Monday, December 12

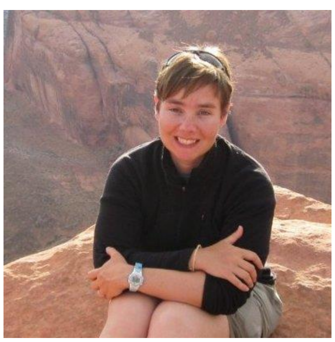
8:15 – 9:45 ***Planet Impact: Galvanize Everyone to Explore Science*** – Dr. Britney Schmidt (Georgia Institute of Technology), Whitney Cobb (McREL International), Theresa Summer (Astronomical Society of the Pacific), Dr. Sanlyn Buxner (Planetary Science Institute), and Dr. Jake Noel- Storr (InsightSTEM).

Planet Impact: AGU Gift 2016
CosmoQuest Collaboration

- CosmoQuest
- Resource Website

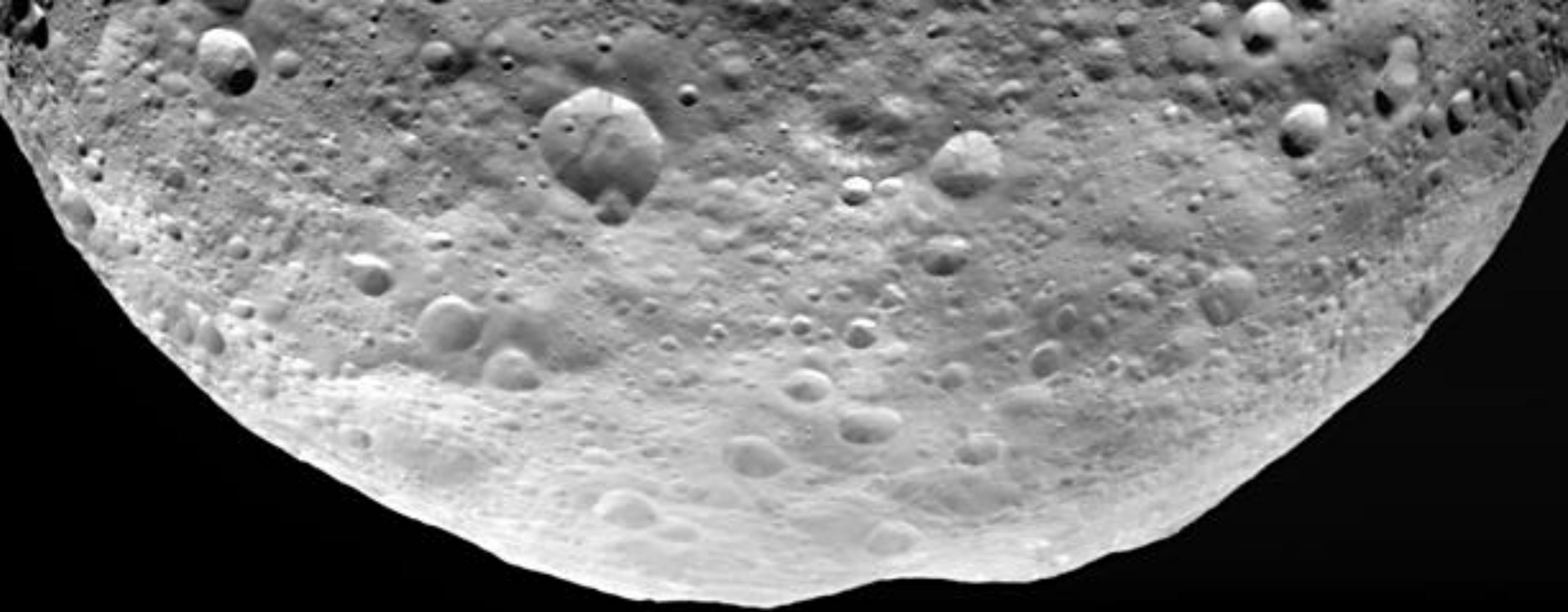
An Assistant Professor at Georgia Tech's College of Earth and Atmospheric Science, **Dr. Britney Schmidt**'s passions revolve around the story of water in our early solar system, including astrobiology: the rise and detection of habitable systems; icy shell and ocean dynamics of icy moons and planets, especially Europa; ice-ocean interactions on Earth and Europa; glaciology of Earth's ice shelves and glacier tongues, and the evolution of water-rich asteroids and other small bodies. She spends large chunks of time researching on Antarctica when she's not rocking to metal, snuggling with her icy-white cat, or cooking with friends and family. britneys@eas.gatech.edu

