

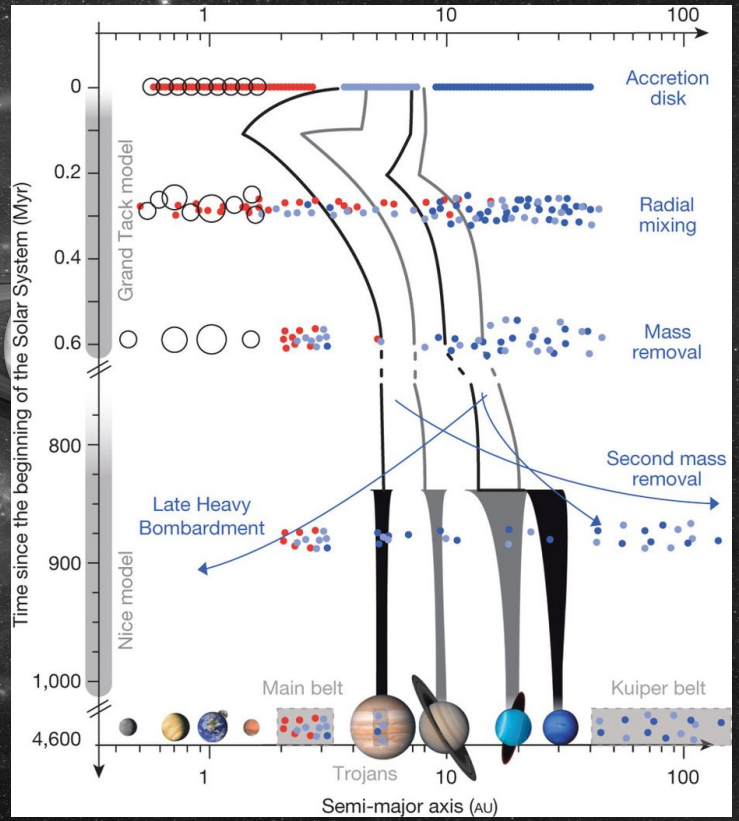
Genesis of Asteroids and evolUtion of the Solar System

GAUSS

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Origin and evolution of Solar System and the like

Past and present-day habitability



(DeMeo et al. 2014, Nature)

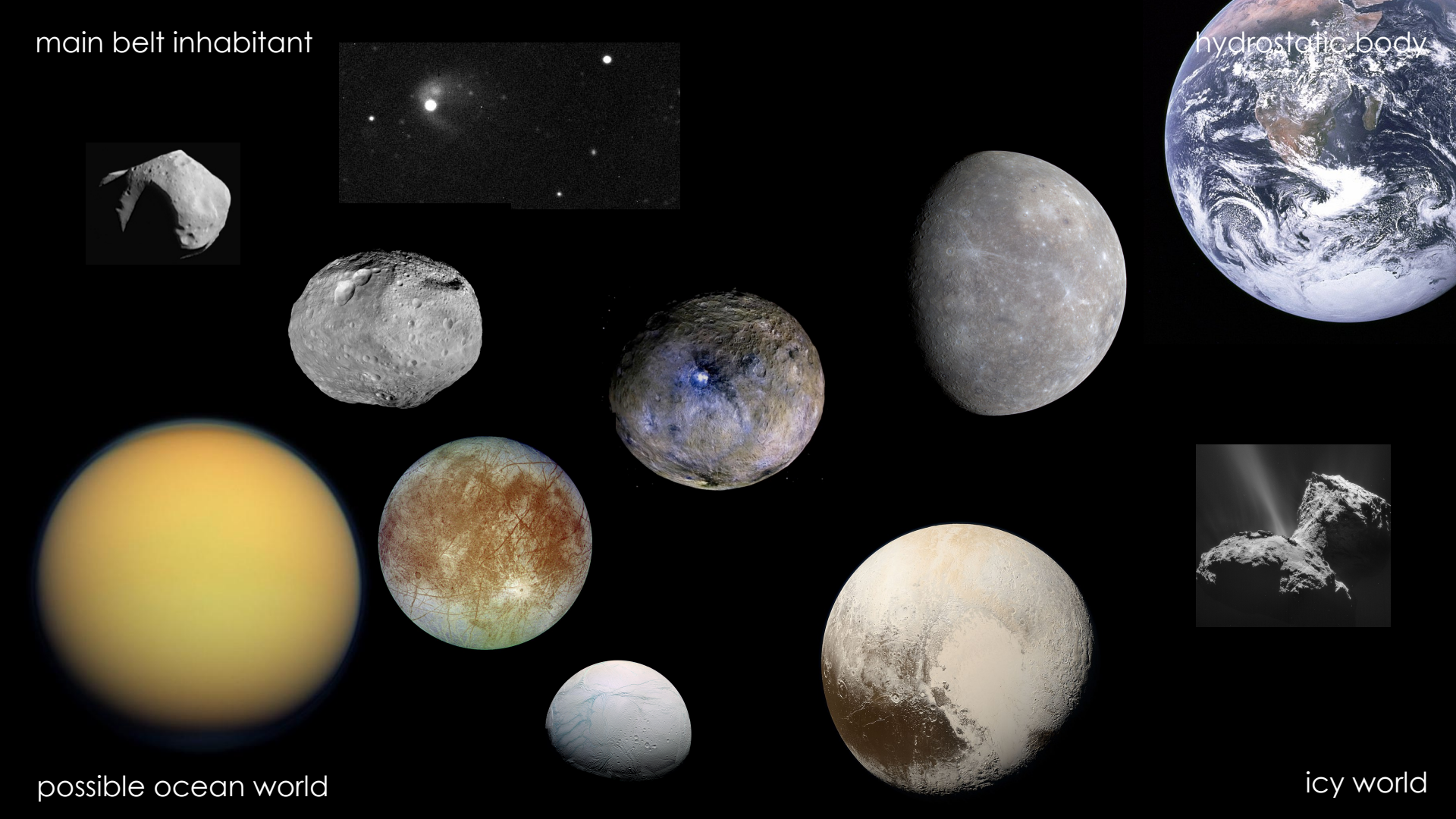
(credit: NASA/JPL-Caltech)

