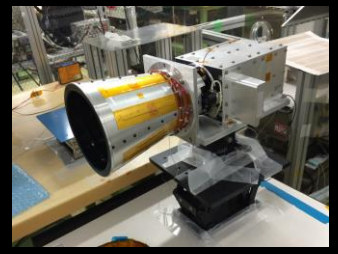
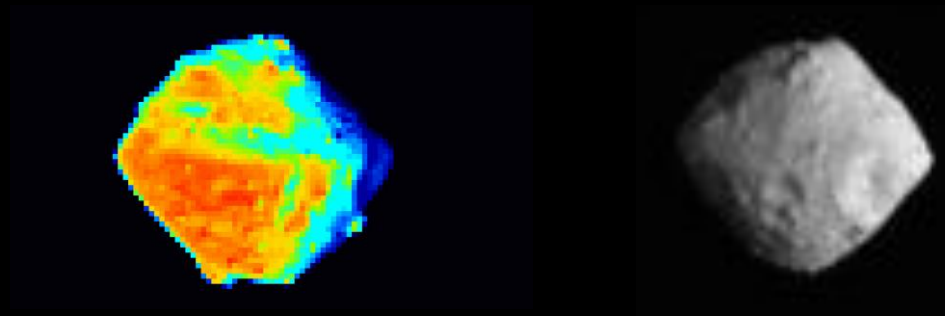
Thermal Imaging to Reveal Highly Porous Nature of C-type Asteroid Ryugu in Hayabusa2 Mission





7th IAA
Planetary Defense Conference

2021/4/26-30

Hayabusa2

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1: ISAS/JAXA, 2: Univ. Tokyo, 3: Rikkyo Univ., 4: Maebashi IT, 5: Chiba IT, 6: Univ. Aizu, 7: Hokkaido Univ. Edu., 8: AIST

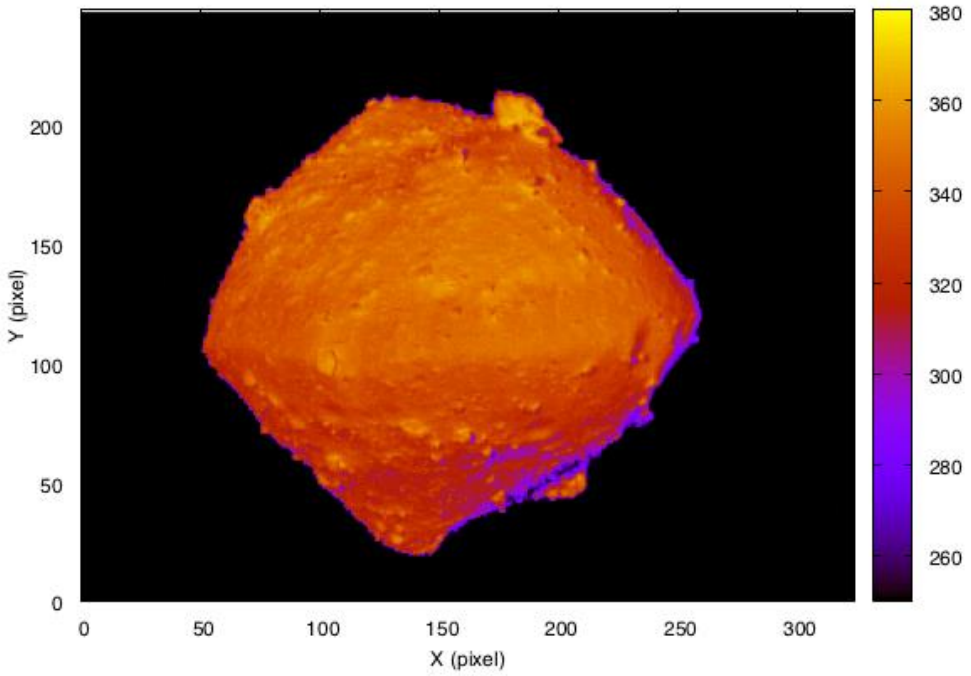
One-rotation Global Thermal Images of Ryugu

Something different from the predicted model

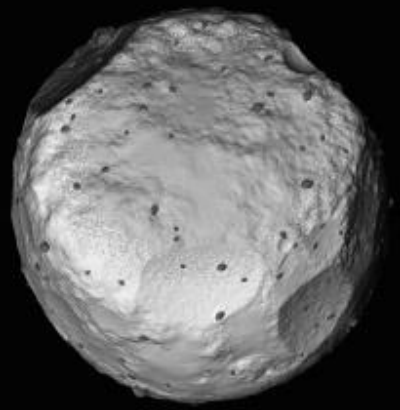
■Mid-Alt Observations:

First global thermal images of an asteroid!