Whitney Cobb designs and implements professional learning models and K12 curriculum for formal and informal settings with McREL International. Her focus is STEM, STEAM and cross-curricular initiatives, aligning to evaluation to ensure outcomes, and planning for systemic implementation. She researches new trends that address the power of multimedia elements, website design, and social media to engage and improve access and equity for diverse learners. She was a teacher and administrator for years. Other than chasing kids? Cooking, eating, teasing her chickens, and loving her family and friends are key pastimes. wcobb@mcrel.org



Dr. Sanlyn Buxner is a research scientist and education specialist at the Planetary Science Institute. She works on several NASA and other federally funded projects to conduct professional development for educators on current topics in planetary science, create science programs for children and teens, and work with scientists to broaden the impact of their research for the public. As part of CosmoQuest, she connects classrooms to scientists to engage in meaningful research projects, working with a team to assess the impact of the overall program. She enjoys watching the stars and camping with her toddler, cooking, and hosting dinner parties. buxner@psi.edu

Dr. Jake Noel-Storr, president of InsightSTEM, is an astrophysicist with two decades experience of working alongside educators as they bring STEM exploration into their classrooms. Jake has run engaging teacher workshops funded by NASA, the American Association for the Advancement of Science, the National Science Foundation, the American Astronomical Society and more... and has been a regular presenter at meetings of the National Science Teachers Associating for almost a decade. Through his brainchild, InSight STEM, Jake develops outreach programs with a network of over 20 other partner organizations nationwide. He connects kids and classrooms with other cool astro-peeps like himself, bringing real-world STEM to you and me. jake@insightstem.com

