OSIRIS-REx
ASTEROID SAMPLE RETURN MISSION

OSIRIS-REx: Sample Return from Asteroid Bennu

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UNIVERSITY OF ARIZONA NASA'S GODDARD SPACE FLIGHT CENTER LOCKHEED MARTIN

ORIGINS — Where did we come from?

SPECTRAL INTERPRETATION — What's out there?

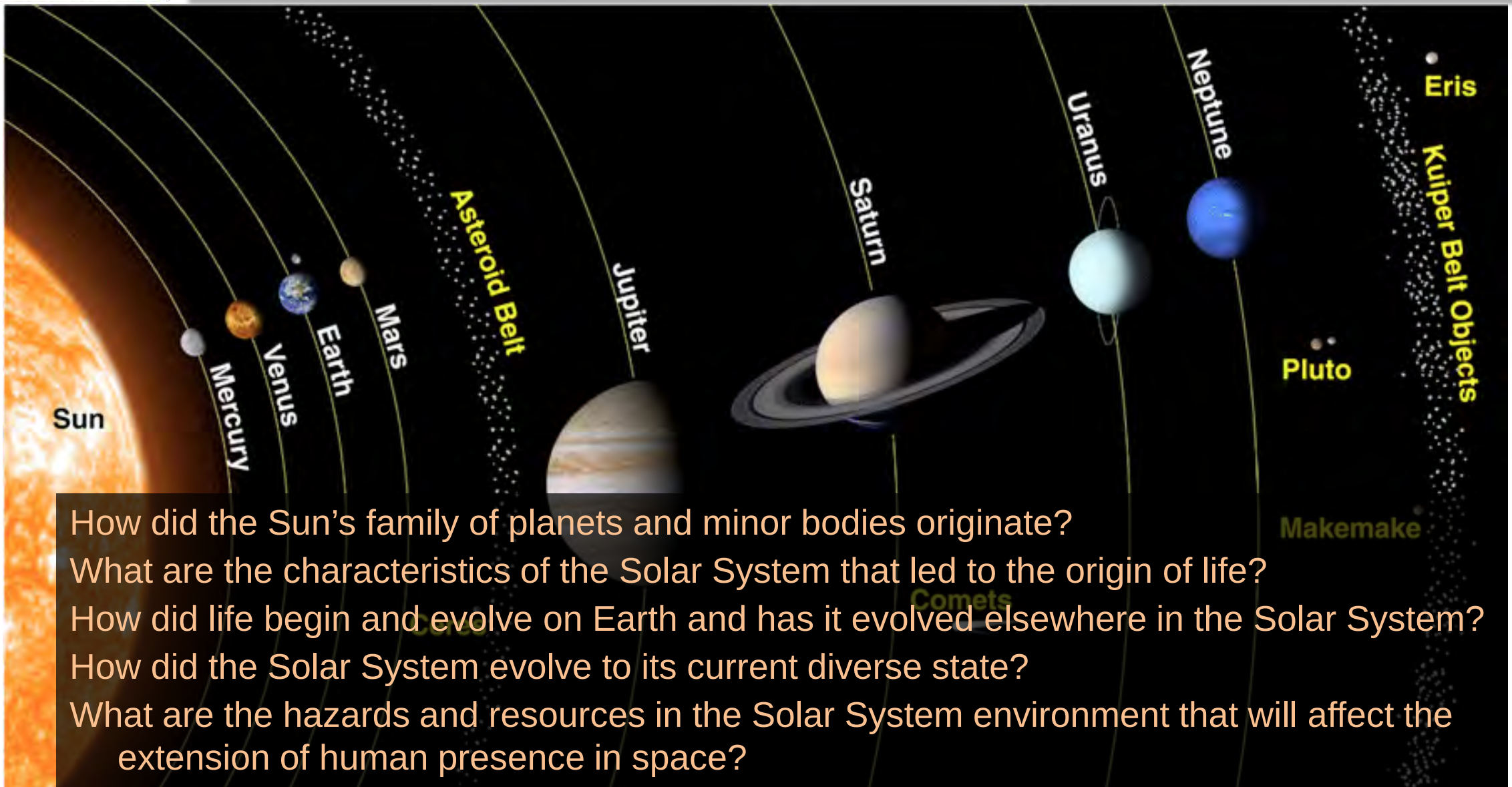
RESOURCE IDENTIFICATION — Can we use it for fuel?

SECURITY — Can we prevent an impact?

REGOLITH EXPLORER — Let's bring samples home!

The Mission's Principal Investigator!

THE ASTEROID BELT



How did the Sun's family of planets and minor bodies originate?

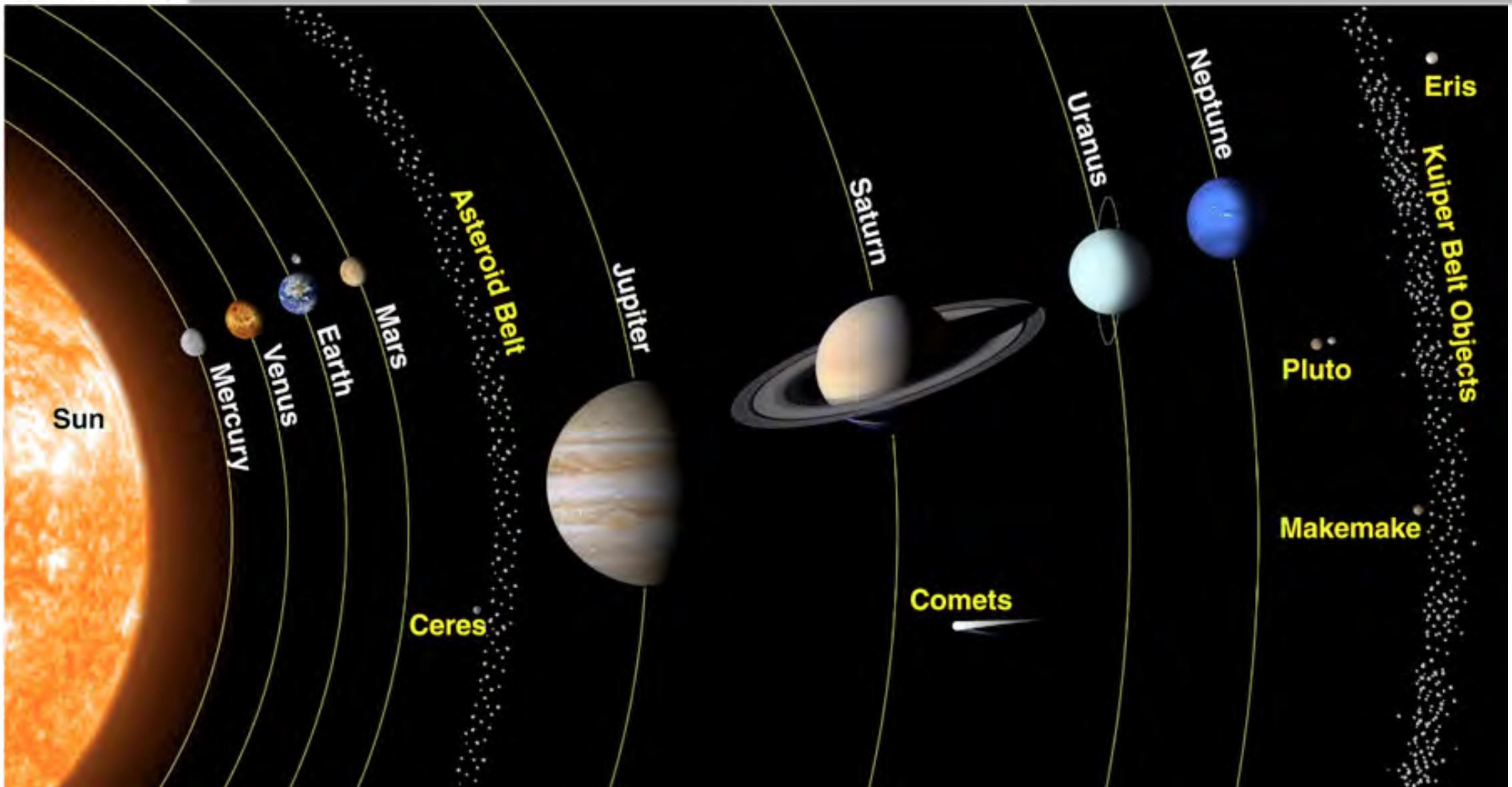
What are the characteristics of the Solar System that led to the origin of life?

How did life begin and evolve on Earth and has it evolved elsewhere in the Solar System?

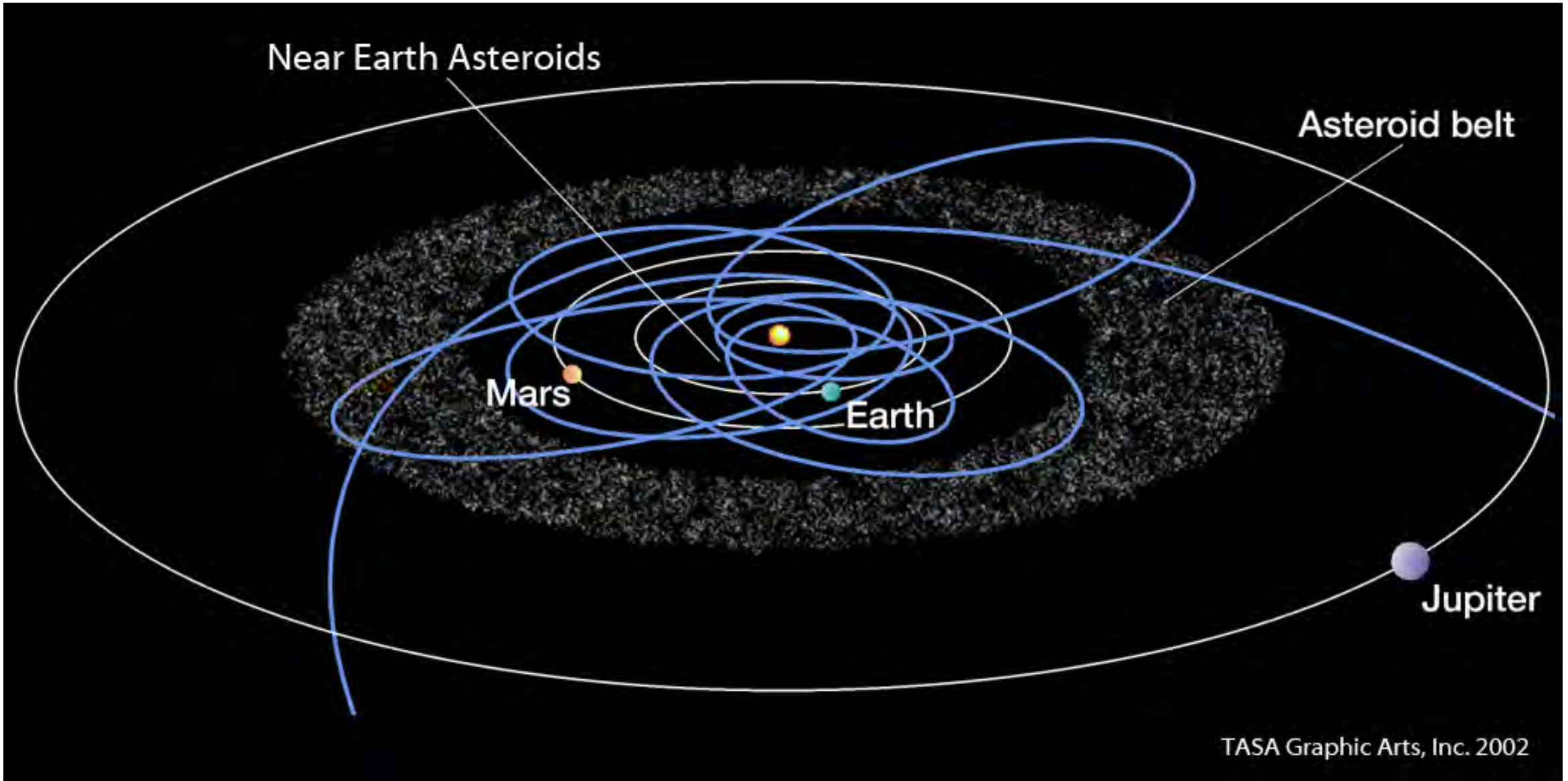
How did the Solar System evolve to its current diverse state?

What are the hazards and resources in the Solar System environment that will affect the extension of human presence in space?