Mid-Alt: 5km (~4.5m/pixel) on 1 Aug 2018



■"Ryugoid" (Reference Asteroid Model)



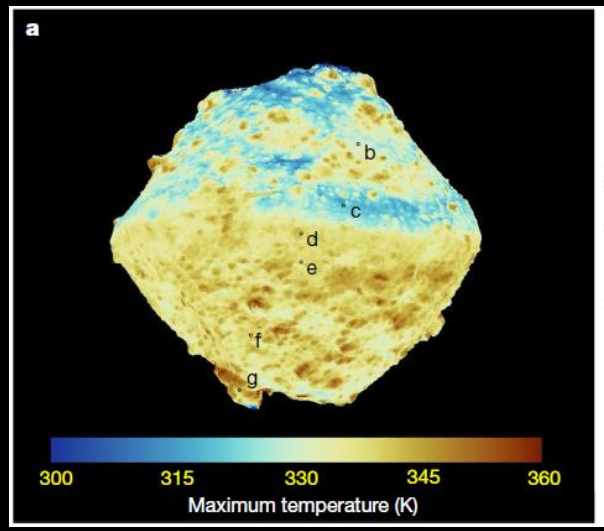
- Ryugoid has many cold boulders

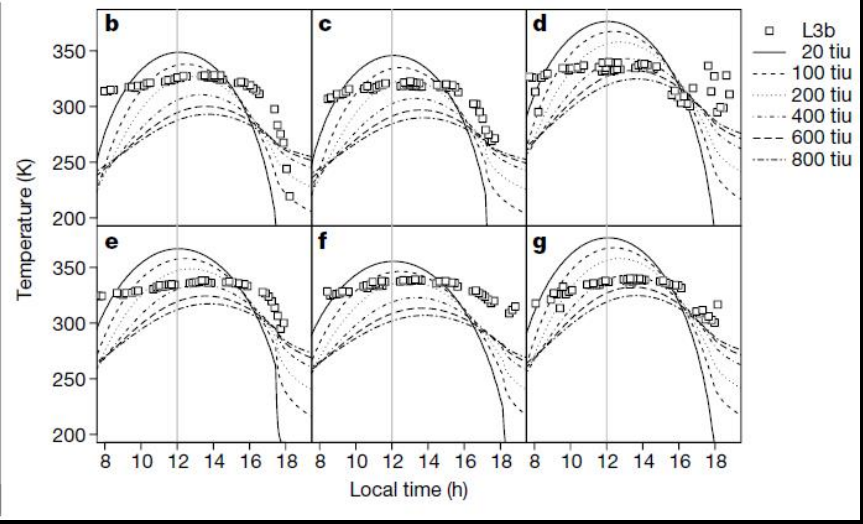
↓

No cold boulders on Ryugu!