Origin and evolution of Solar System and the like

Past and present-day habitability



(credit: NASA/JPL-Caltech)


main belt inhabitant
hydrostatic body
possible ocean world
icy world

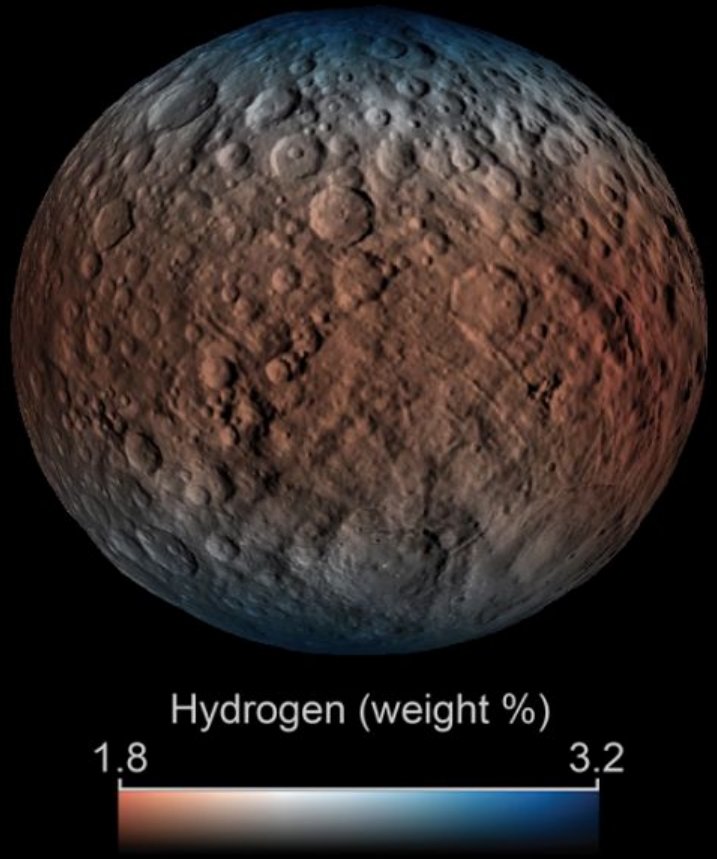
Ceres revealed by Dawn

Water-rich, carbon-rich, and organics!



(credit: NASA)

Ubiquitous water ice



(Prettyman et al. 2017, Science)

