

# ExoBio: Exogenous contributors of pre-Biotic material to the early Earth

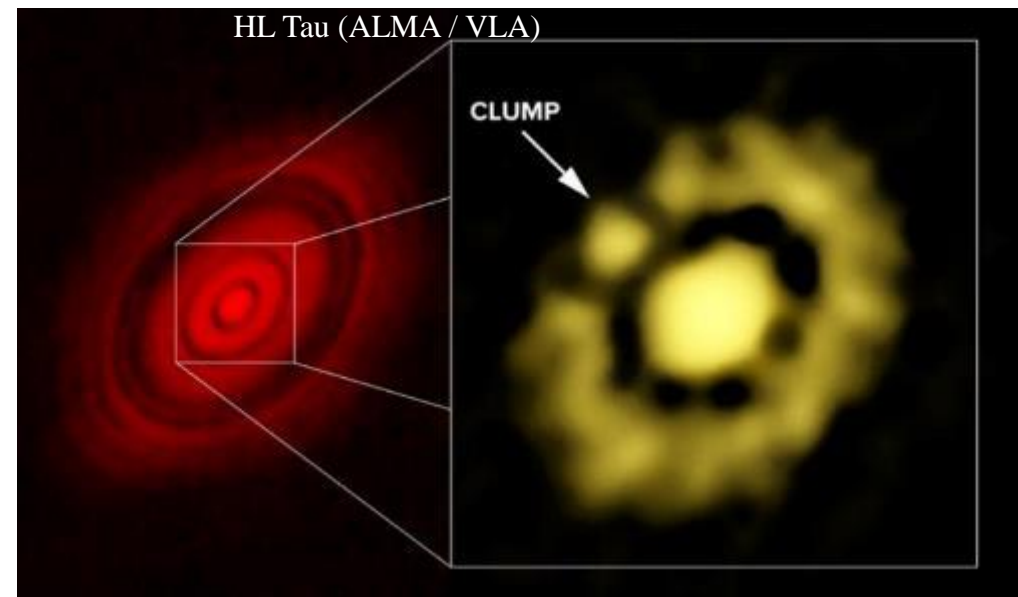
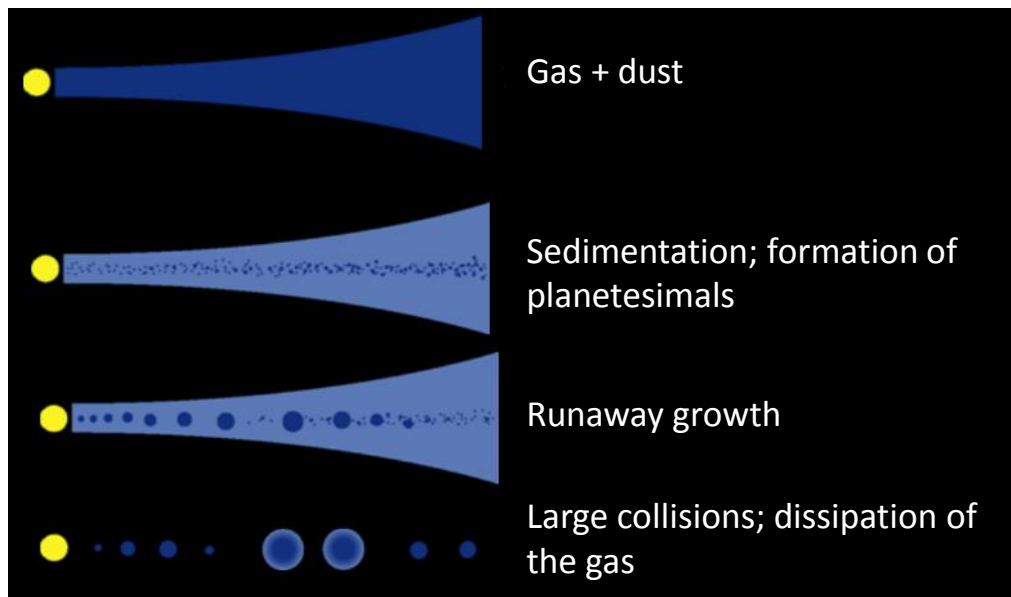


# The small bodies: witnesses of the primordial solar system

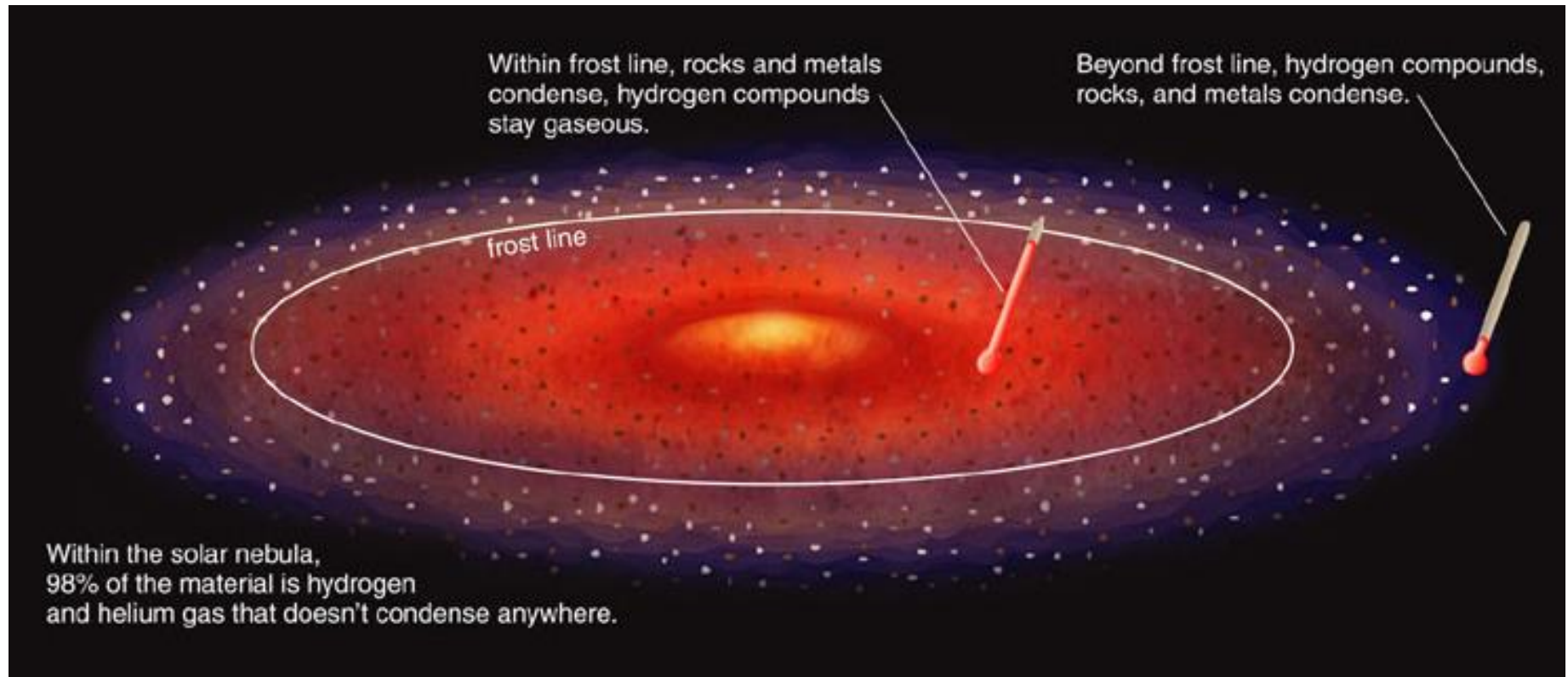
Which processes have governed the formation and evolution of the primordial solar system?  
What implications for the study of exoplanetary disks?