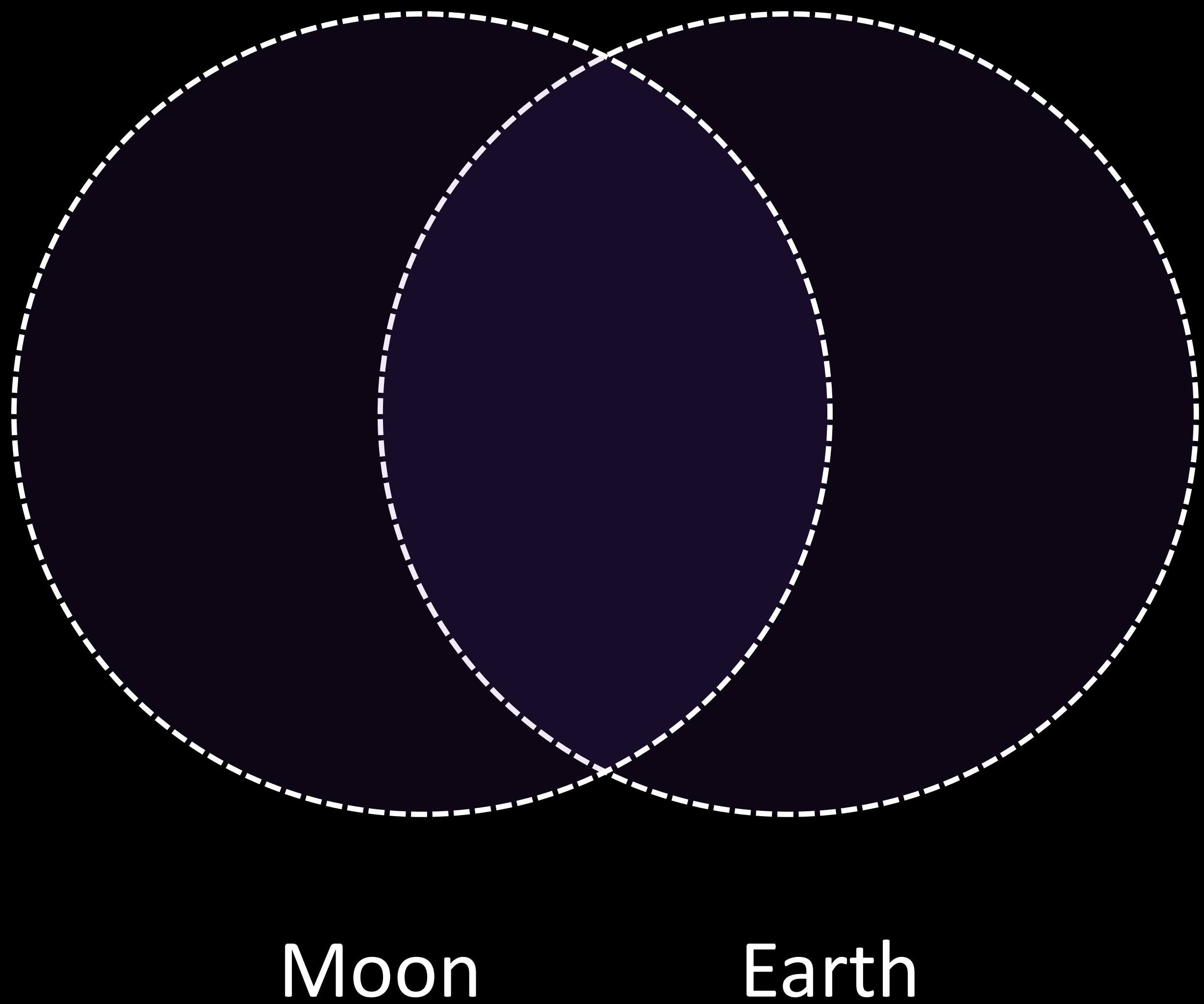


Planet Impact

Britney Schmidt (Georgia Tech), Jake Noel-Storr (InSight STEM)
Whitney Cobb (McREL), Sanlyn Buxner (Planetary Science Institute)
Theresa Summer (Astronomical Society of the Pacific)

CosmoQuest X

Why the Moon?



Today’s Objectives

- Introductions
- Investigate
  - Context for NEO
    - Mental Models
    - Patterns in the Sky
  - STEAM: engagement & analysis
  - Planetary Mappers
    - Citizen Science
    - Hands-on, real-world applications

Trios model the relationship between …

- Earth & Sun
- Earth & Moon
- Earth, Moon & Sun

- Tip: all solar system bodies orbit counterclockwise!
- Challenge: How long is a Moon day? Prove it!

Moon Phase and Solar Eclipse

During a solar eclipse, the Moon appears to completely cover the Sun. What phase of the moon is just before and after a solar eclipse?

- Full Moon
- New Moon
- First quarter Moon
- Last quarter Moon
- It can happen in any phase

Describe your thinking on a sticky. Share with your table

From Uncovering Student Ideas in Astronomy
Keely and Sneider, 2011

Guam Moon

Leah, living on Guam, observes a half moon in the night sky. What does her friend, Maria, who lives in New York, see?