Large abundance of water

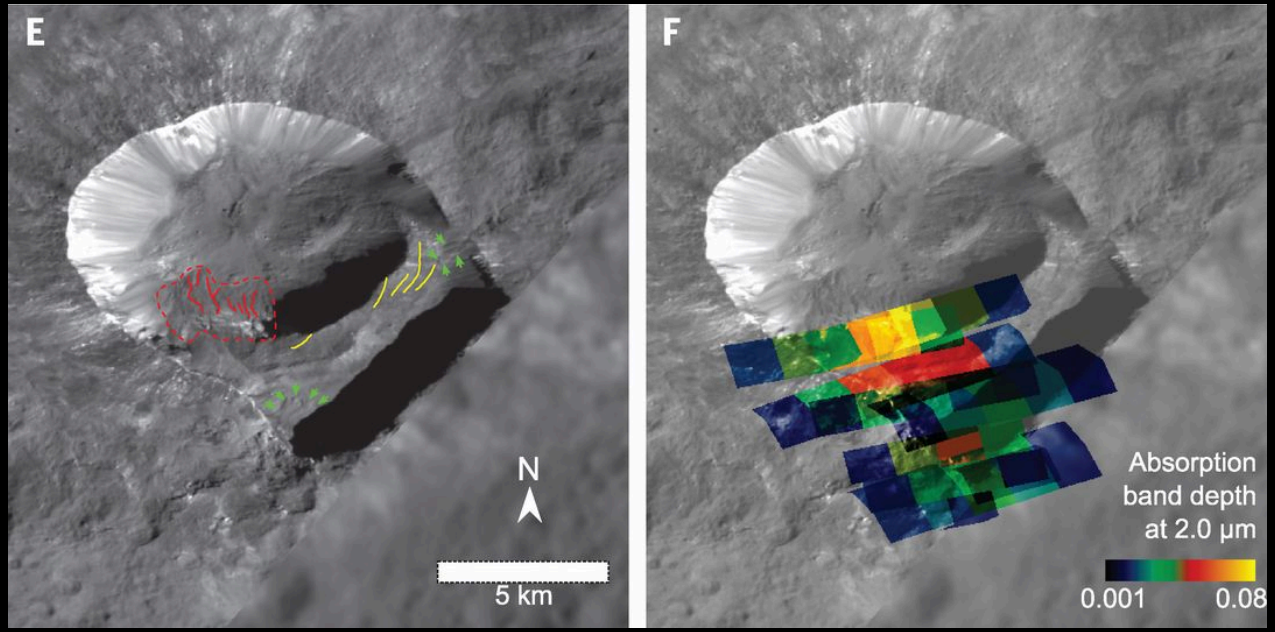


Earth 0.1 vol.%

Mars 0.05 vol.%

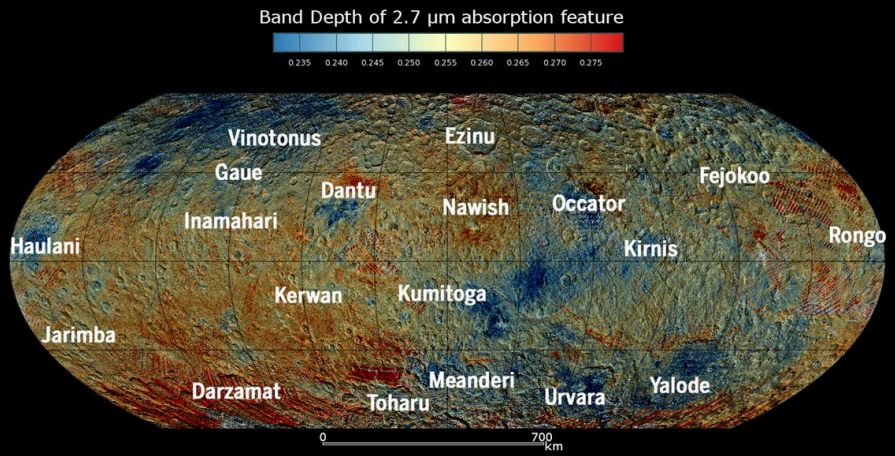
Ceres ~40 vol.%

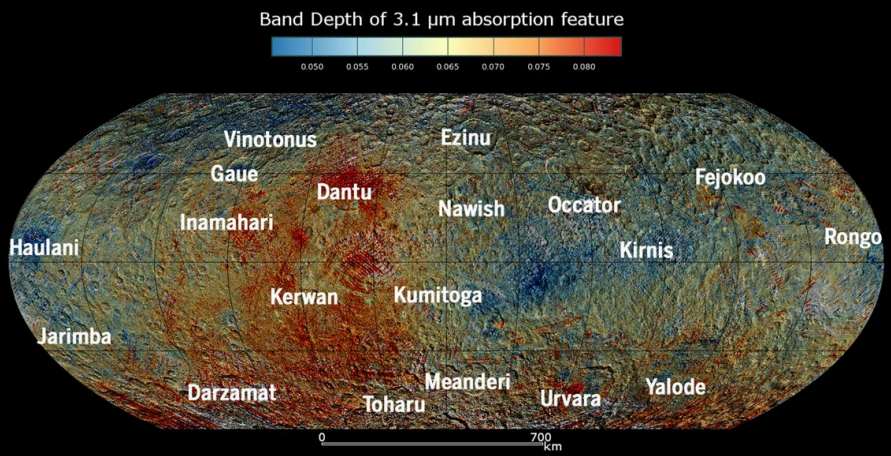
Exposed water ice on the surface



(Combe et al. 2016, 2018; Platz et al., 2017; Schorghofer et al. 2016)