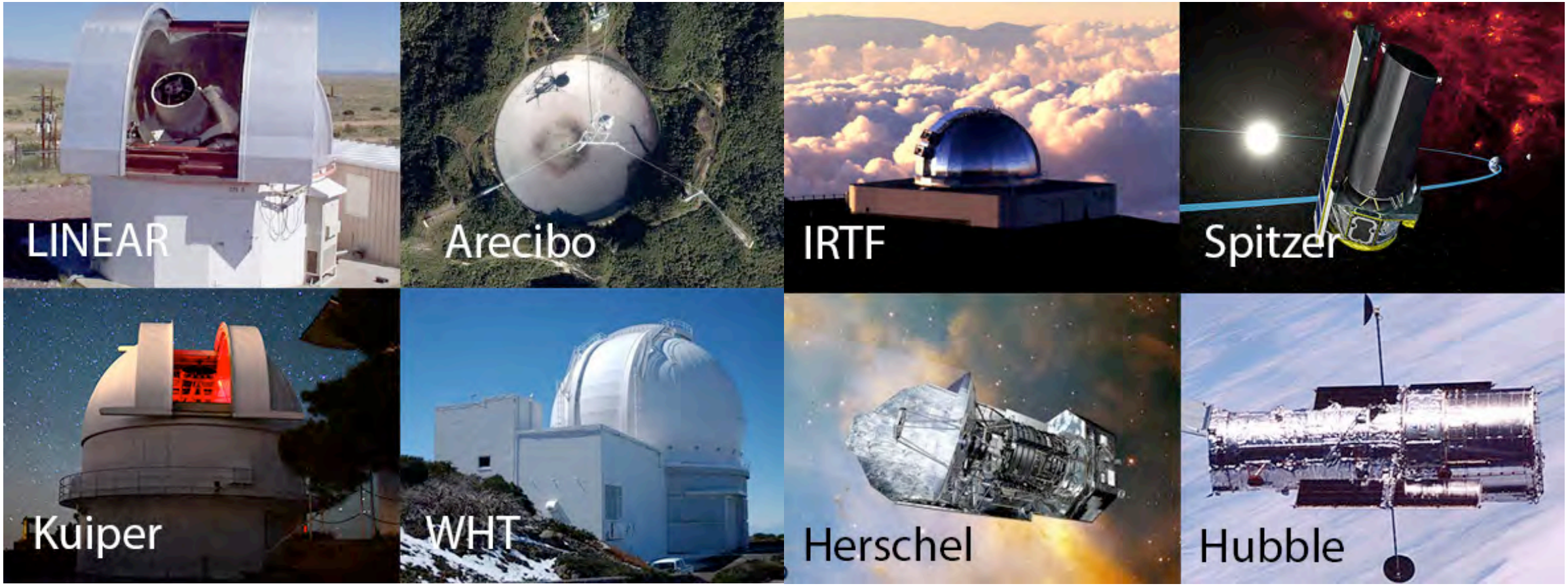
THE ASTEROID BELT



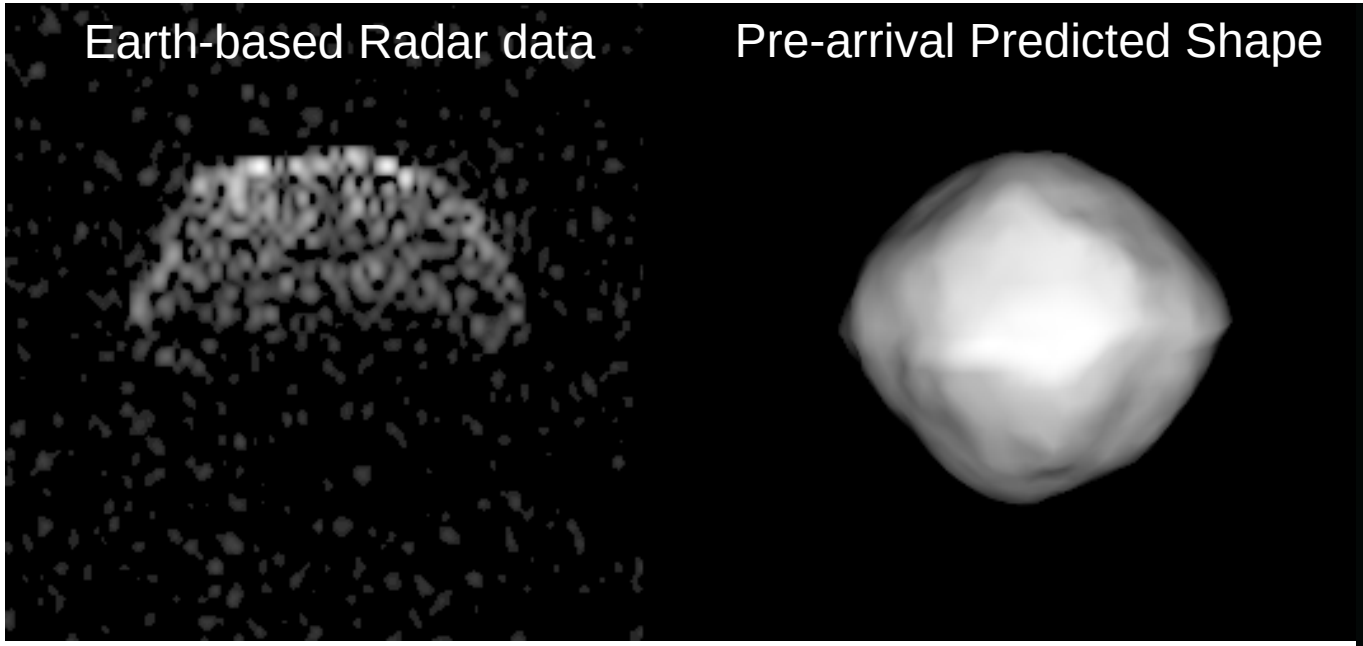
NEAR-EARTH ASTEROIDS

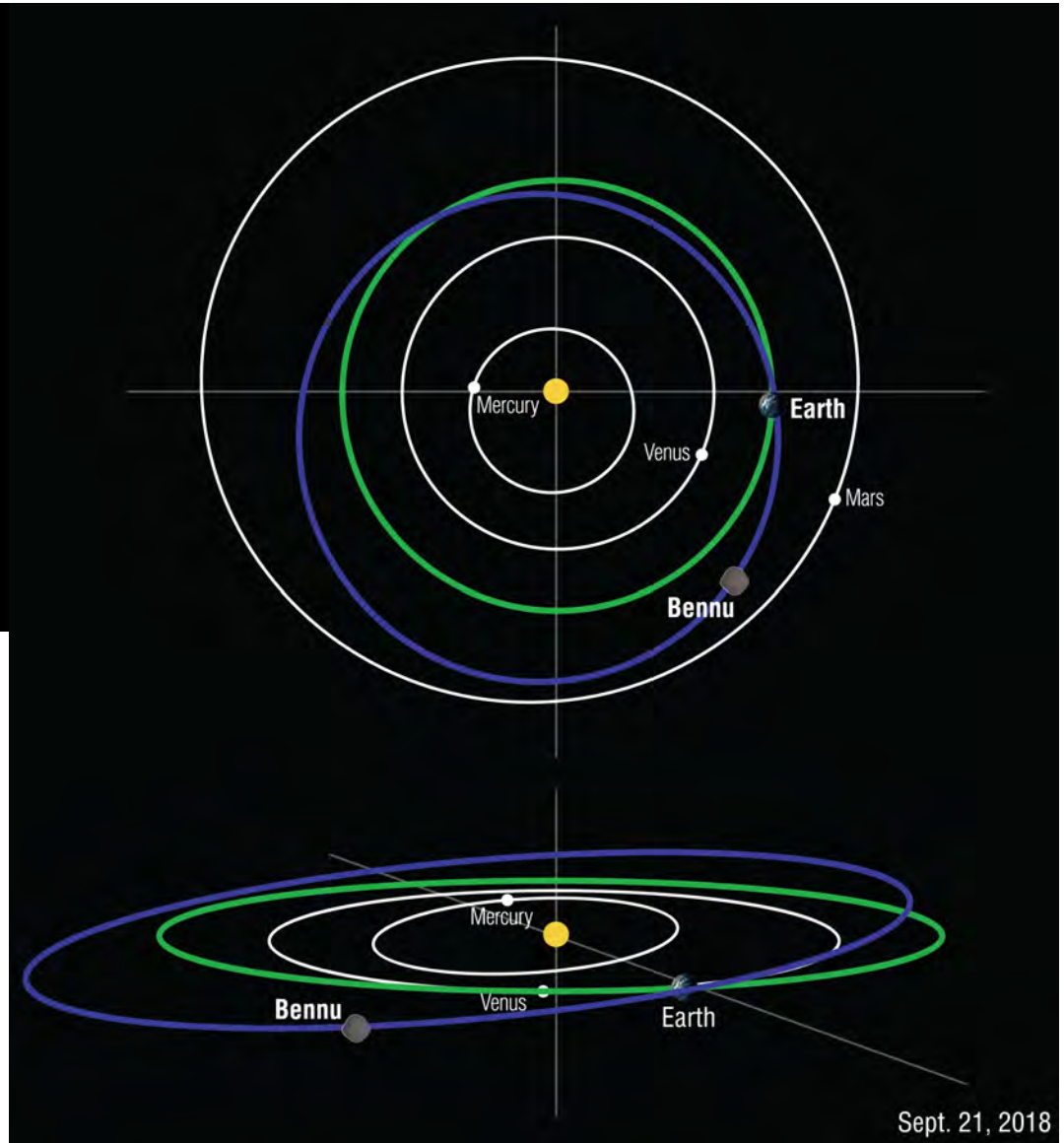


TELESCOPES ON EARTH AND IN SPACE



ASTEROID BENNU IS VERY WELL CHARACTERIZED





Size = ~500 m

Shape = spheroidal “spinning top”

Rotation state = 4.3 hr period

How Tall is Asteroid Bennu?

~510 m

443 m

324 m

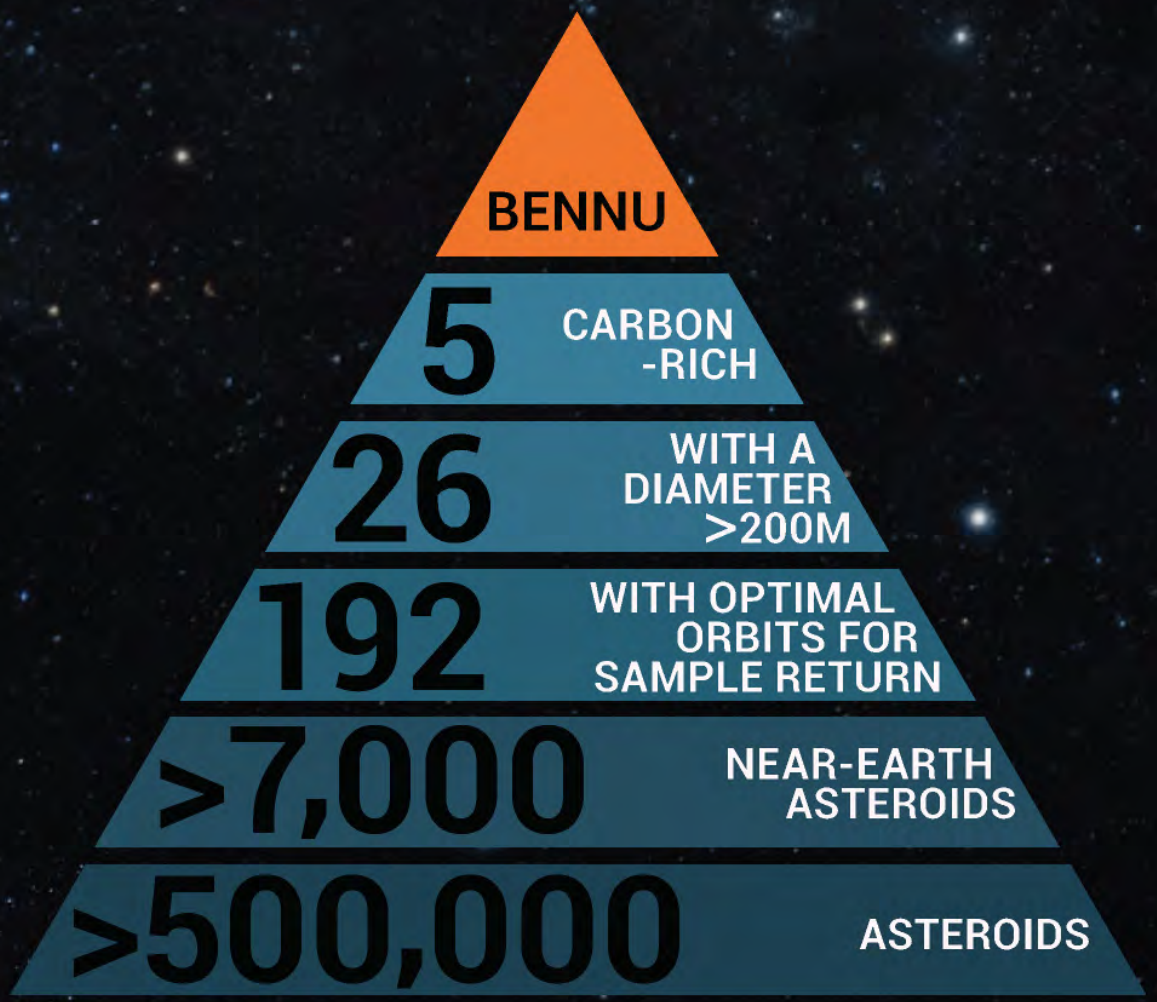
Bennu

Empire State Building

Eiffel Tower

November 22, 2016

How Was Asteroid Bennu Chosen?



CHARACTERISTICS: Proximity to Earth, orbit, and size

COMPOSITION: Bennu is primitive and carbon-rich (expected to have organic compounds and water-bearing minerals like clays)

POTENTIAL FOR ORGANICS: We hope to find organic molecules on Bennu like those that may have led to the origin of life on Earth!

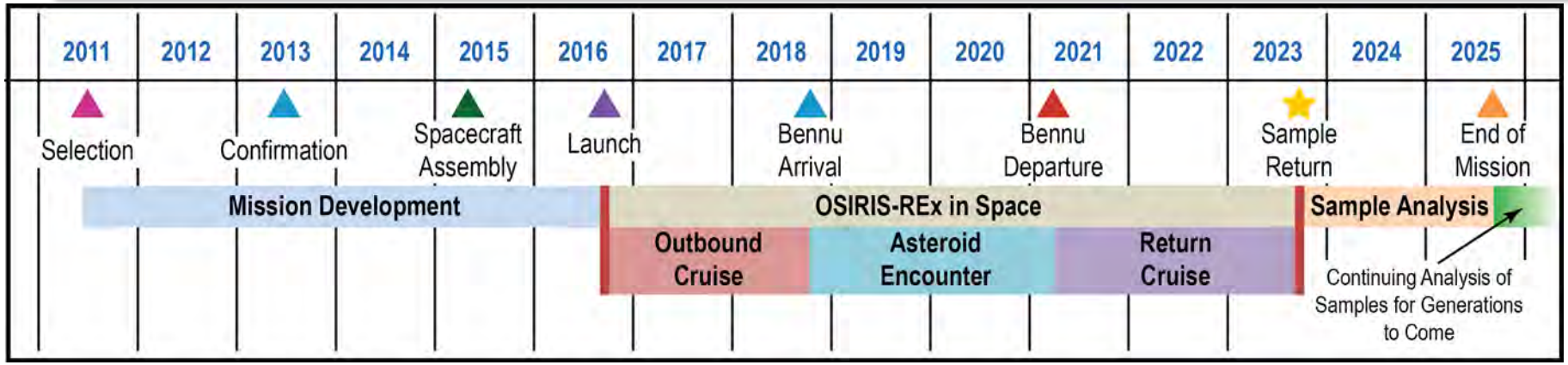
Osiris – The Mythology

- Osiris was an Egyptian god-emperor, son of the sky and Earth
- He brought agriculture, and therefore life, to the world
- Likewise, **OSIRIS-REx** seeks to return samples of an asteroid that may contain organics that led to the origin of life on Earth

Asteroid (101955) 1999 RQ36 is now . . .

