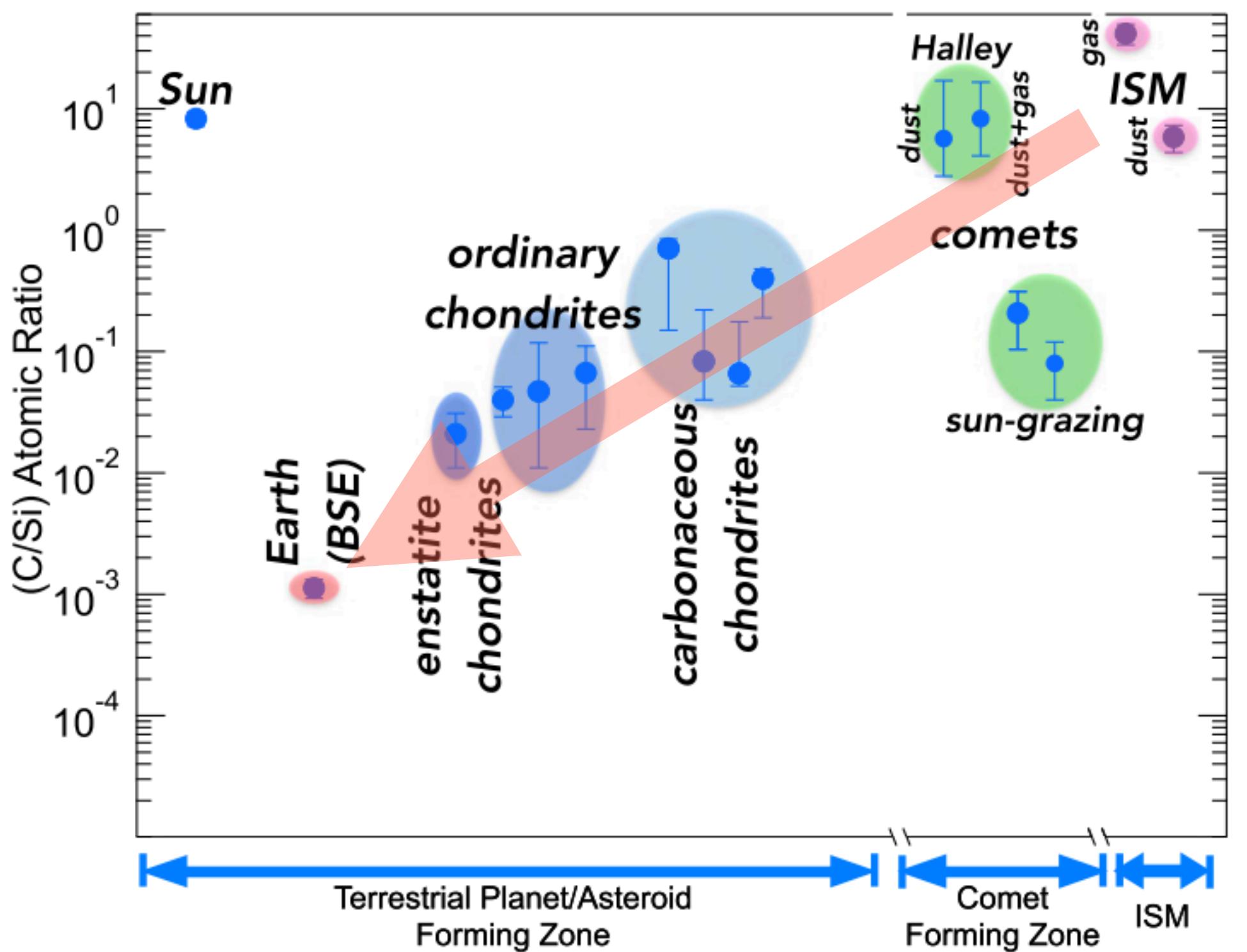
@tim_lichtenberg
timlichtenberg.net

Sebastiaan Krijt

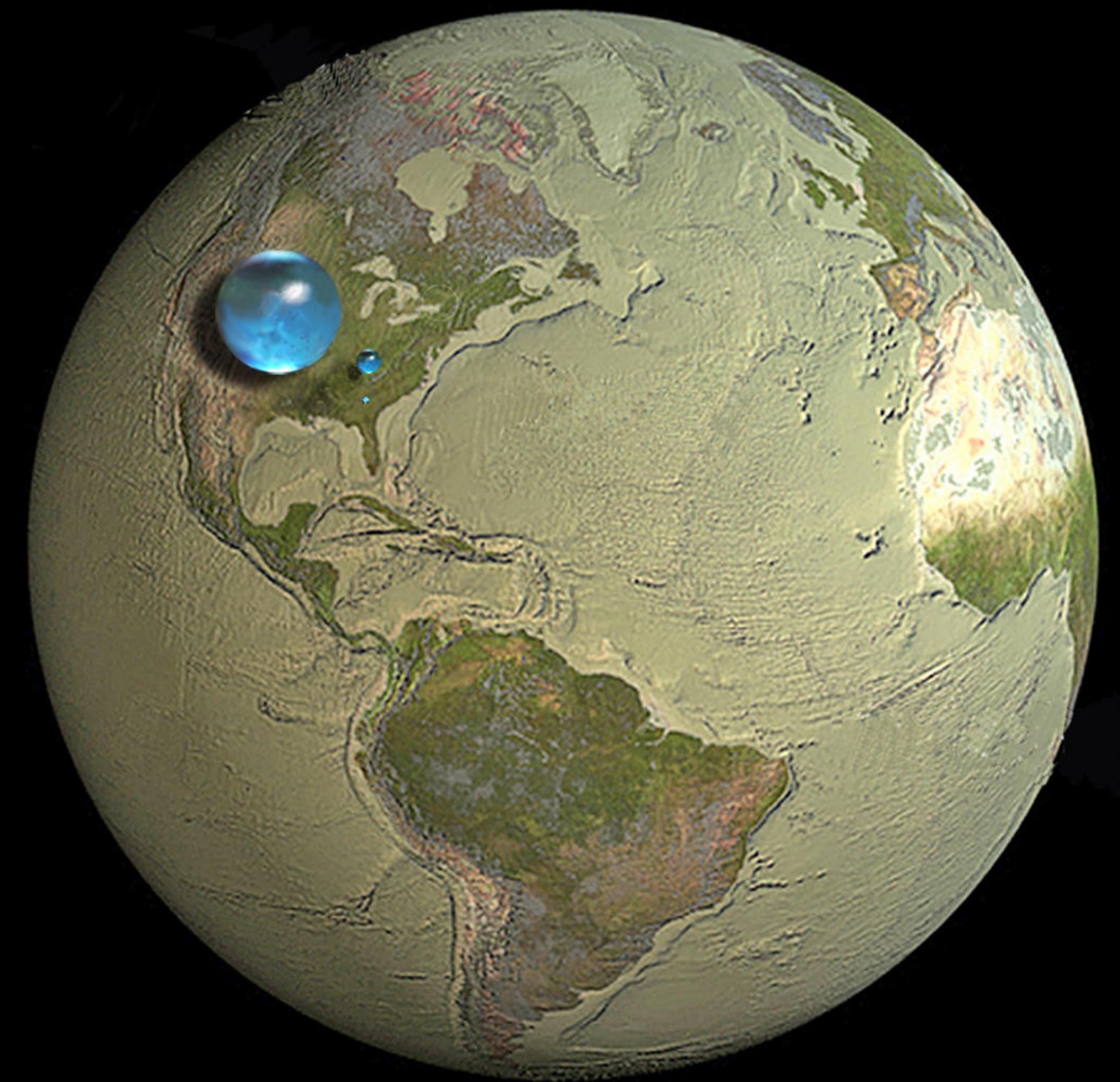


@astrobas
skrijt.com

Water + carbon depletion during planet formation



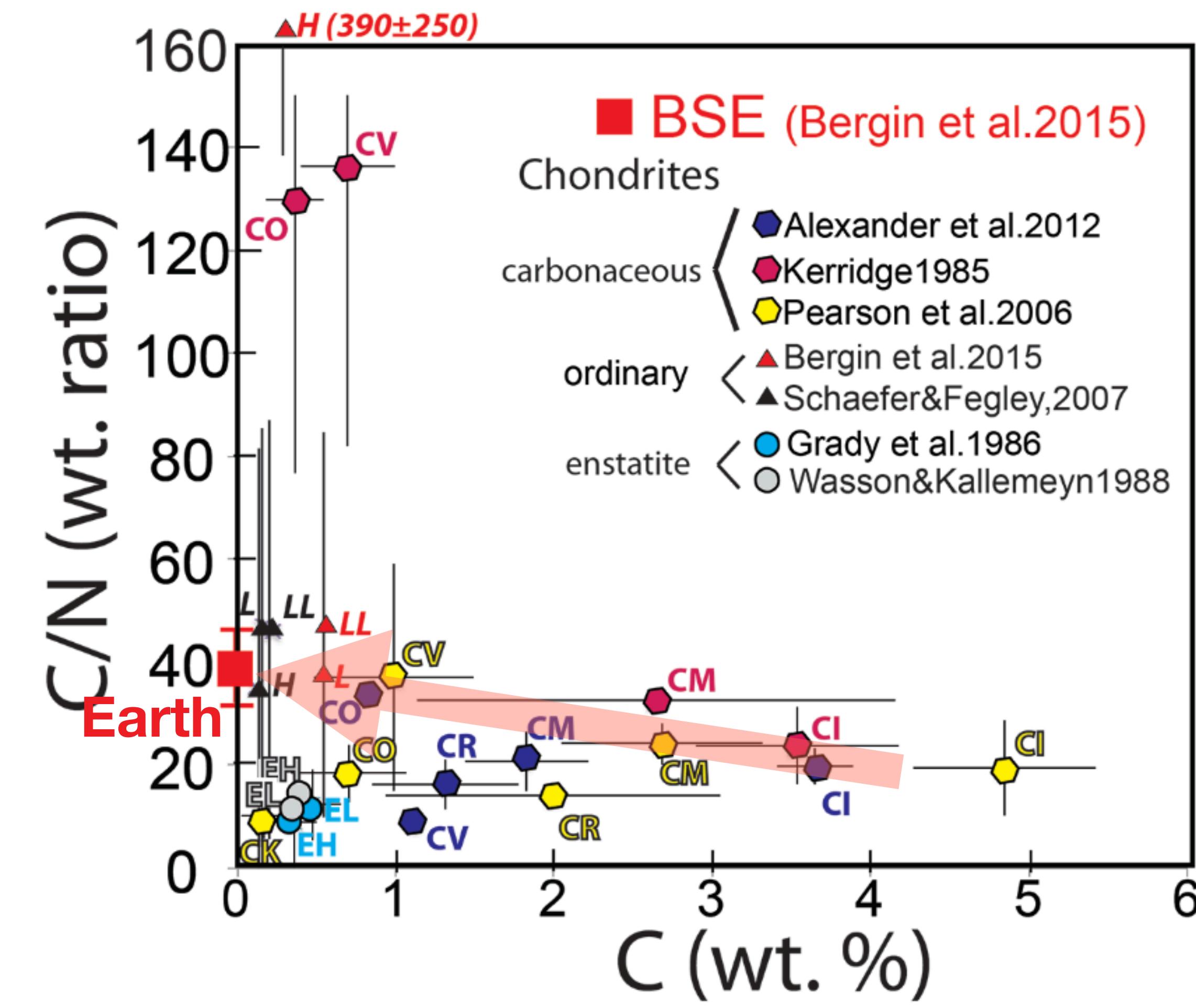
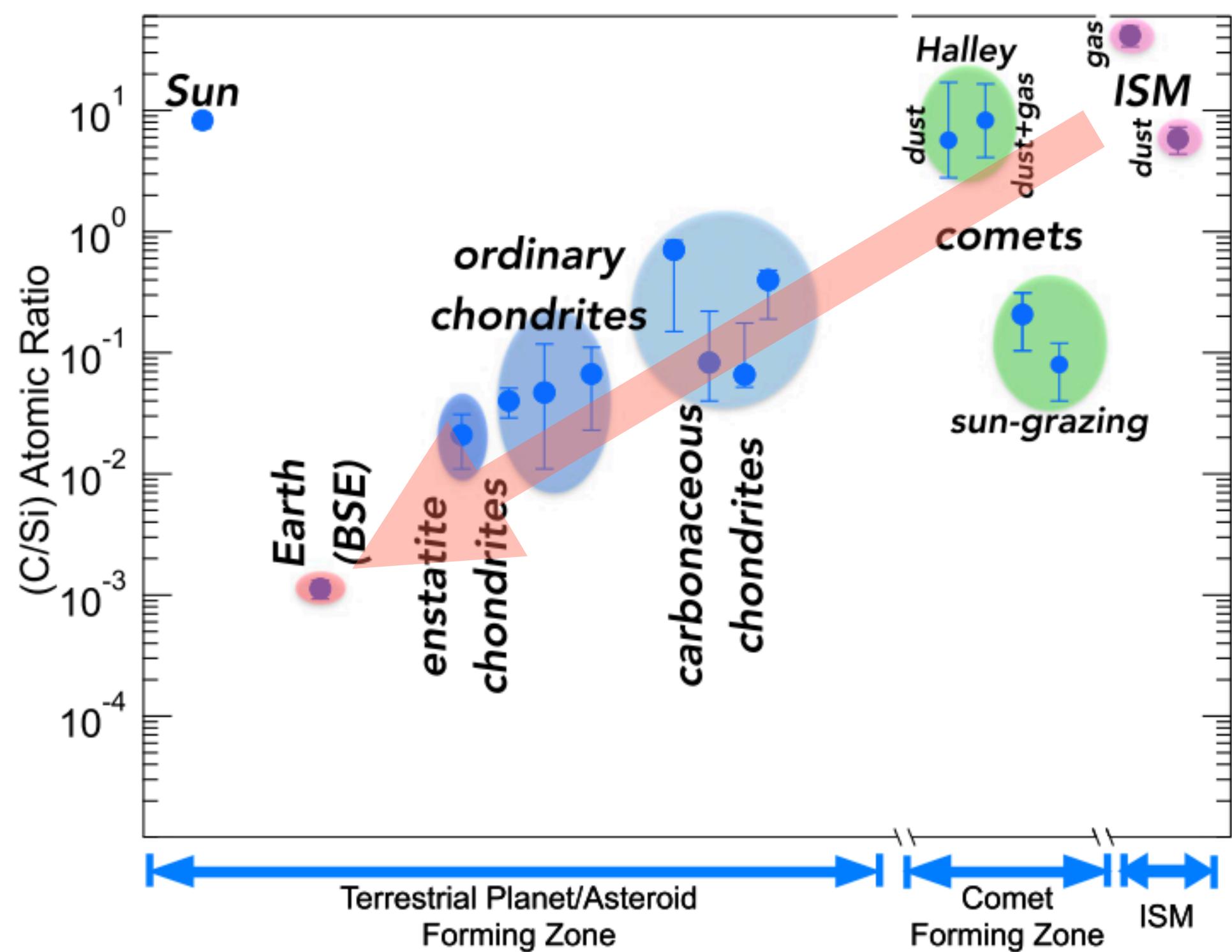
The World's Water