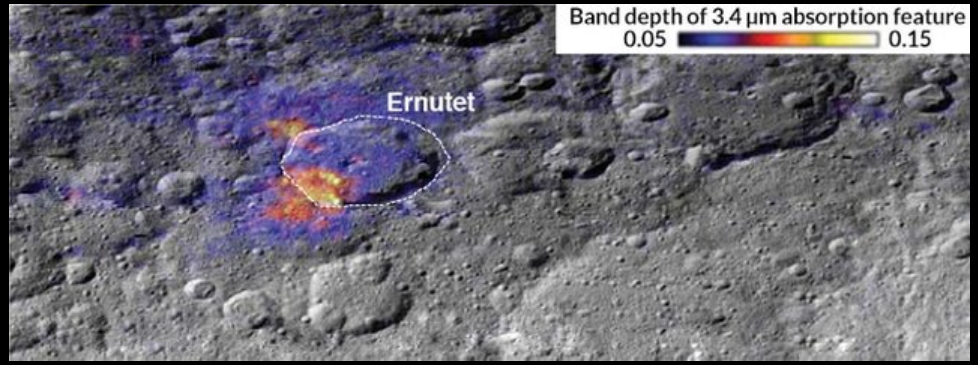
Globally distributed ammoniated phyllosilicate



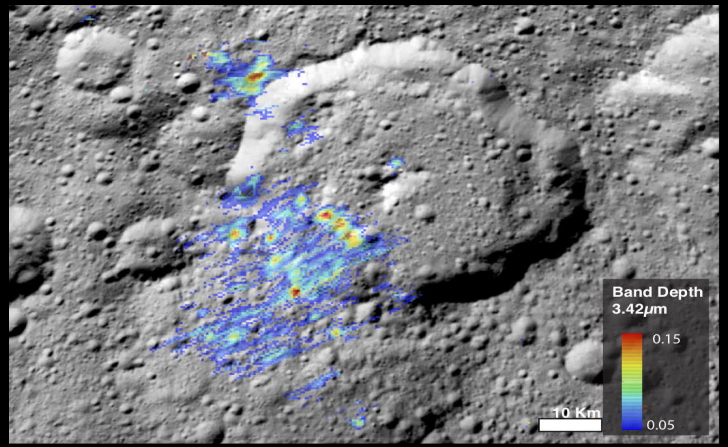


(De Sanctis et al. 2015, Nature; Ammannito et al. 2016, Science)

Organics



(De Sanctis et al. 2017, Science)



(Kaplan et al. 2018, GRL)

