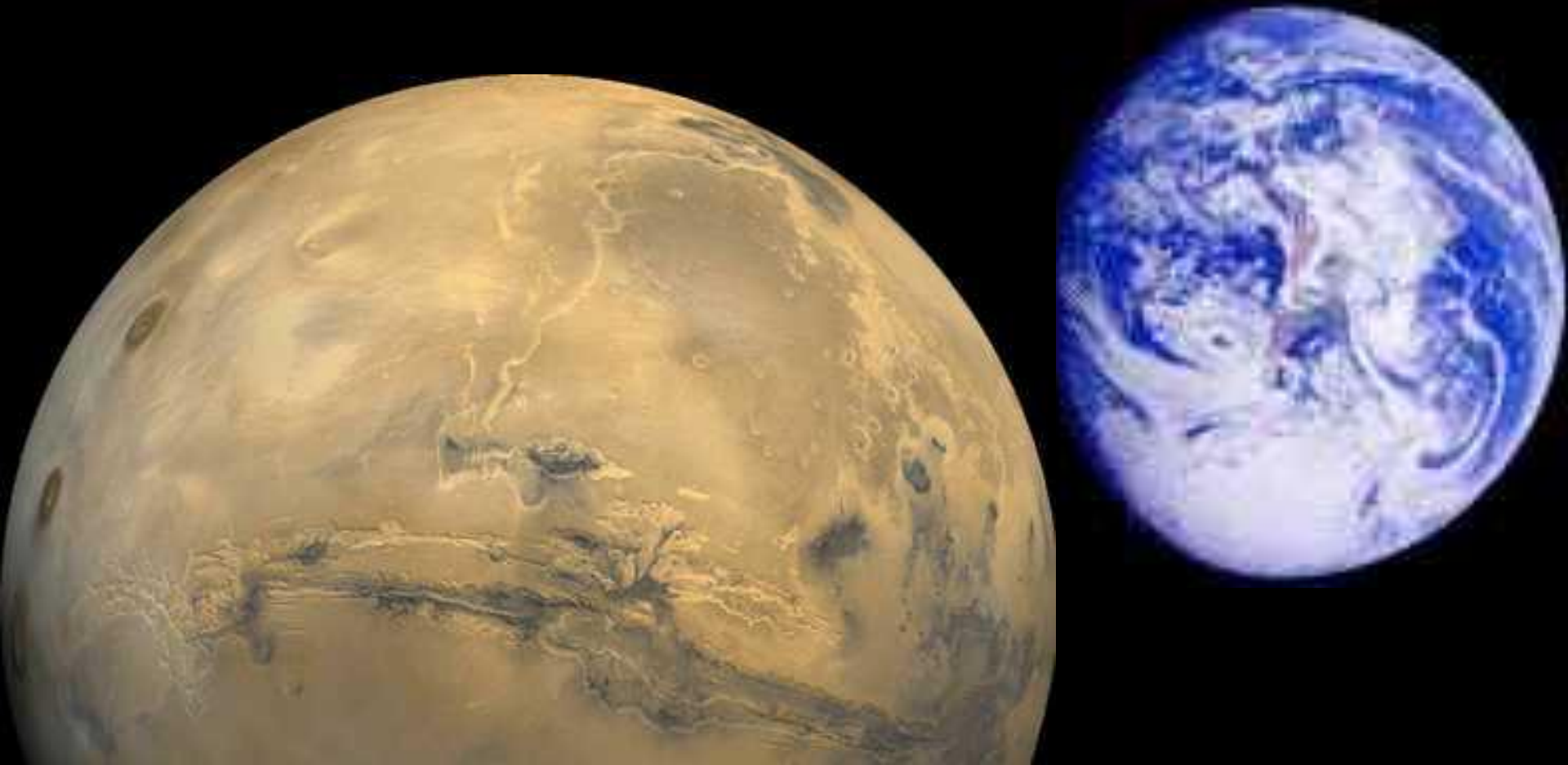
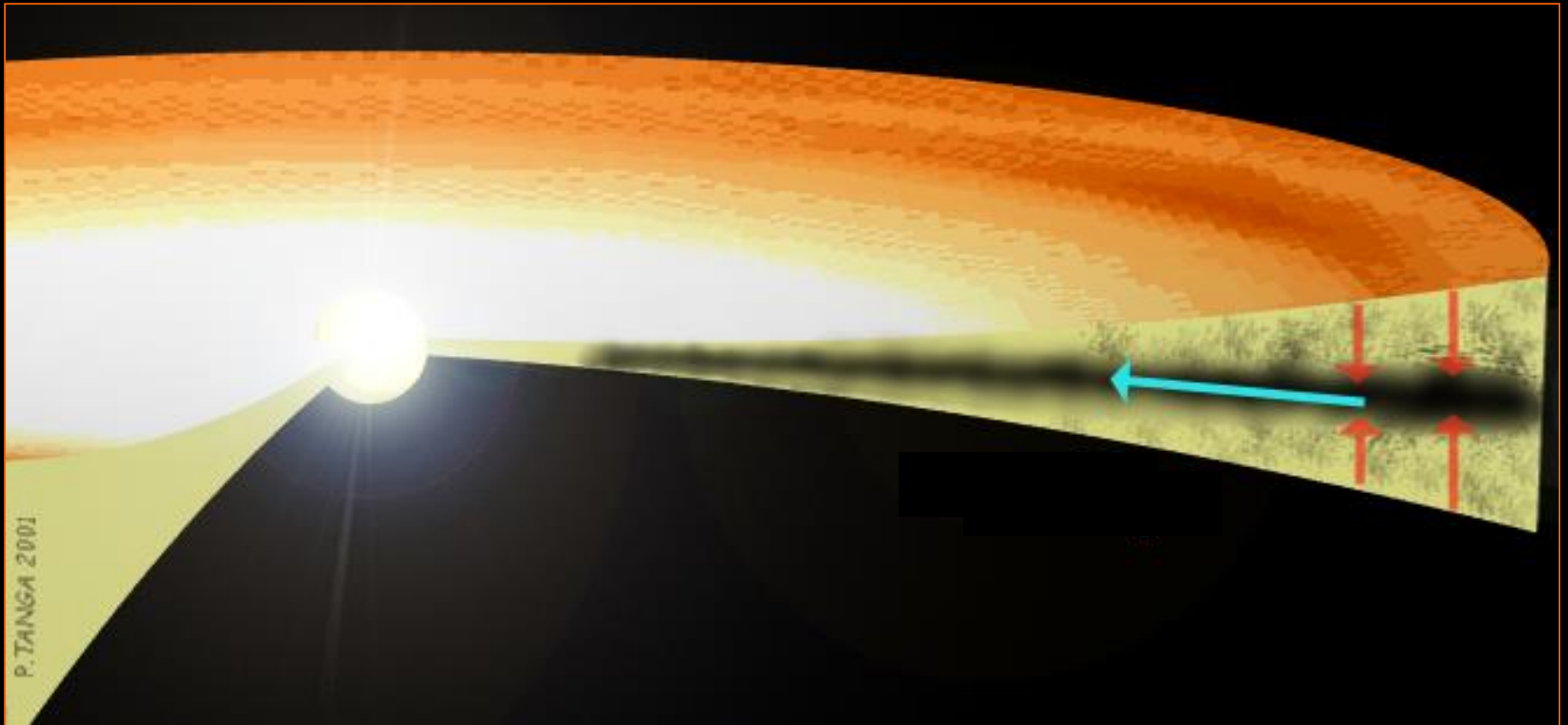