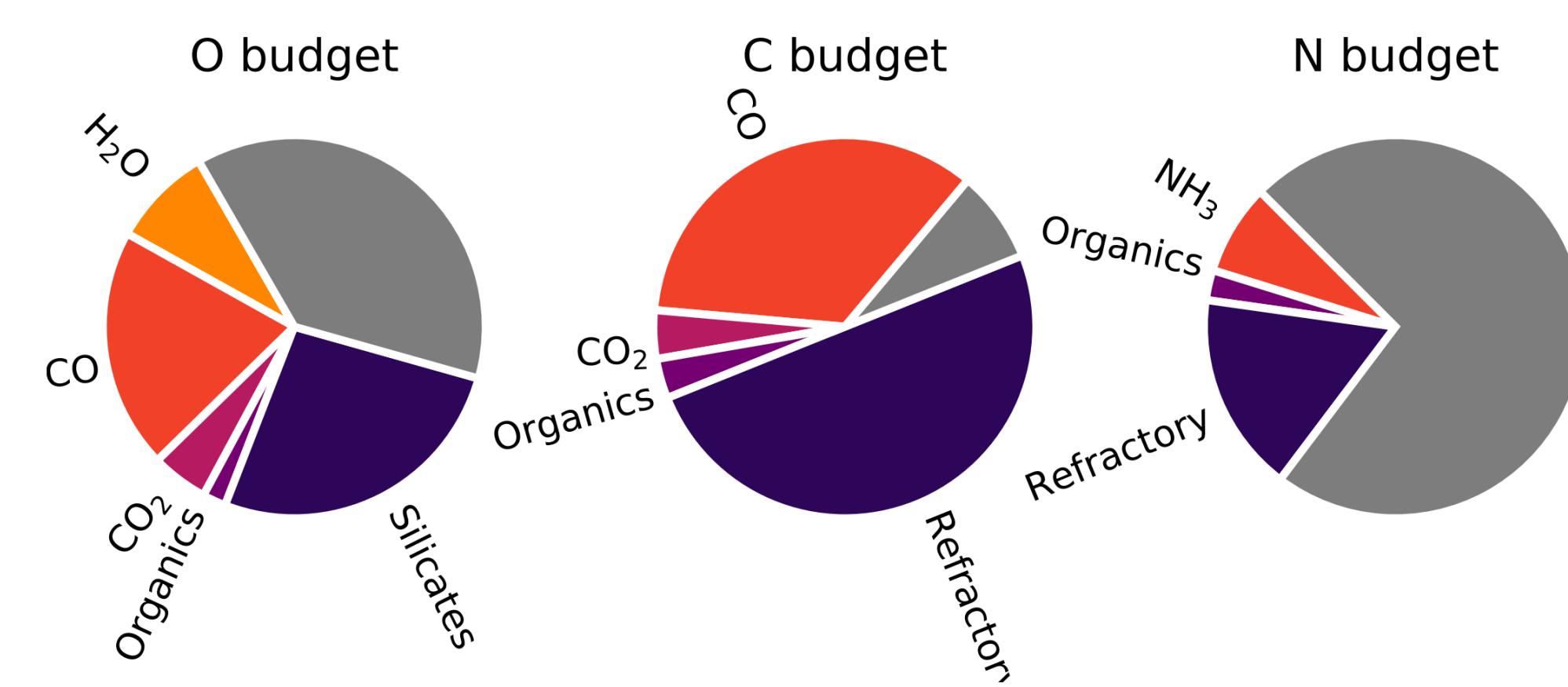
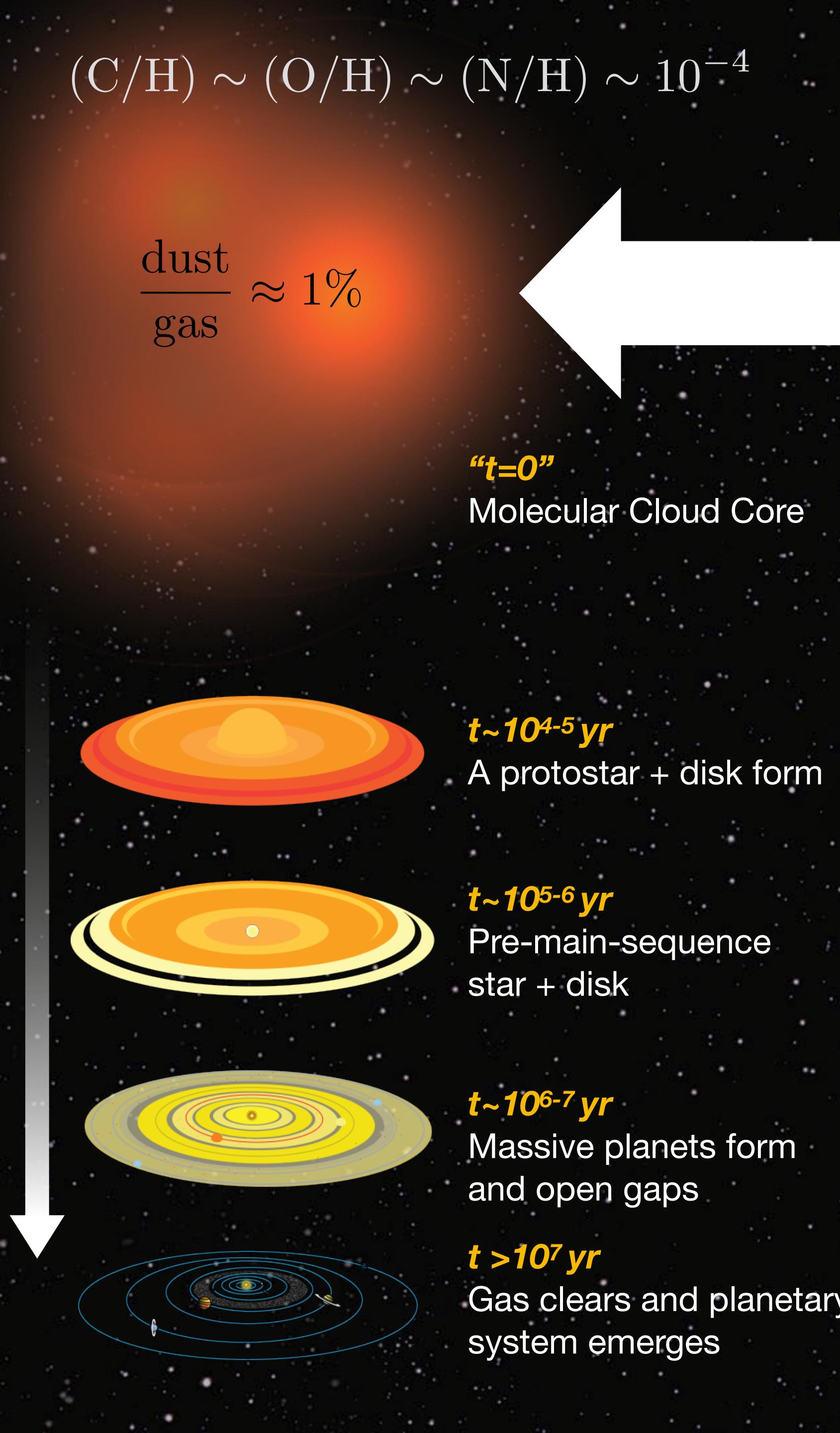
- All water on, in, and above the Earth
- Liquid fresh water
- Fresh-water lakes and rivers

Howard Perlman, USGS,
Jack Cook, Woods Hole Oceanographic Institution,
Adam Nieman
Data source: Igor Shiklomanov
<http://ga.water.usgs.gov/edu/earthhowmuch.html>

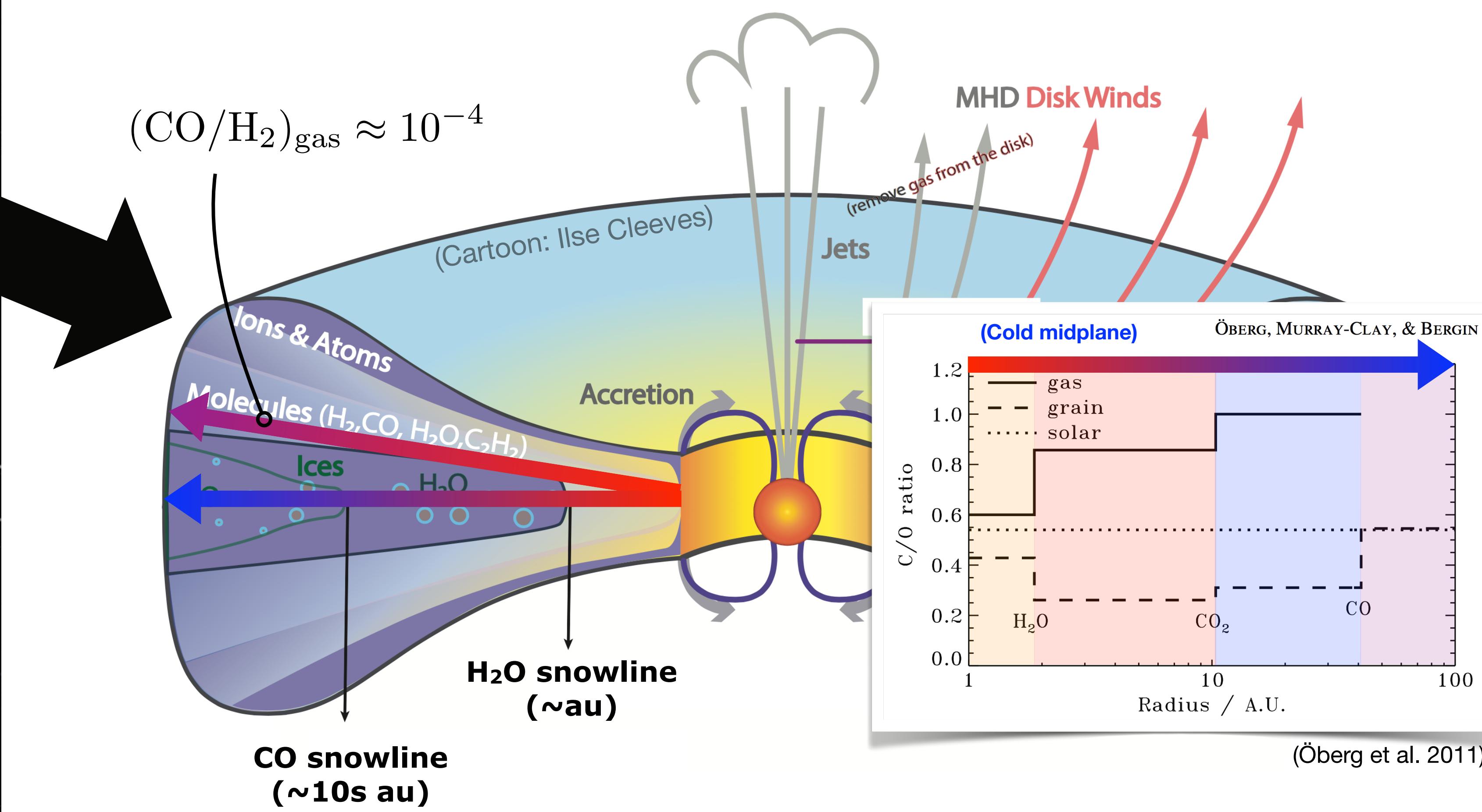
Water + carbon depletion during planet formation



$$(C/H) \sim (O/H) \sim (N/H) \sim 10^{-4}$$

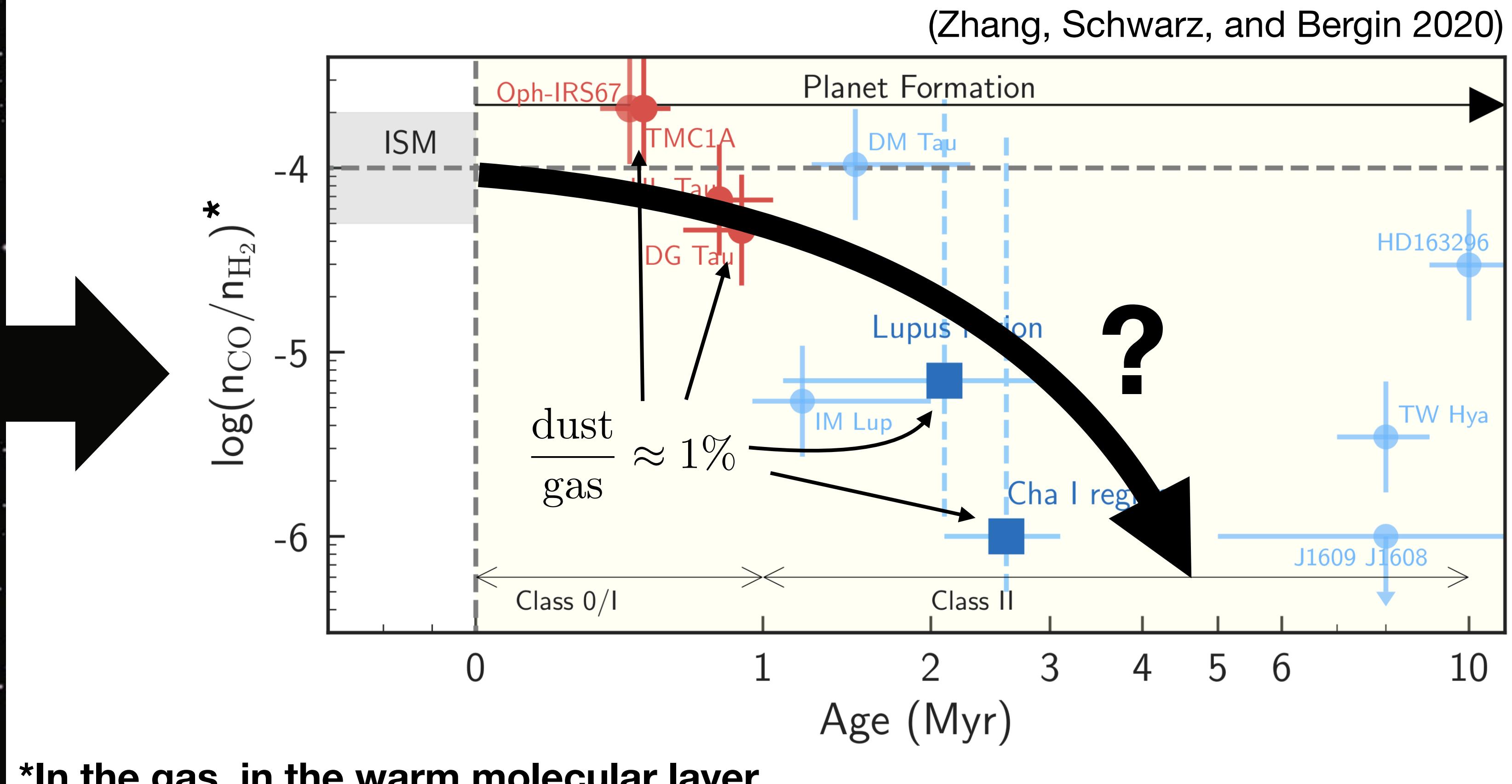
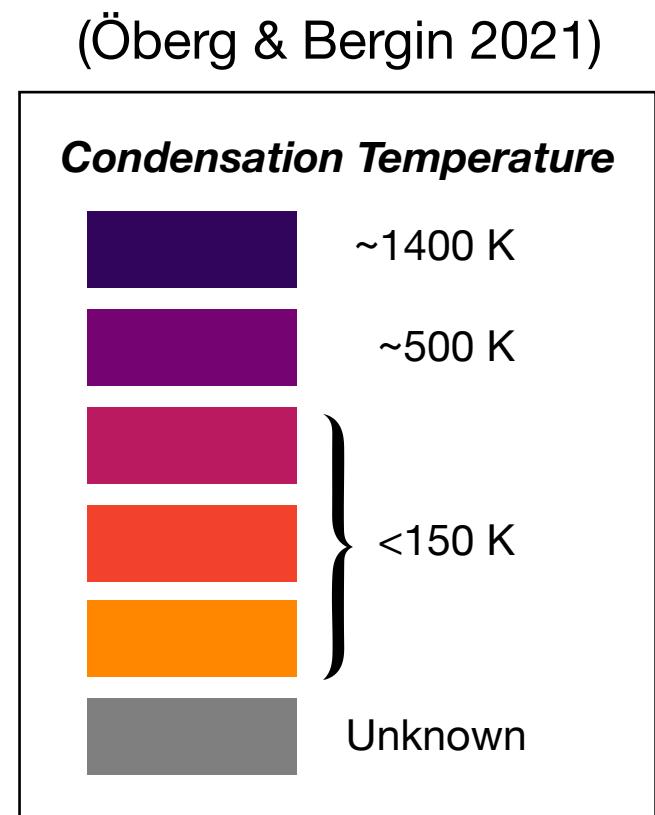
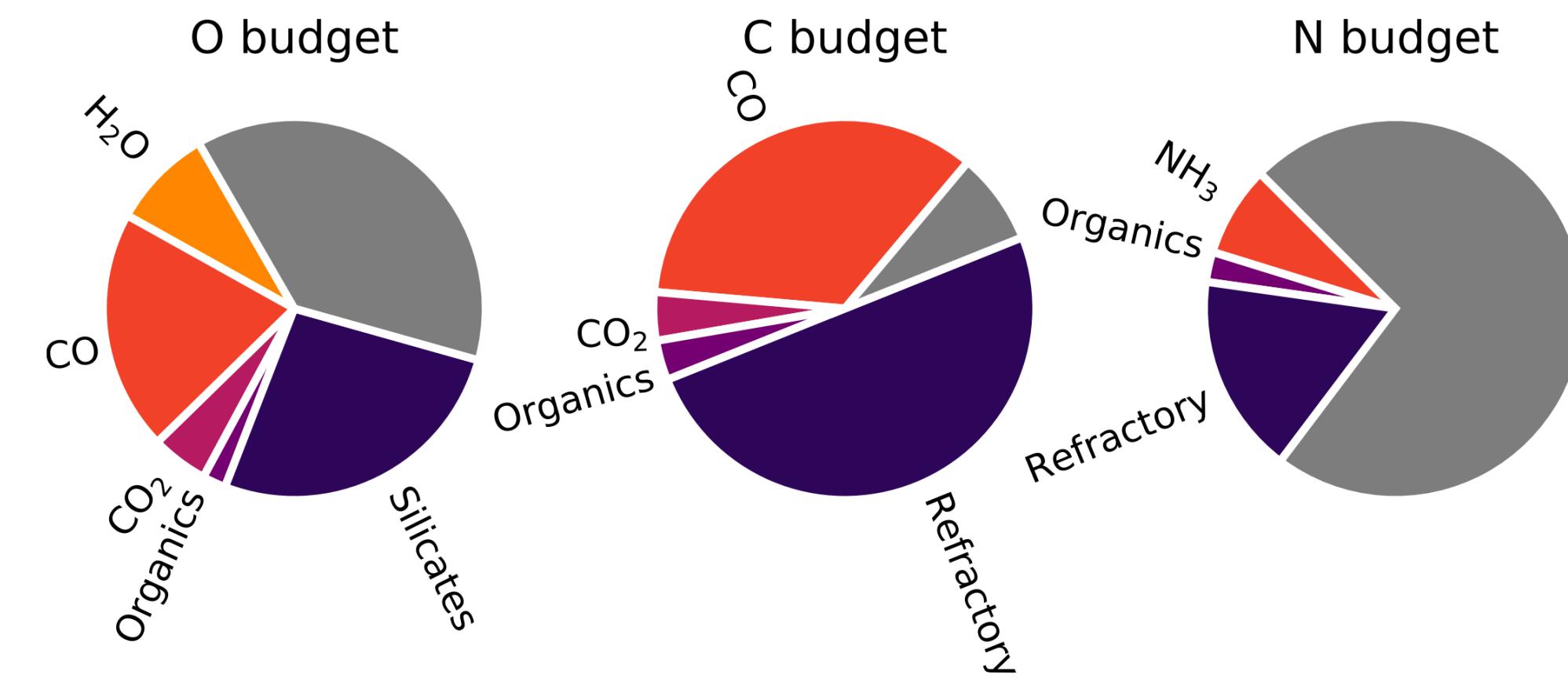
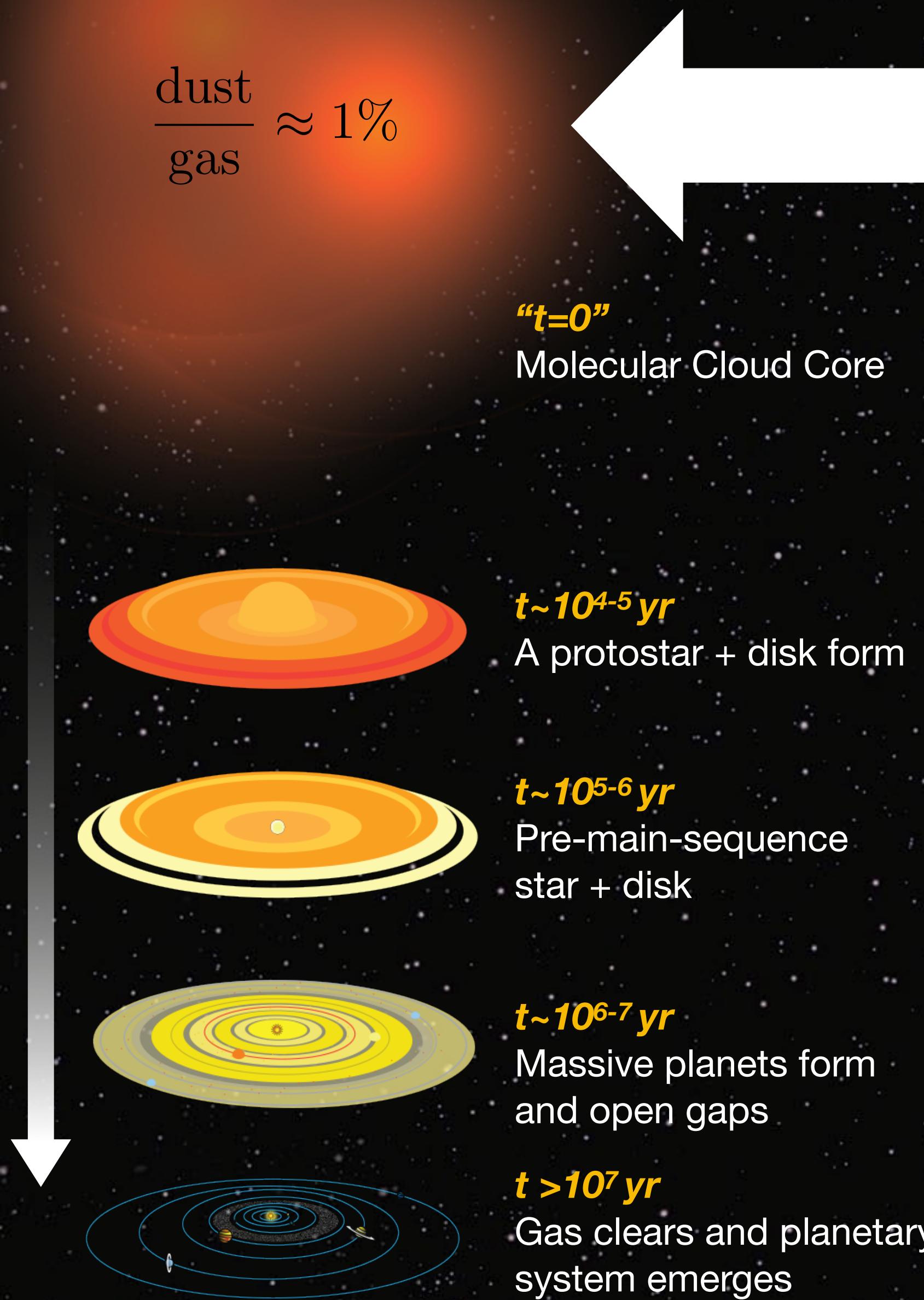