- Half moon
- New moon
- Waxing crescent
- Waning crescent
- Full moon

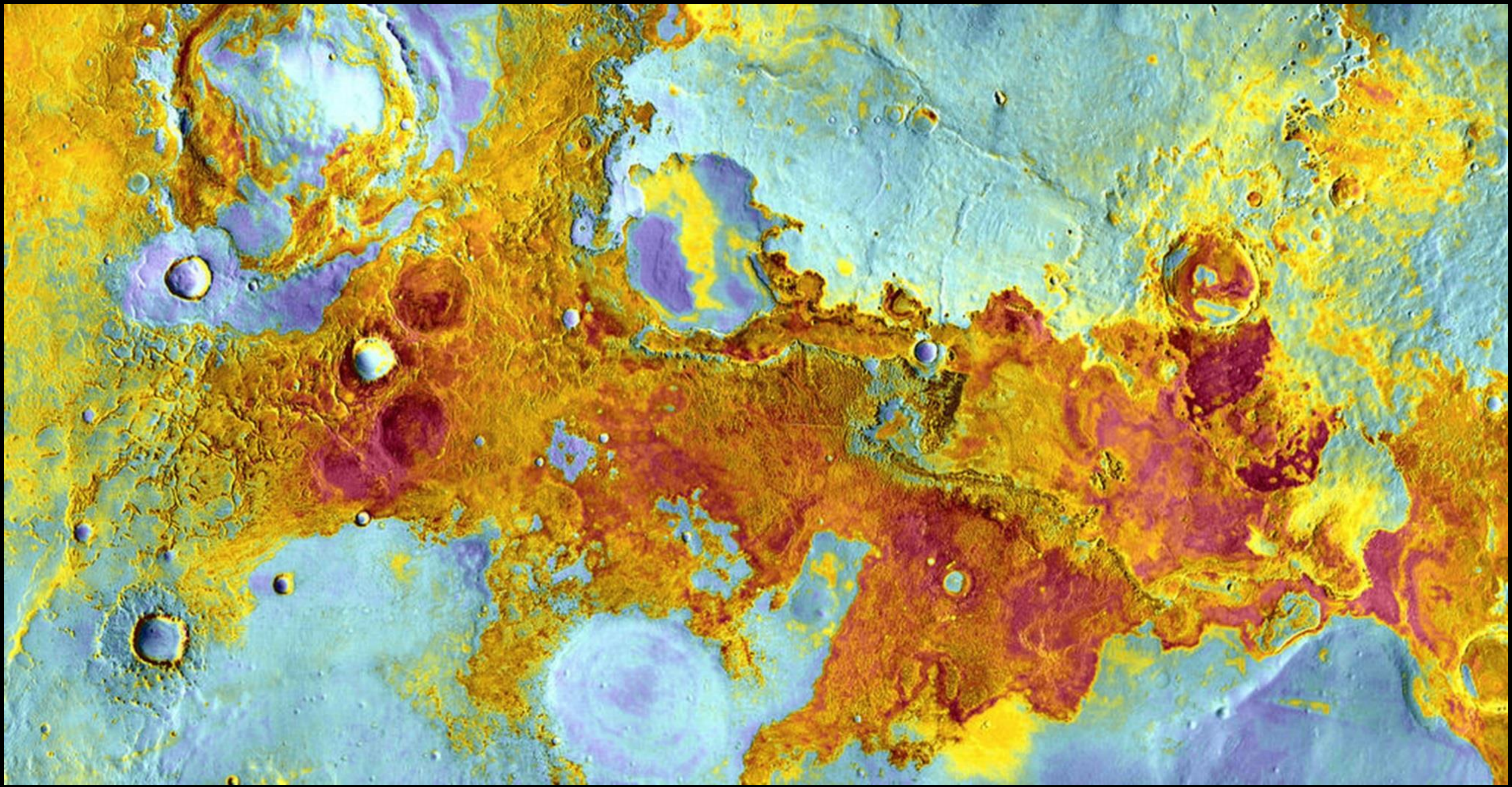
From <u>Uncovering Student Ideas in Astronomy</u>
Keely and Sneider, 2011