The small bodies of the solar system represent the last vestiges of planetesimals and protoplanets

The solar system as a model system that we can study in detail, and even in situ with space missions



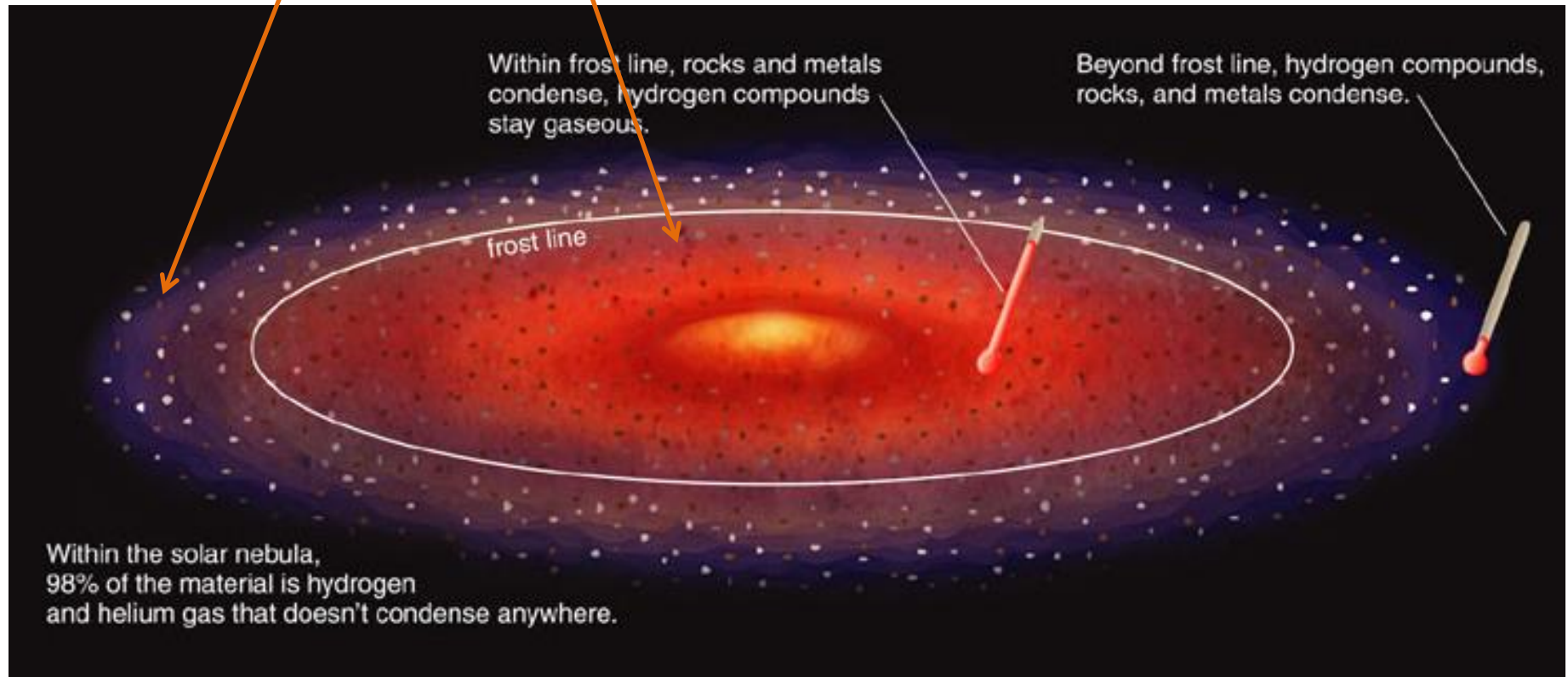
# The small bodies: witnesses of the primordial solar system



# The small bodies: witnesses of the primordial solar system

**“Evolved” small bodies**

**“Primitive” small bodies**

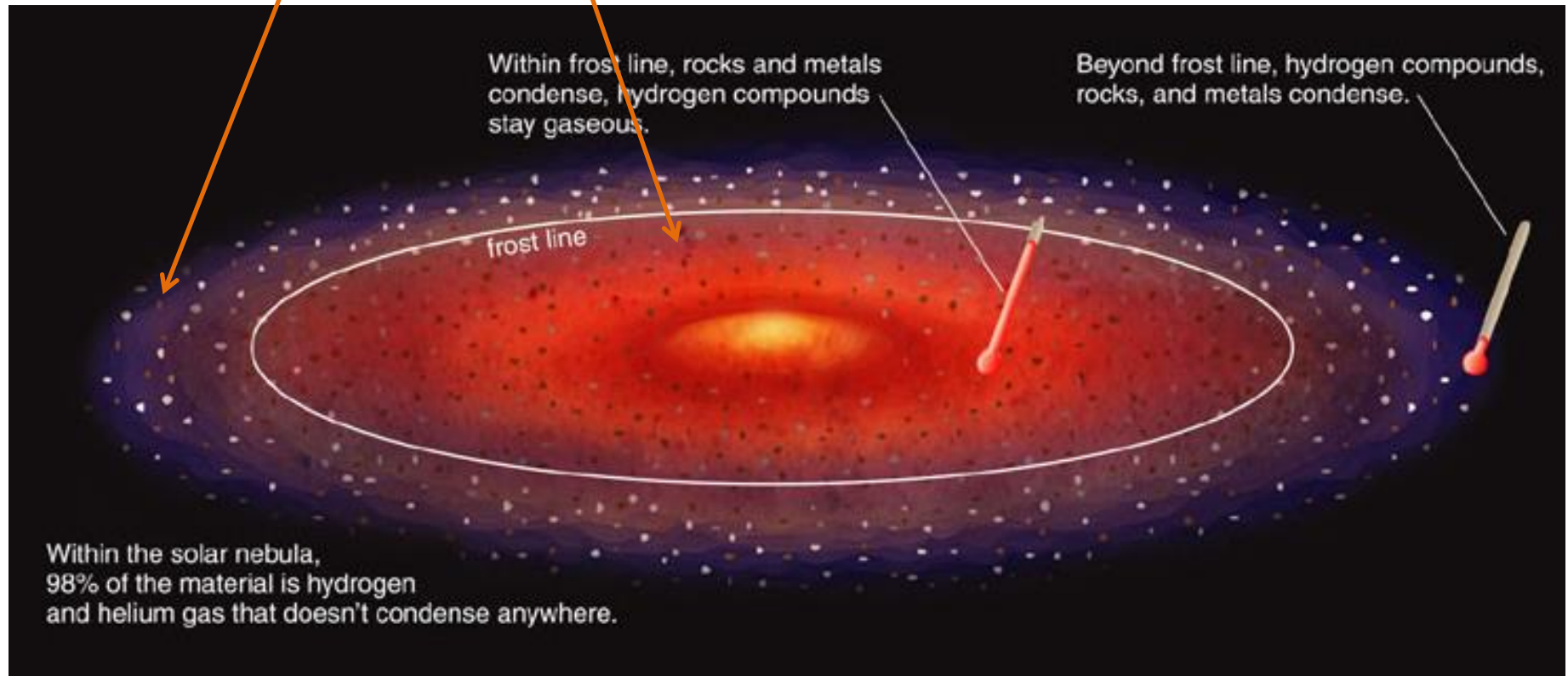
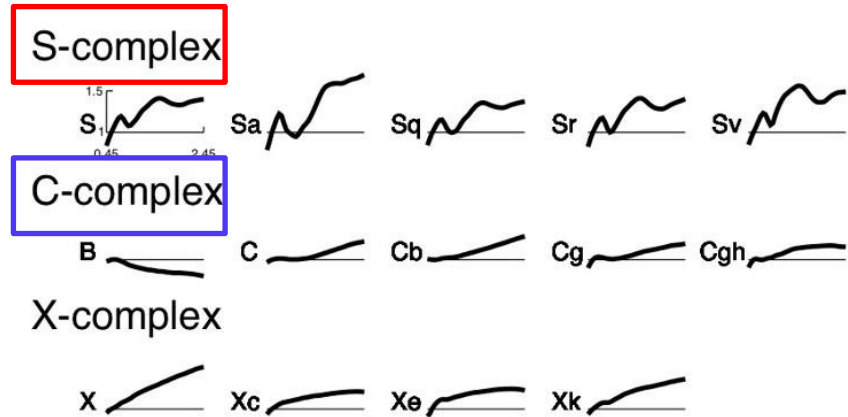