(Öberg & Bergin 2021)

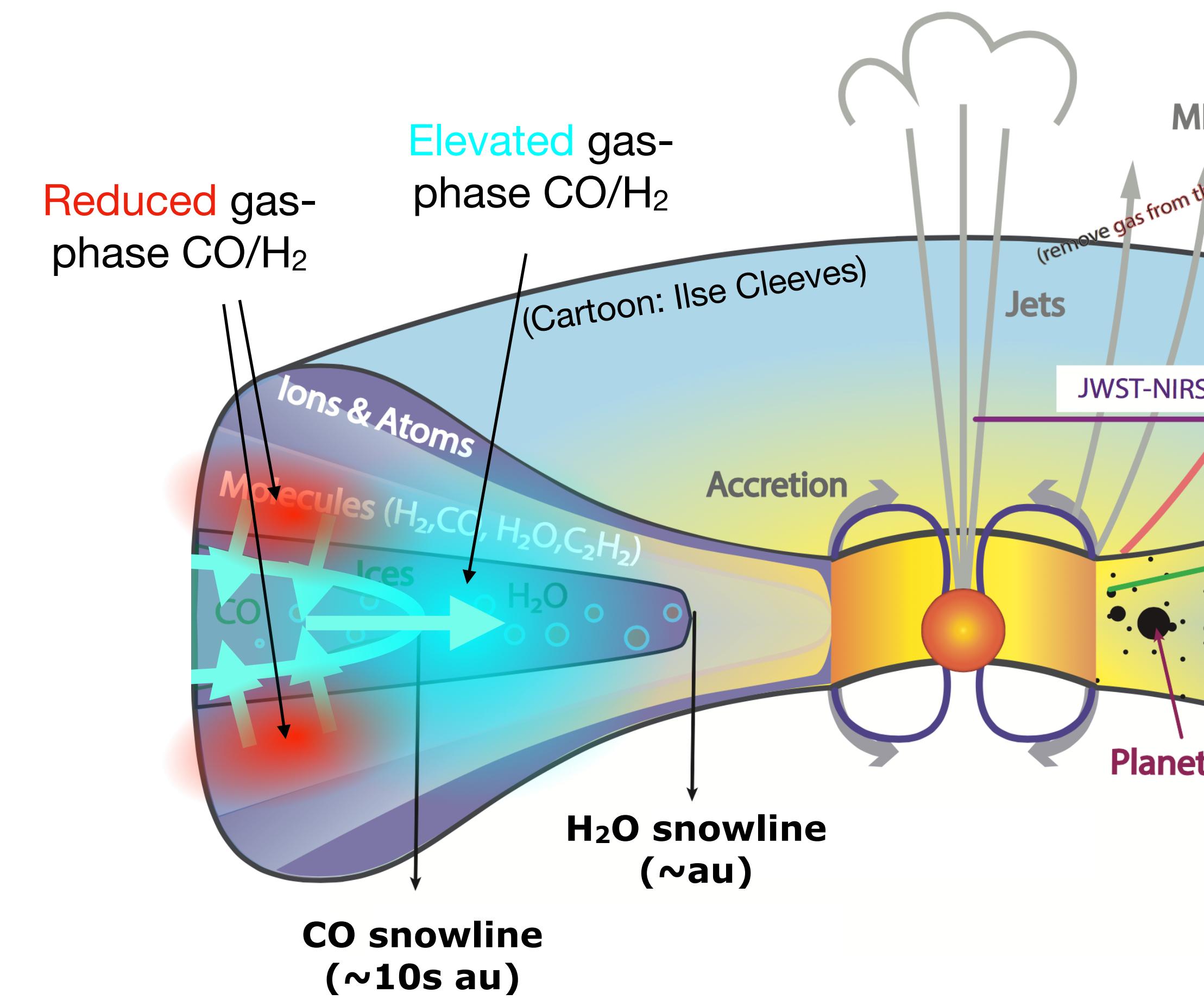
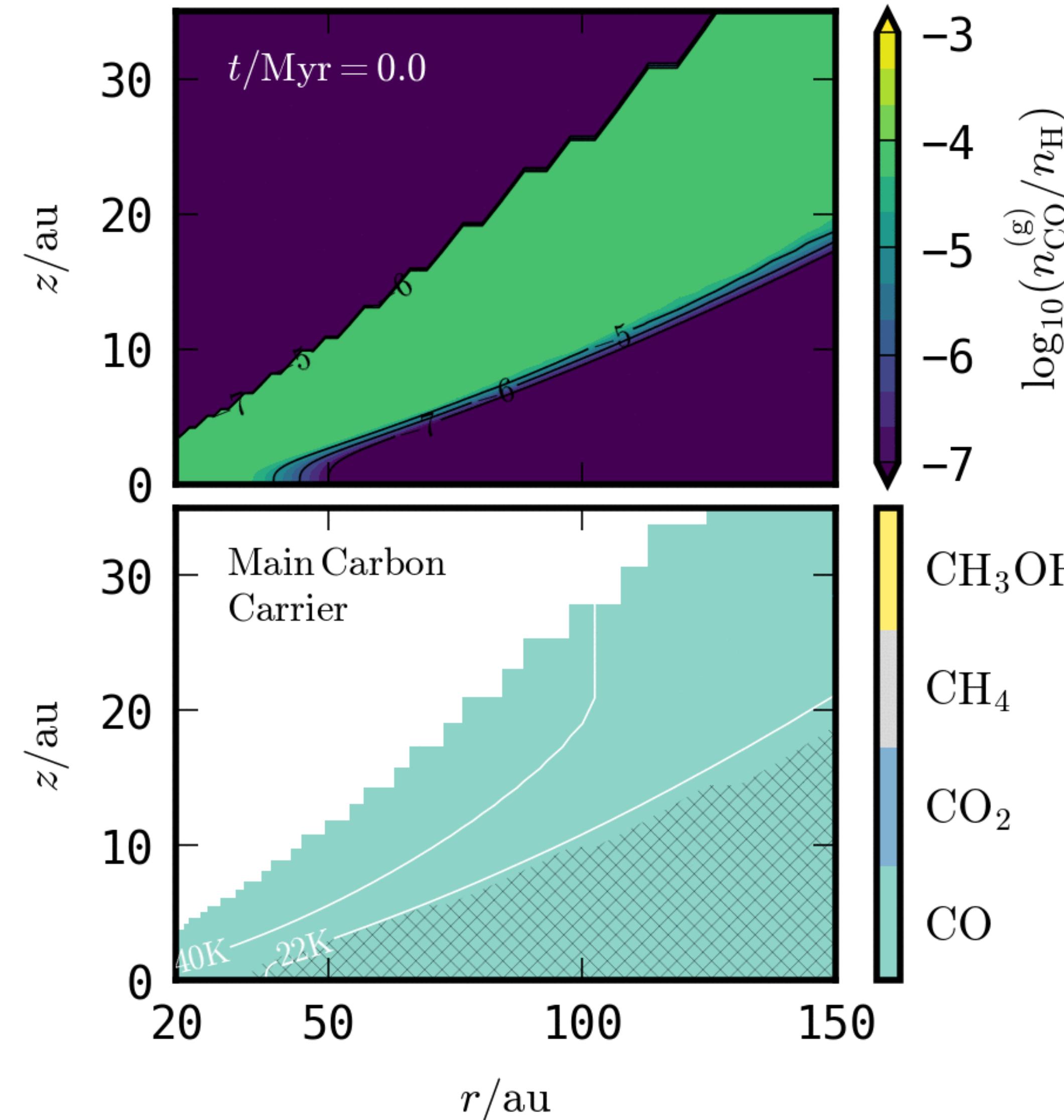


(Öberg et al. 2011)

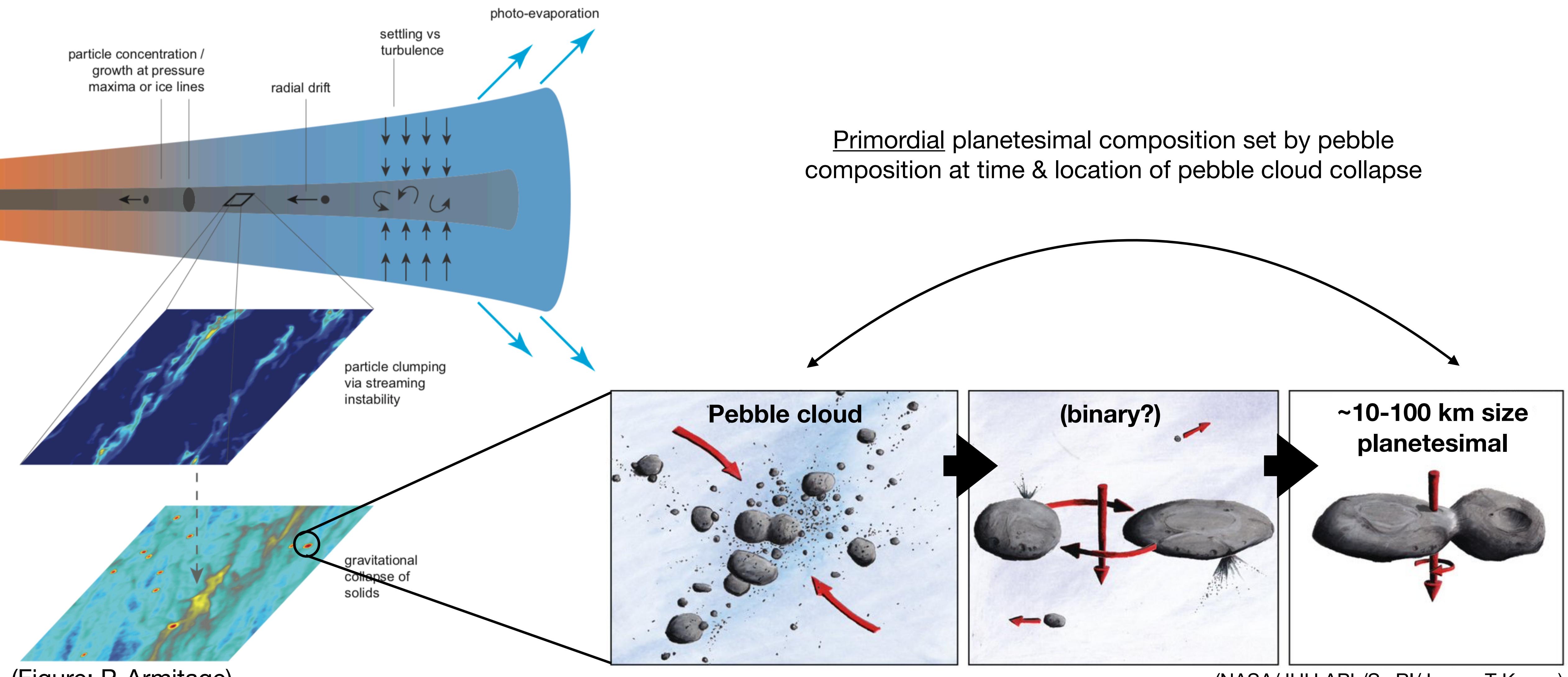
$$(C/H) \sim (O/H) \sim (N/H) \sim 10^{-4}$$



Sequestration of CO ice on pebbles in the midplane?