Keeping Grounded

- Mental Models
- Talking…
- Drawing…
- Writing about ideas…

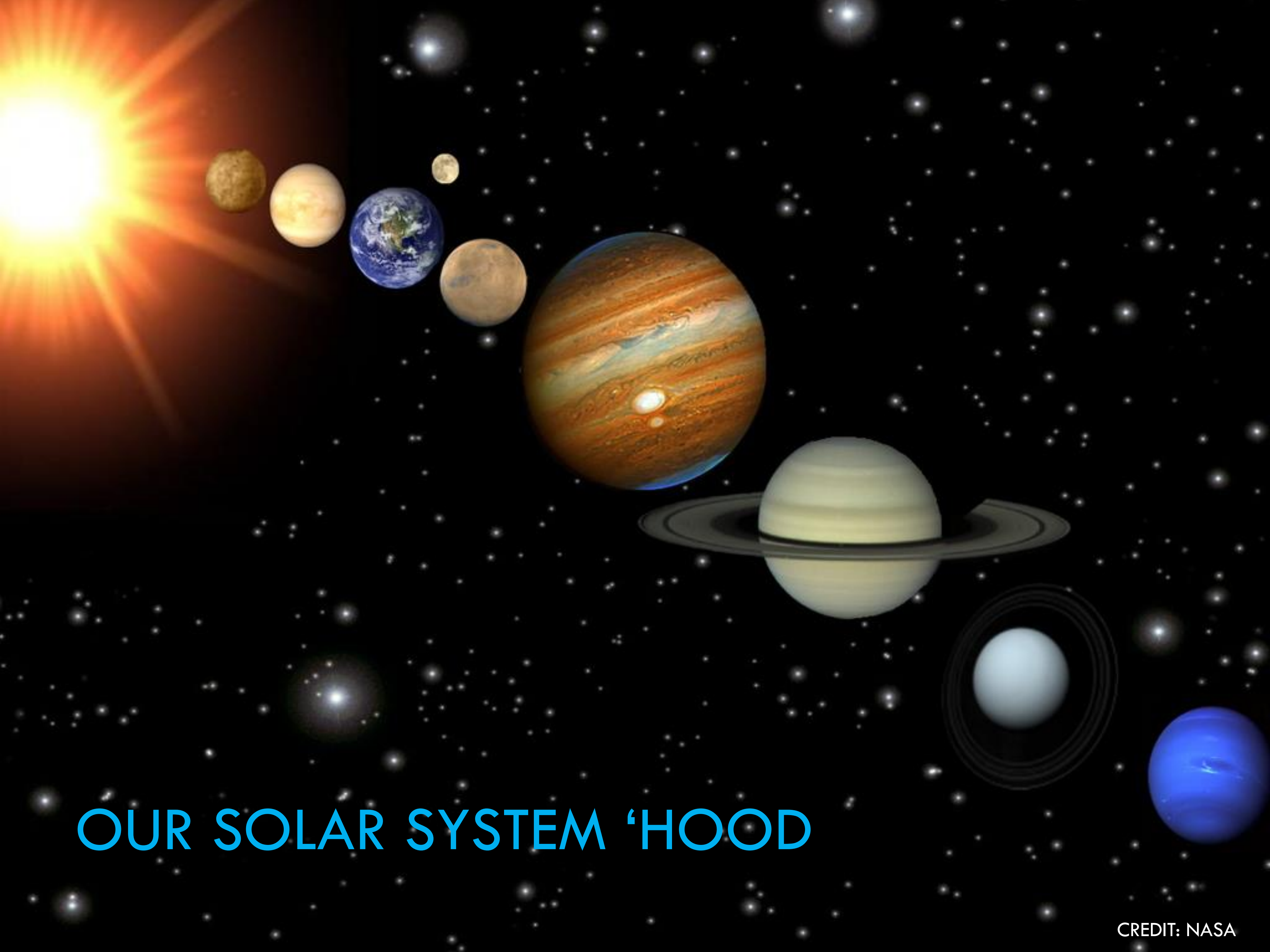
ART & THE COSMIC CONNECTION

Sense-Making with the Elements of Art