# The small bodies: witnesses of the primordial solar system

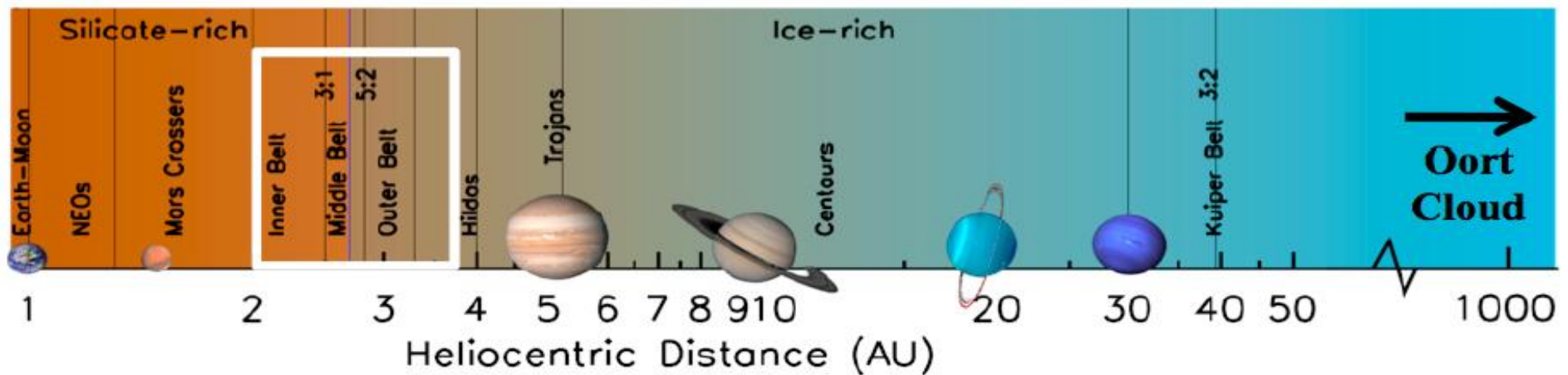
**“Evolved” small bodies**

**“Primitive” small bodies**



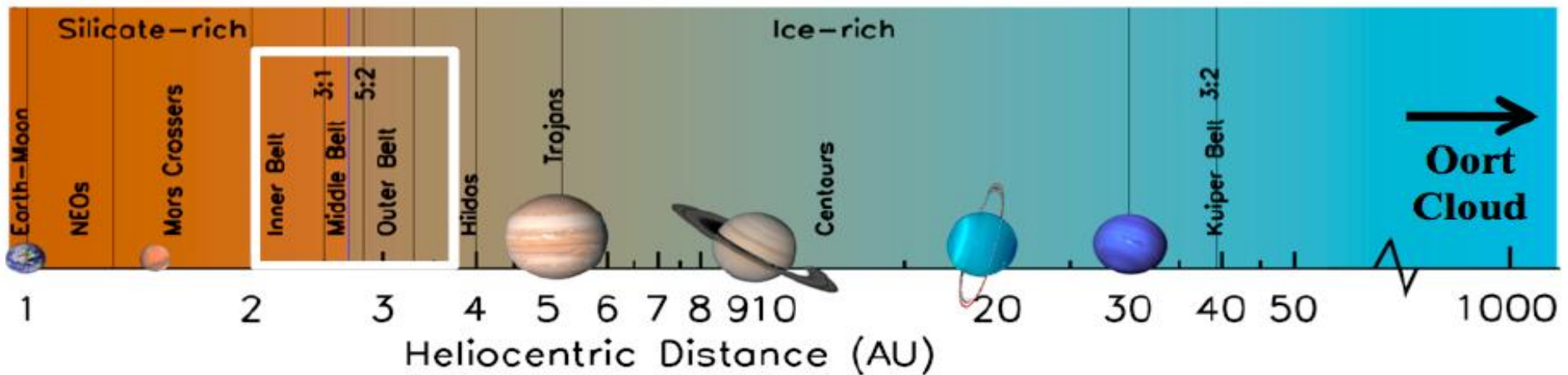
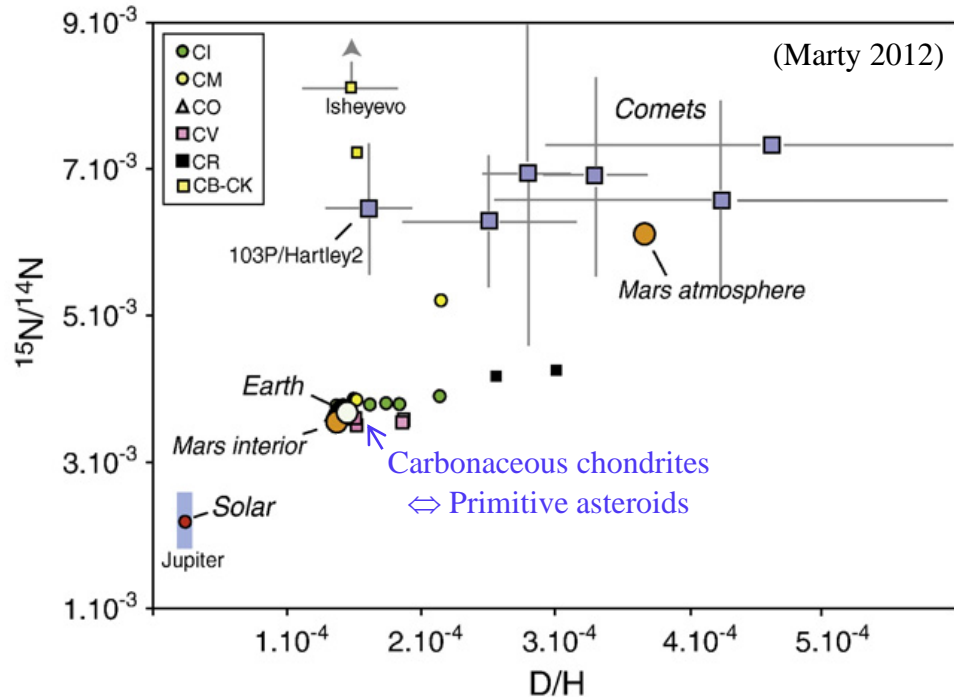
# The small bodies: witnesses of the primordial solar system

What about the origin of Earth's water and other volatiles?