- No flat areas

■ "Flat" Diurnal Temperature Profile

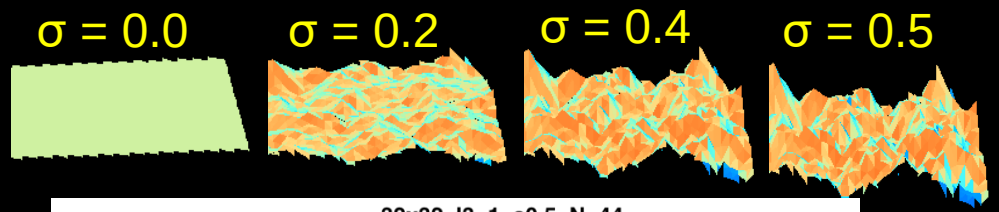


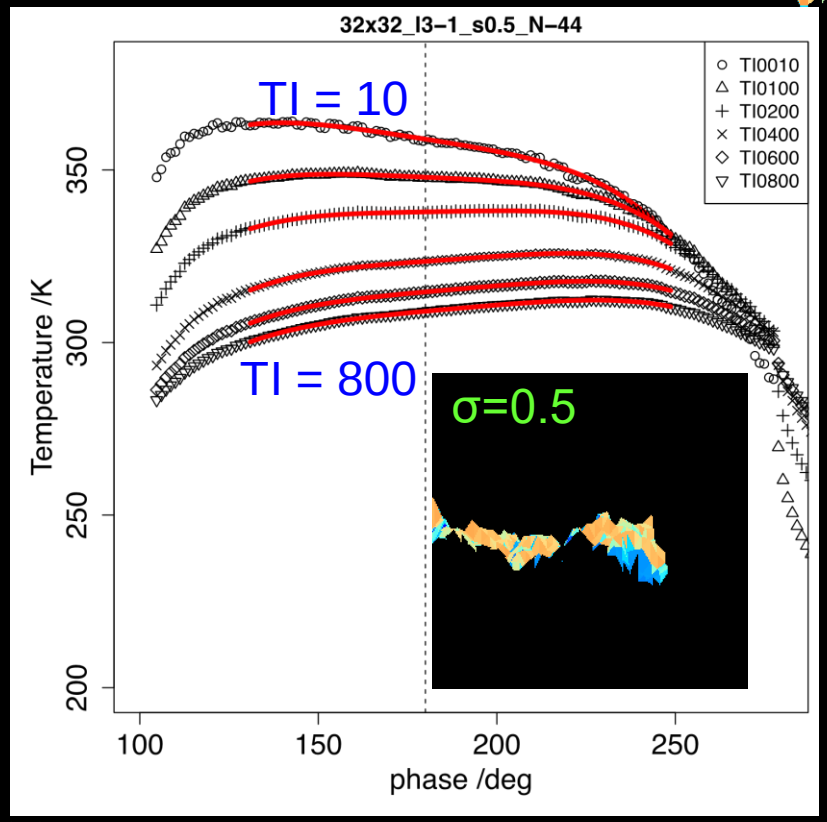


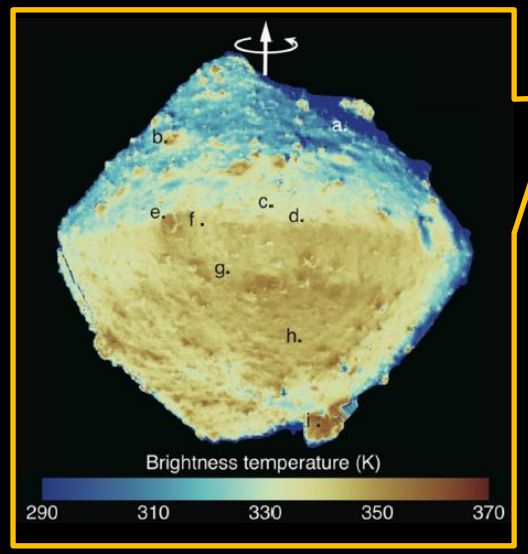