# *Extreme phenomena in the process of Earth formation*

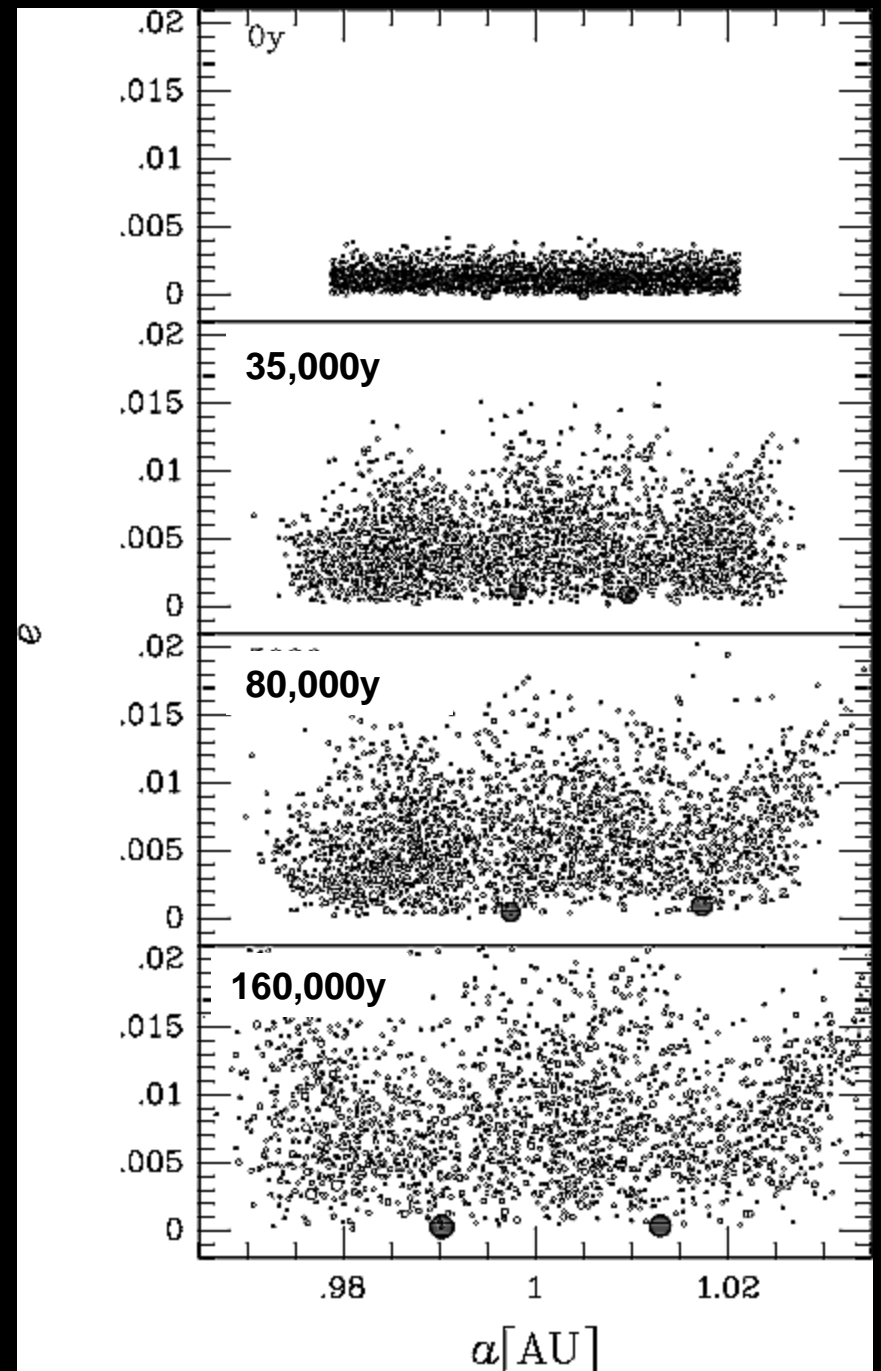
**A. Morbidelli** (Observatoire de la Cote d'Azur, Nice, France)