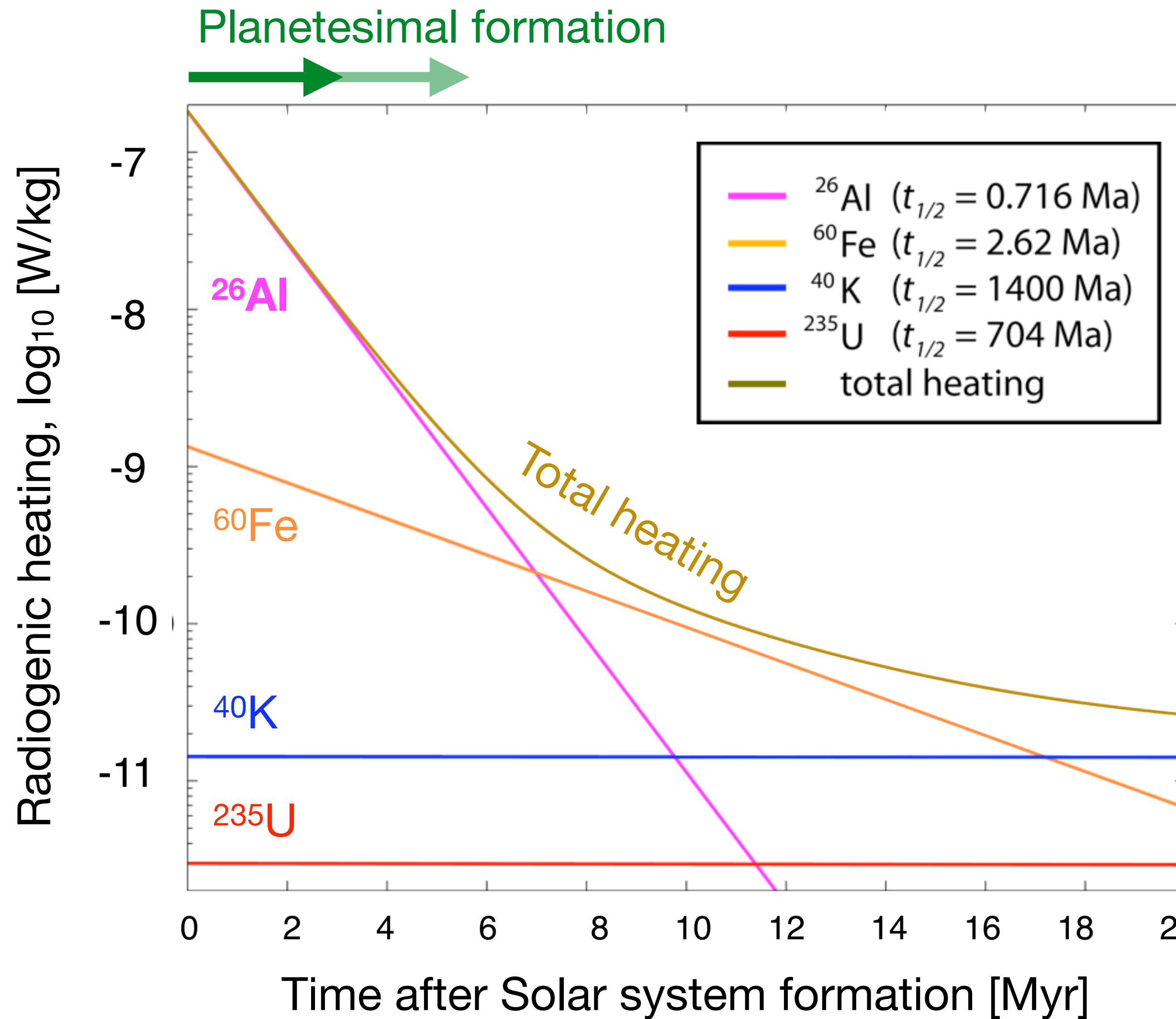


From Pebbles to Planetesimals: Where and When?

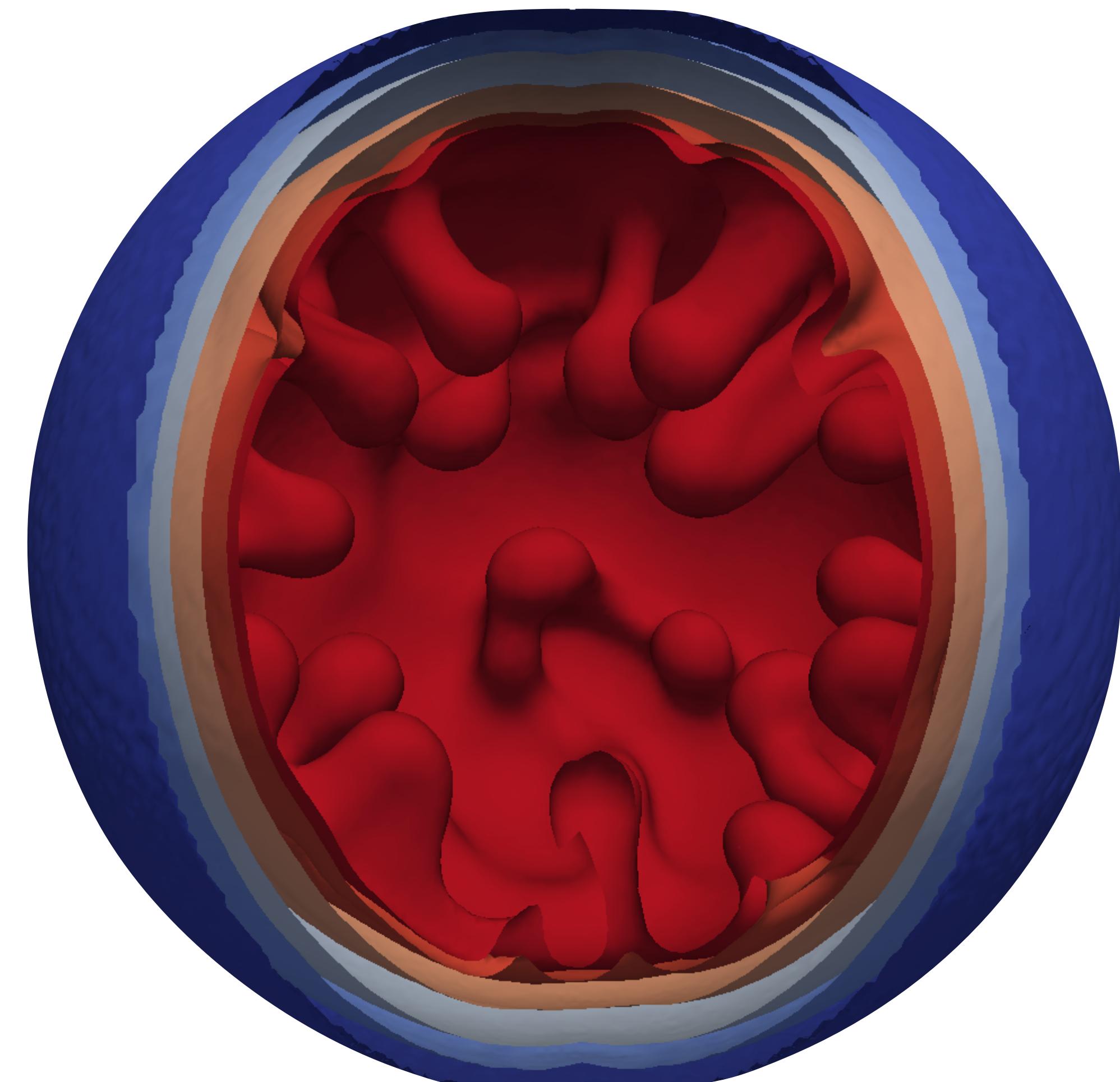
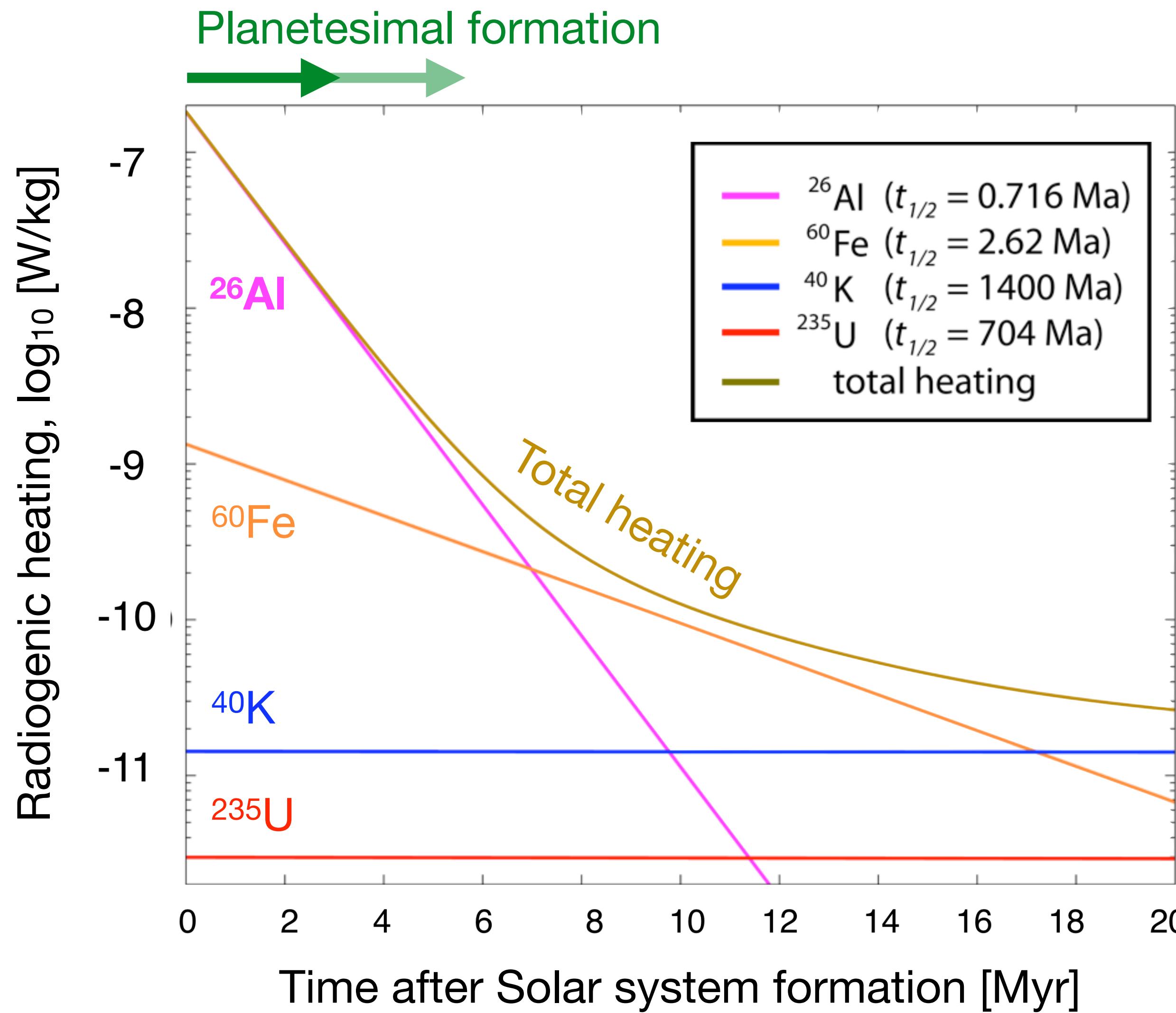




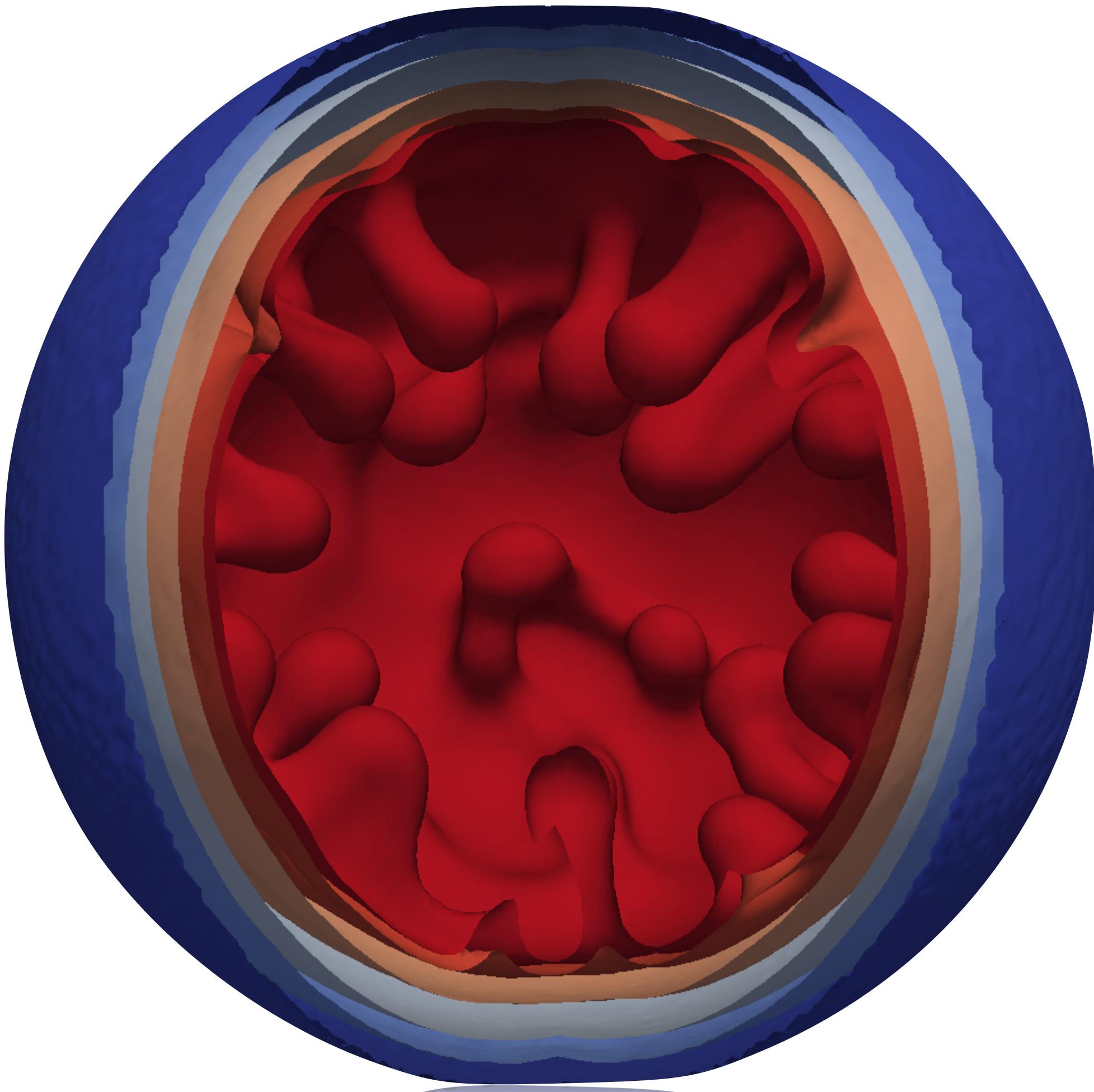
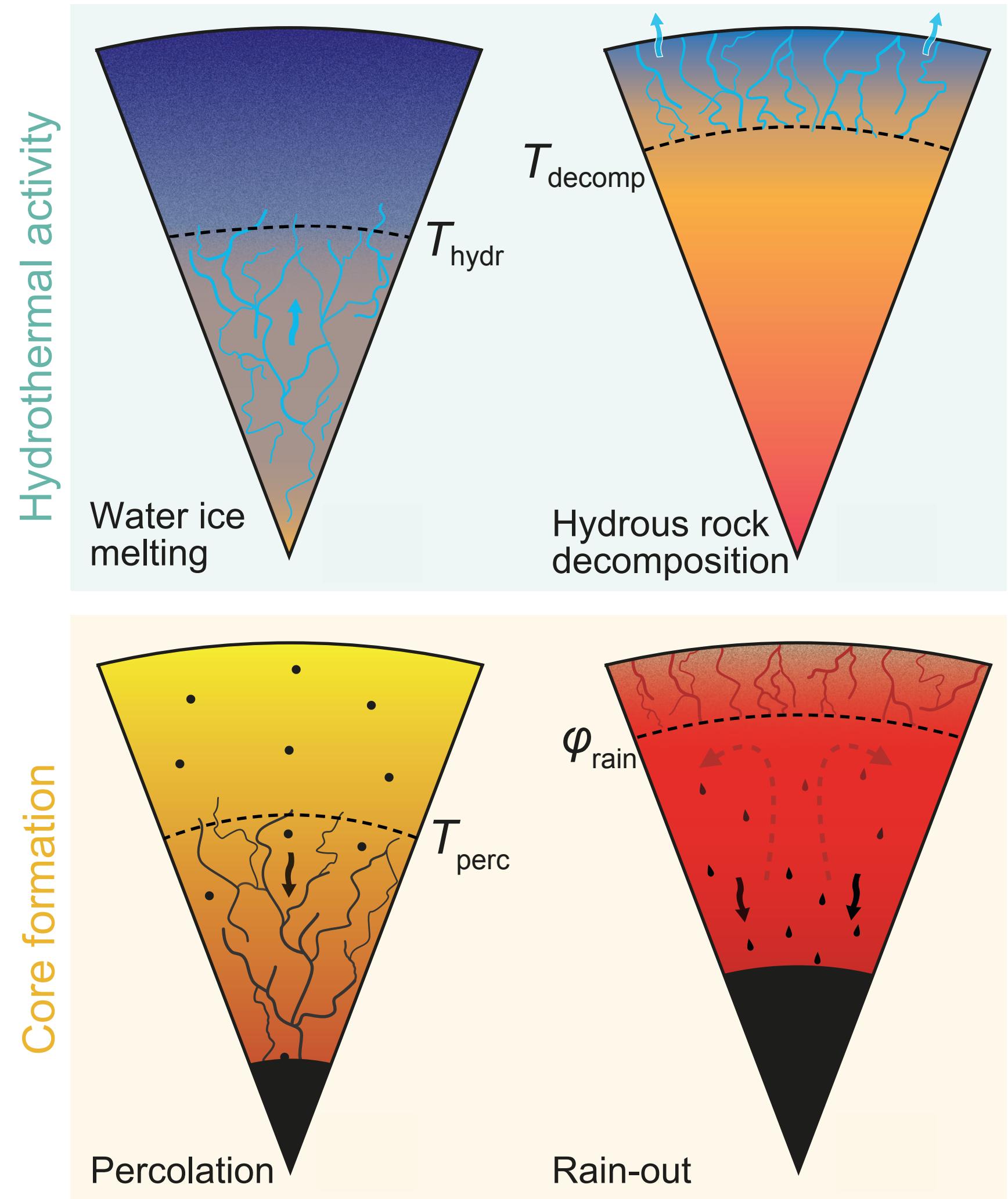
Thermal evolution from radiogenic heating