- **Bennu!** The name was selected in an international contest run by the Planetary Society
- Bennu is an Egyptian mythological bird that was born from the heart of Osiris
- It is associated with the Sun, creation, and renewal

Mission Timeline



- Selection: May 25, 2011
- Confirmation: April, 2013
- Spacecraft Assembly: February, 2015
- Launch: September, 2016
- Bennu Arrival: August, 2018
- **TAG!!! October 20, 2020**
- Bennu Departure: March, 2021
- Sample Return: September, 2023
- End of Mission and Sample Analysis: September, 2025

Building the Spacecraft!

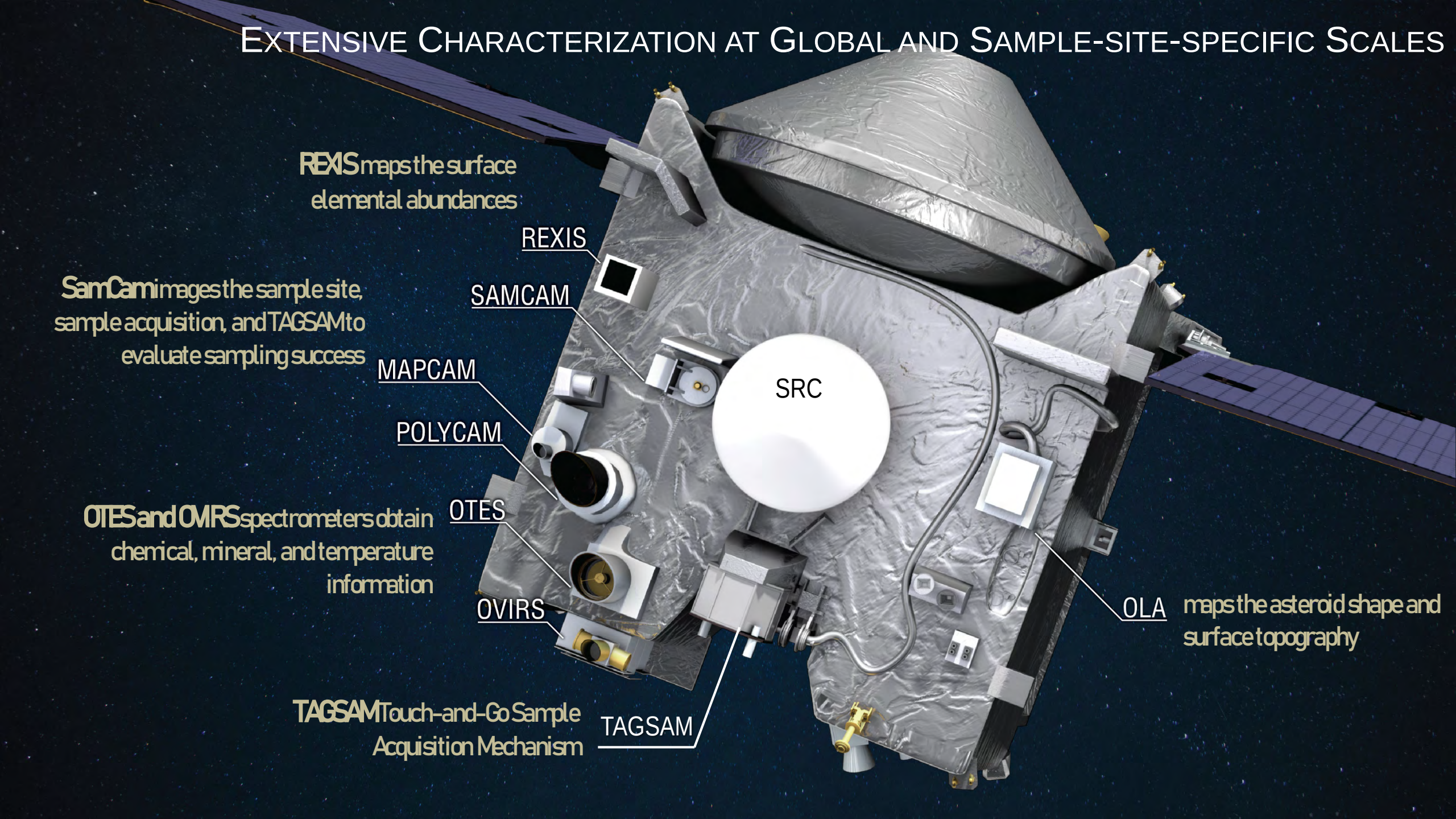
Length: 20.25 ft with solar panels deployed

Width: 8 ft

Height: 10.33 ft ~Size of 15 passenger van

Weight:1940 lbs without fuel

Extensive Characterization at Global and Sample-site-specific Scales



Launch – September 8, 2016

First Images – August 17, 2018

Here the spacecraft is 15 miles away from Bennu!

PolyCam Image Mosaics
December 2, 2018
33 centimeters/pixel

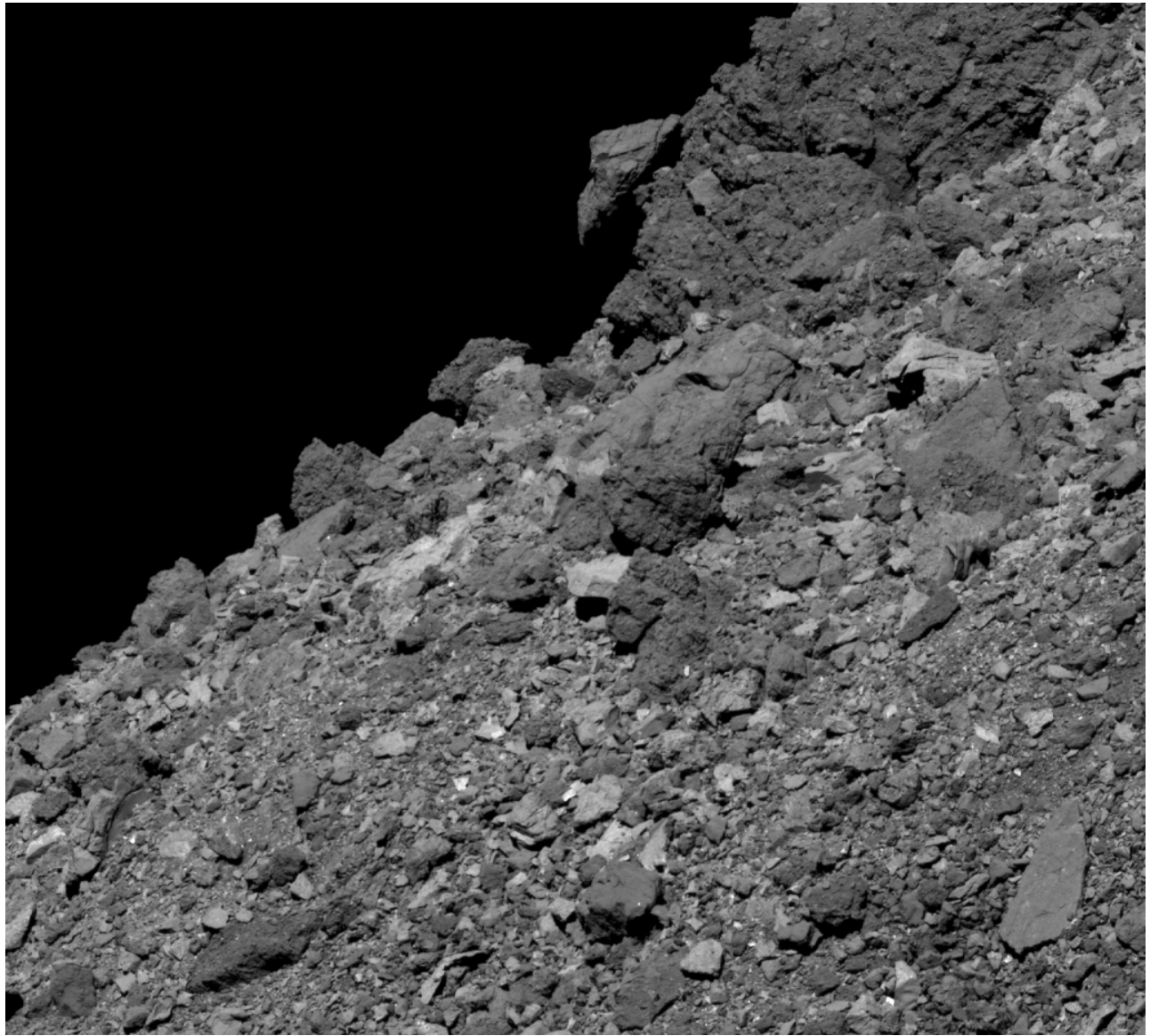
OSIRIS-REx mapped Bennu all of 2019, which allowed scientists to make lots of interesting observations

What observations can you make about Bennu?

LIST YOUR OBSERVATIONS IN THE CHAT.

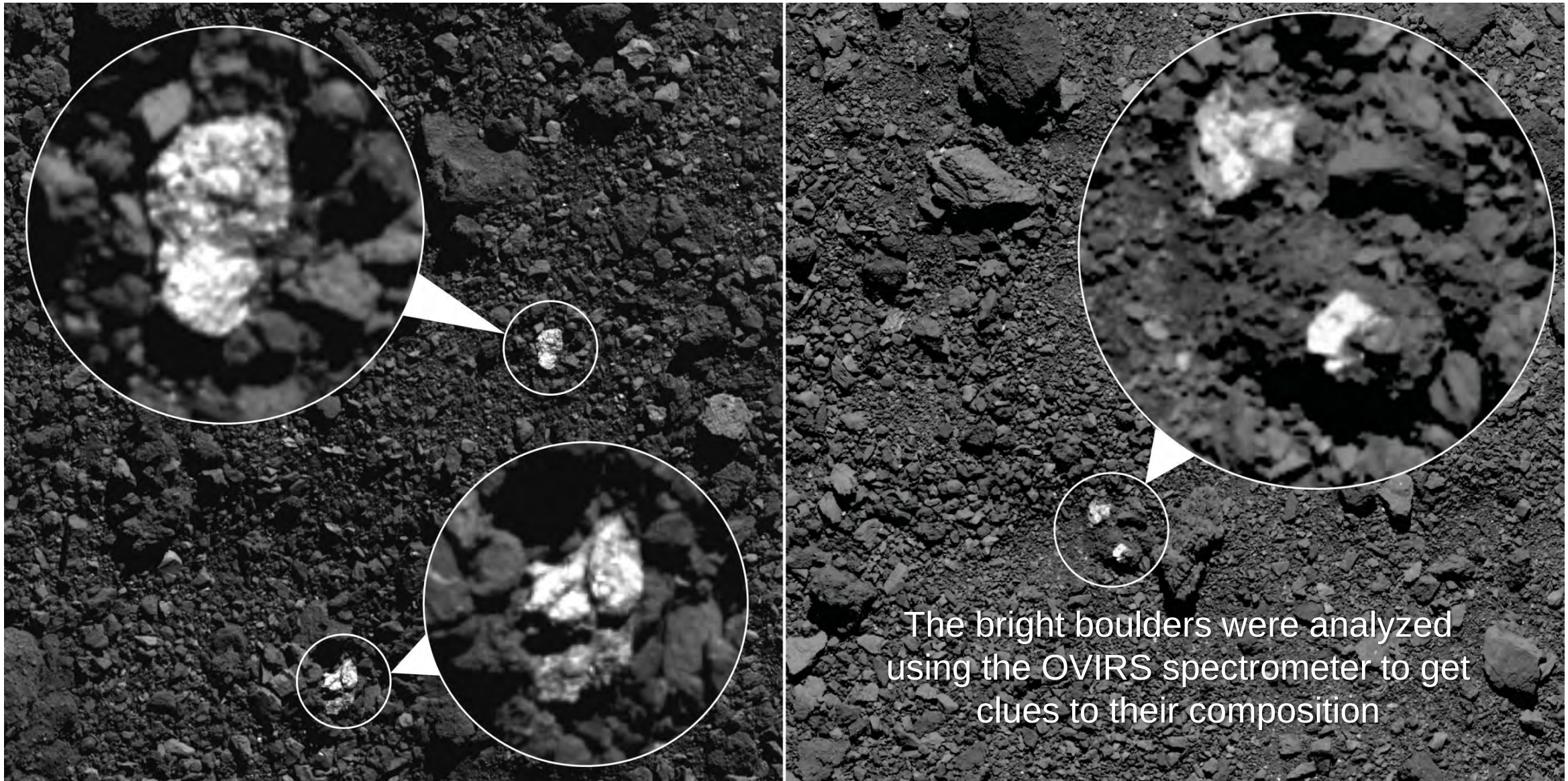
Surprise! Bennu is very rocky!