# The 4 steps of terrestrial planet formation: I: from dust to planetesimals



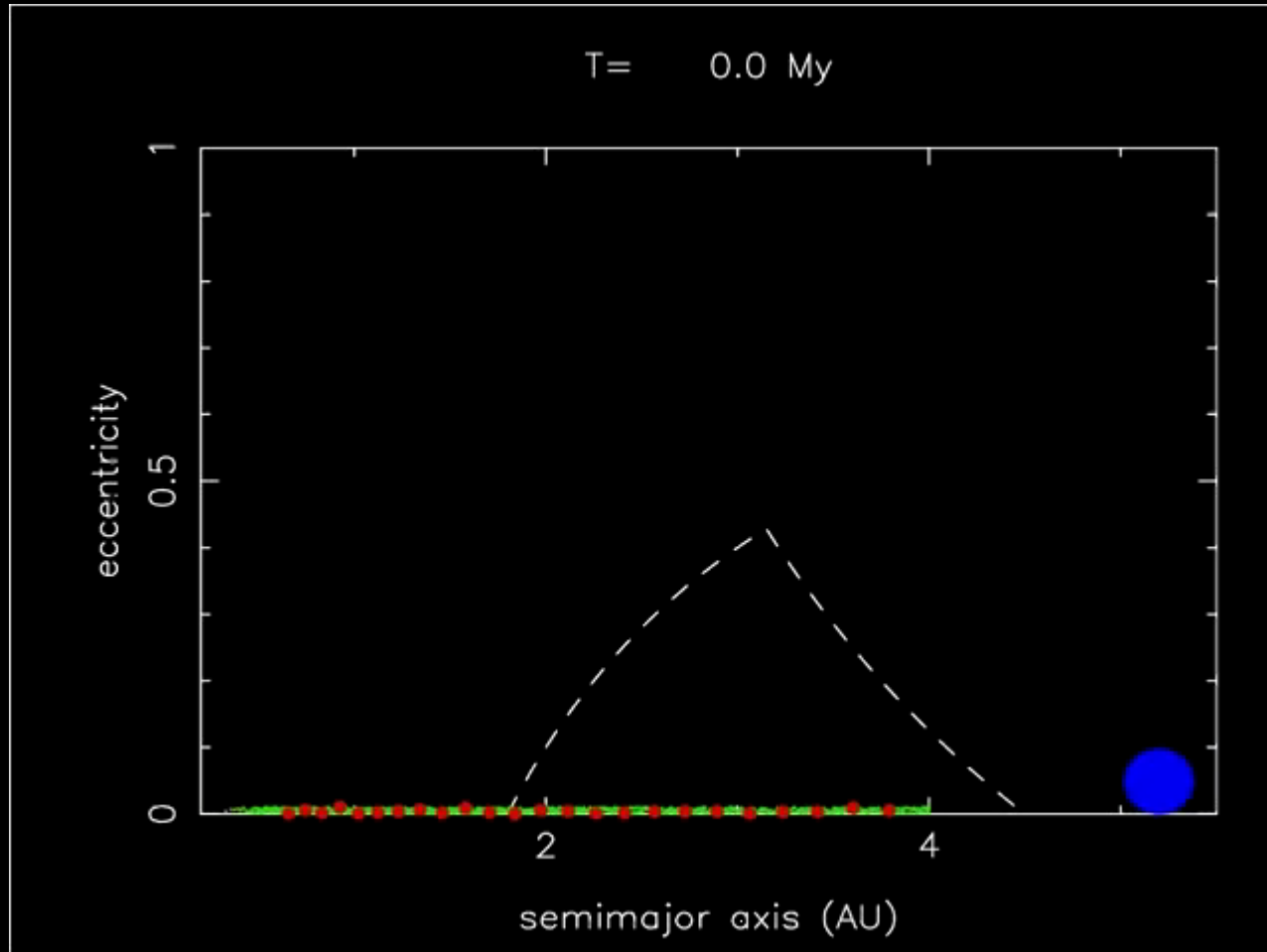
# The 4 steps of terrestrial planet formation: II: from planetesimals to planetary embryos