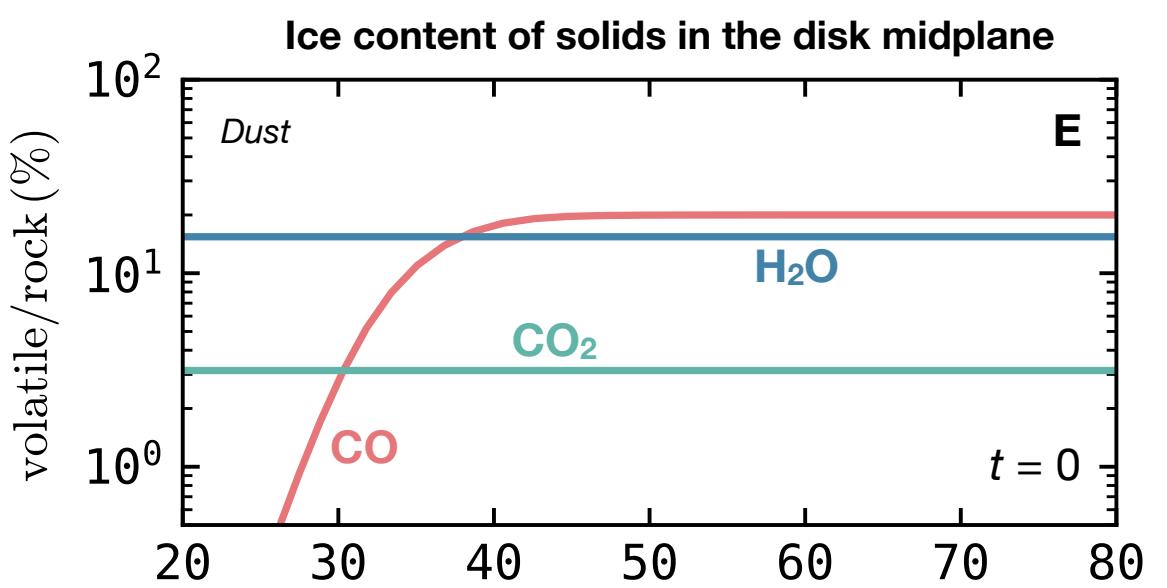
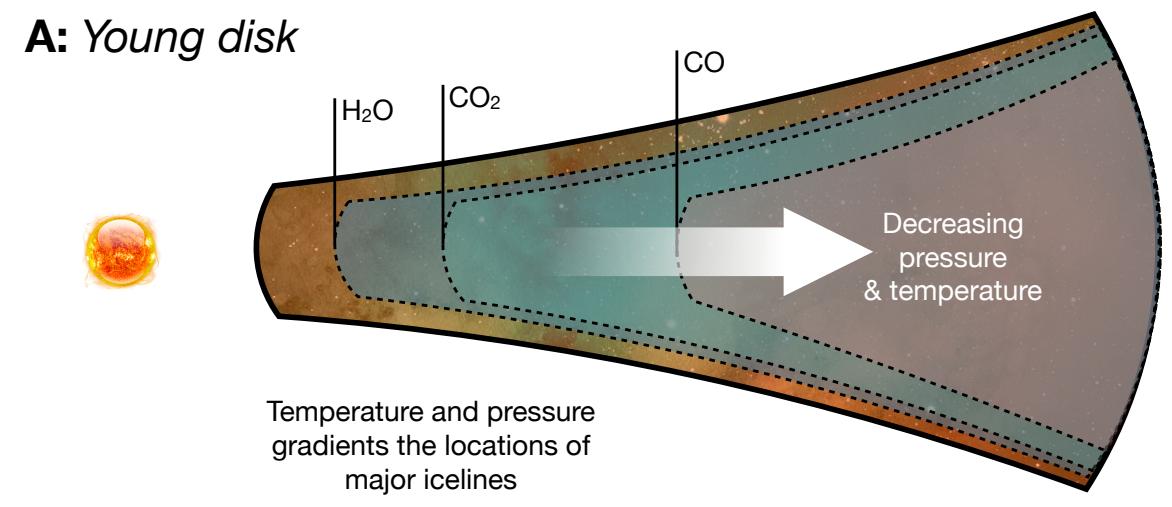
Thermal evolution from radiogenic heating



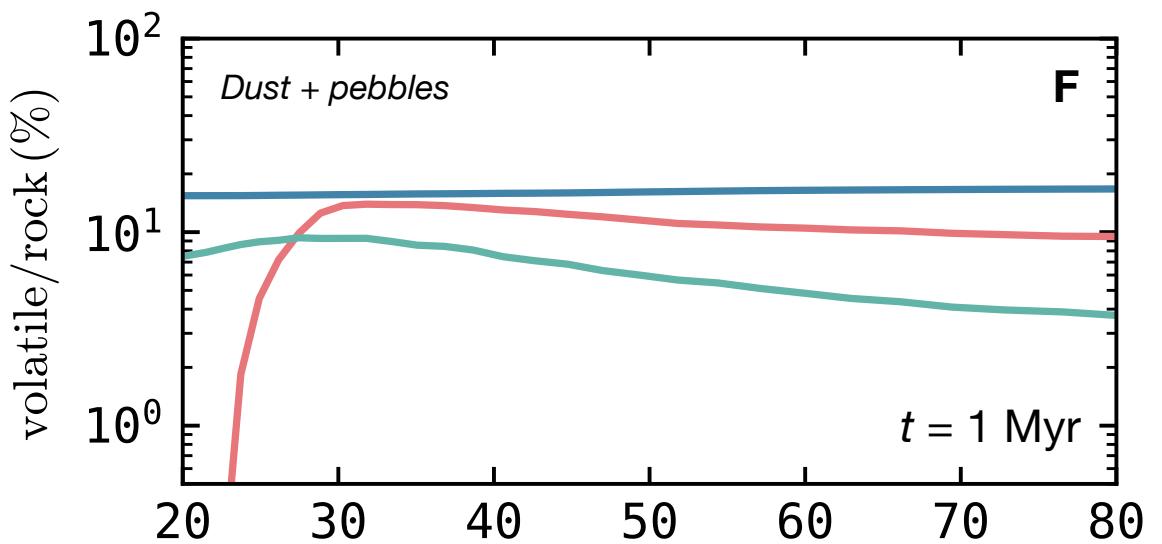
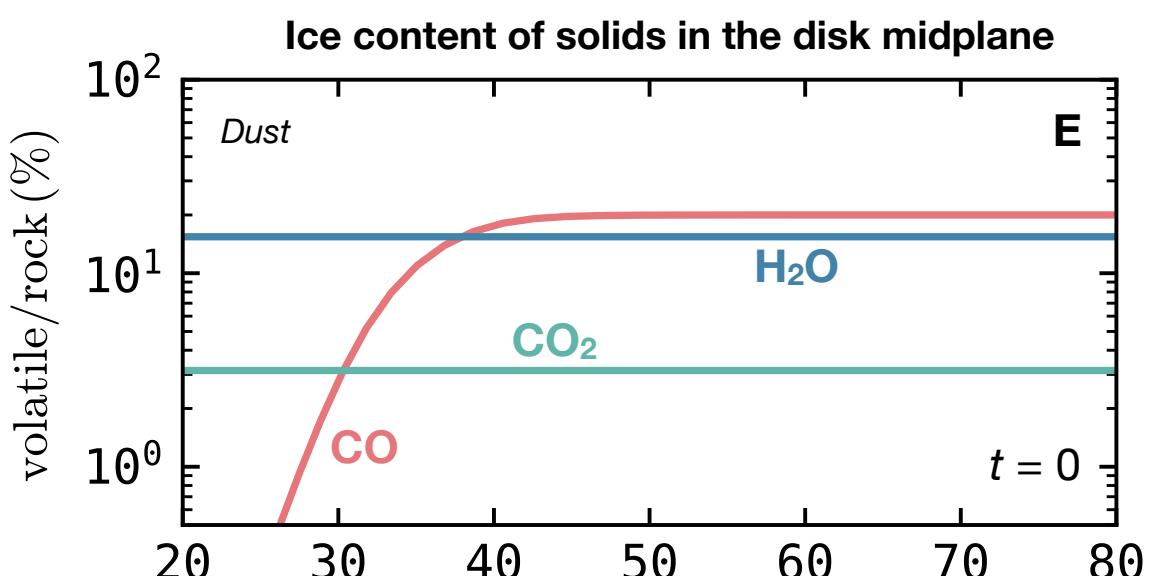
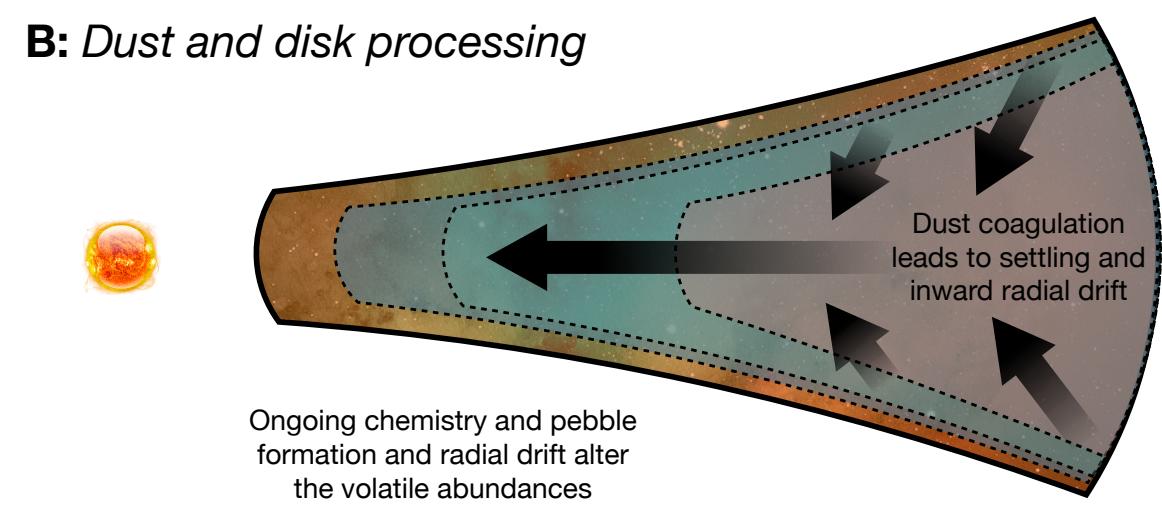
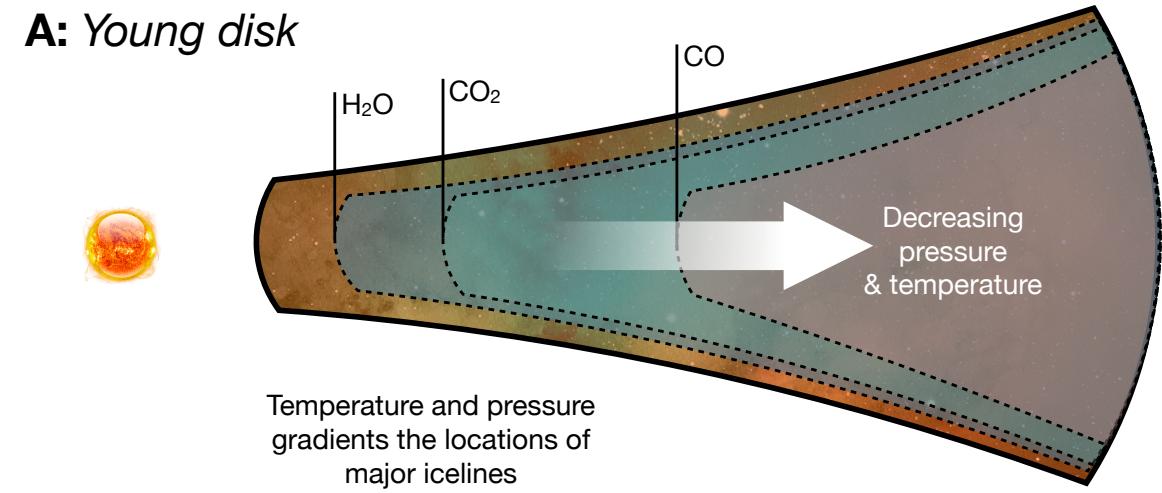
Compositional evolution from radiogenic heating