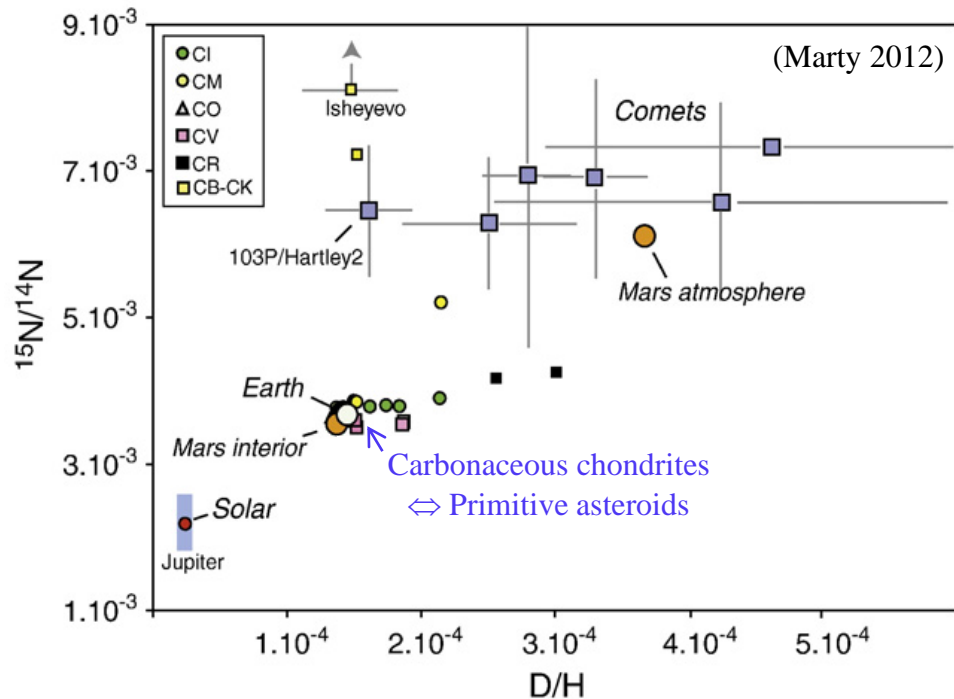
# The small bodies: witnesses of the primordial solar system

What about the origin of Earth's water and other volatiles?

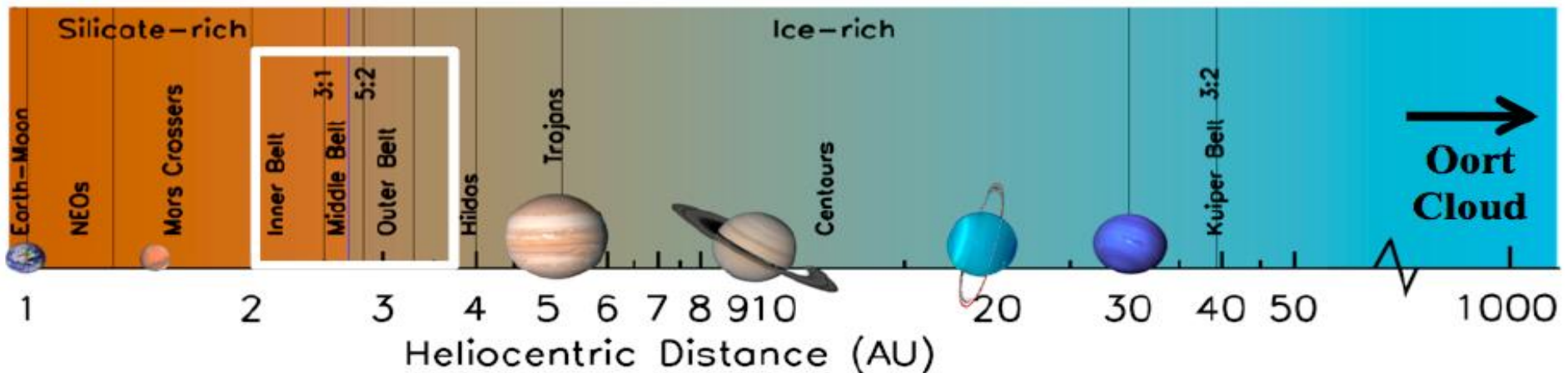
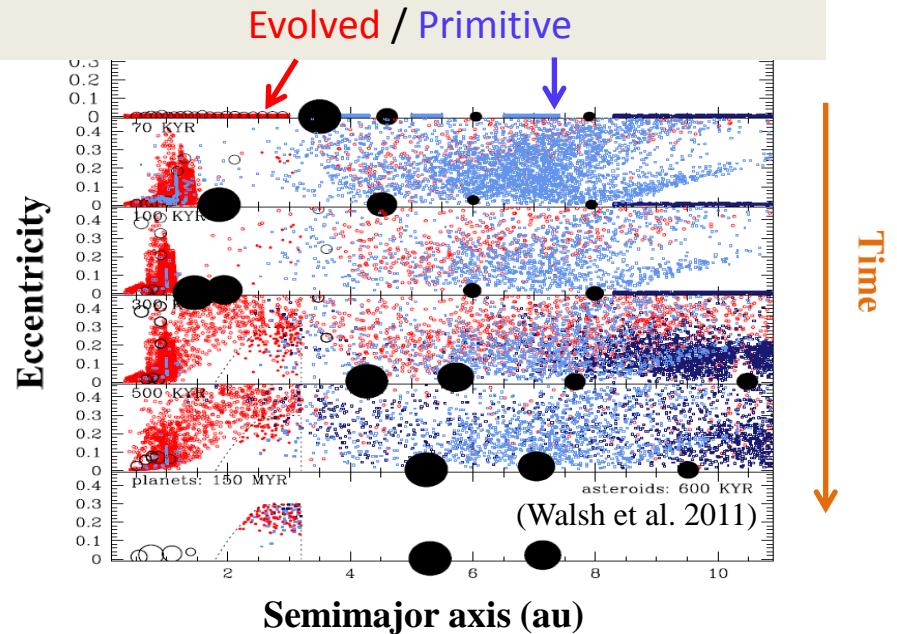


# The small bodies: witnesses of the primordial solar system

What about the origin of Earth's water and other volatiles?



Planetary migrations → planetesimal mixing





**ExoBio:**

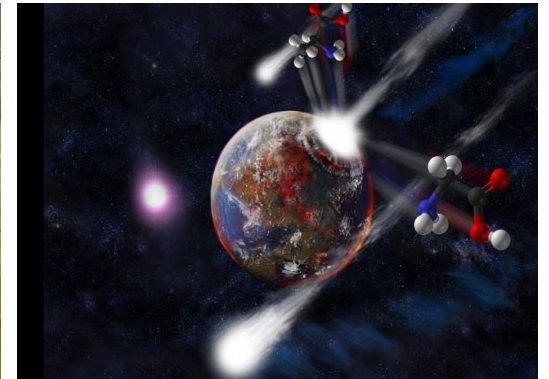
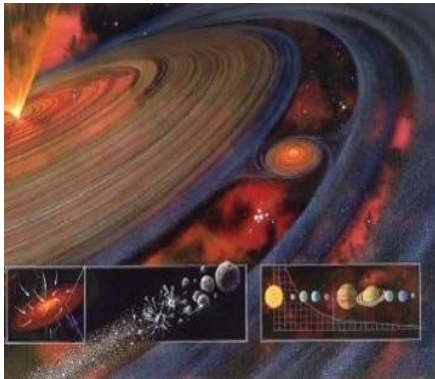
**Exogenous contributors of pre-Biotic material to the early Earth (6/2017-5/2020)**