- Scientists expected Bennu's surface to be fine-grained, like a sandy beach…
- Instead OSIRIS-REx was greeted by a rugged world littered with boulders – the size of cars, the size of houses, the size of football fields
- The largest boulder on Bennu is called BenBen – as tall as 6 story building
- This makes sample collection more challenging

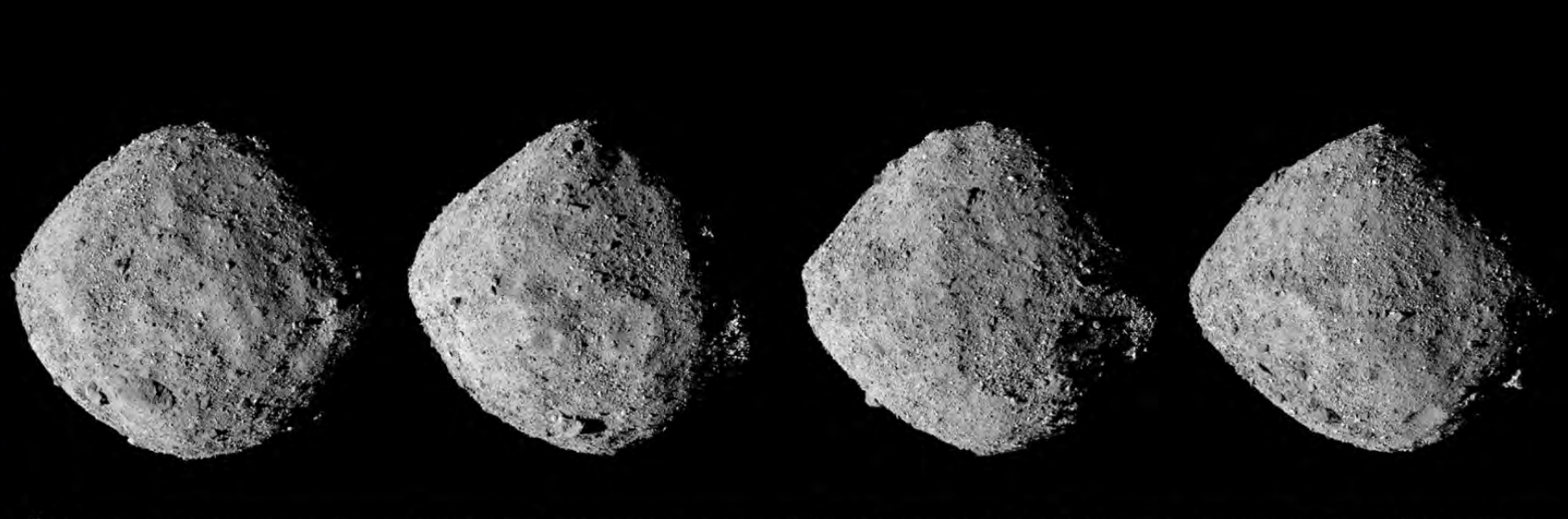


Surprise! Bennu is active!

Surprise! Bennu contains material from another asteroid!



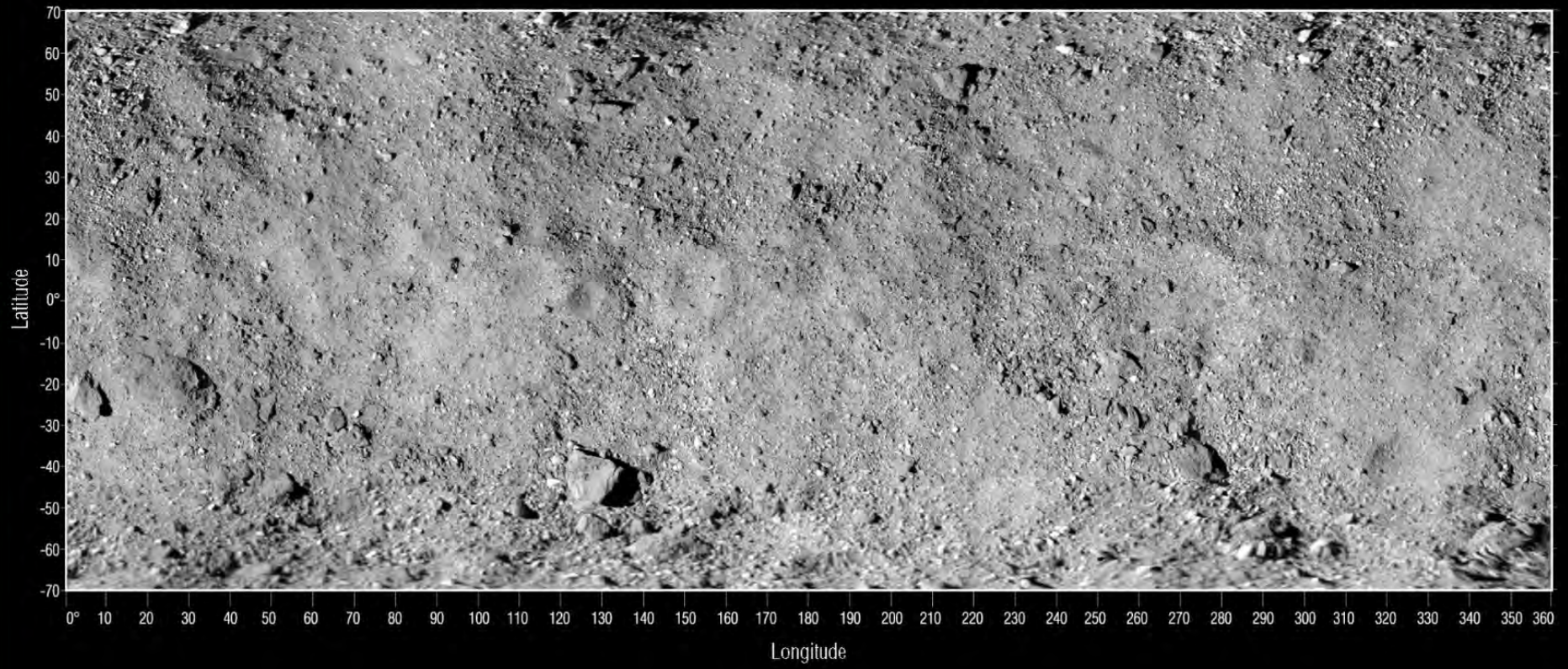
Rubble pile video



CHOOSING THE SAMPLE SITE:

What considerations do you think went into choosing a sample site on Bennu?

PUT YOUR ANSWERS IN THE CHAT.



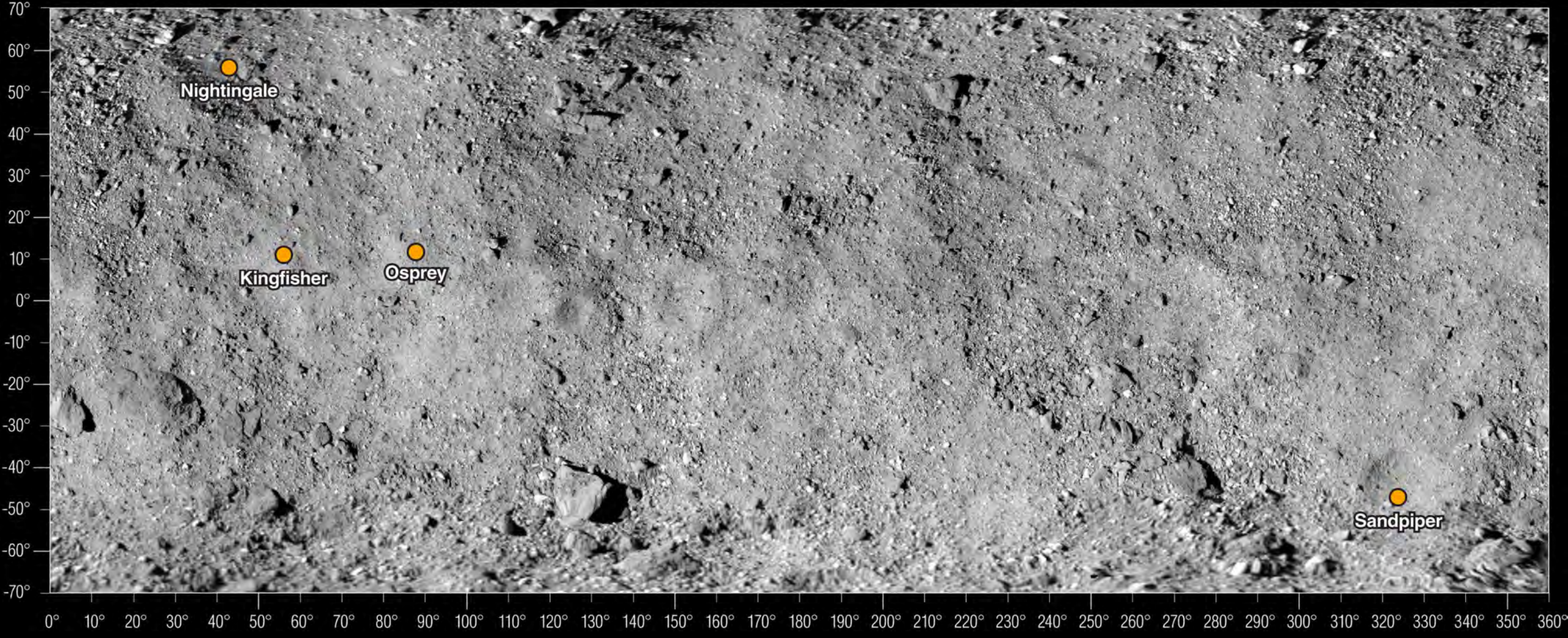
How did we choose the sample site?

Deliverability: The spacecraft must be easily maneuvered in and out of the site

Sampleability: The sample site must have rocks and debris 2 cm or smaller so the TAGSAM head can capture it

Safety: When the Touch and Go Sample Acquisition Mechanism (TAGSAM) head contacts the surface, the spacecraft must avoid any damage

Science Value: The sample site should have *pristine regolith* with carbon-rich, diverse and primitive materials, and hydrated minerals


Nightingale
Kingfisher
Osprey
Sandpiper
70°
60°
50°
40°
30°
20°
10°
0°
-10°
-20°
-30°
-40°
-50°
-60°
-70°
0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180° 190° 200° 210° 220° 230° 240° 250° 260° 270° 280° 290° 300° 310° 320° 330° 340° 350° 360°

☑ 

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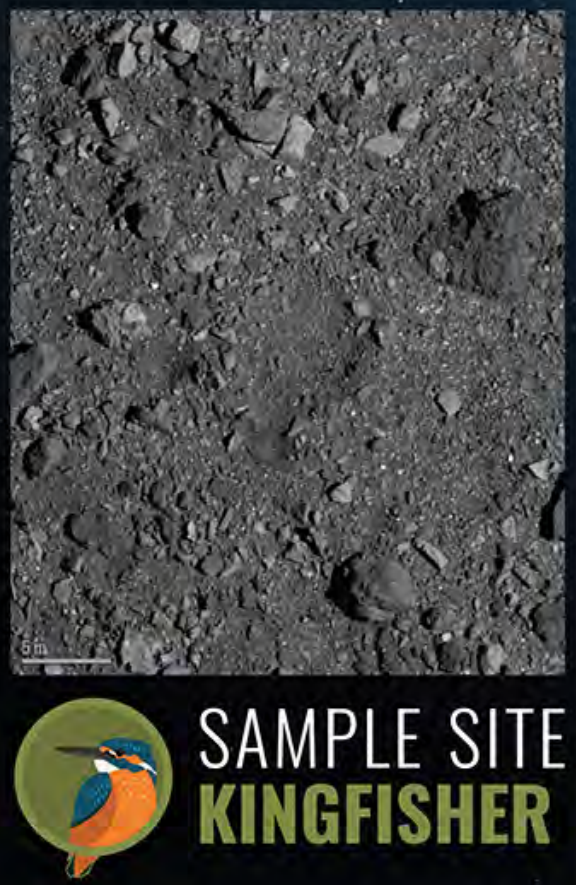
https://it-it.facebook.com/OSIRISREx/videos/463578204487051/