Highly Porous & Rough Surface on Ryugu!

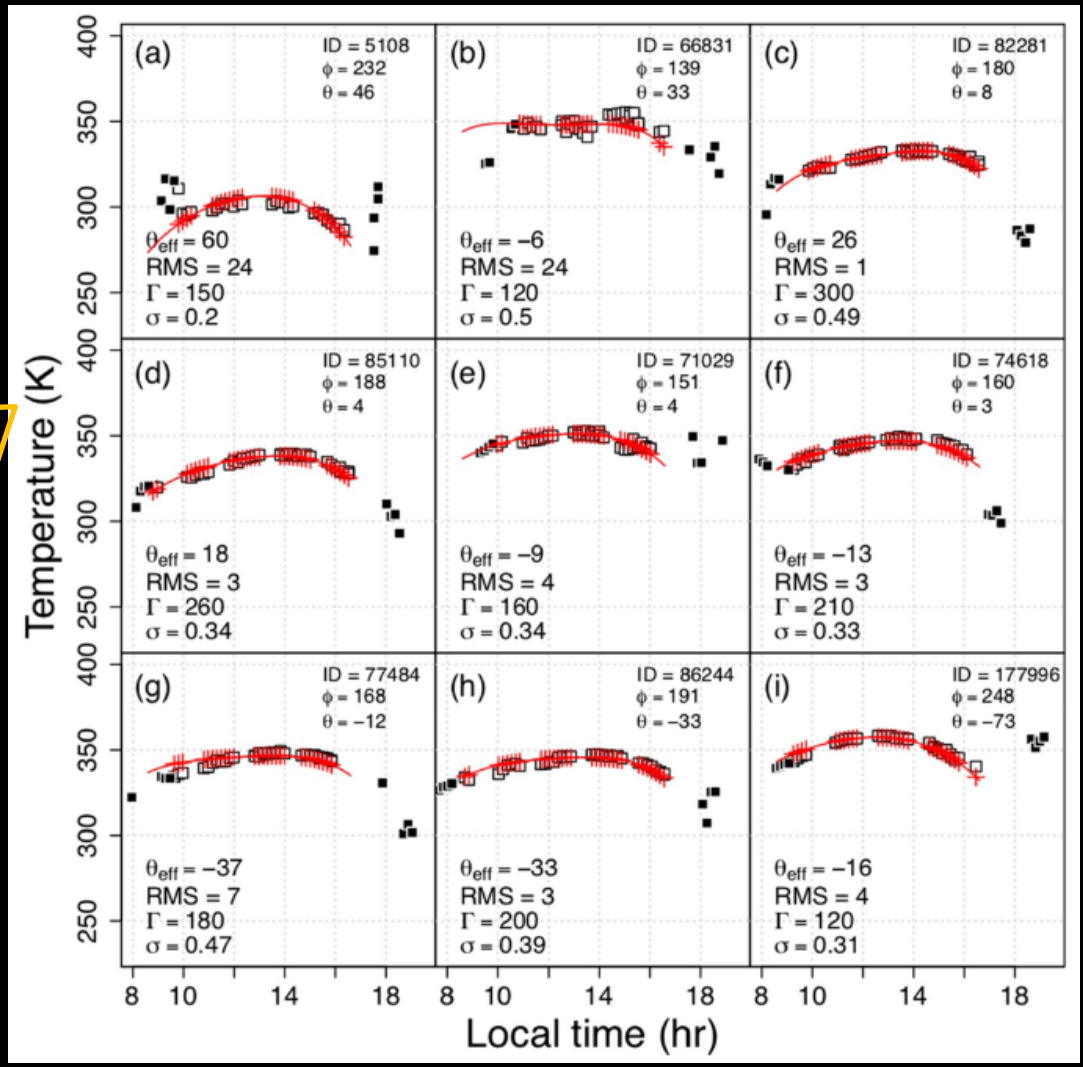
■ **Diurnal temperature profiles show that Ryugu surface is highly porous & rough!**