- The first-ever spectroscopic survey of the “small” near-Earth asteroids
- Sample return missions from primitive near-Earth asteroids
- A long-term survey of mid/outer solar system small bodies

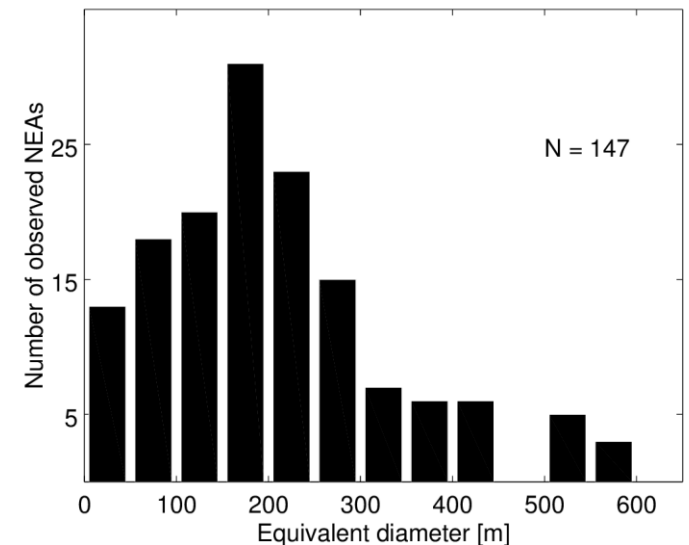
# Why near-Earth asteroids do matter

- The closest building blocks of the solar system
  - ✓ Relevant for the origin of prebiotic material on the early Earth
  - ✓ Study of small-sized asteroids
- Accessible targets for space missions
  - ✓ Science
  - ✓ Water/mineral resources
- Planetary defense



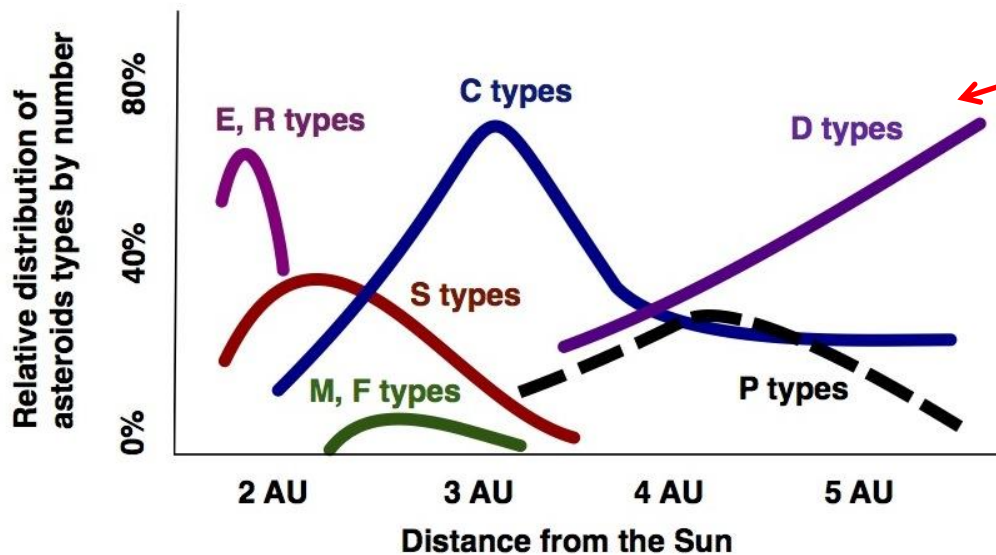
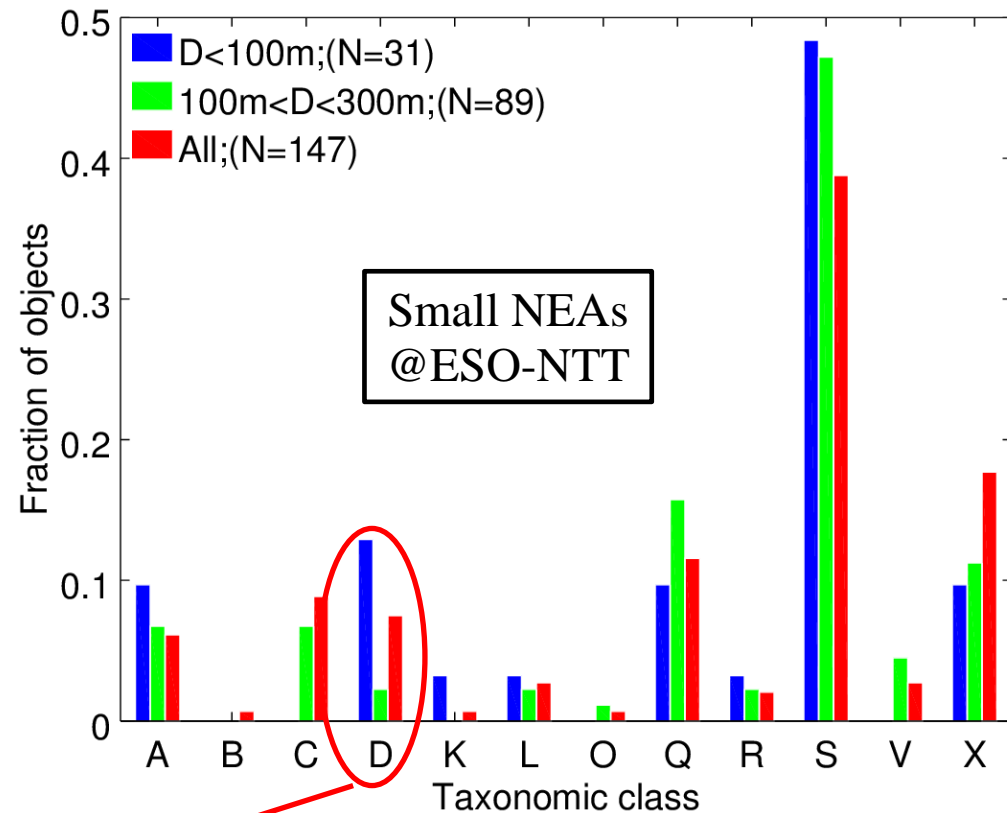
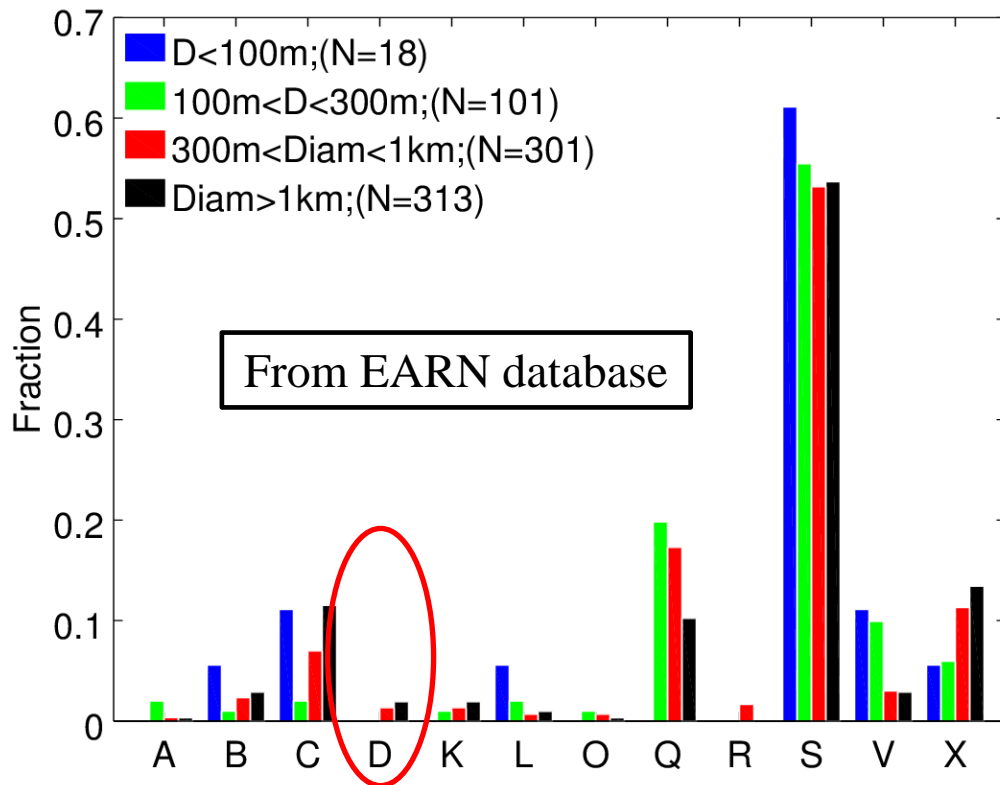
# Guaranteed Time Observations of “small NEAs” @ ESO-NTT