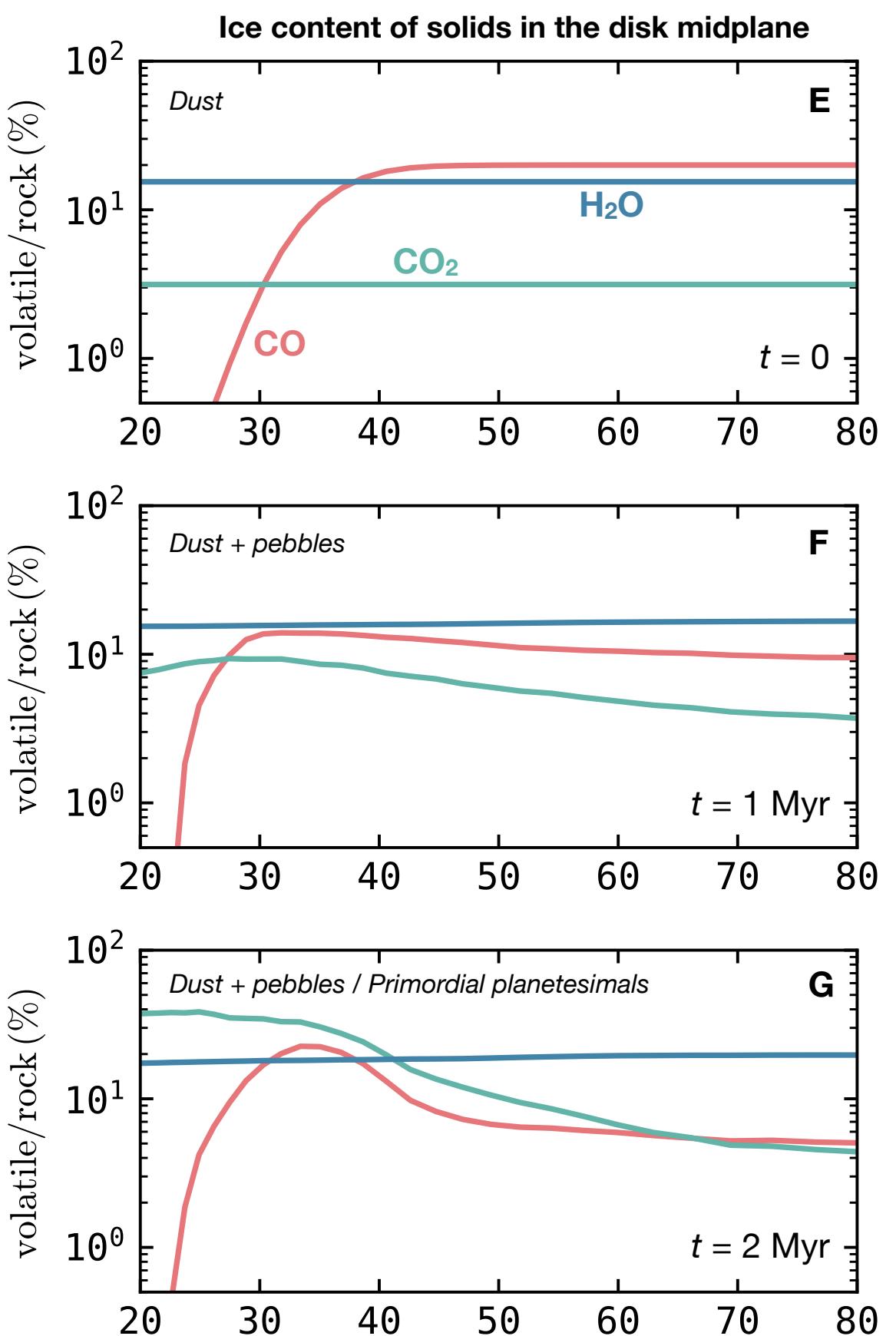
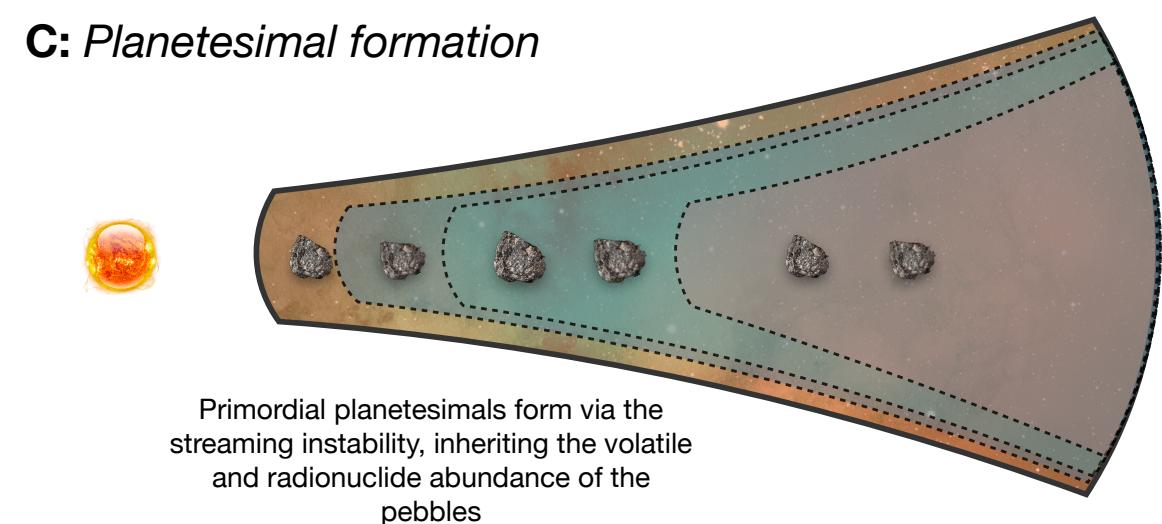
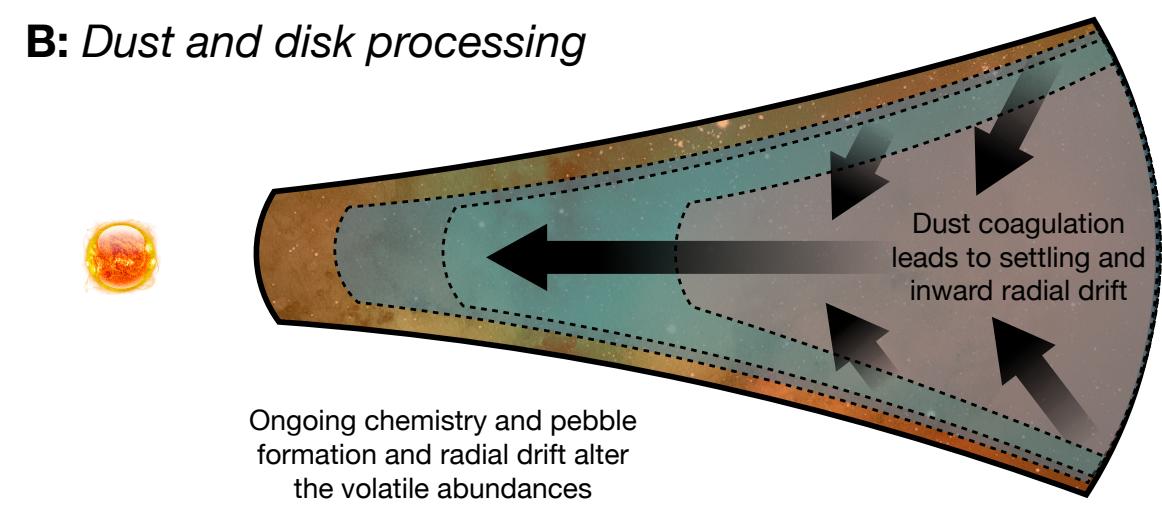
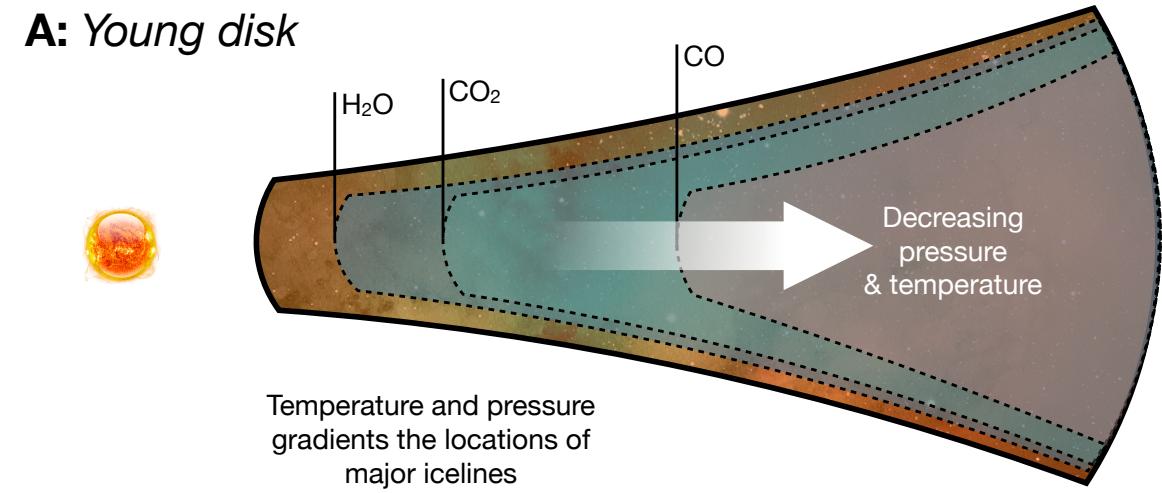
Volatile content of evolved planetesimals



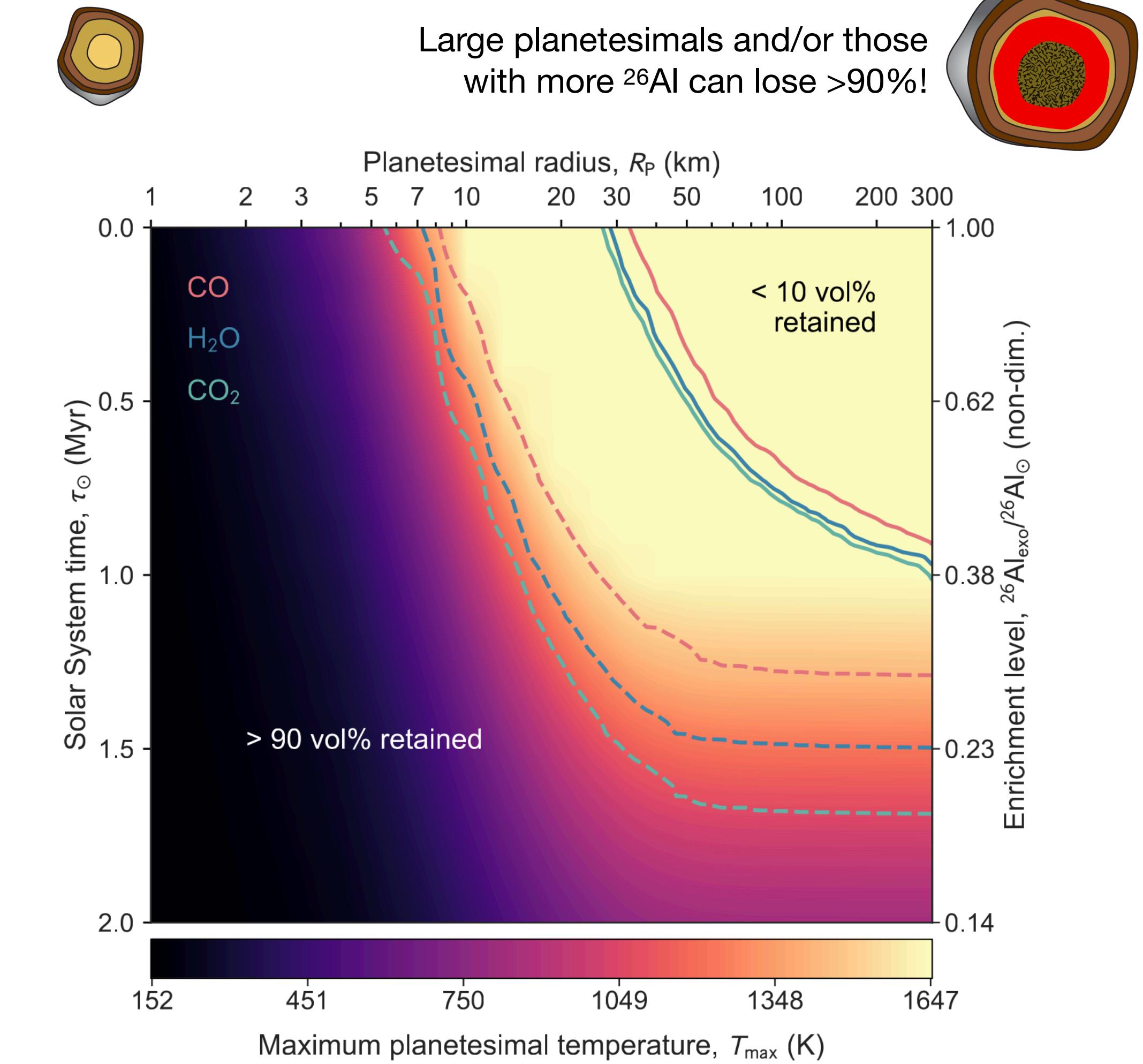
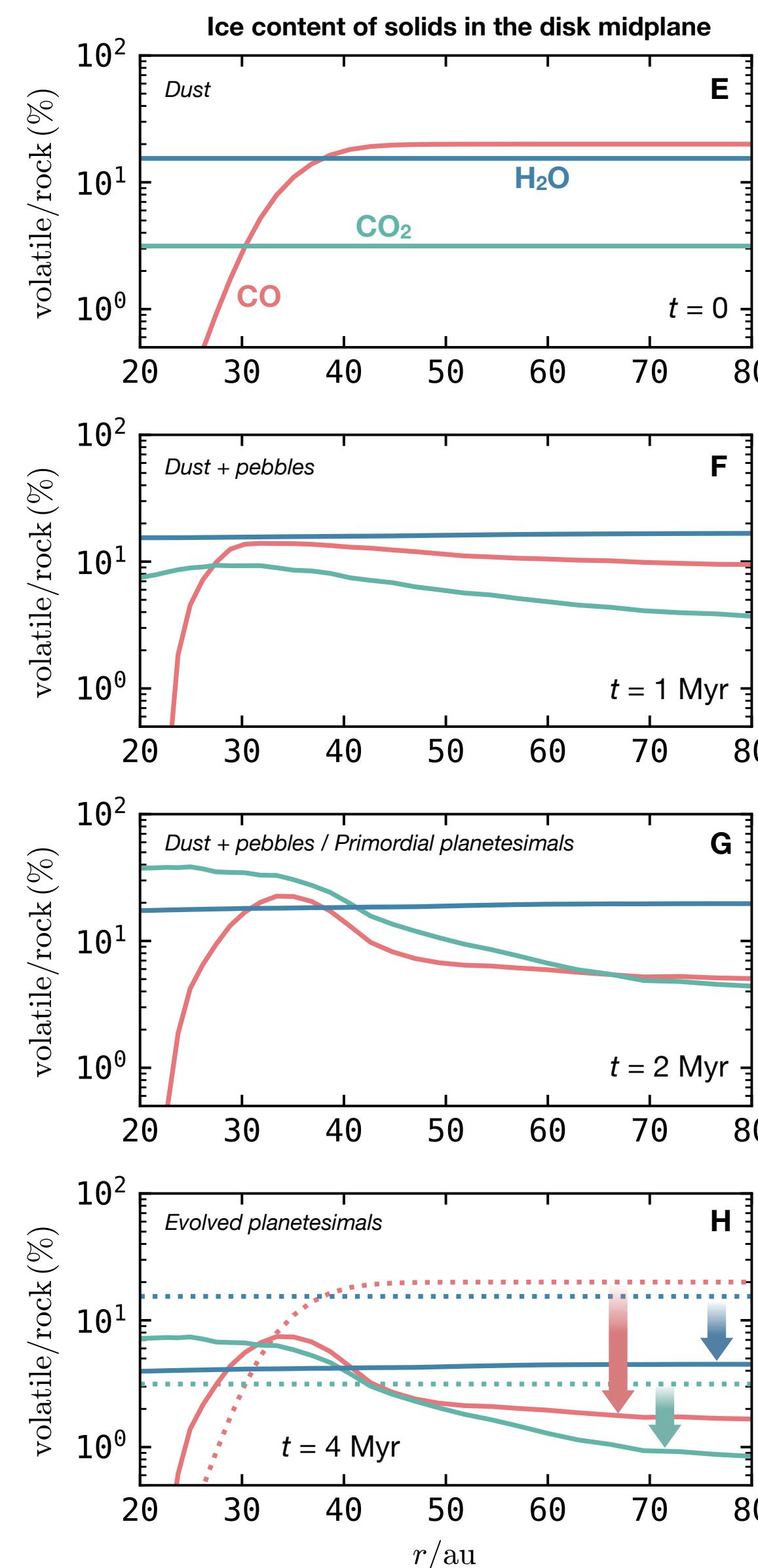
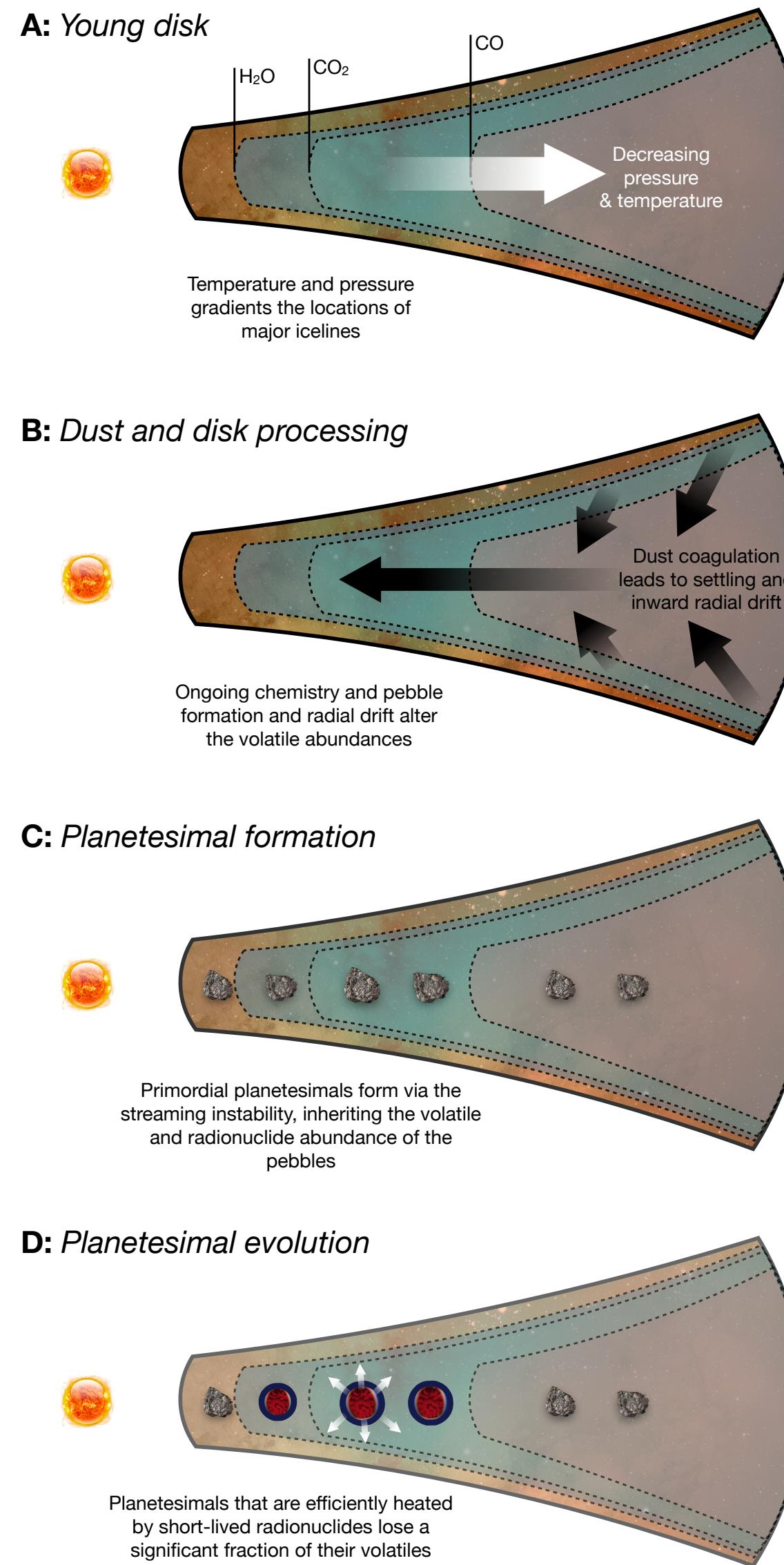
Volatile content of evolved planetesimals