Shimaki+ Icarus (2020) / Senshu+ *in prep*
TI = 150~300tiu, Roughness = 0.3~0.5







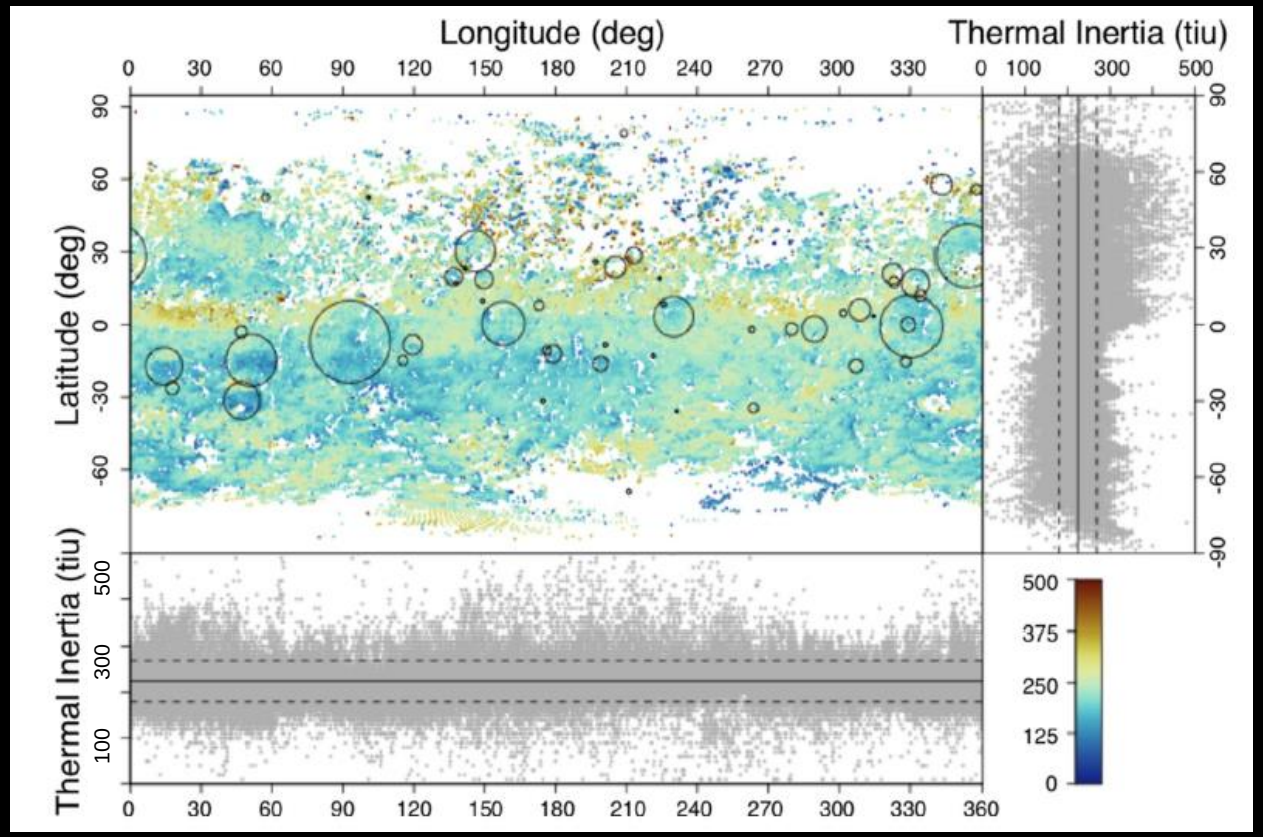


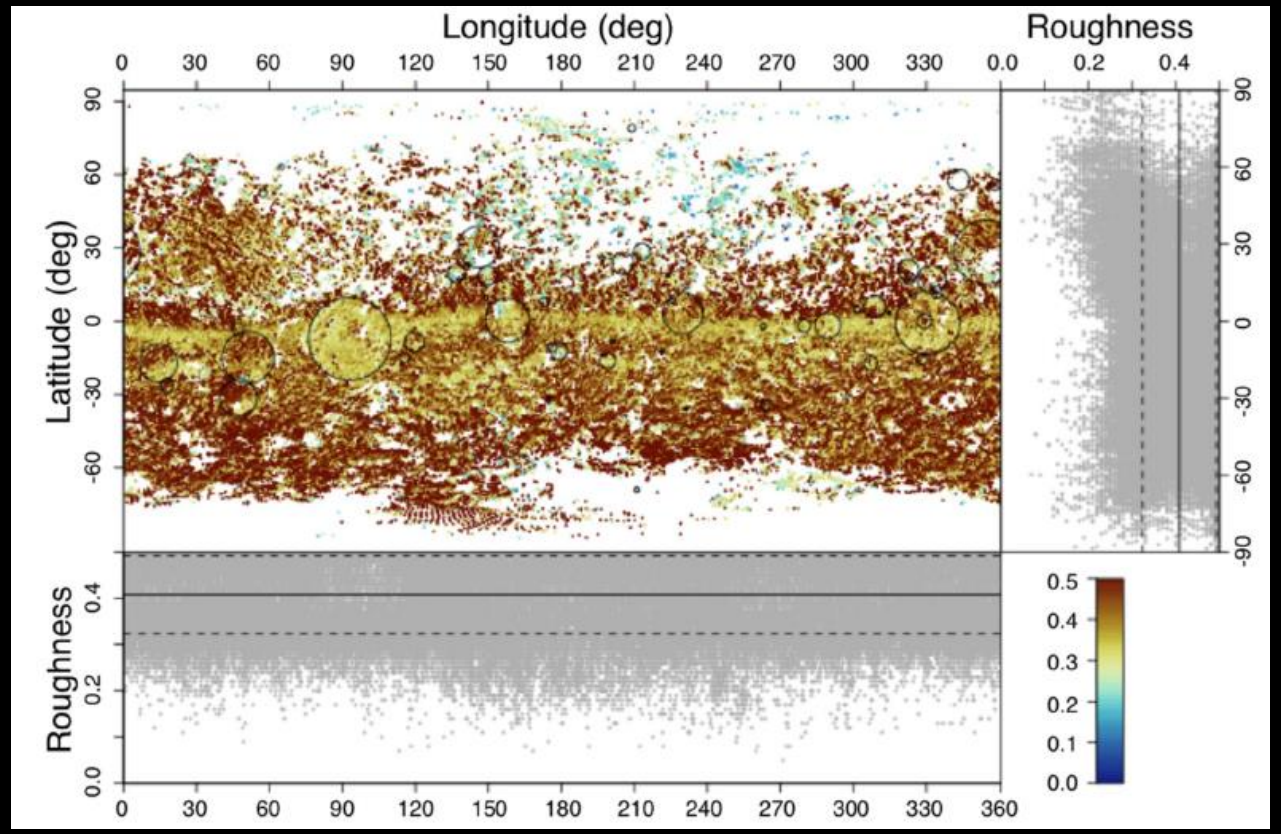
Highly Porous & Rough Surface on Ryugu!