NASA/JPL-Caltech/UCLA/MPS/DLR/IDA

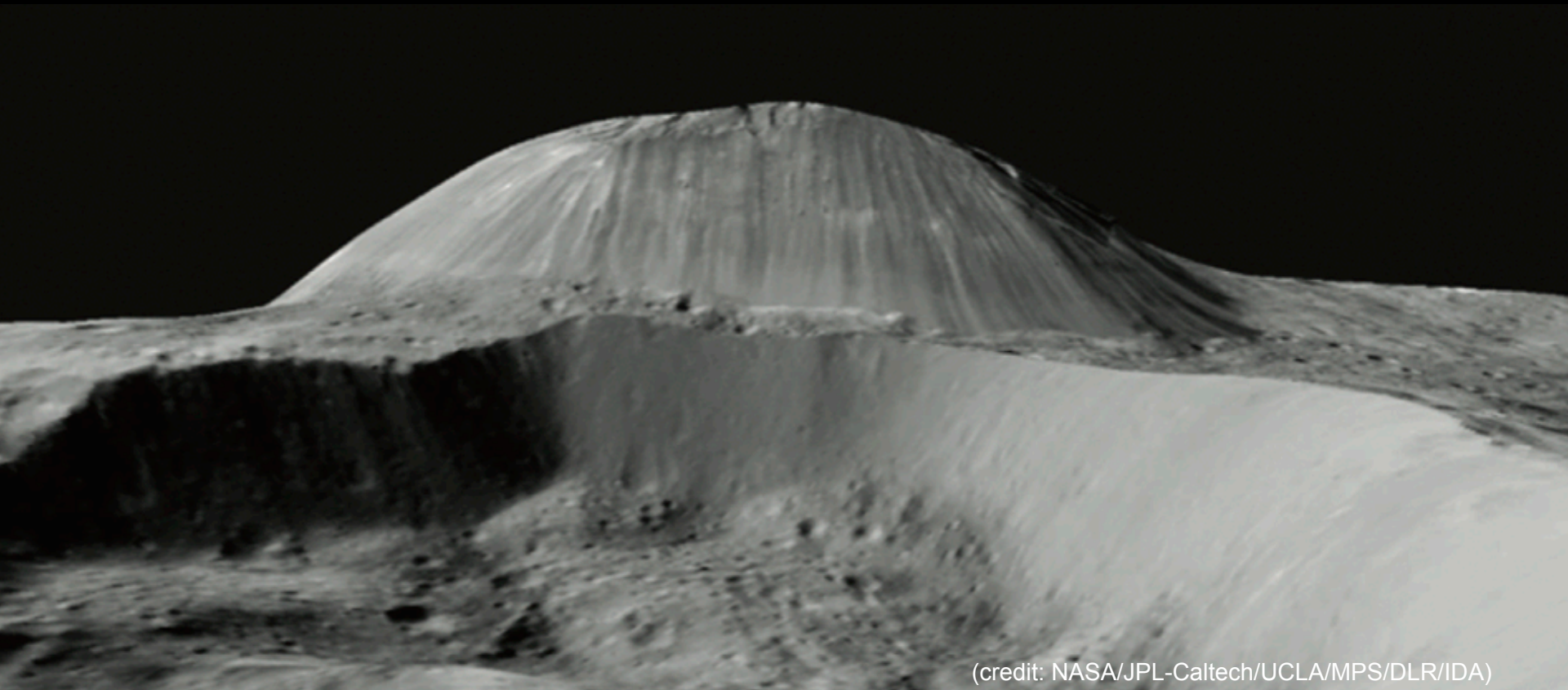
Ceres revealed by Dawn

Geologically active



(credit: NASA)

Ahuna Mons – young cryovolcano



(credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA)

Ahuna Mons – young cryovolcano

- The emplacement of 4-km high Ahuna Mons requires a partially molten source – indicates subsurface brine pockets (Ruesch et al., 2016, 2019)
- Bright streaks are rich in Na-carbonate (Zambon et al., 2017)
- Emplacement is recent
- Brine mixture eutectic temperature is about 245K, possibly lower if ammonia remains



Occator crater – recent hydrothermal activity



- Crater dating indicates Occator to be 10s My old (Nathues et al., 2017, Neesemann et al., 2019)
- Cerealia Facula (central deposit) appears to be even younger (Scully et al., 2018)
- Geology indicates that Cerealia Facula formed by a recurring, eruptive process
- Central dome similar to cryovolcanic features found on icy satellites

(credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA)