# The 4 steps of terrestrial planet formation:

## III: from embryos/planetesimals to planets

## IV: Late Accretion

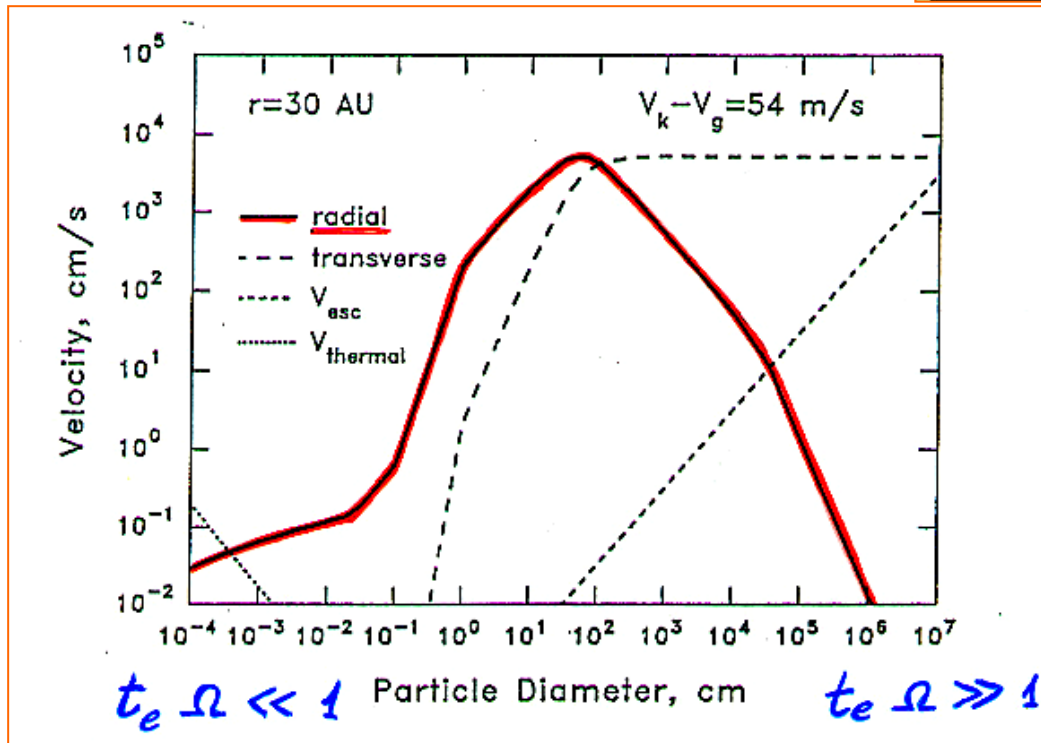
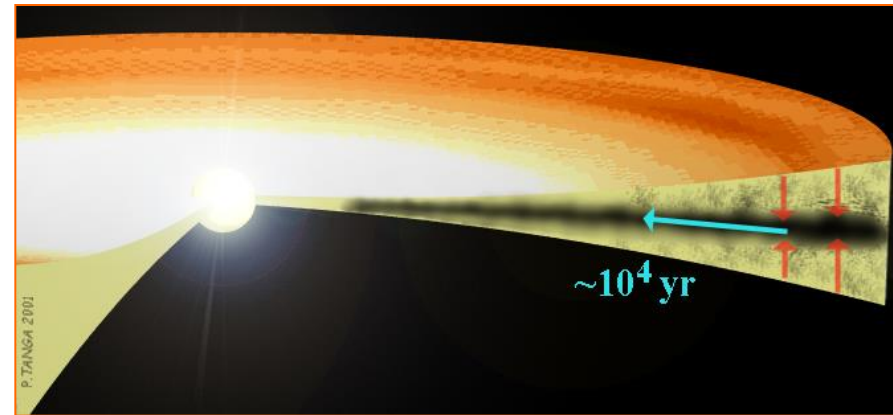