NASA's Discovery and New Frontiers Programs

http://discovery.nasa.gov

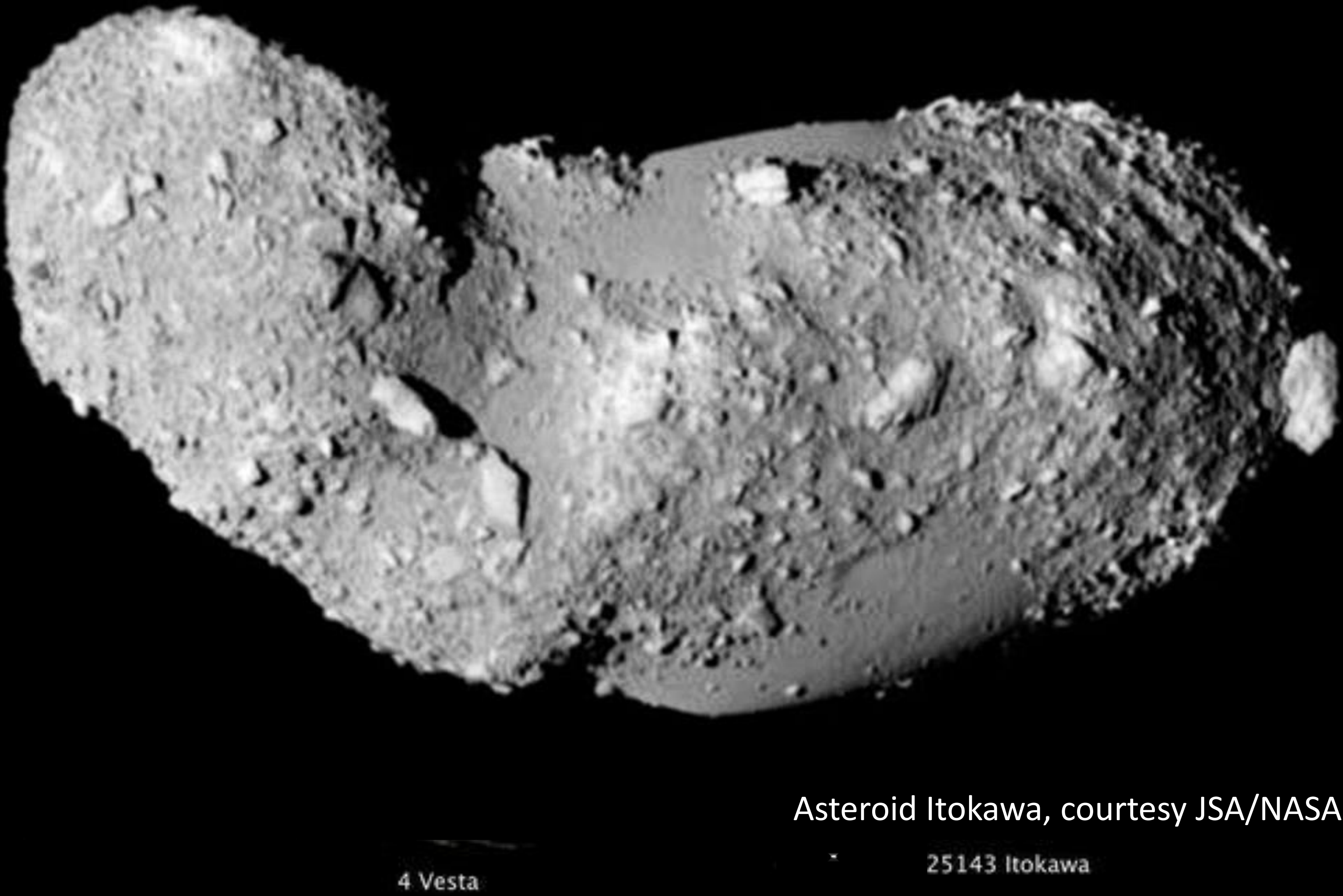


OUR SOLAR SYSTEM ‘HOOD

CREDIT: NASA


CREDIT: NASA/JPL