Occator crater – recent hydrothermal activity

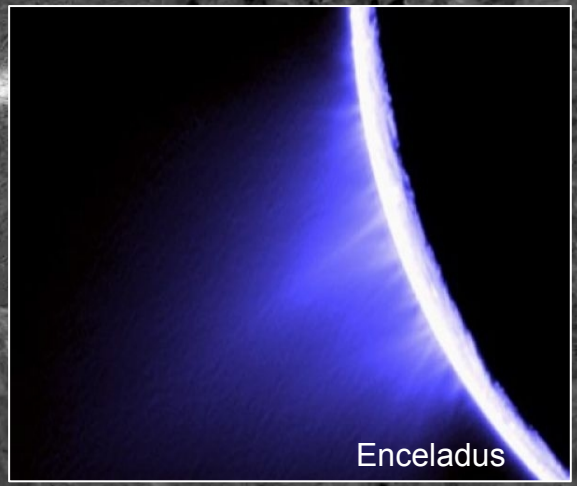


Cerealia Facula

Sodium carbonate
Ammonium salts

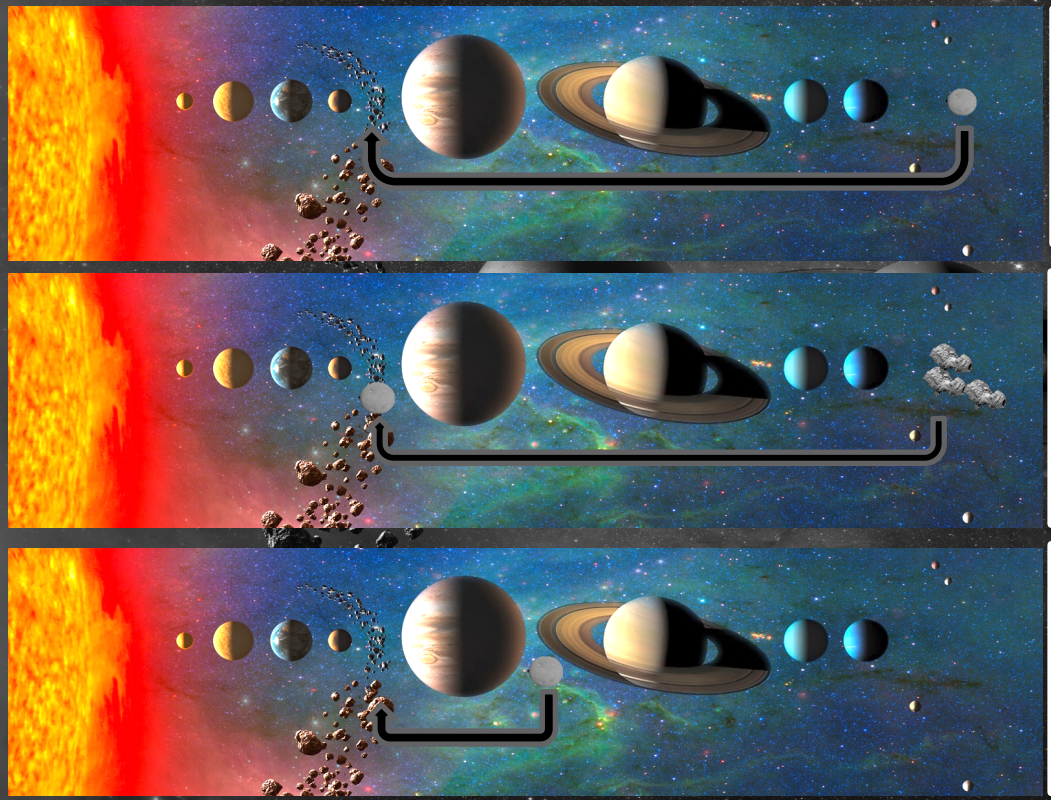
(De Sanctis et al. 2017, Science)

Vinalia Faculae



(credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA)

Origin and evolution of Solar System and the like



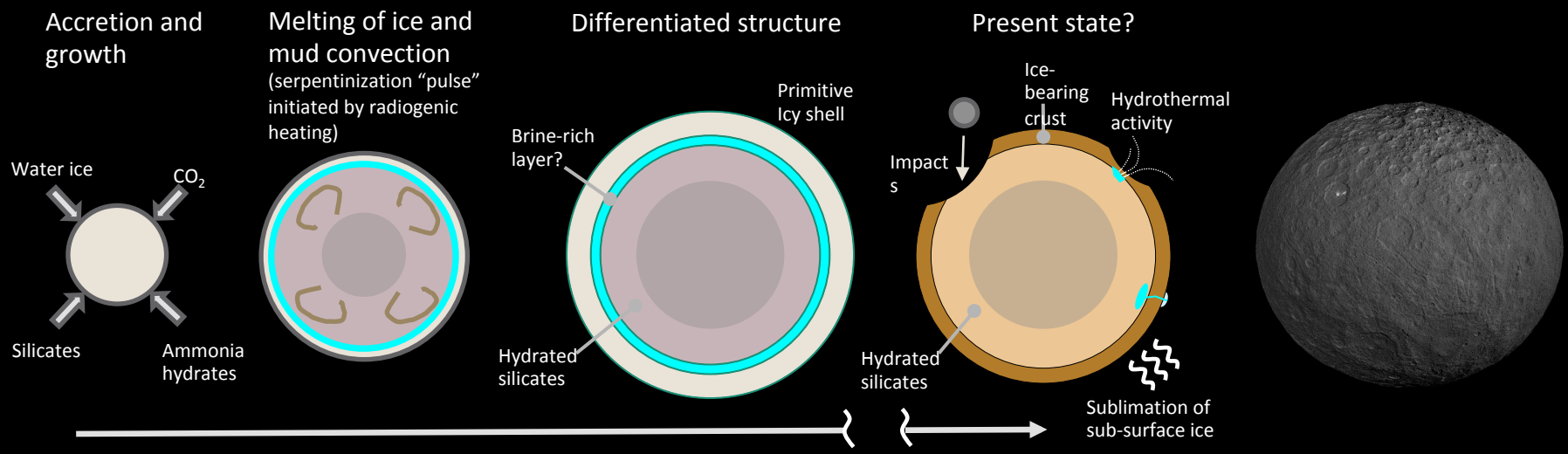
Ceres may have formed in the trans-Neptunian disk, before it was implanted into the main belt (e.g., McKinnon, 2012)

Ceres formed closer to its present position by accreting material that drifted inward from greater distances (e.g. Mousis +Alibert, 2005)

Ceres formed between the orbits of the giant planets and was scattered due to giant planet growth and migration (Raymond +Izodoro, 2017)