Volatile content of evolved planetesimals

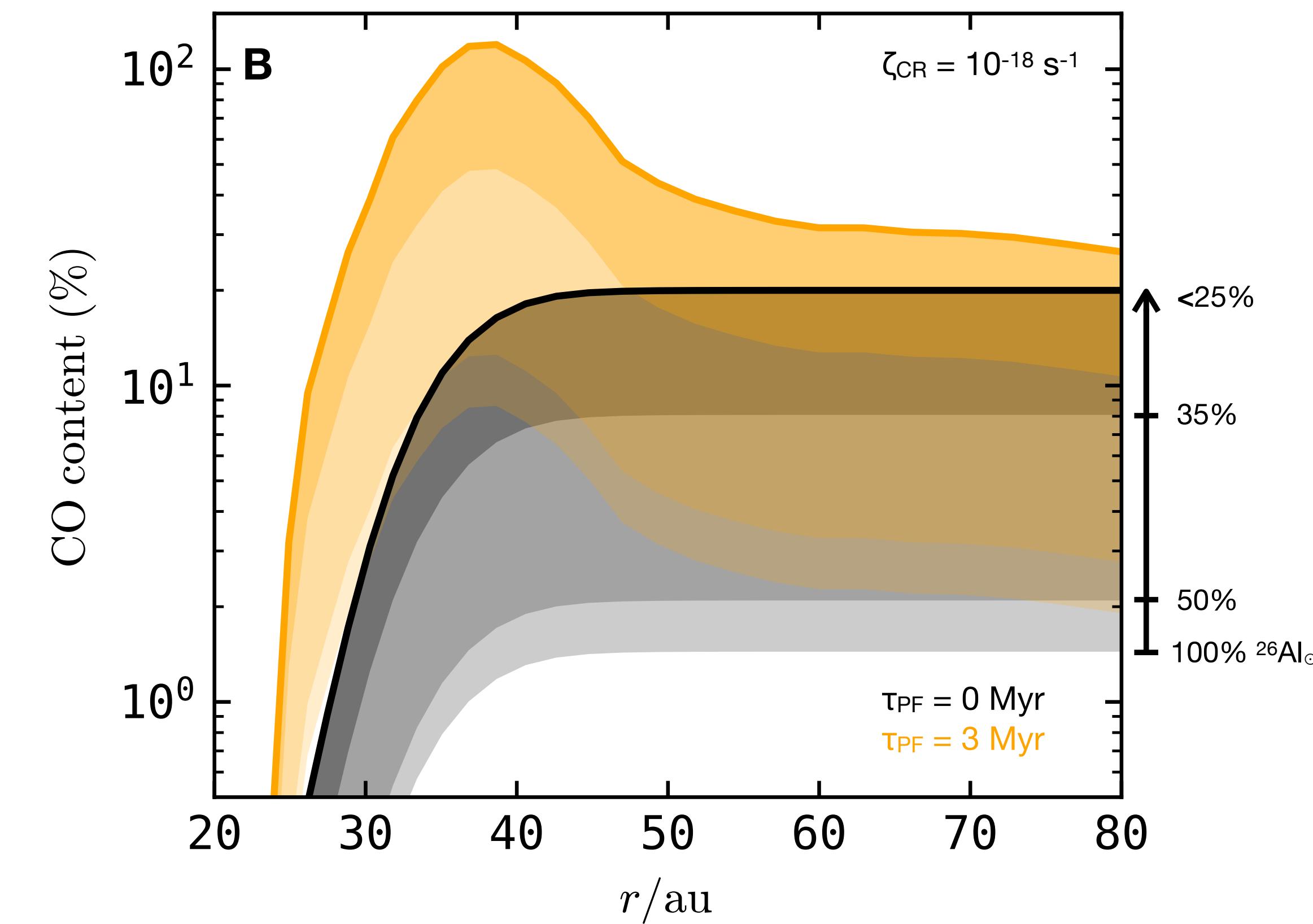
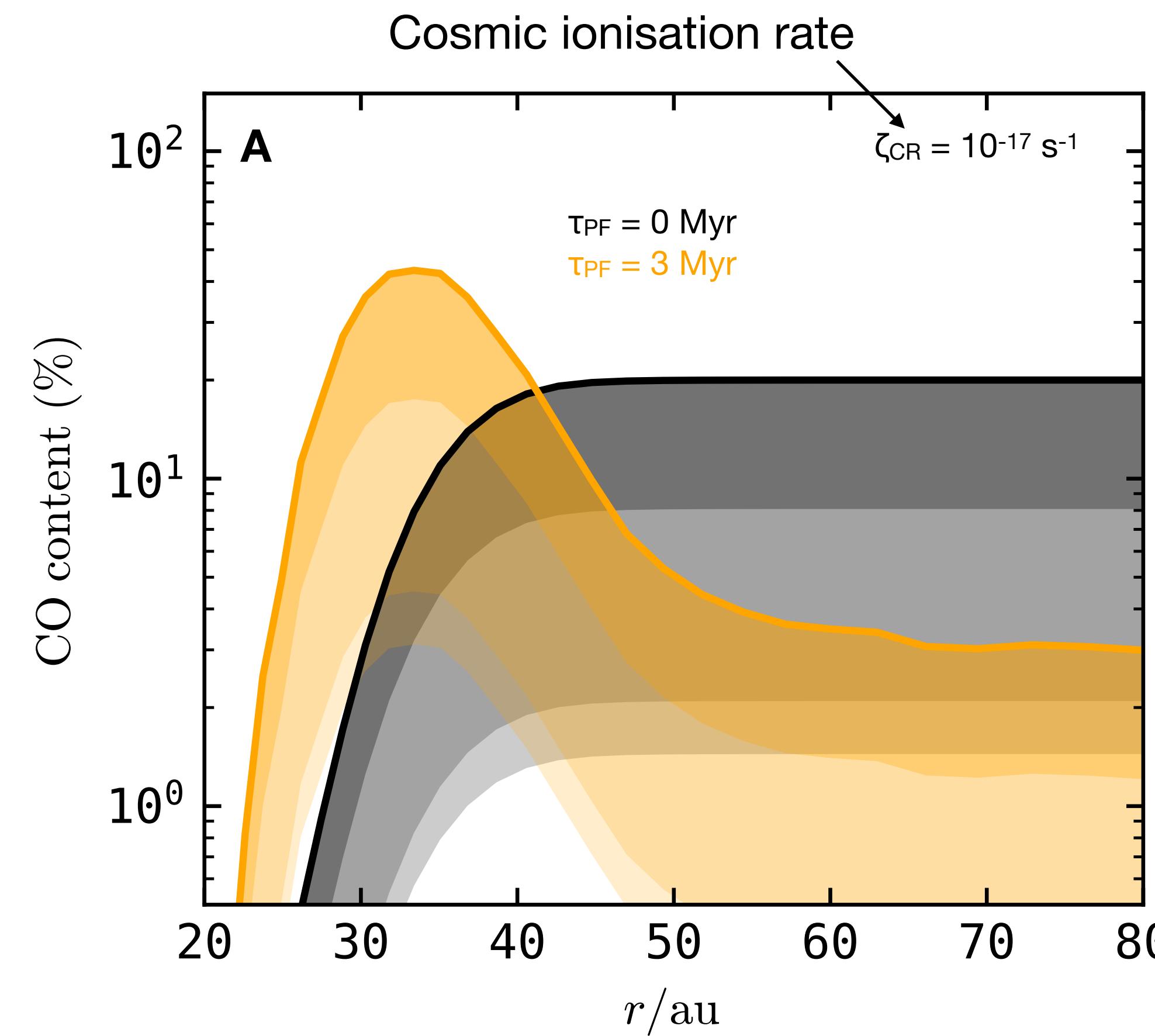


Volatile content of evolved planetesimals



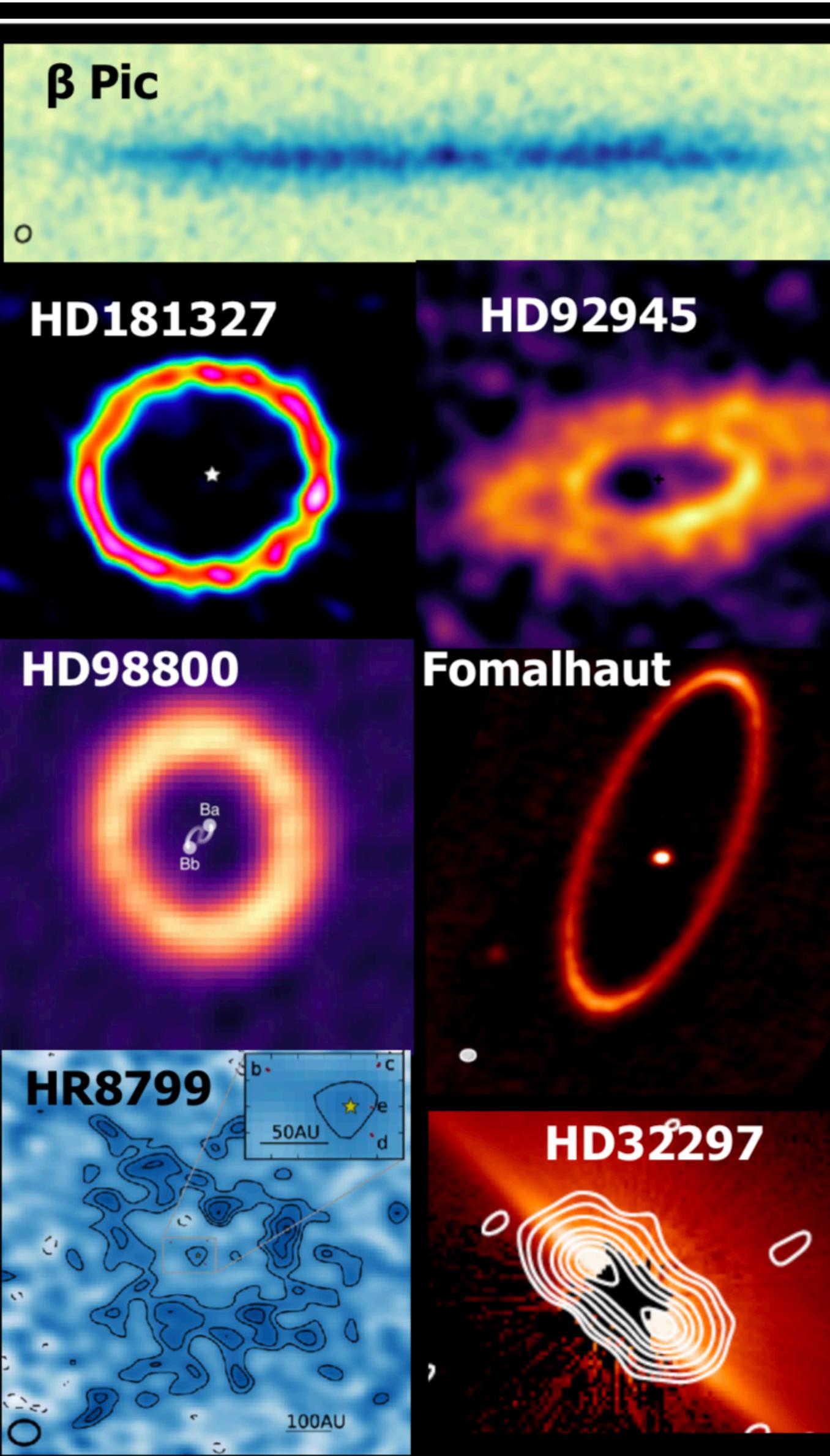
Volatile content of evolved planetesimals

Final volatile (in this case CO) content of evolved planetesimals can be *very* different from that of microscopic dust grains at $t=0$, depending sensitively on radial location & both disk processes and thermal evolution of planetesimals.