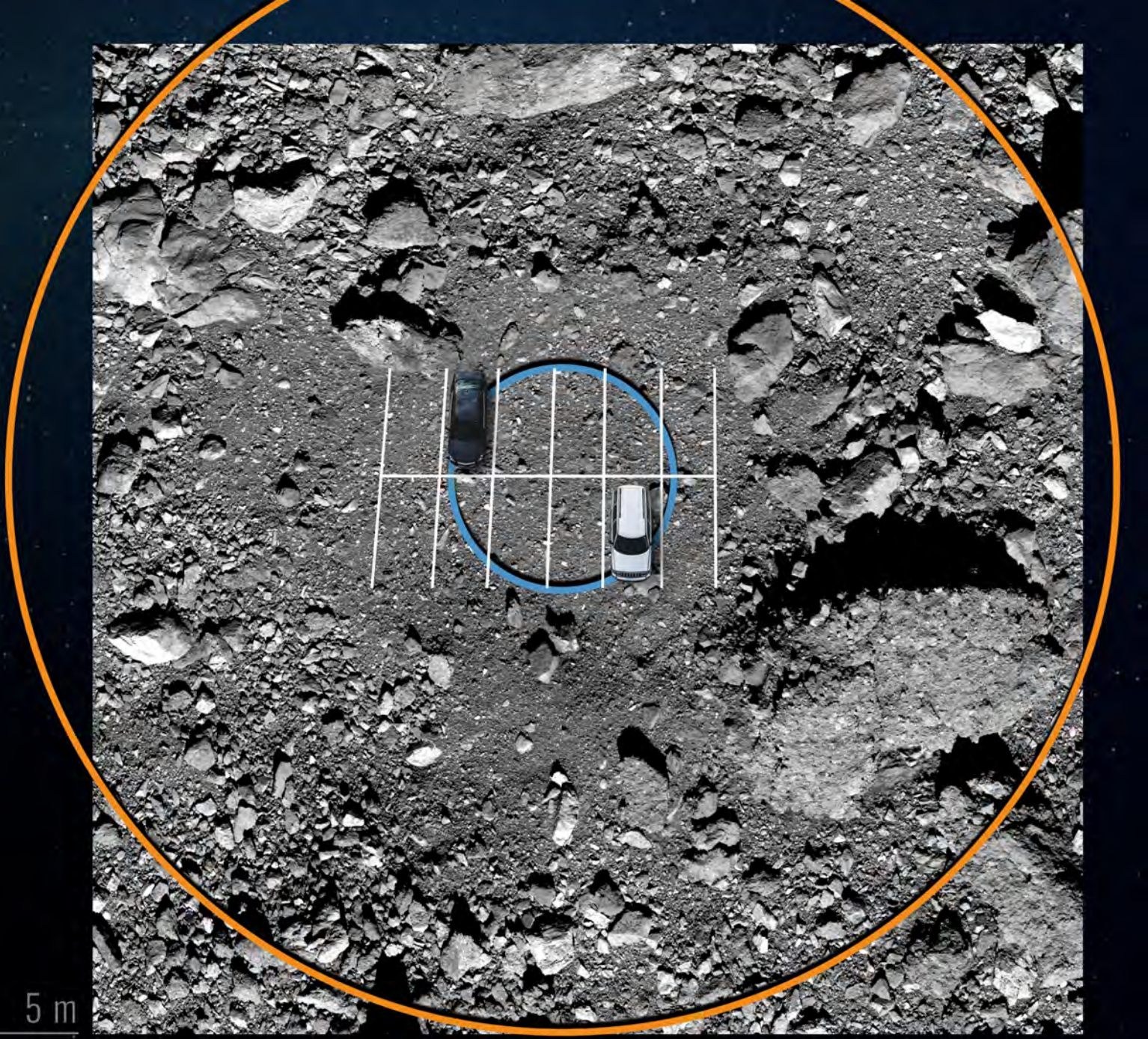


Which sample site would you choose as the primary sample site & **WHY**?

PUT YOUR ANSWERS IN THE CHAT.

SAMPLE SITE
NIGHTINGALE

OSIRIS-REx PRIMARY SAMPLE SITE

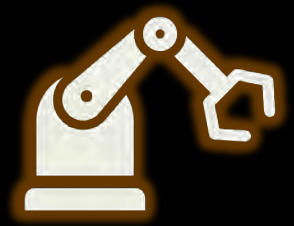


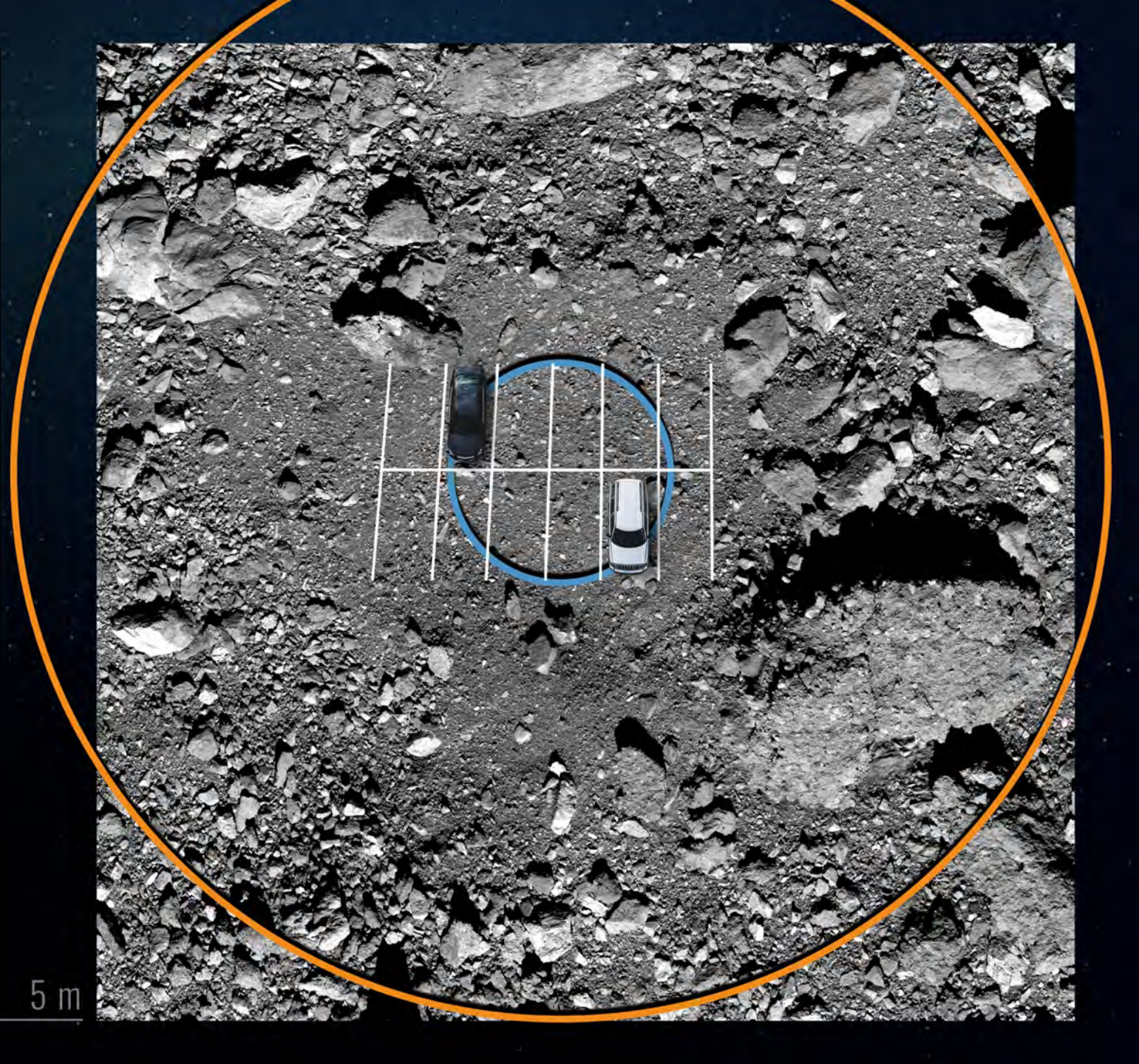
5 m

- Site is as big as a few parking spots or a tennis court and is surrounded by building-sized boulders

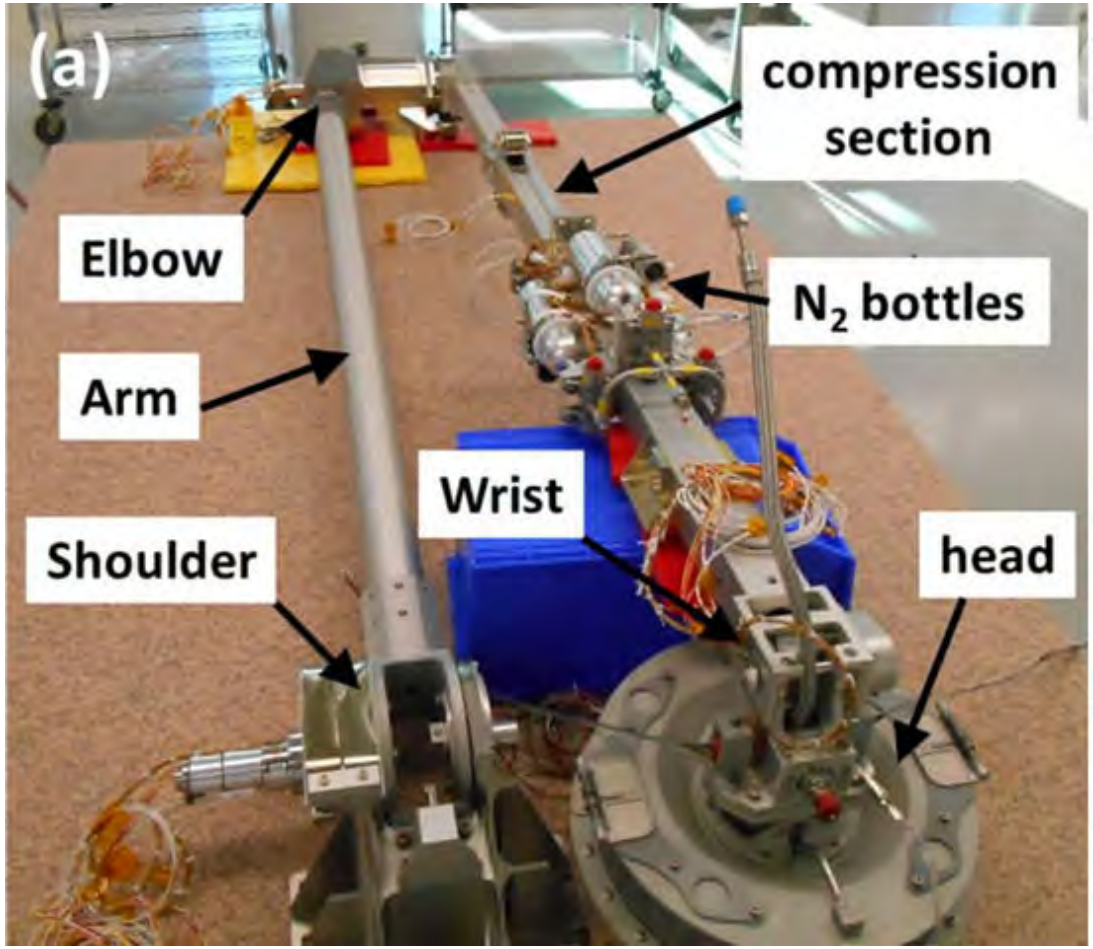
- Nightingale contains mostly fine-grained, dark material
- Nightingale also has the highest color variation, which suggests diverse materials

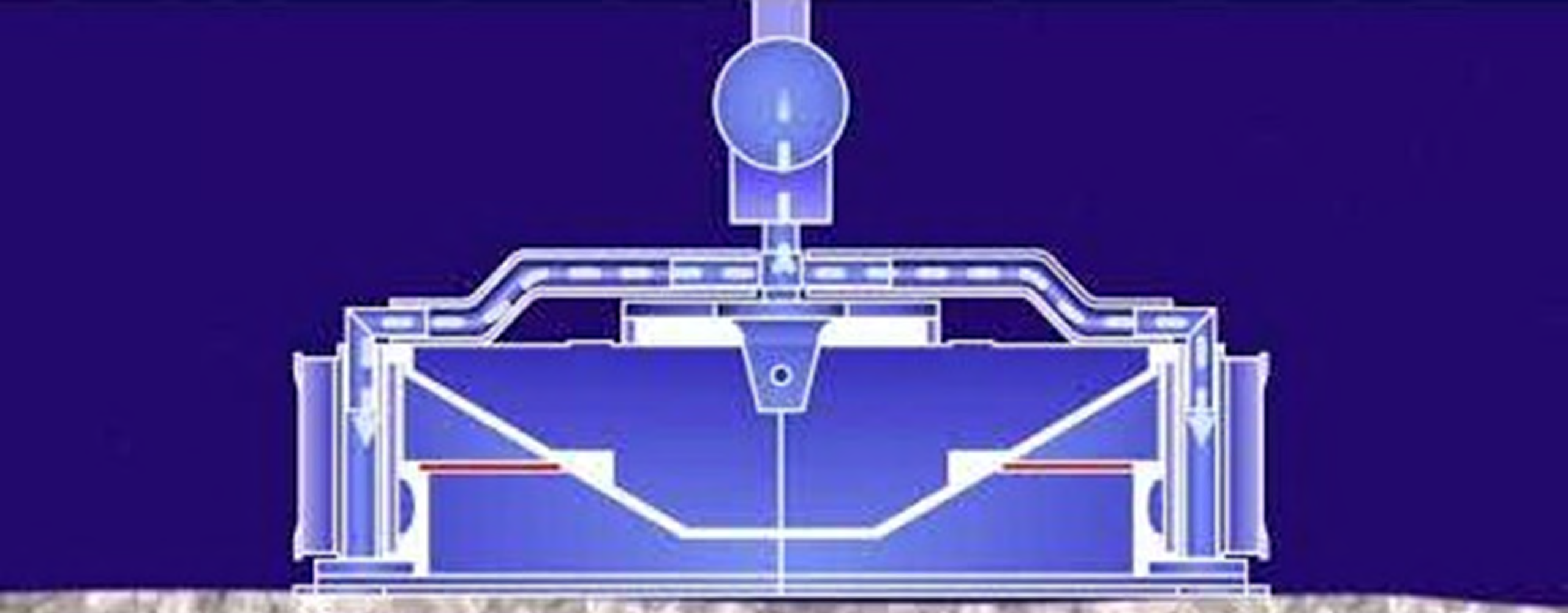
- We have the site, now how do we get the sample?