(credit: NASA/JPL-Caltech)

Origin and evolution of Solar System and the like

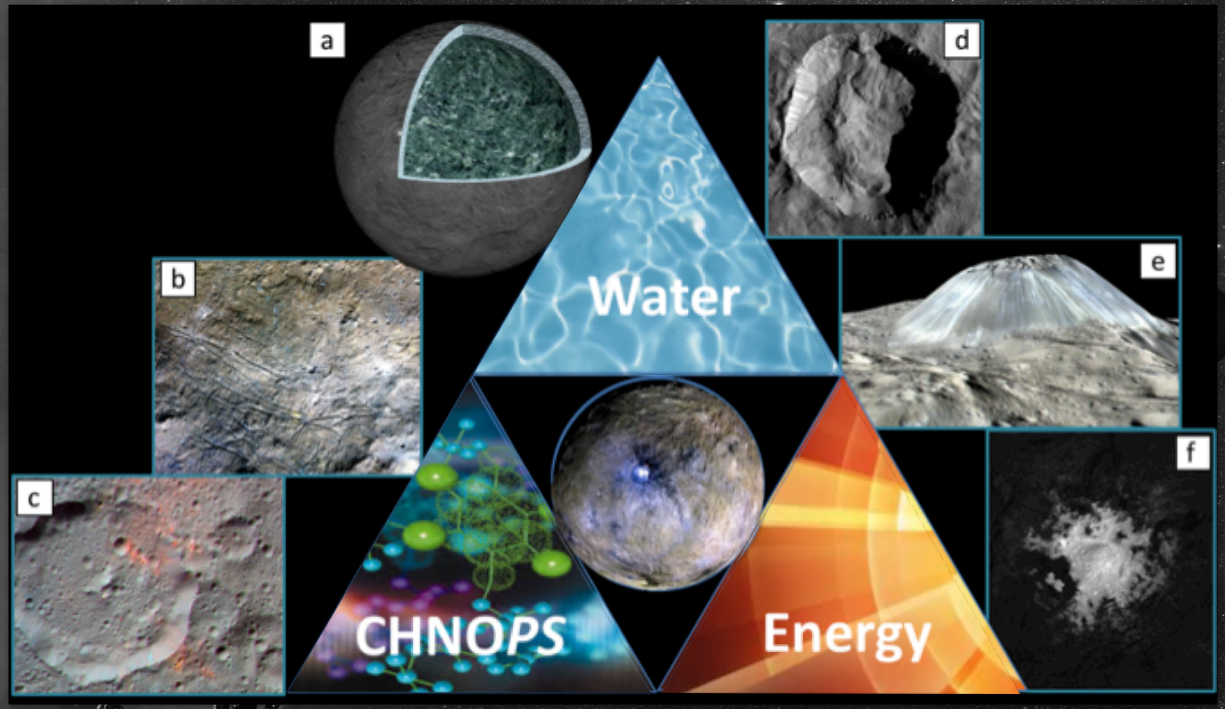


- Residue and brine separate, resulting in chemical fractionation
- Surface and bulk elemental composition differ

Castillo-Rogez&McCord, 2010, *Icarus*; Neveu et al., 2015, *GRL*; Rivkin et al. 2011, *SSR*; Castillo-Rogez et al., 2016, 2017

(credit: NASA/JPL-Caltech)

Past and present-day habitability



(credit: NASA/JPL-Caltech)