- Extremely poorly known (characterized << discovered << estimated)
- 30 observing nights over 4 semesters (4/2015 – 3/2017)
- Most of our targets were observed soon after their discovery
- 147 small NEAs characterized by visible spectroscopy (homogeneous sample!)



- ✓ Results published in four refereed papers:
  - Perna et al. 2018, P&SS 157, 82
  - Barucci, Perna et al. 2018, MNRAS 476, 4481
  - Popescu, Perna et al. 2018, MNRAS 477, 2786
  - Ieva, Dotto, Epifani, Perna et al. 2018, A&A 615, A127
- ✓ and presented at four national and international meetings:
  - LXI Congresso SAlt, Padova, 12-15 Sep 2017 (invited)
  - European Planetary Science Congress, Riga, 17-22 Sep 2017 (invited)
  - XIV Congresso Nazionale di Scienze Planetarie, Bormio, 4-9 Feb 2018
  - MIAPP “NEOs” Scientific Programme, Garching, 14 May/8 Jun 2018 (invited)

# Small NEAs @ ESO-NTT: taxa distribution (vs. literature)



Asteroidal contribution to terrestrial pre-biotic material even more important than previously foreseen!



# Sample return missions from primitive near-Earth asteroids



**JAXA Hayabusa 2**  
**Ryugu orbit: 2018-2019**  
**Samples back to Earth: 2020**



**NASA OSIRIS-REx**  
**Bennu orbit: 2018-2020**  
**Samples back to Earth: 2023**

# Sample return missions from primitive near-Earth asteroids



**JAXA Hayabusa 2**  
**Ryugu orbit: 2018-2019**  
**Samples back to Earth: 2020**



**NASA OSIRIS-REx**  
**Bennu orbit: 2018-2020**  
**Samples back to Earth: 2023**

**“Why do you need to return samples when you can just land on the surface?”**

# Sample return missions from primitive near-Earth asteroids

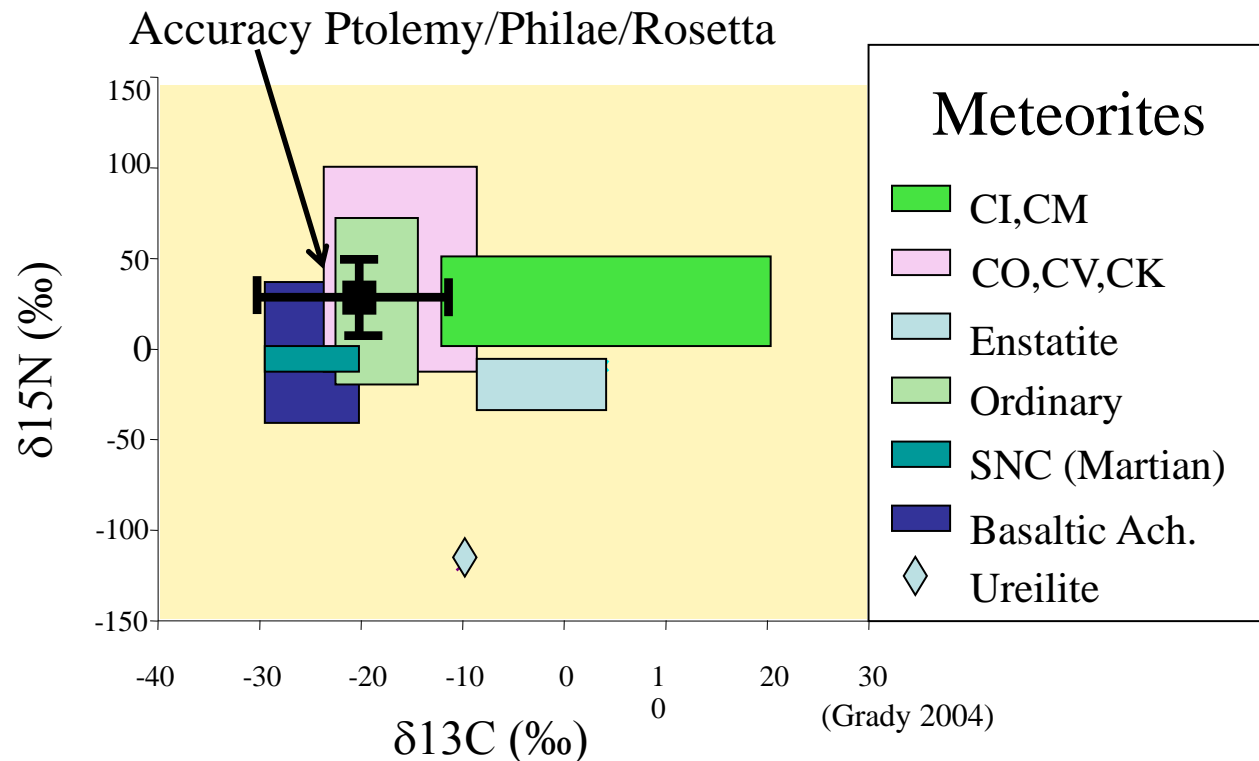