Touch-and-Go Sample Acquisition Mechanism (TAGSAM)

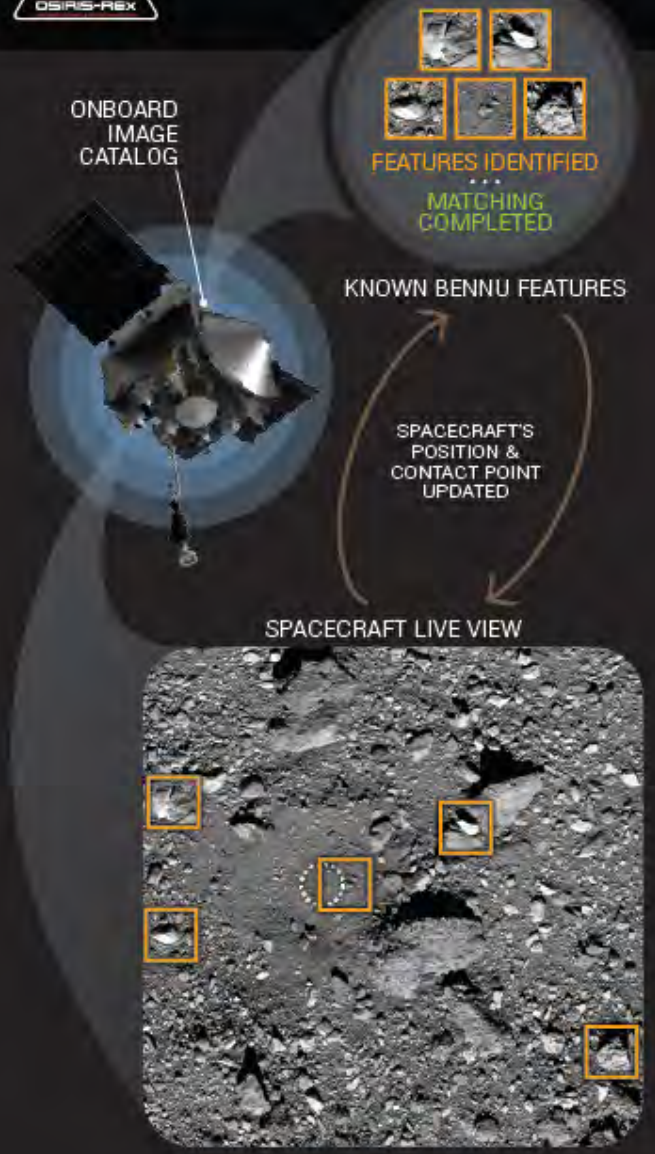


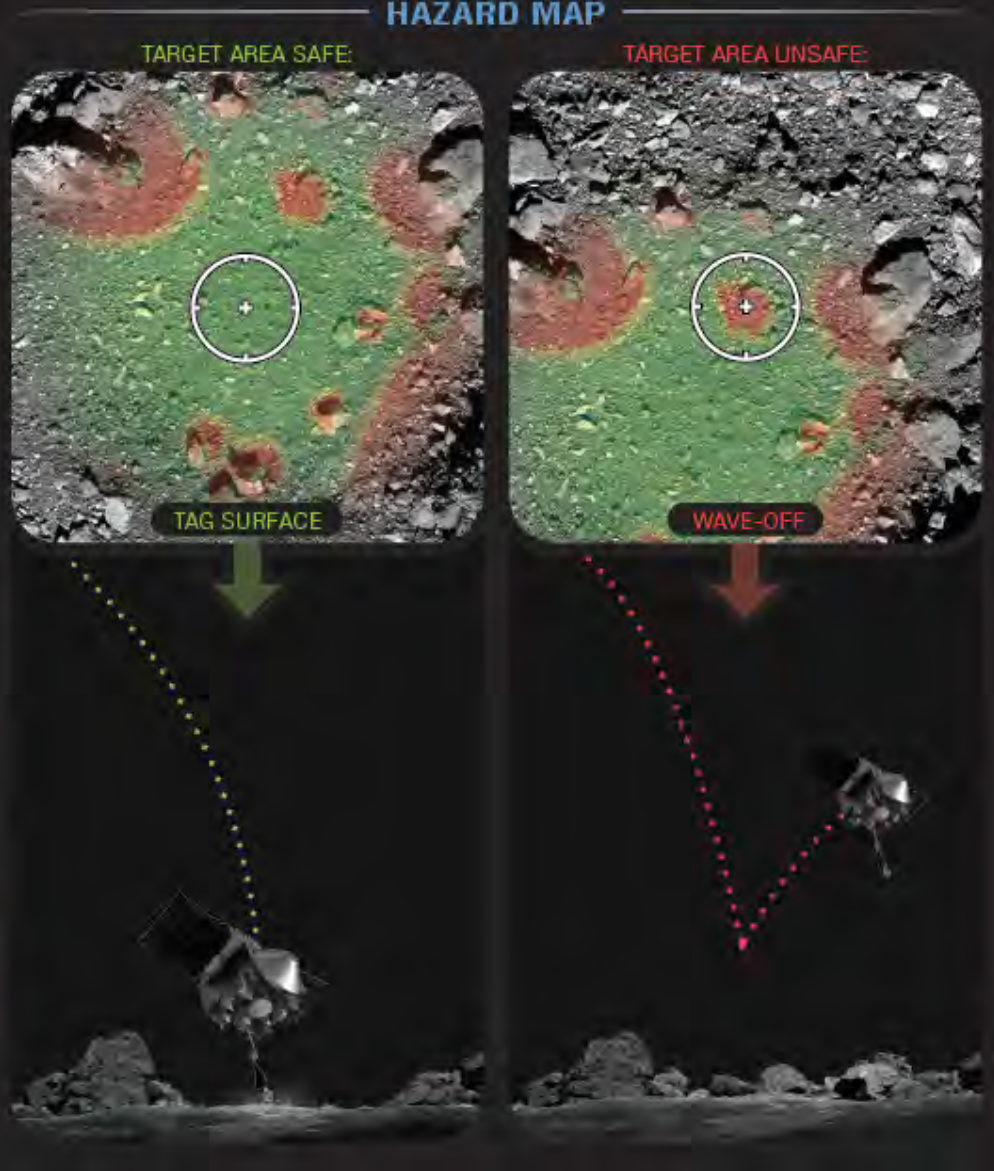


https://www.youtube.com/watch?v=NjlGYHJ2560&feature=youtu.be

NATURAL FEATURE TRACKING

NAVIGATION DURING SAMPLE COLLECTION



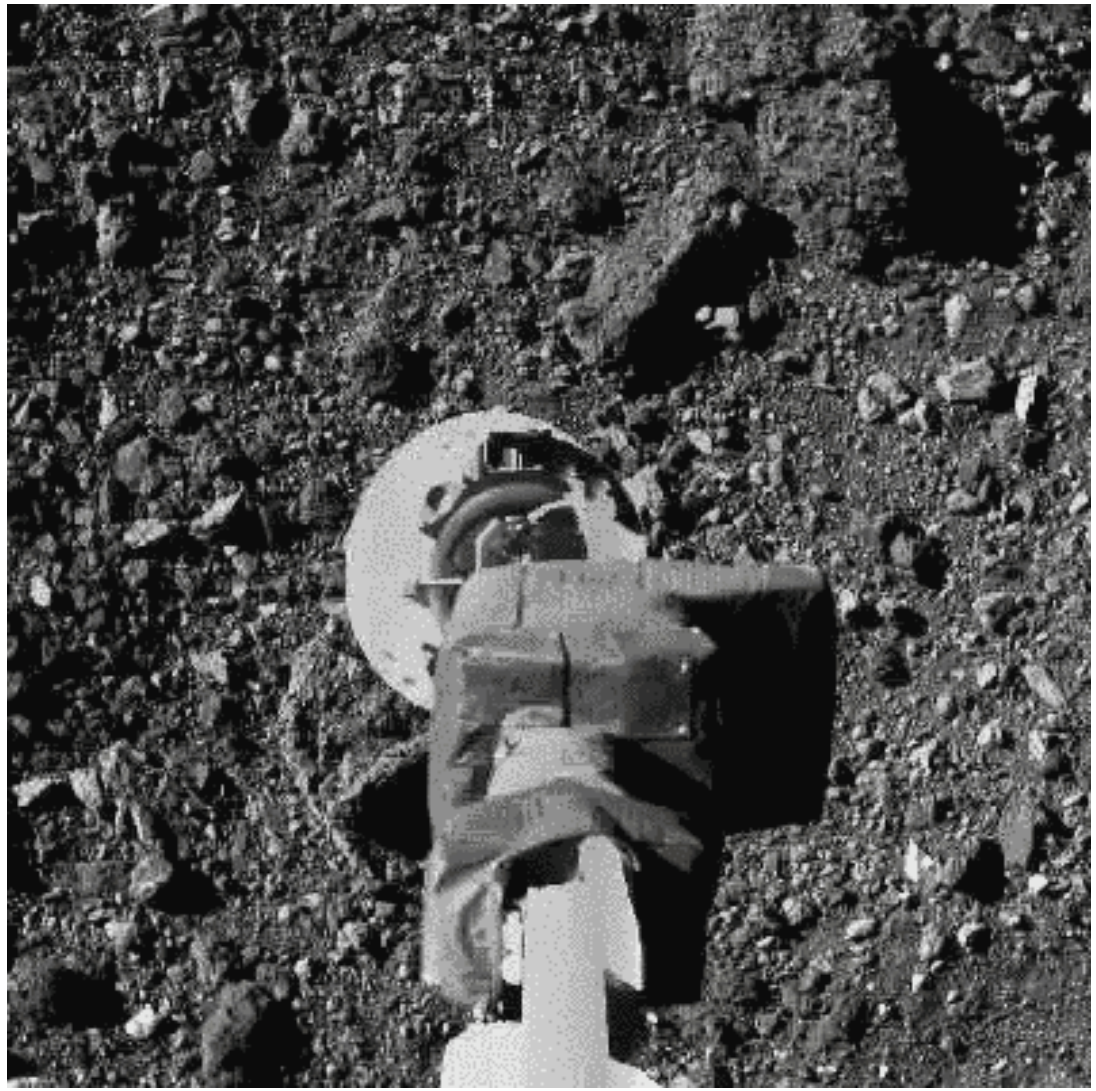


Touch And Go rehearsals!

Two rehearsals

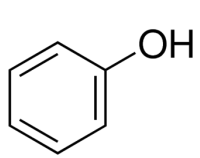
April 14 and August 11, 2020

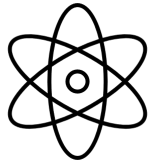
View of TAG from the SAMCAM

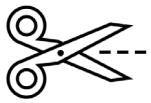


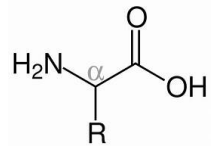
A big international team

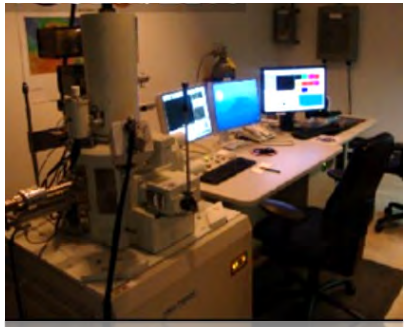
Sample analysis by scientists at NASA JSC



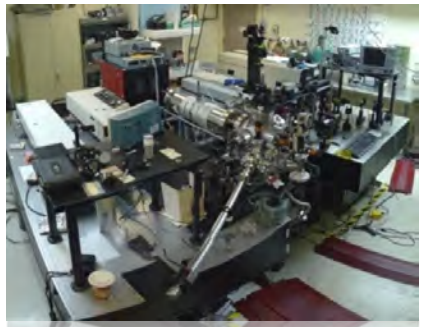




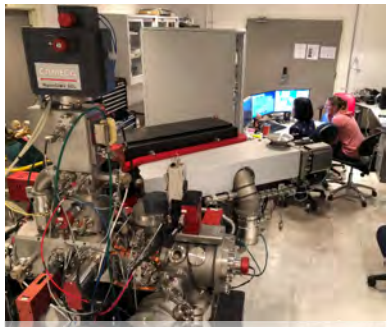




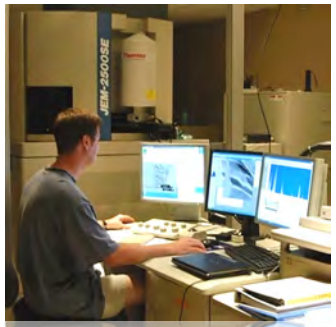
Chemistry



Organic mapping



Isotopes



Crystallography

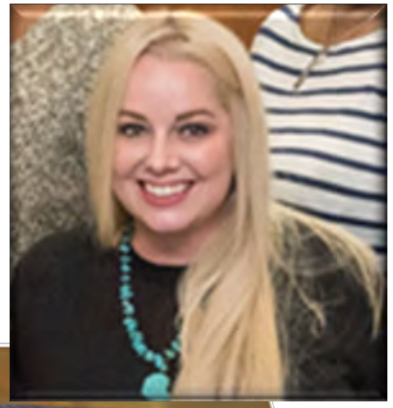
Sample extraction

Organics

Curation at NASA JSC is the first step!