# **Some extreme aspects of terrestrial planet formation, of interest for our team at OCA**

- **Planetesimal formation by streaming instability**
- **The Moon-forming giant impact**
- **Fluid dynamics in the proto-Lunar disk**
- **Late accretion and its signature on the current geophysical structure of the Earth**

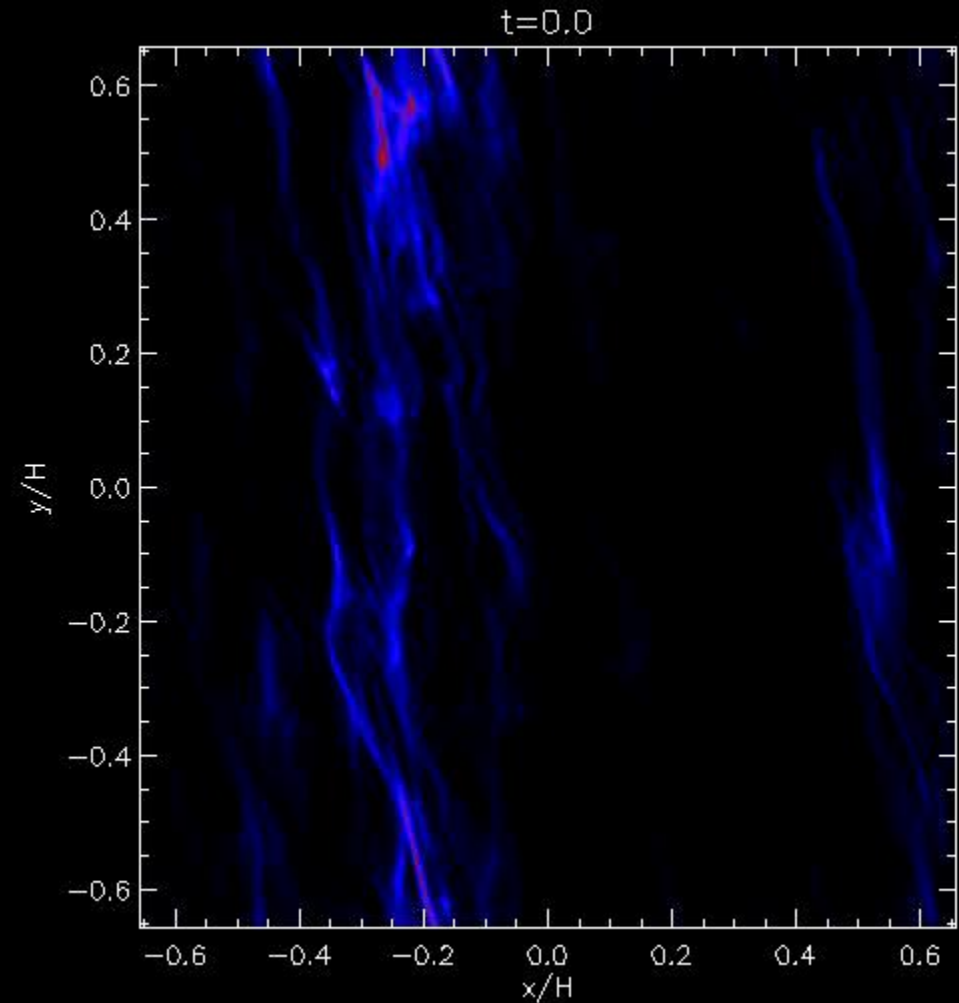
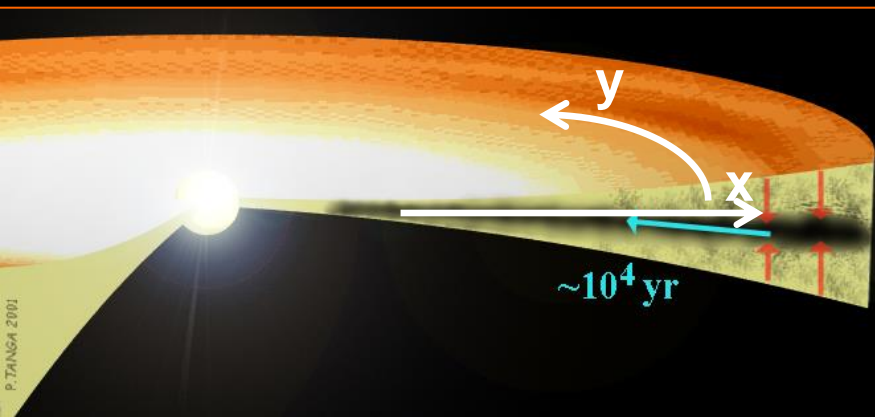
# The planetesimal formation problem