GAUSS

sample return from Ceres

mission scenario and international context

2020 2025 2030 2035

Chang'e-5

ExoMars

HX-1

Mars2020

Lucy

JUICE

Psyche

MMX

CAEX

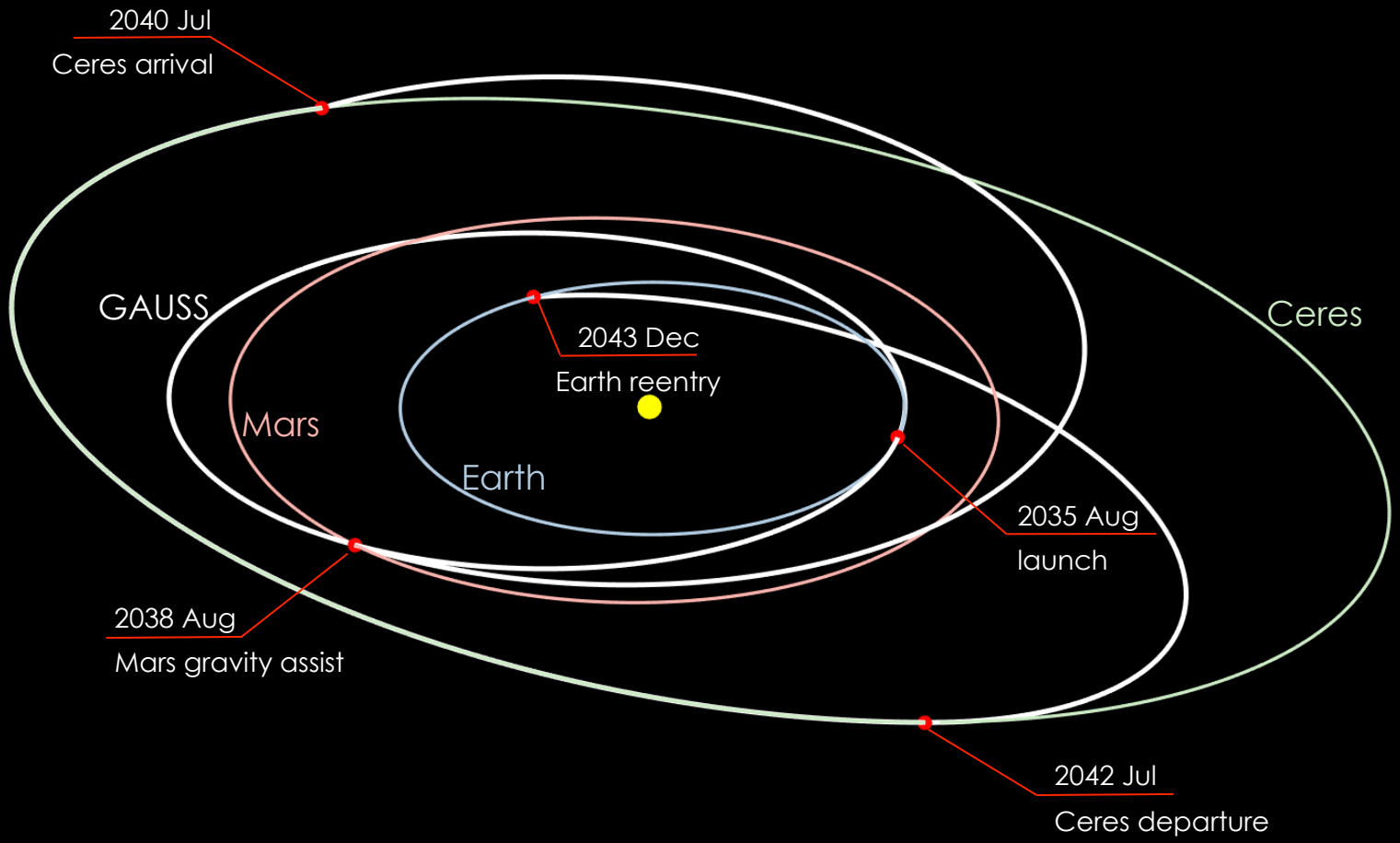
Europa clipper

Dragonfly

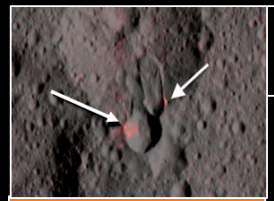
Comet Interceptor

GAUSS	orbiter + lander + return capsule
	L-class or M-class with significant international contribution

Preliminary trajectory design



Sites of interest



Recently exposed organic matter

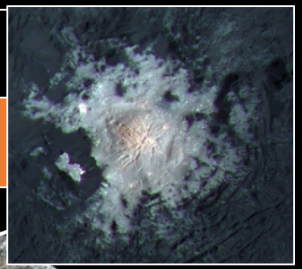
Obis. 1, 4 (IS/SR)

Average Surface
[C]~20wt.%
Ceres' material (incl. ice) + Infalls

Obis. 1 (O+IS/SR), 4, 8 (IS/SR), 5 (IS)

Recent (ongoing?) cryovolcanic activity

Obis. 5 (IS), 2, 6 (O), 7 (IS/SR) ,



60° N

30° N

0°

30° S

60° S

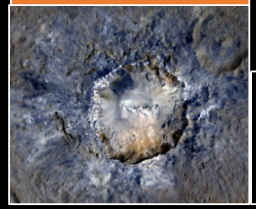
Ernutet crater

Haulani crater

Occator crater

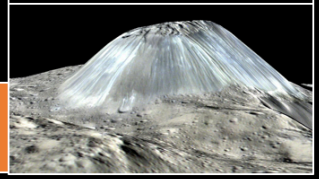
Ahuna Mons

Obis. 1, 3 (IS/SR)



Freshly exposed crustal material (<3 My)

Volcanic feature sourced from mantle



Obis. 4, 7 (IS/SR), 5 (O+IS)

“There and back again”

Extended proposing team

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