**JAXA Hayabusa 2**  
**Ryugu orbit: 2018-2019**  
**Samples back to Earth: 2020**



**NASA OSIRIS-REx**  
**Bennu orbit: 2018-2020**  
**Samples back to Earth: 2023**

**“Why do you need to return samples when you can just land on the surface?”**



# Sample return missions from primitive near-Earth asteroids



**JAXA Hayabusa 2**  
**Ryugu orbit: 2018-2019**  
**Samples back to Earth: 2020**



**NASA OSIRIS-REx**  
**Bennu orbit: 2018-2020**  
**Samples back to Earth: 2023**

**“Why do you need to return samples when we have meteorites?”**



# Sample return missions from primitive near-Earth asteroids



**JAXA Hayabusa 2**  
**Ryugu orbit: 2018-2019**  
**Samples back to Earth: 2020**



**NASA OSIRIS-REx**  
**Bennu orbit: 2018-2020**  
**Samples back to Earth: 2023**

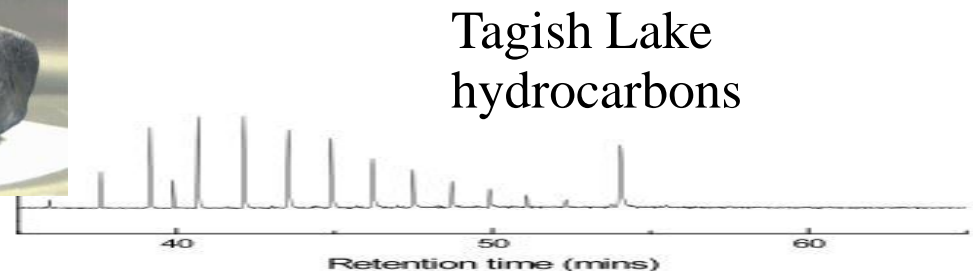
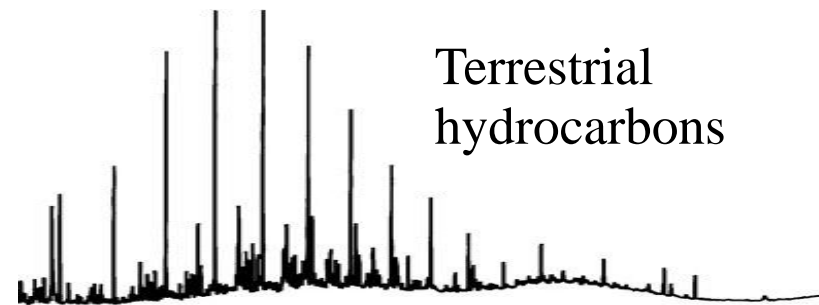
**“Why do you need to return samples when we have meteorites?”**



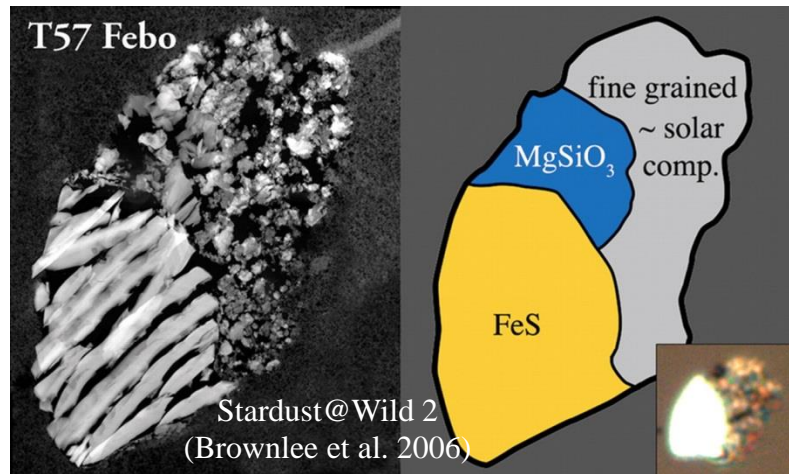
(University of Western Ontario, University of Calgary)



(Image courtesy of Mike Zolensky, NASA JSC)

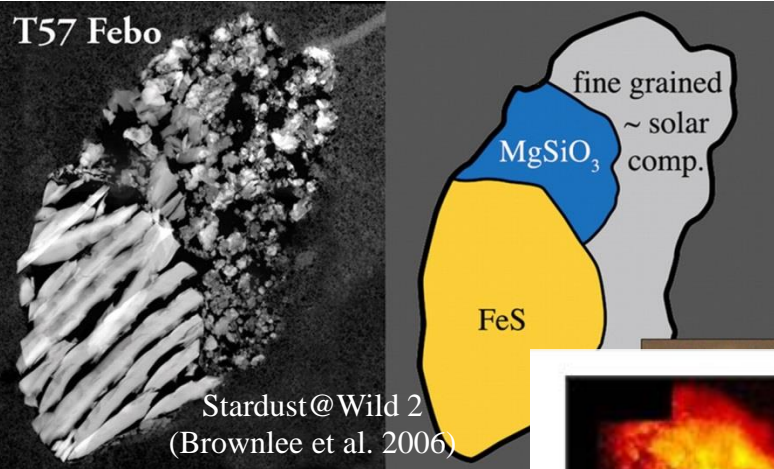


# Sample return missions from primitive near-Earth asteroids

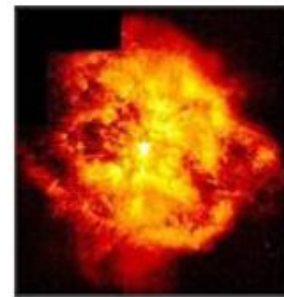


# Sample return missions from primitive near-Earth asteroids

T57 Febo



Stardust@Wild 2  
(Brownlee et al. 2006)