Thermophysical model of Ryugu

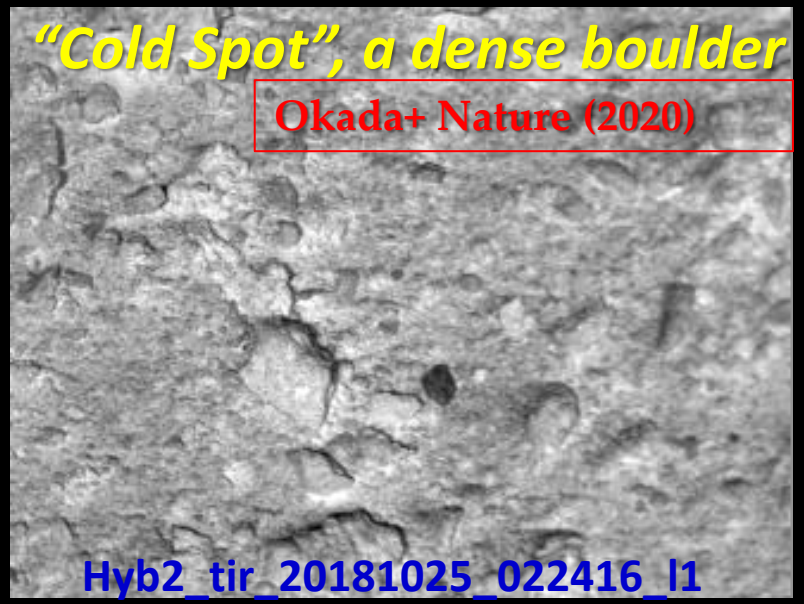
Shimaki+ Icarus (2020)

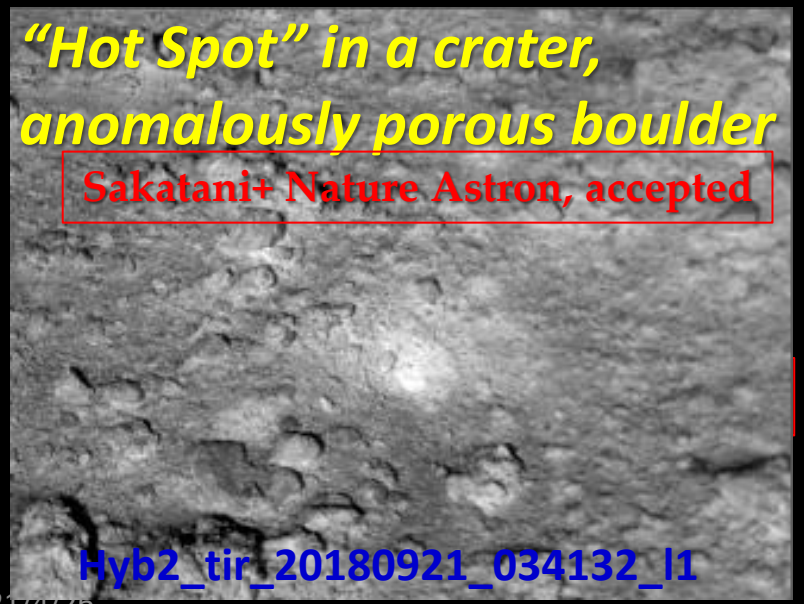
- Thermal Inerita = 225 ± 45 tiu
- Roughness parameter: σ = 0.41 ± 0.08