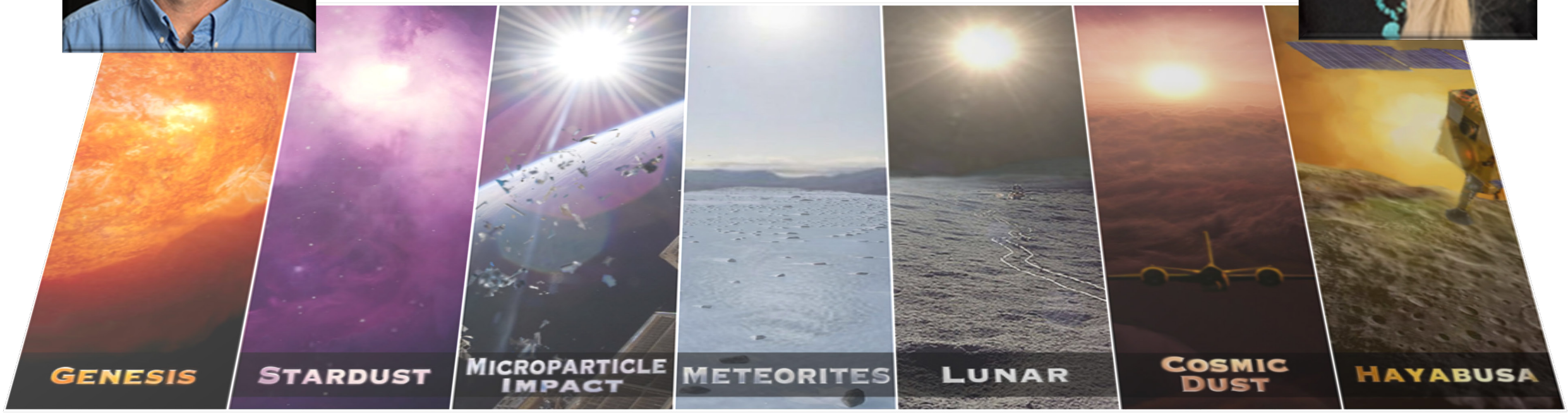




JSC OSIRIS-REx Curation Team



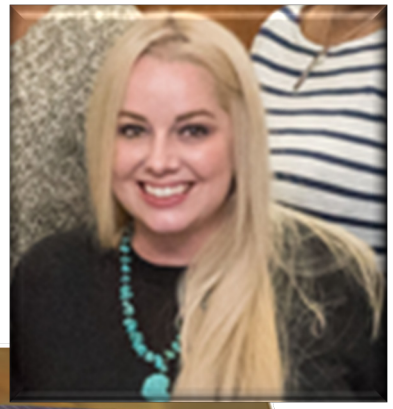




JSC OSIRIS-REx Curation Team



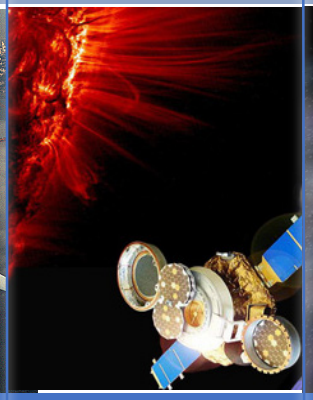
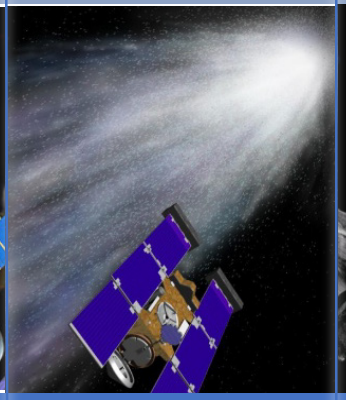
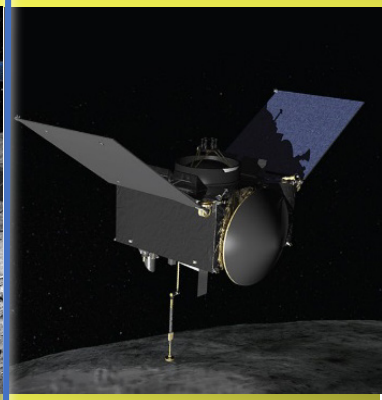
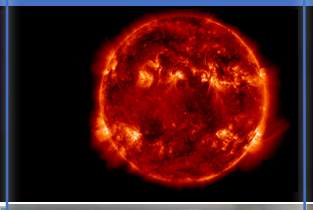
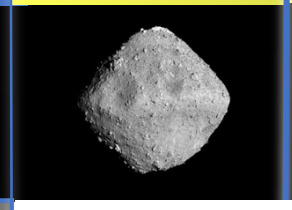
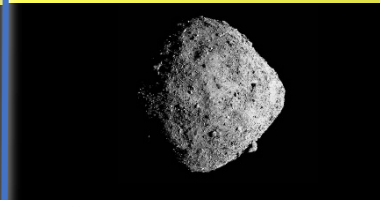
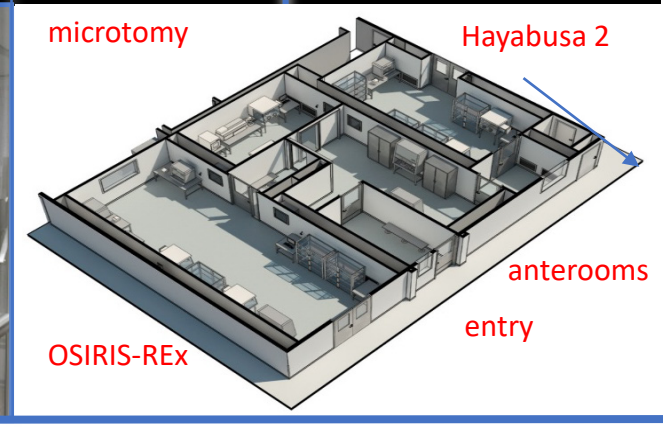




What does an Astromaterials Curator do?

PUT YOUR ANSWERS IN THE CHAT.

Astromaterials Curation at NASA JSC

1969	1978	1981	2004	2006	2011	2021	2023
6 Apollo Mission Lunar Rocks	US Antarctic Meteorites	Stratospheric Cosmic Dust	GENESIS	STARDUST	HAYABUSA 1	Hayabusa2	OSIRIS [redacted]
							
Various sites on Moon	Asteroids/ Moon /Mars	Comets / Asteroids	Solar wind @ L1 point	Comet Wild2	Asteroid Itokawa	Ryugu	Bennu
							
							

JSC Curation Role in OSIRIS-REx

2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025

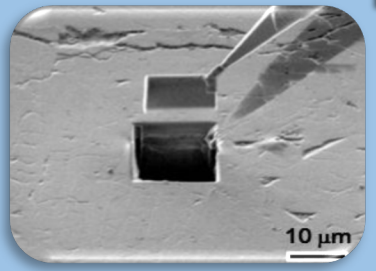
Phase B Phase C/D Phase E Phase F

1) Archiving for contamination control and knowledge

"CSI" in reverse

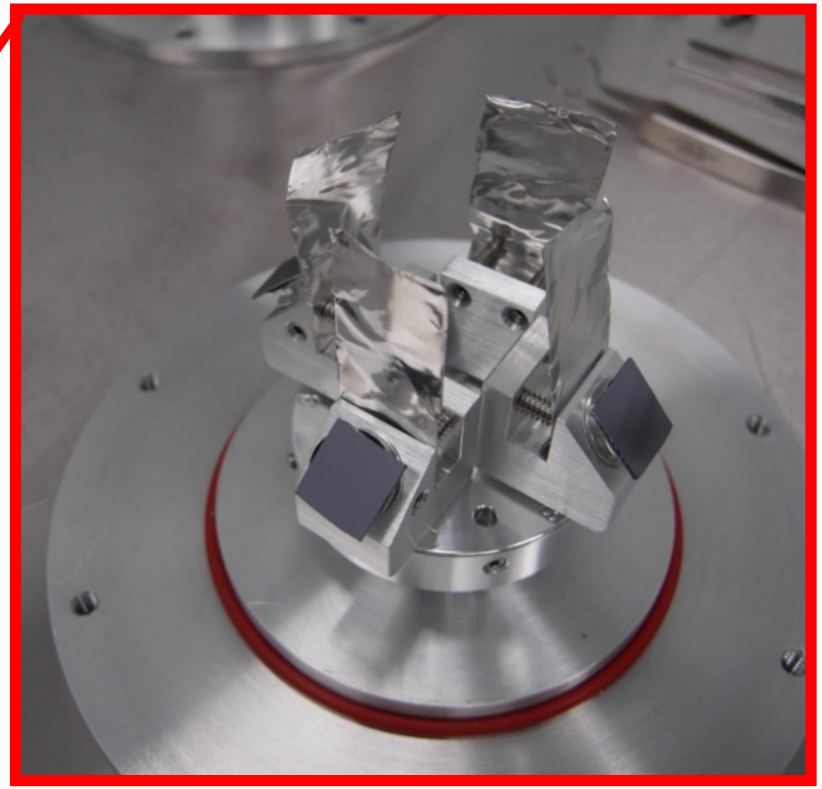
2) Establish new cleanroom (ISO5 / Class 100)

3) Sample Recovery



4) Preliminary Examination & 2 [illegible]

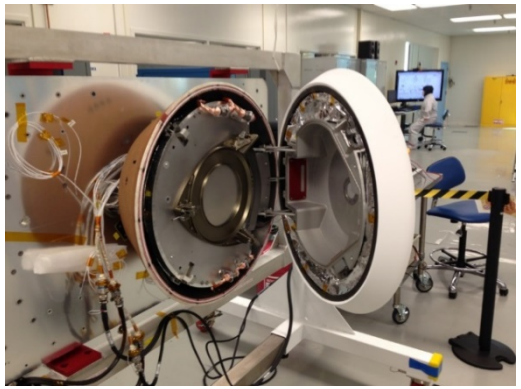
Contamination Control & Knowledge

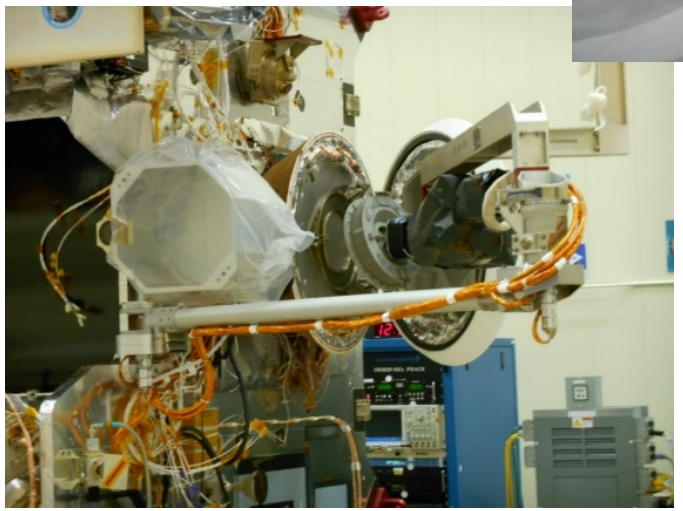


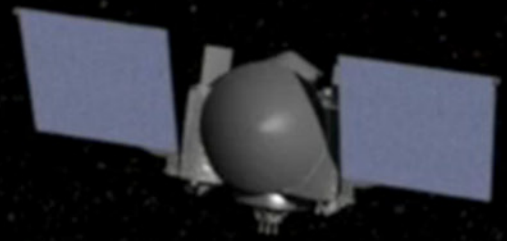
Witness plates from cleanrooms
Al foils
Si wafers

One of each immediately analyzed and the rest archived

Materials Archive and Witness Plates: Contamination Control & Contamination Knowledge