**Stars**  
Stellar nucleosynthesis  
Nature of stellar condensate grains

**The Interstellar Medium**  
IS grains, mantles & organics



**The proto-solar nebula**  
Accretion disk environment,  
processes and timescales

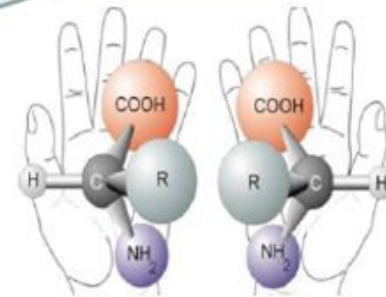


**Planetary formation**  
Inner Solar System Disk & planetesimal  
properties at the time of planet formation



**Accretion history,**  
alteration processes,  
impact events,  
regolith

**Life**  
Nature of  
organics in NEAs

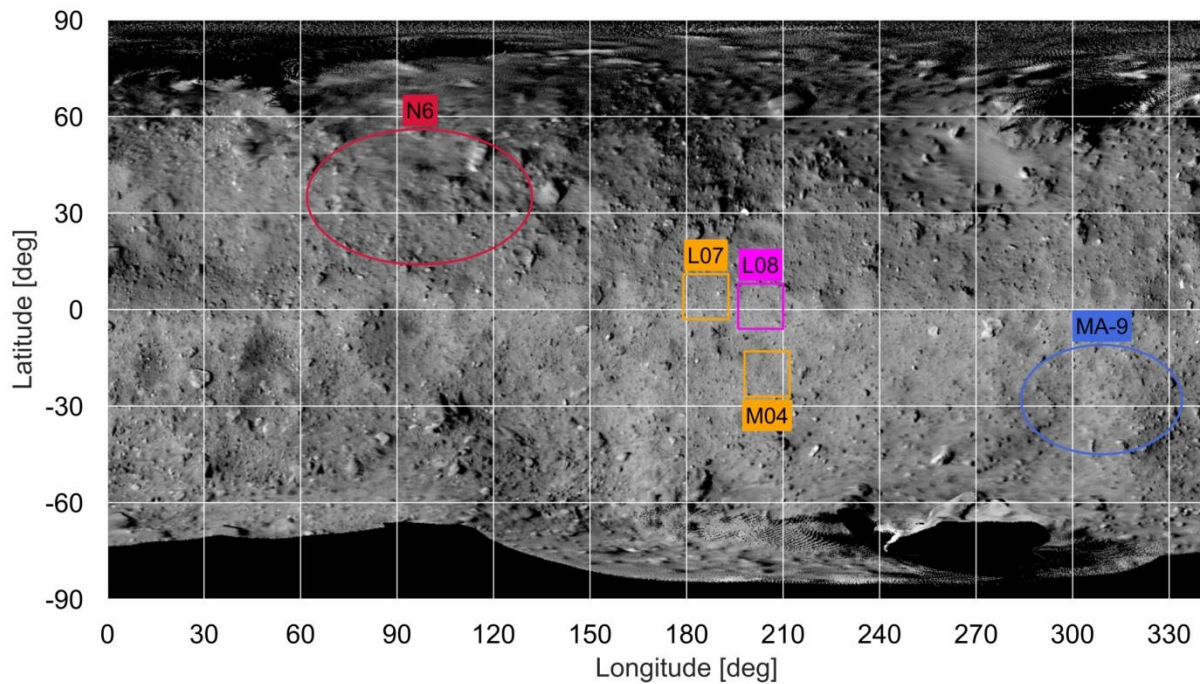
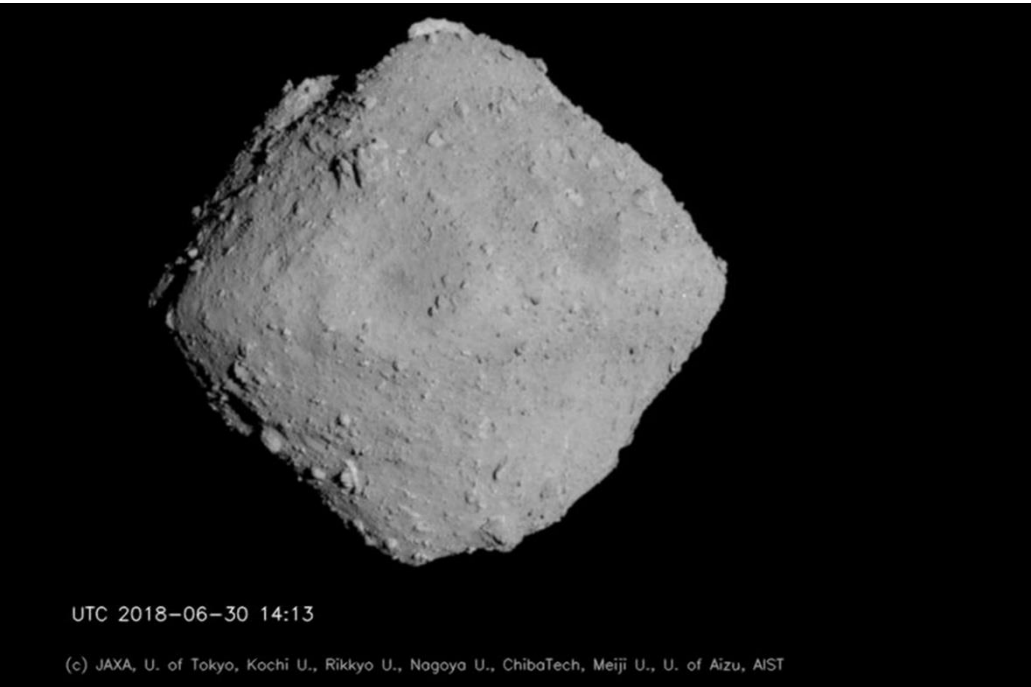


**The Earth**  
Impact hazard  
Evolution of life on Earth



# Hayabusa 2 @ Ryugu

2 papers in preparation  
(under embargo)





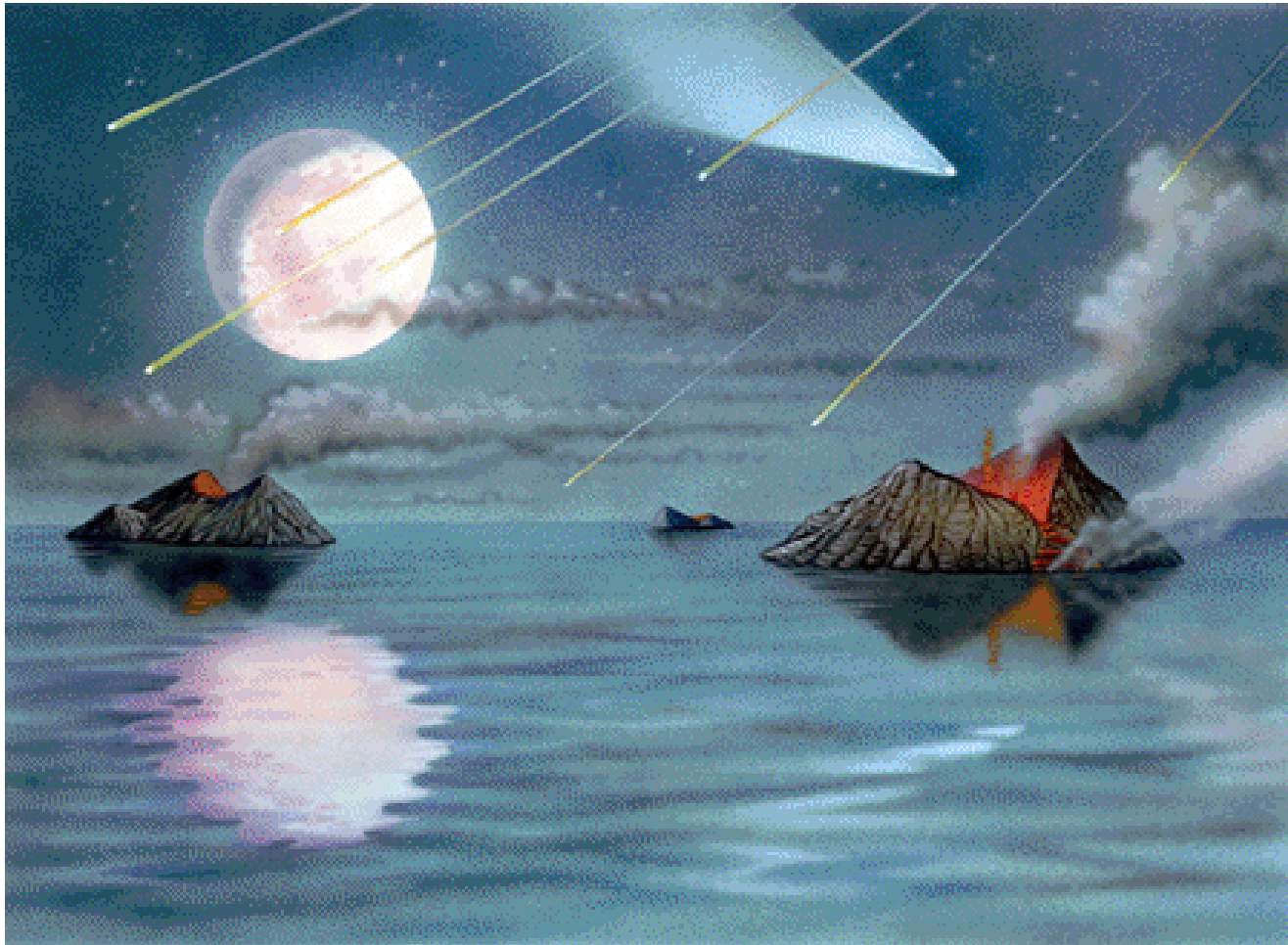
## **Mid/outer solar system small bodies**

- ✓ Long-term ongoing work, but 4 papers already published
  - leva et al. 2018, MNRAS 479, 260
  - Perna et al. 2018, MNRAS 475, 974
  - Hromakina et al. 2018, MNRAS 474, 2536
  - Epifani et al. 2018, A&A, in press

## **Supervising and dissemination activities**

- ✓ 2 PhD and 1 Master students supervised
- ✓ European Researchers' Nights 2017 and 2018
- ✓ Several events at INAF-OAR
- ✓ 1 TV and 2 radio interviews
- ✓ 2 news on MEDIA INAF

# Thank you!



This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement n. 664931