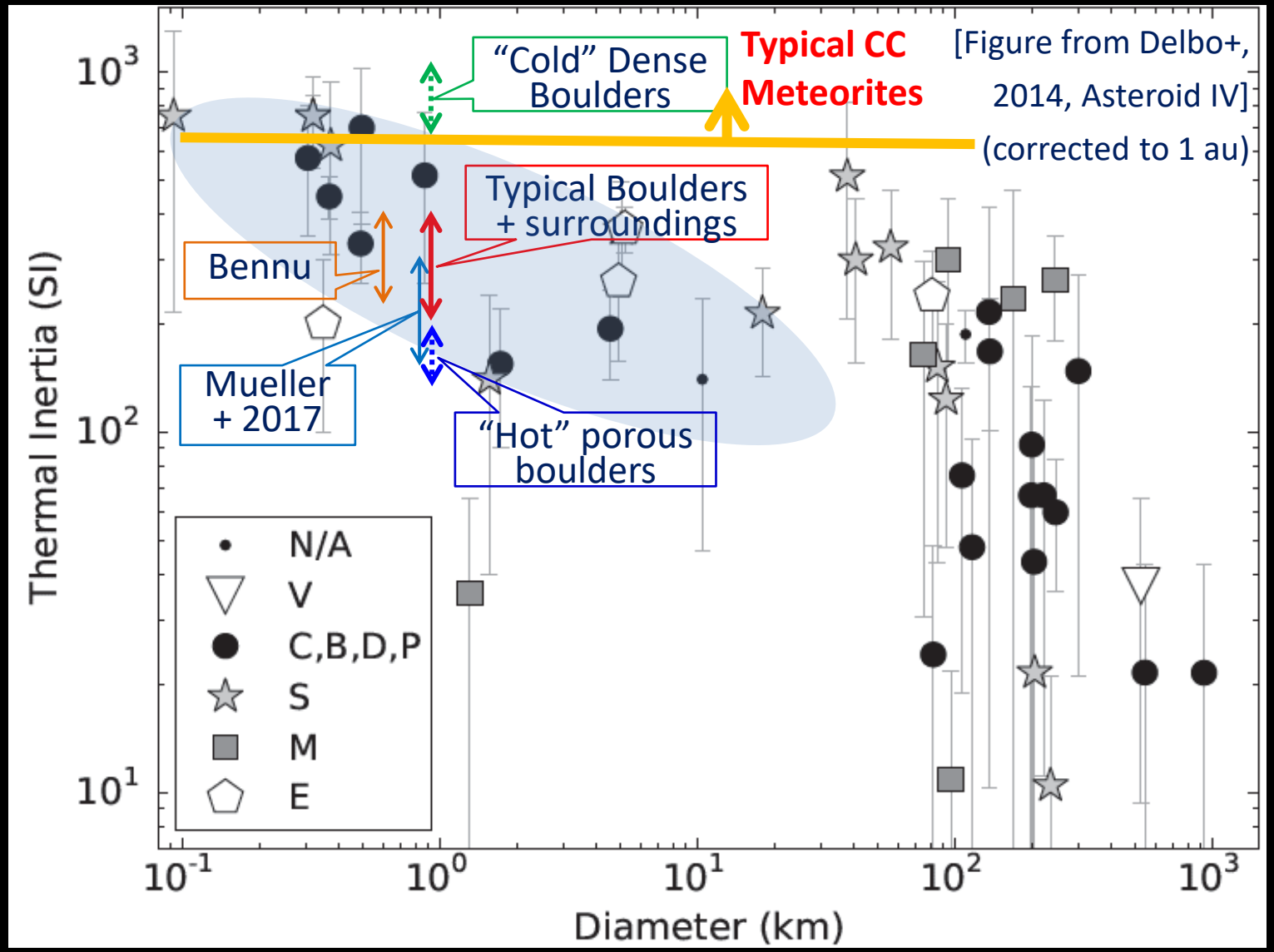


Cold Spot and Hot Spot – Porosity variations





- Asteroid size vs Thermal inertia



Summary

The surface temperature and the derived thermal inertia of Ryugu was imaged by TIR, even in the night or shaded side.

The surface of Ryugu is covered with highly porous boulders and rocks (low strength).

The surface of Ryugu is very rough, to the scale of < 10cm (thermal skin depth).

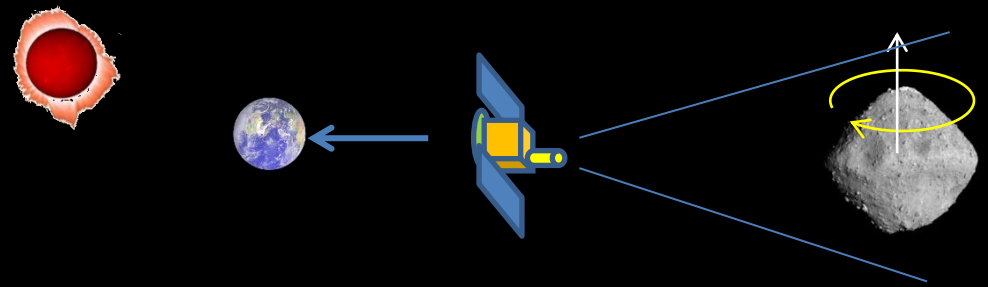
A variation of porosity is found on Ryugu, indicating the different degree of alteration in the parent bodies.