Dust particles run headwind

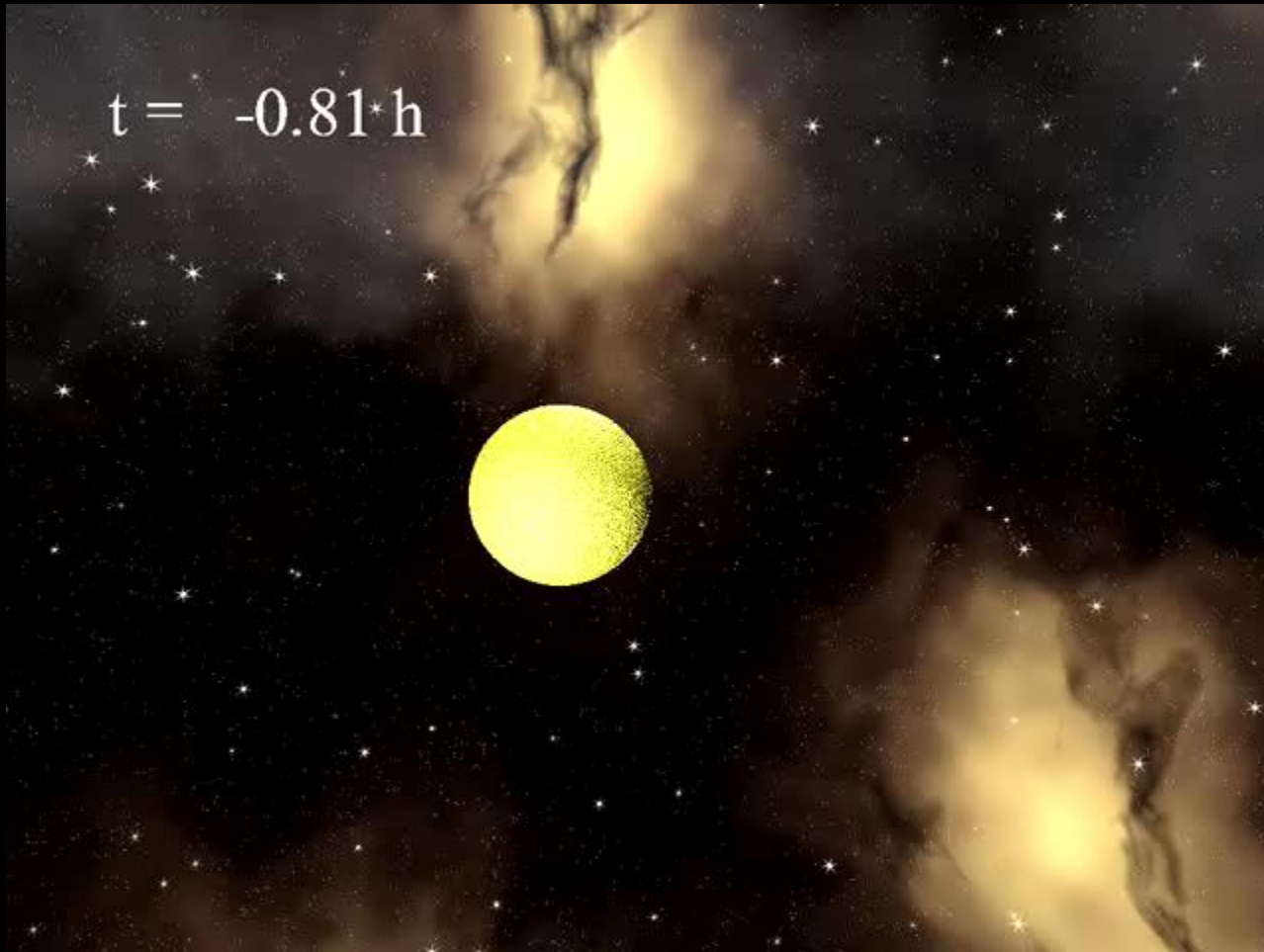


Weidenschilling 1977-..

**A promising solution: particles are attracted in turbulent structures and, once concentrated enough change the dynamics of the gas which enhances the particle clumping. (streaming instability)**