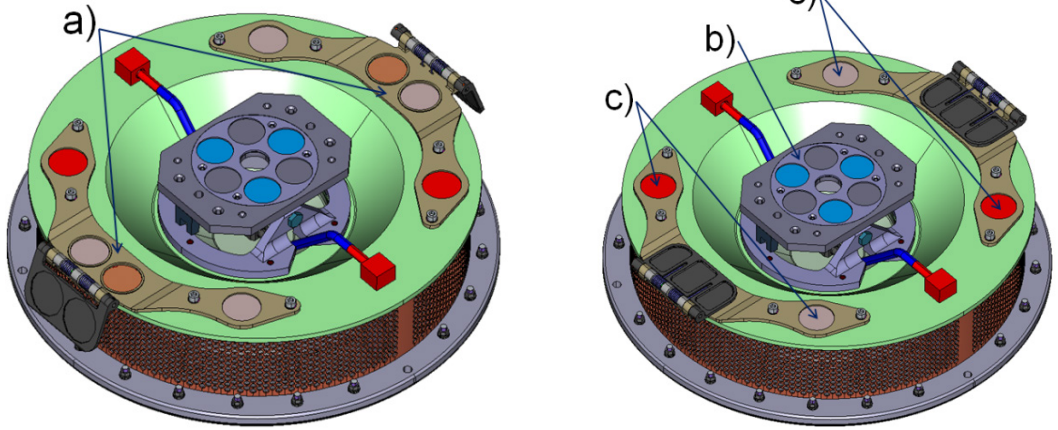






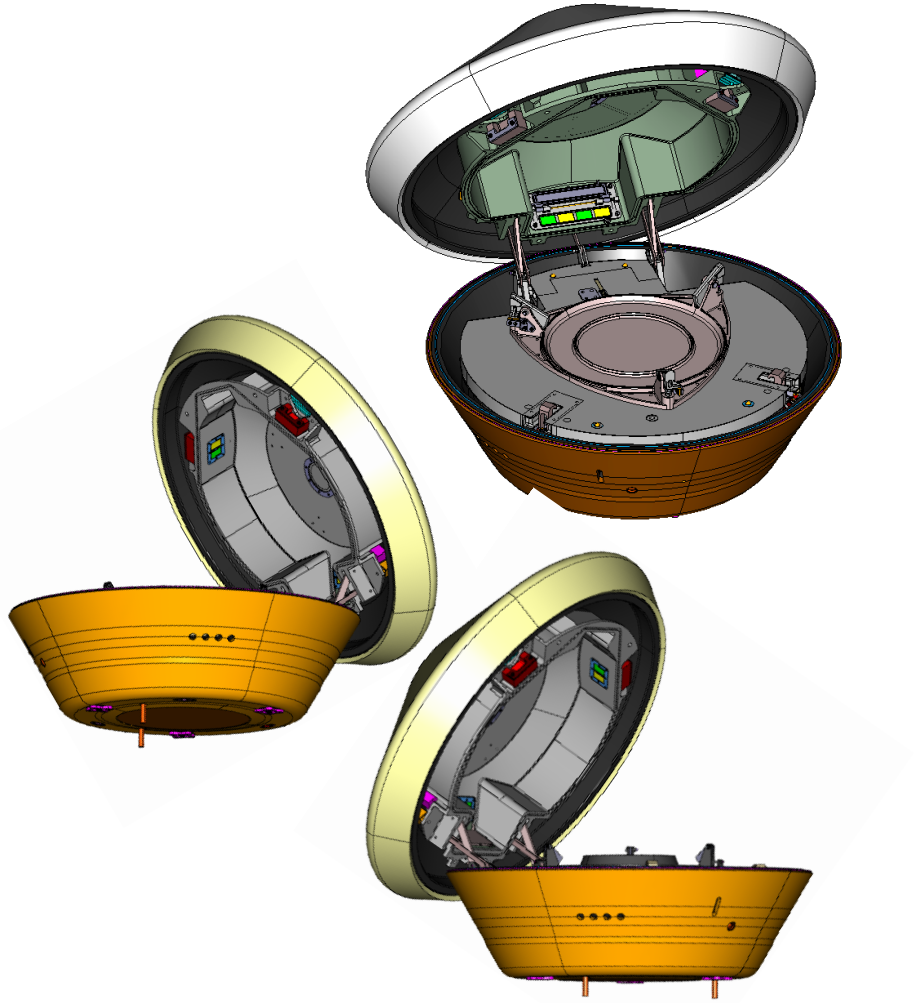
Bennu Arrival - August 2018

More Witness Plates



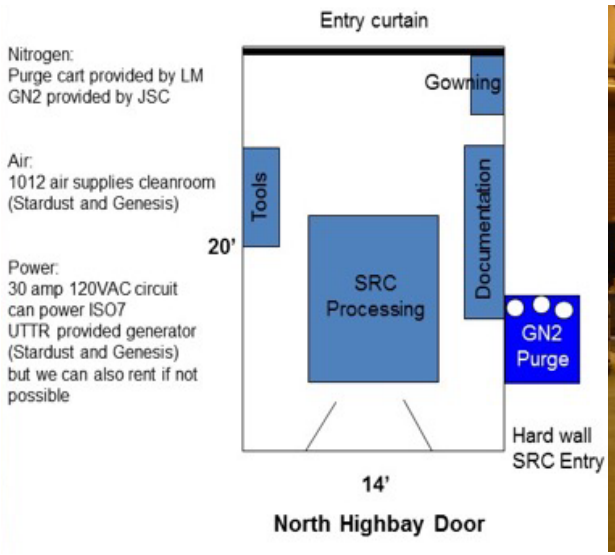
Collect contamination knowledge during flight operations

Sample Return Capsule



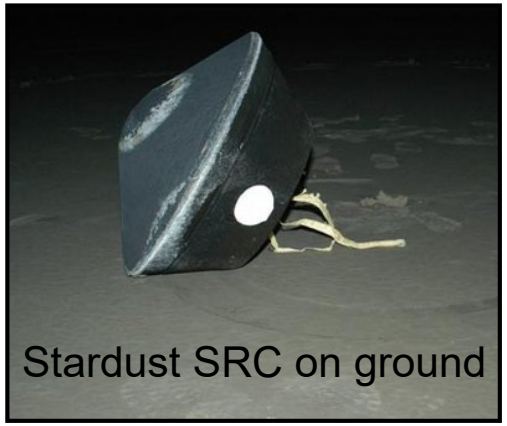
Recovery in Utah – Curation scientists working with Lockheed


Recovery rehearsals at UTTR



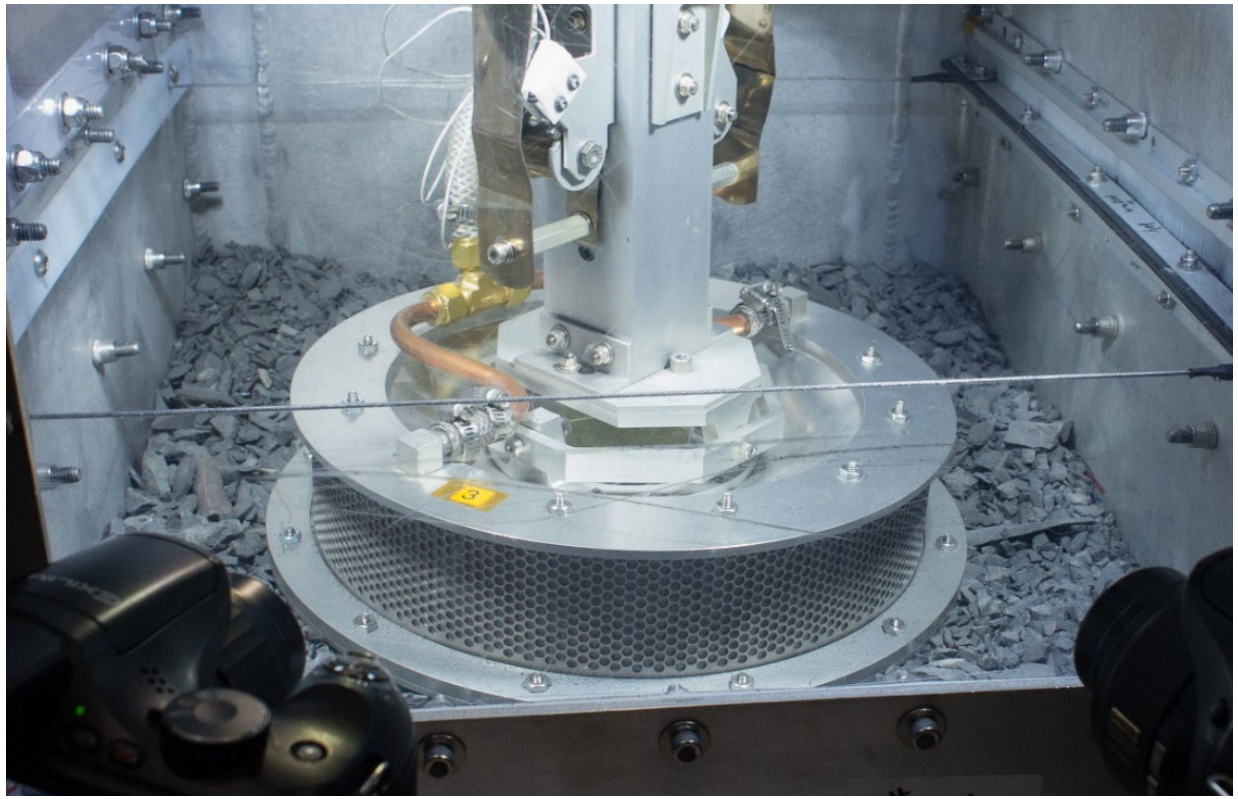

Portable Cleanroom
at UTTR – Genesis 2004

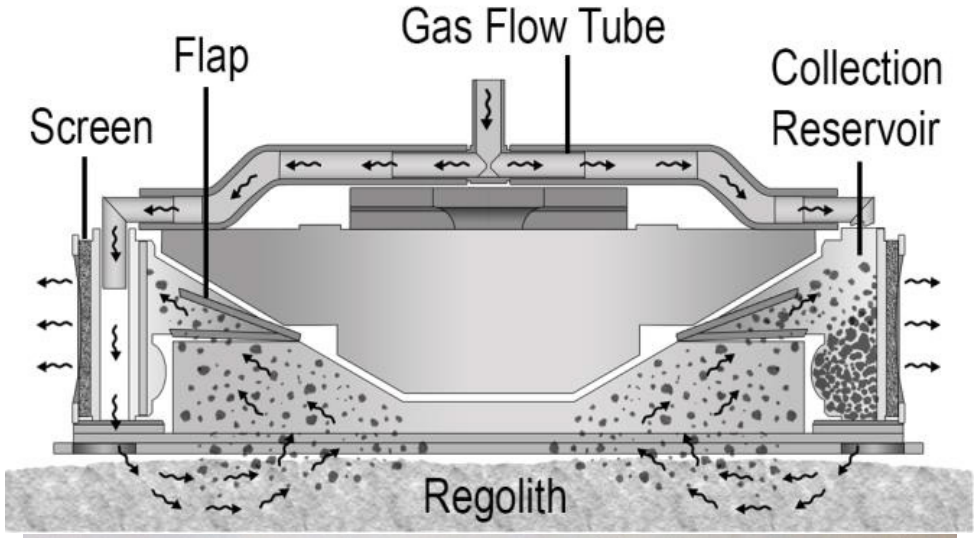
Transport to Houston, JSC


Stardust SRC on ground


Stardust capsule entry 2006

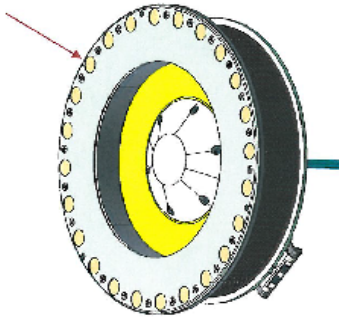
Bulk sample

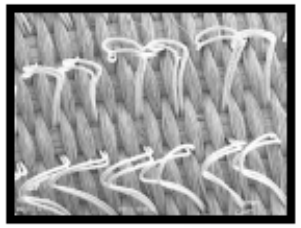




Material that will be inside of the TAG-SAM head

Contact pad samples





SS Velcro SEM Image

Currently testing – Christopher Snead @ JSC

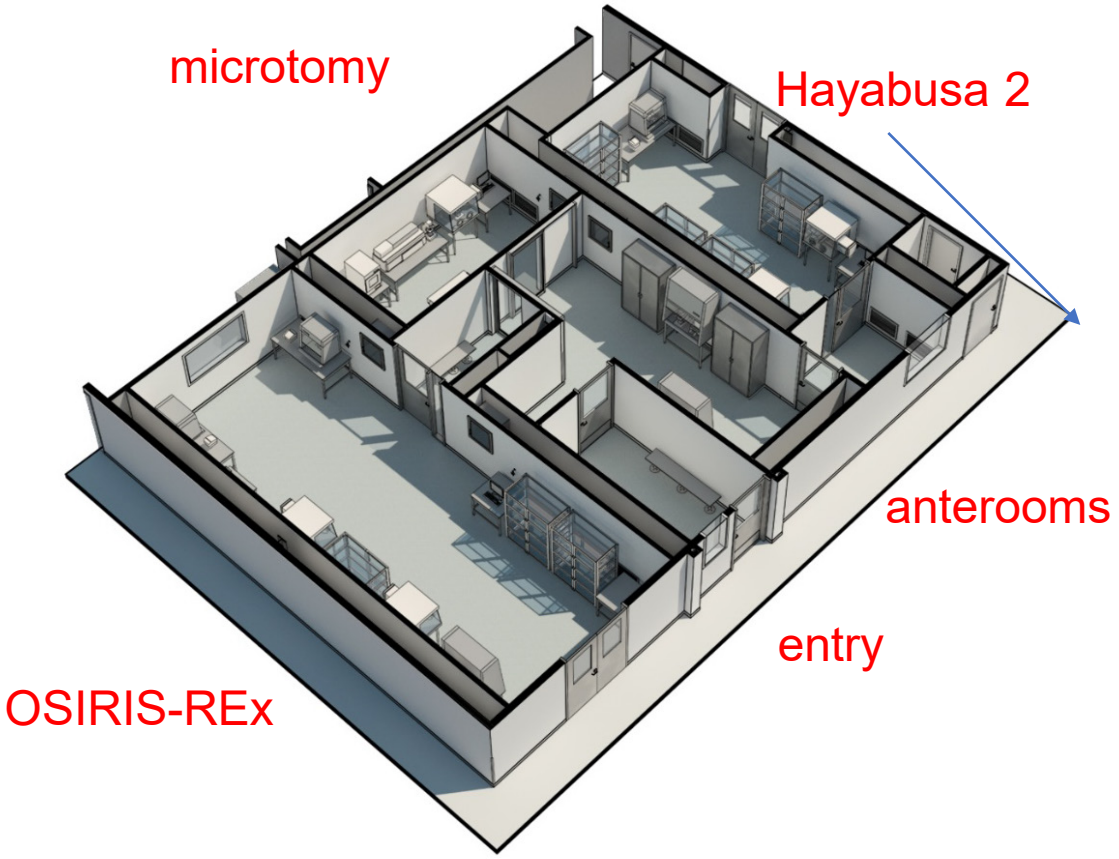
Contact Pads

- Collect top layer of surface material
- Will be useful for space weathering, exposure, and regolith studies

Clean labs currently under Construction!

New OSIRIS-REx cleanroom will be adjacent to new Hayabusa 2

Curation clean lab construction



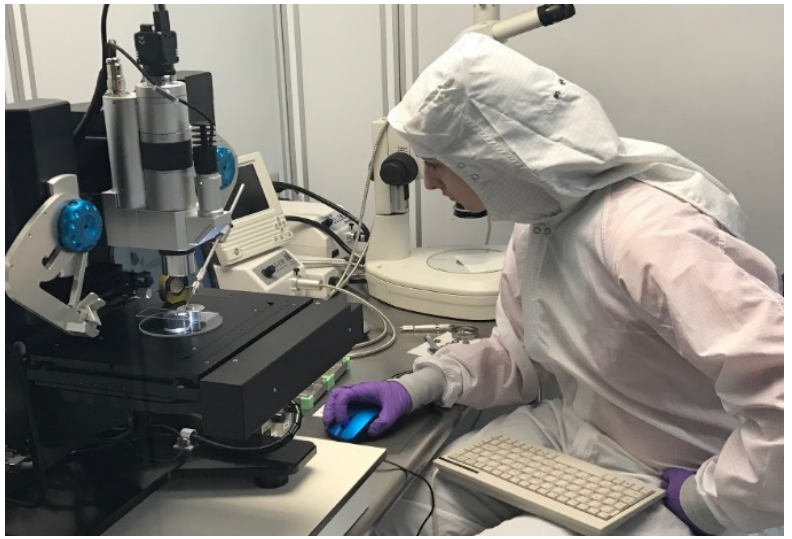
What will happen first in this new lab?

Outfitting and Rehearsals

Sample storage, processing and handling in nitrogen gas glove boxes

- Disassembly first

What will happen next in this new lab?



Characterization of returned material

Build a catalog of the returned material

Join the Mission on the Web!

AsteroidMission.org

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