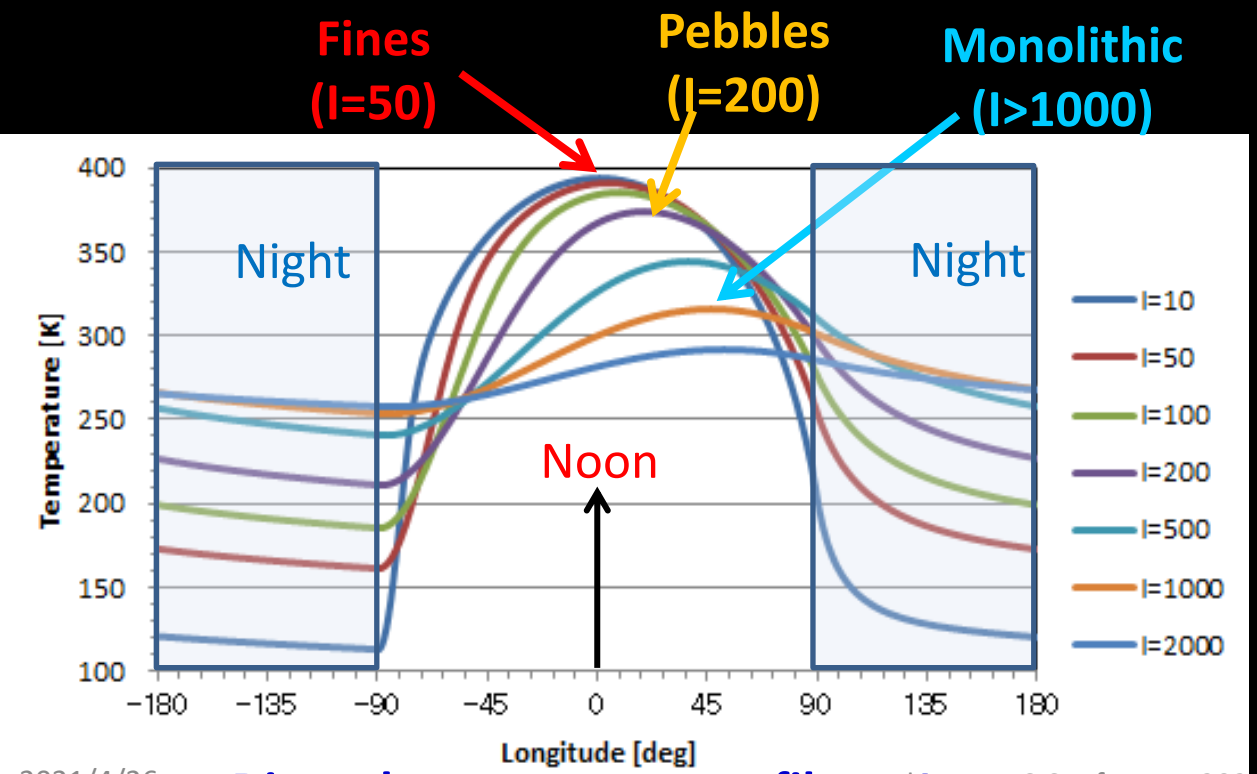
Thank you

Direct Thermal Observations in Hayabusa2

Temperature and its diurnal profile will reveal the properties

Thermal Imaging from Home Position

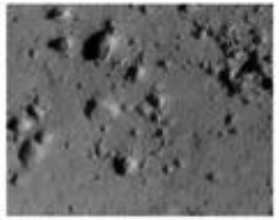
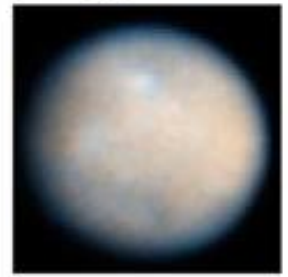




Diurnal temperature profile at 1au

Thermal Inertia vs. Surface State

Thermal Inertia: I [J m^{-2} s$^{-0.5}$ K^{-1}]	$I = (k\rho C)^{0.5}$ Surface Physical State
~ 10	Very high porosity (~80%), Ceres, Martian soils
~ 50	Fine sand : Lunar regoilth (d ~ 100 μm or less)
100 ~ 200	Sandy regolith (d ~mm): Eros soil
200 ~ 400	Pebbles (d ~cm): Itokawa's Muses-Sea Regio
400 ~ 1000	Boulders, Rocks (d < m): Itokawa's rough terrain
1000 ~ 2000	Rocks with high porosity
2000 ~	Monolithic rocks

25143 Itokawa	433 Eros	The moon	1 Ceres
$\Gamma = 600$	$\Gamma = 150$	$\Gamma = 50$	$\Gamma = 10$
			
Coarse regolith and boulders	Finer and thicker regolith	Mature and fine regolith	Very fine regolith ??