# The Moon-forming giant impact

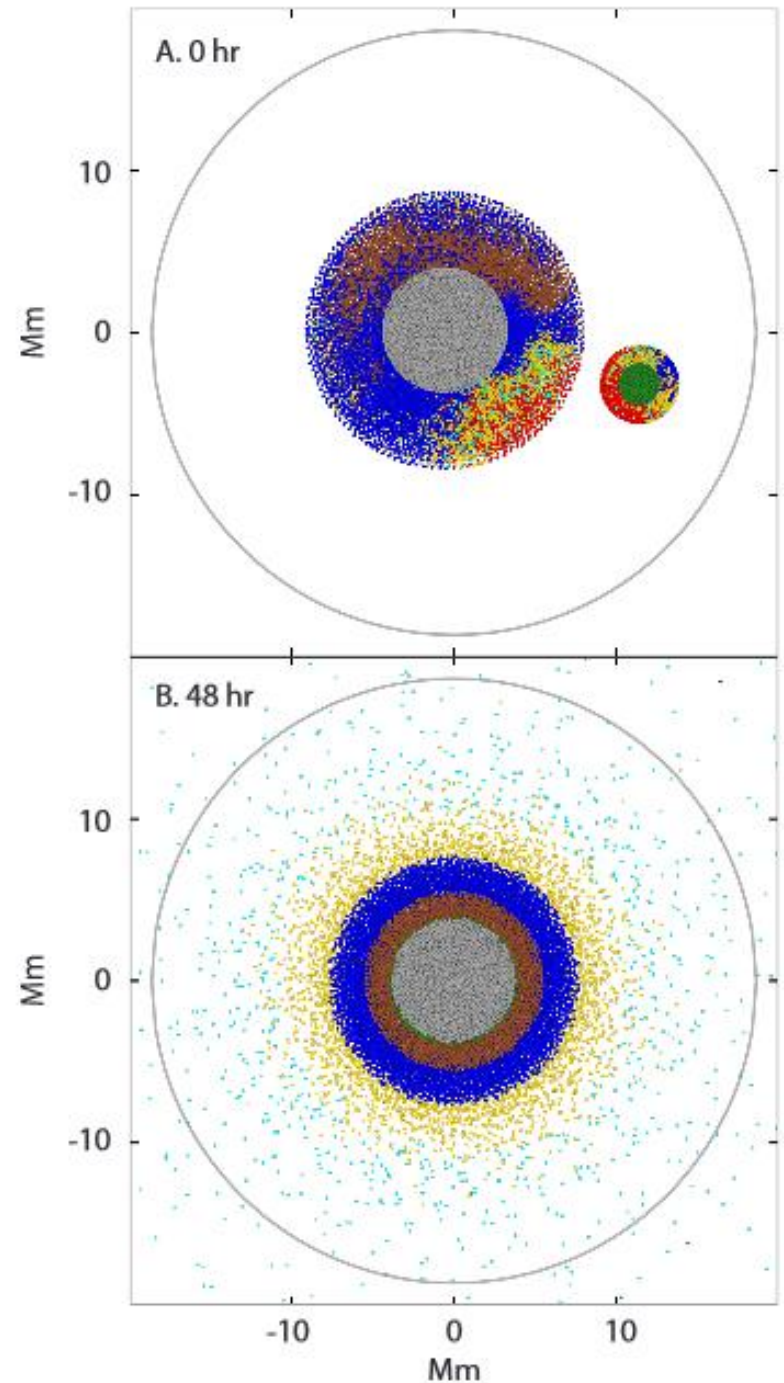


SPH simulations. Courtesy: W. Benz



**Recent geochemical evidence shows that the Earth was not fully mixed and did not undergo full core-mantle equilibration during the Moon forming event.**

**Need to resolve the Earth dynamics during the collision**

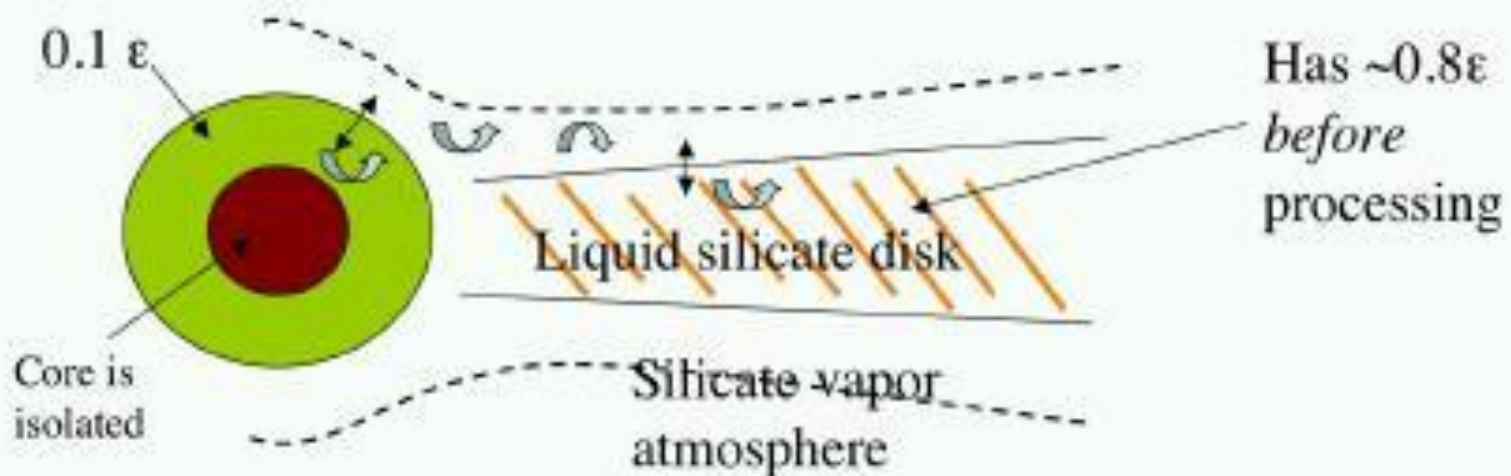


The Earth and the Moon have identical isotopic compositions. Still it is difficult to derive the Moon material entirely from the Earth.