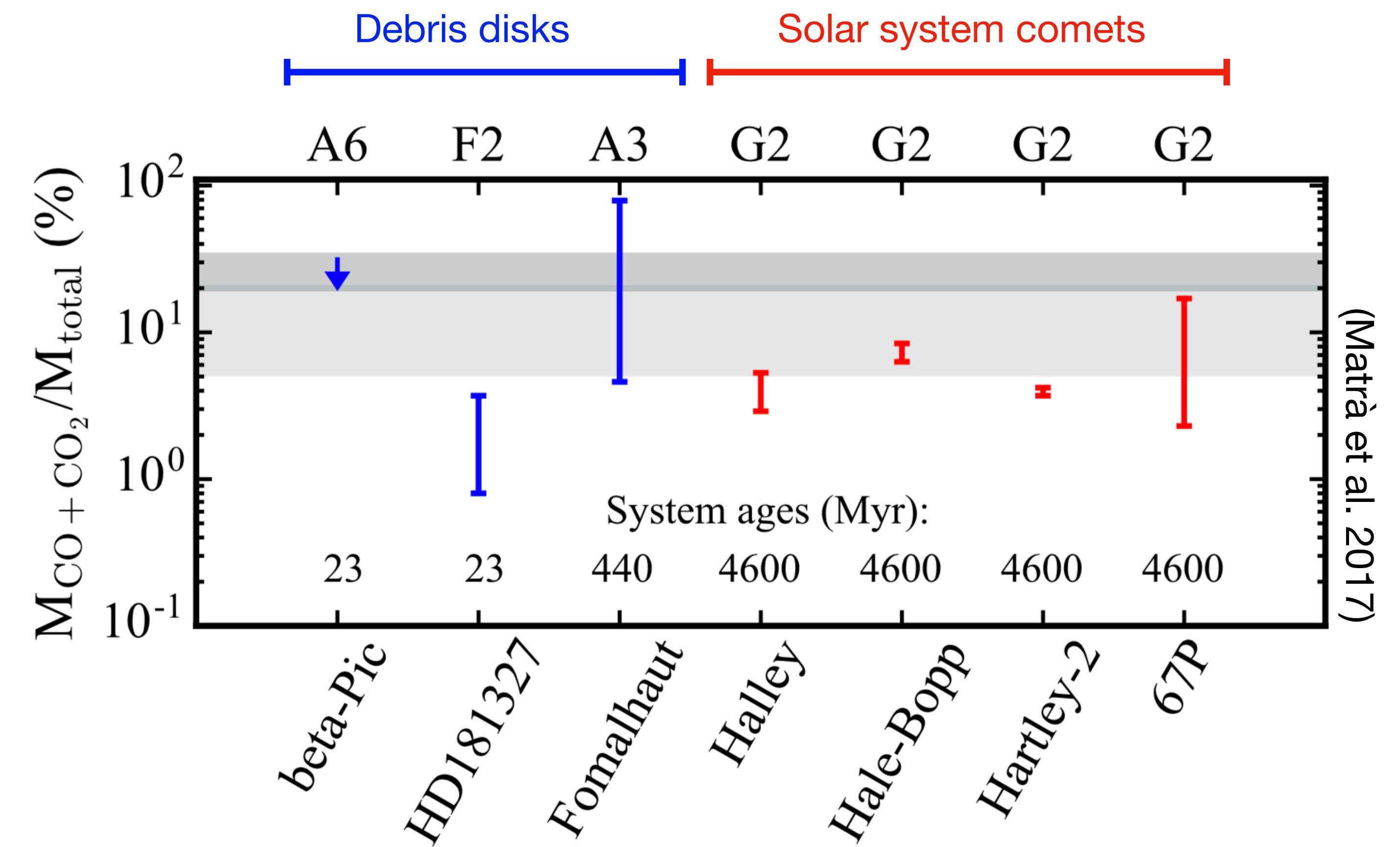




Exo-comet compositions in Gas-rich Debris Disks

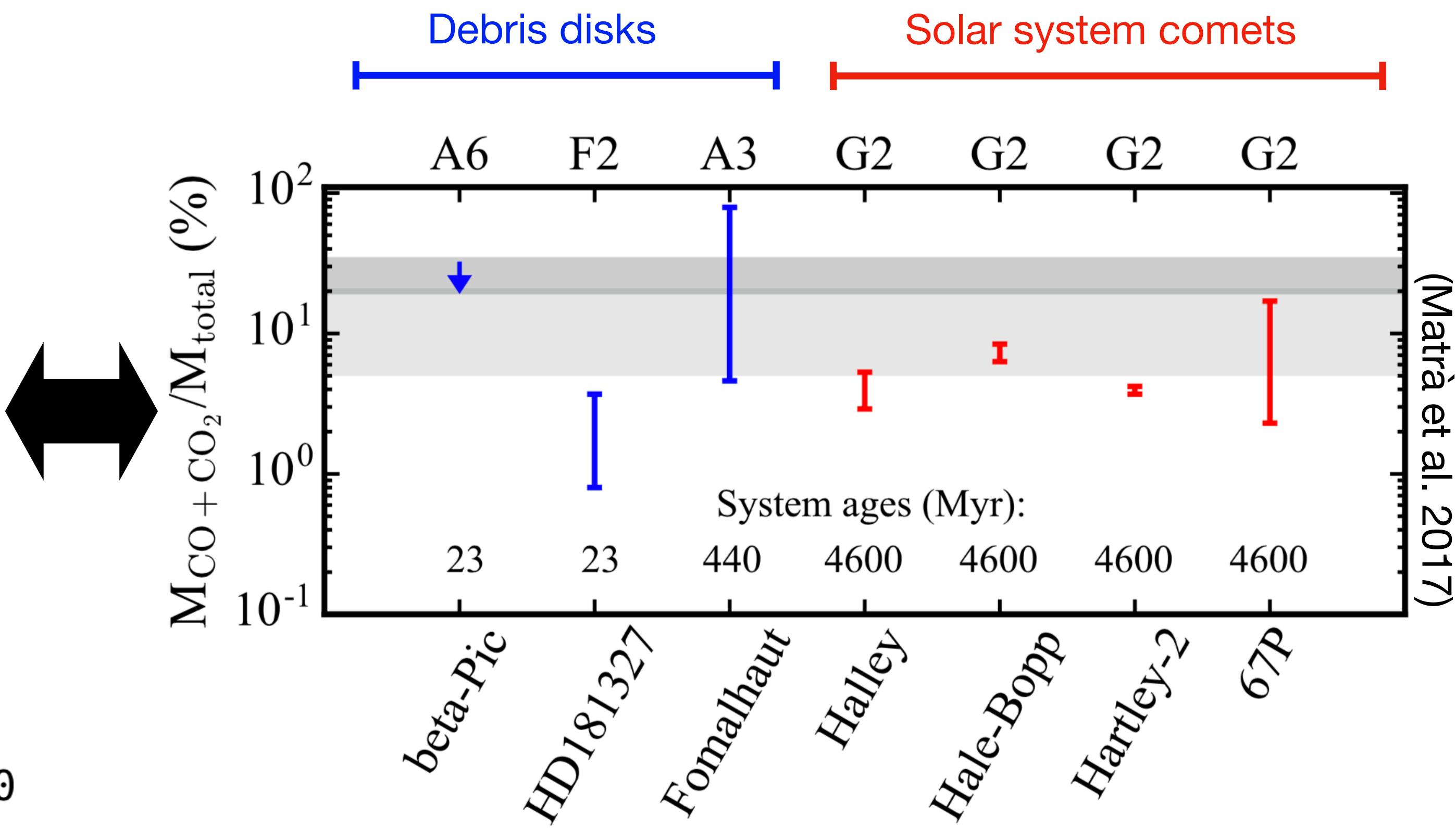
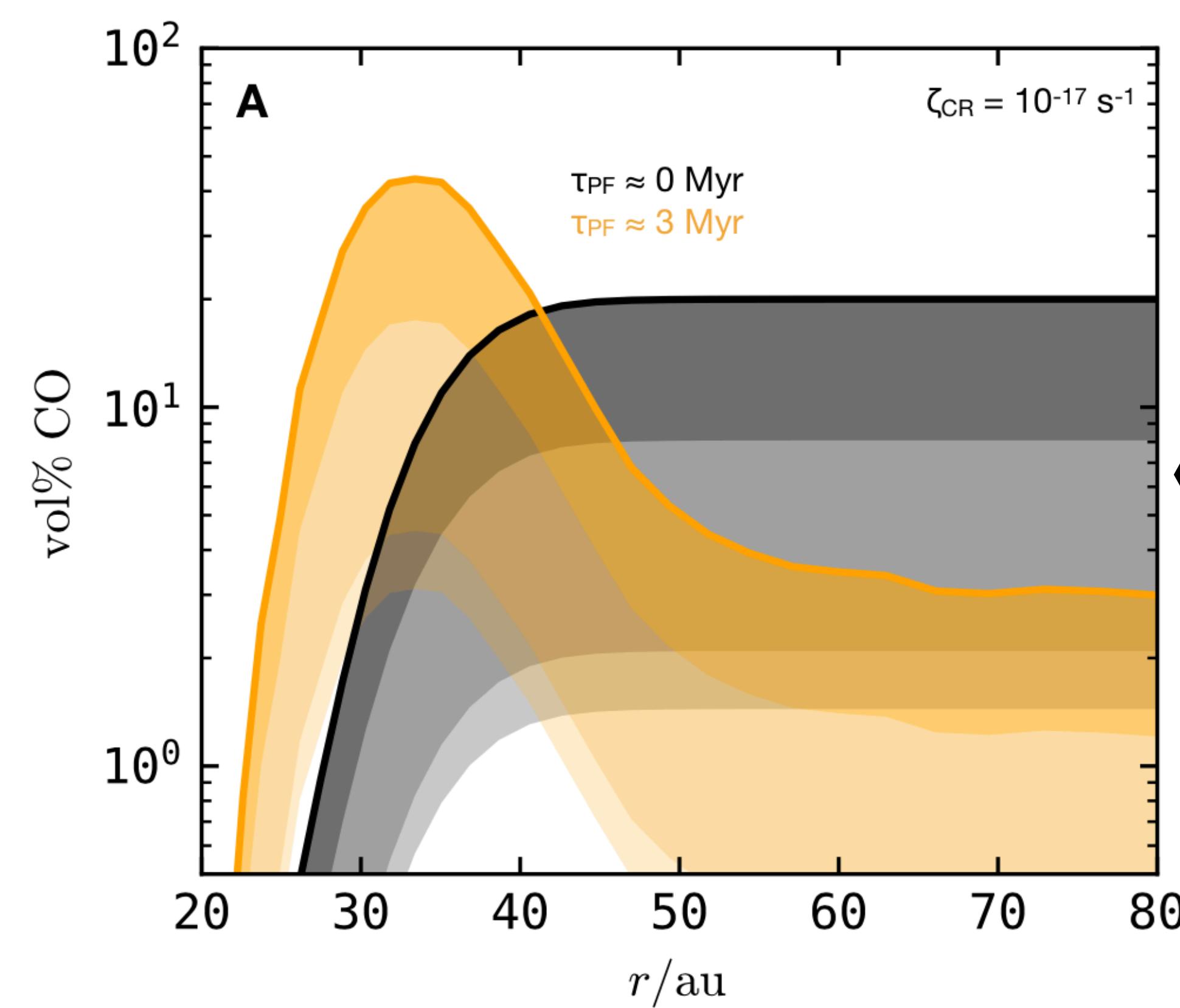


Collage of debris disks as seen by ALMA in sub-mm continuum (Wyatt 2019)



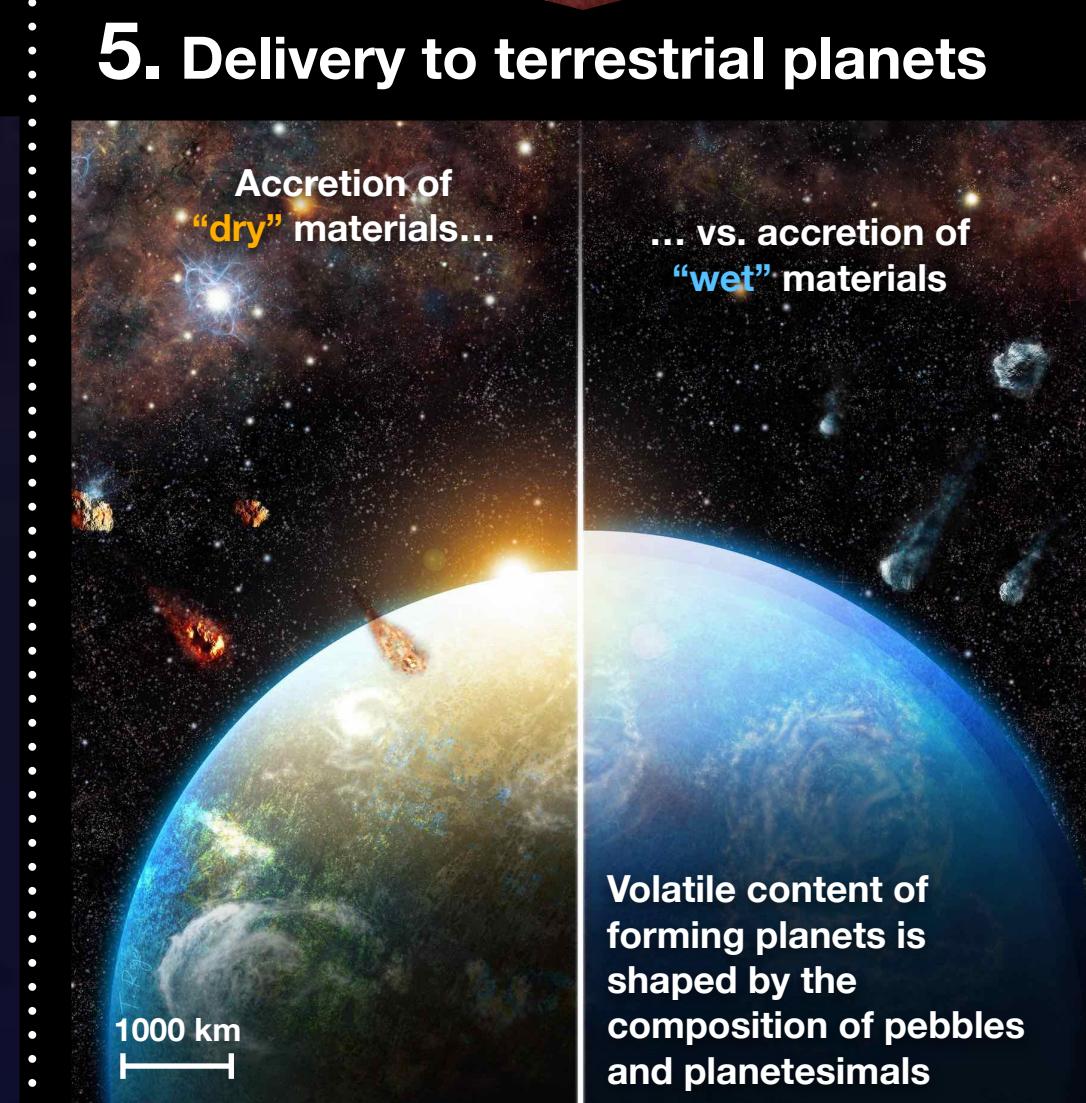
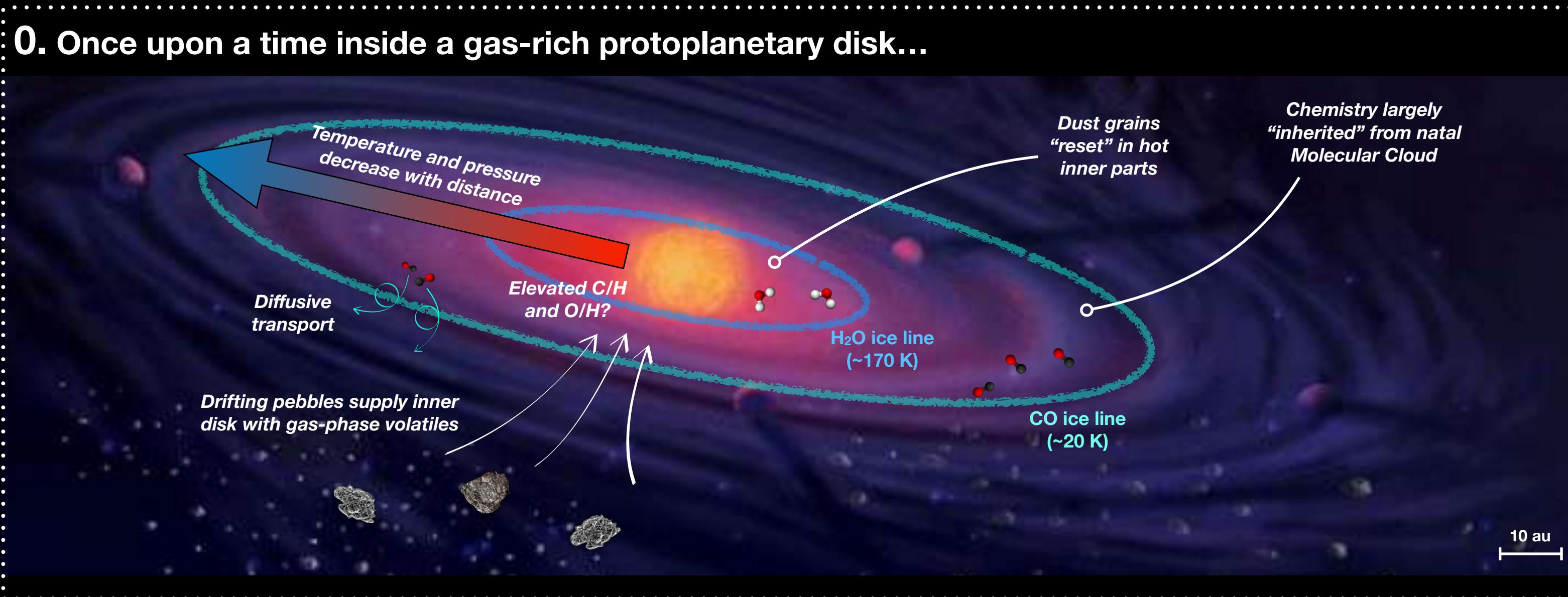
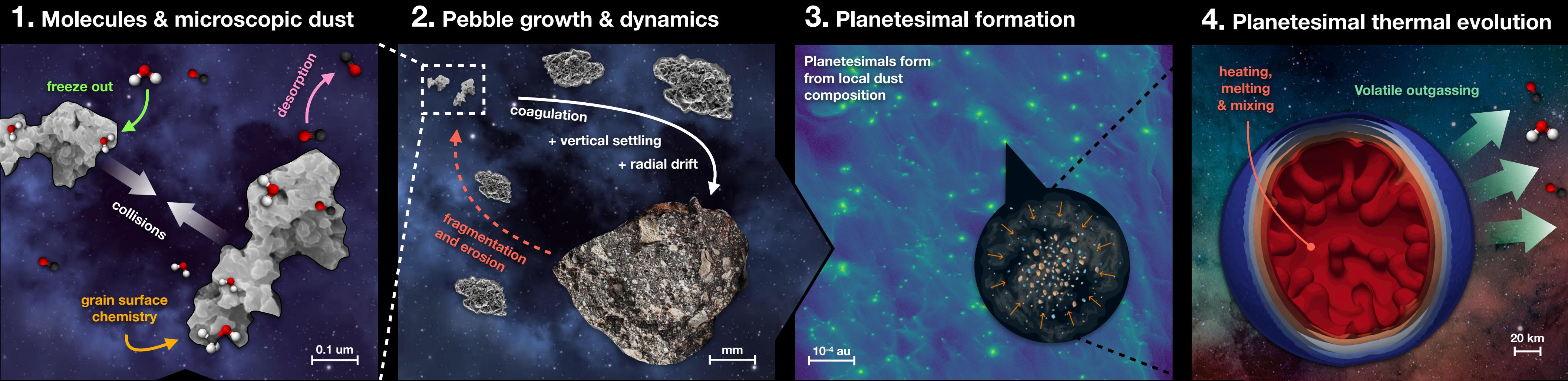
Evolved planetesimals vs. exo-comets

Comparing model predictions of planetesimal volatile content to observational constraints (for example from gas-rich debris disk) will shed light on the planetesimal formation process



System-level fractionation of carbon from disk and planetesimal processing

Lichtenberg & Krijt (2021), *ApJL*



@tim_lichtenberg
timlichtenberg.net



@astrobas
skrijt.com