Earth-Moon equilibration via the proto-lunar disk hydrodynamics?

Pahlevan and Stevenson, 2007

pahlevan@oca.eu

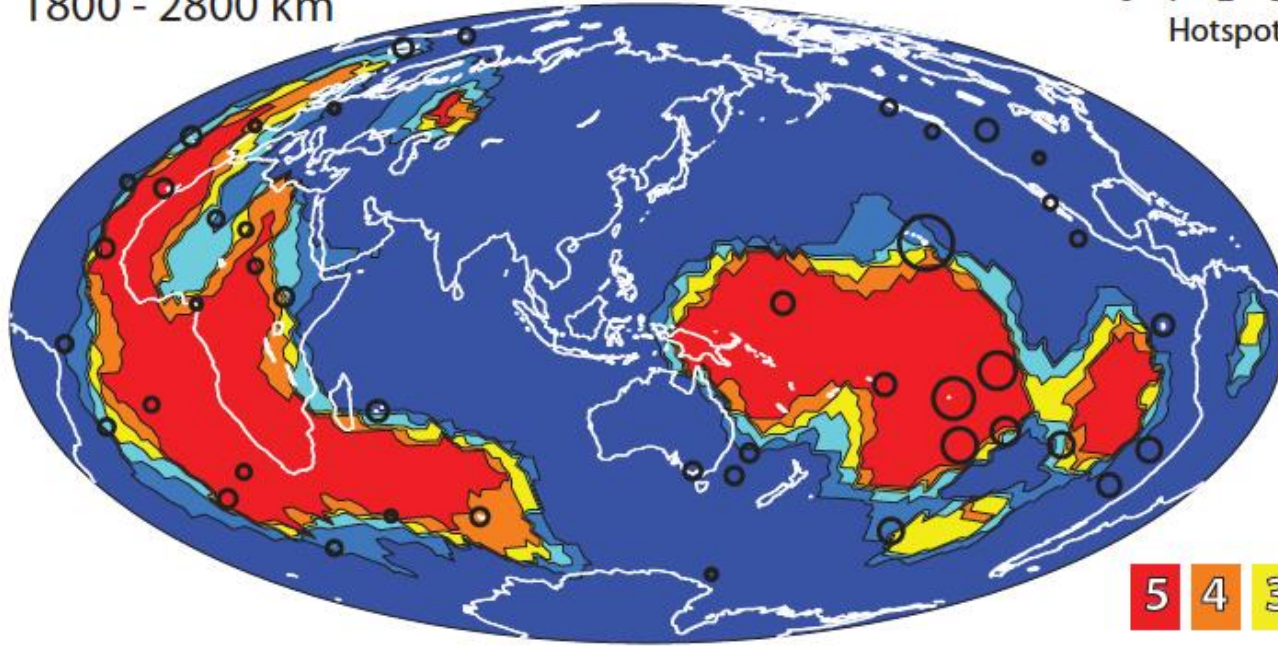
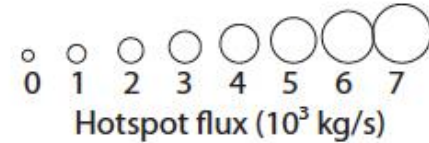


**After the Moon-forming event we expect the Earth to have accreted 0.5-1% of its mass**

**Given that the Moon accreted much less mass it is likely that most of the mass delivered to the Earth was in a few big bodies (D~2000km)**

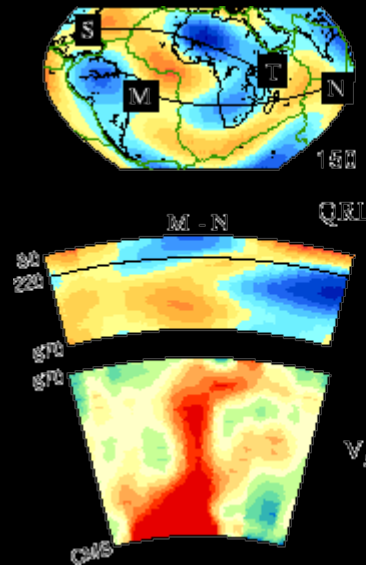
**What is the effect of these intermediate size impacts?**

1800 - 2800 km



# Mantle super-plumes in the Earth (structures stable on billions of yr according to Forte et al.)

BQR OCA (Morbidelli, Nolet, Ritzma, Forte, Jutsi)



# CONCLUSIONS

- **Planet formation definitely involves extreme physical processes (bi-fluid dynamics, fluids at the edge of condensation, giant impacts and extreme EOS, mantle convection at high temperatures )**
- **We are probably not the best team to address these problems**