SMALL SOLAR SYSTEM BODIES



Asteroid Itokawa, courtesy JSA/NASA

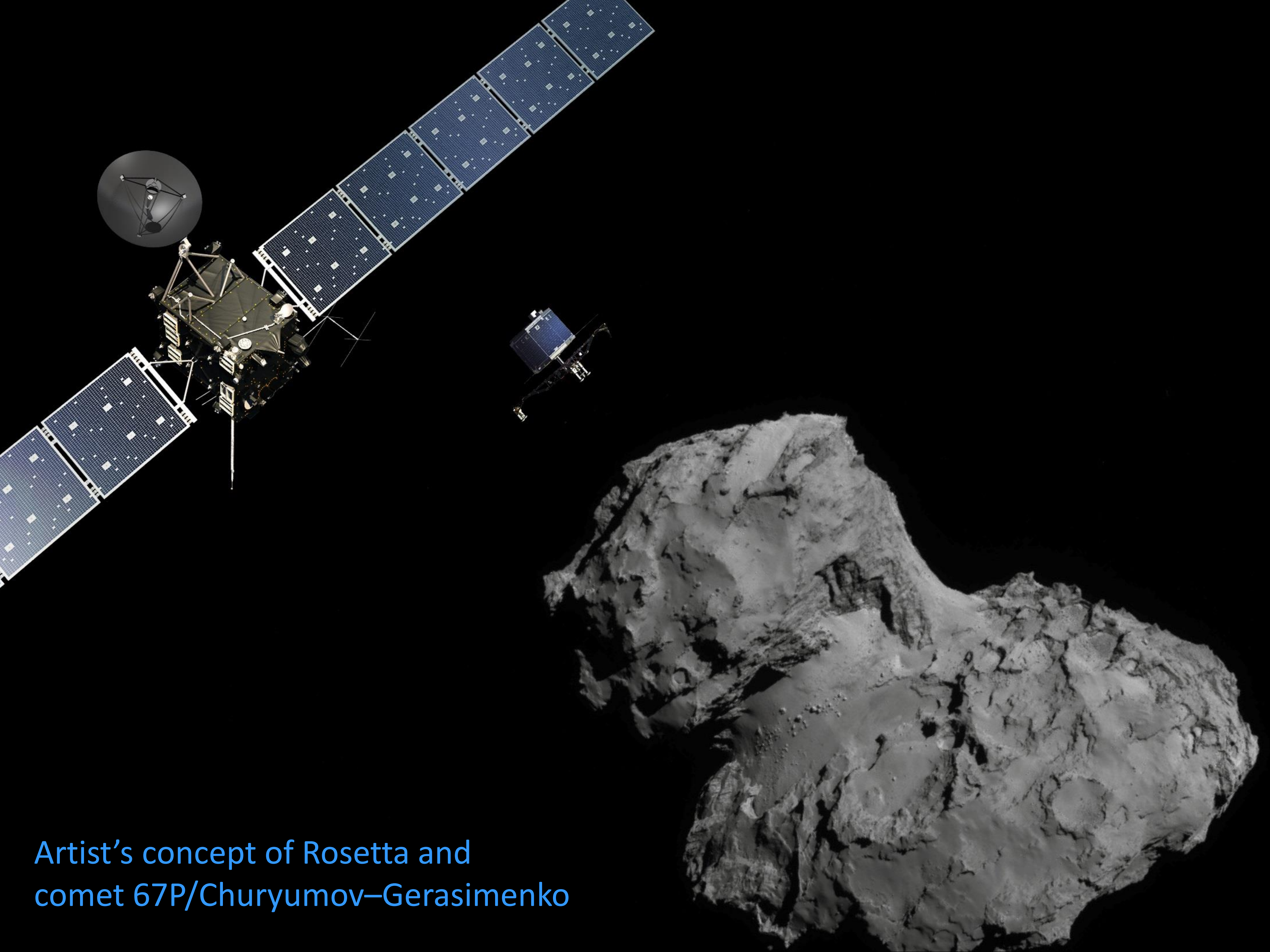
ASTEROID EROS

~ 34 km × 11 km × 11 km

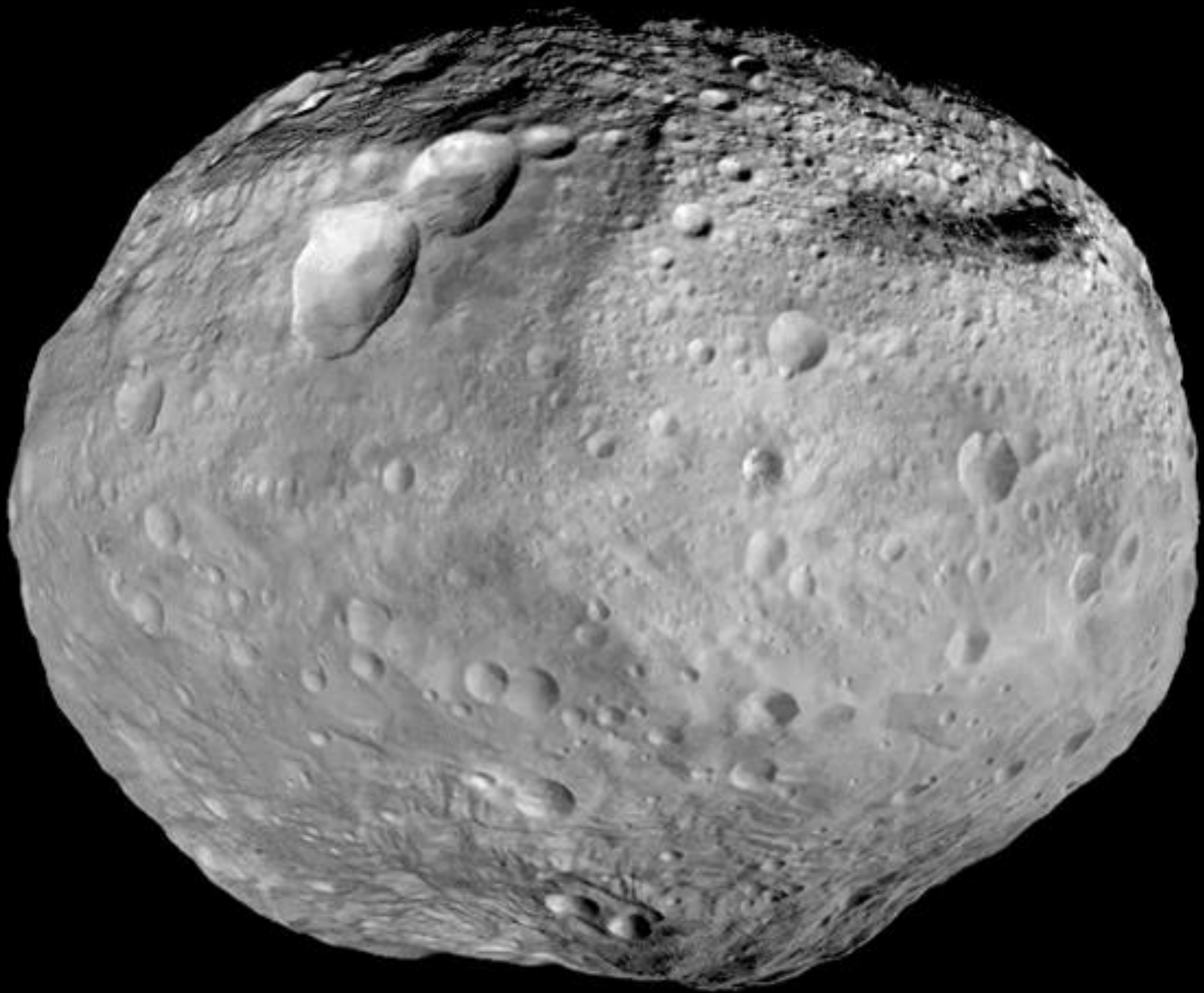
Image: NASA/JHUAPL

Nucleus of Comet Wild 2

CREDIT: NASA/JPL-Caltech/Univ. of Washington



Artist's concept of Rosetta and
comet 67P/Churyumov–Gerasimenko

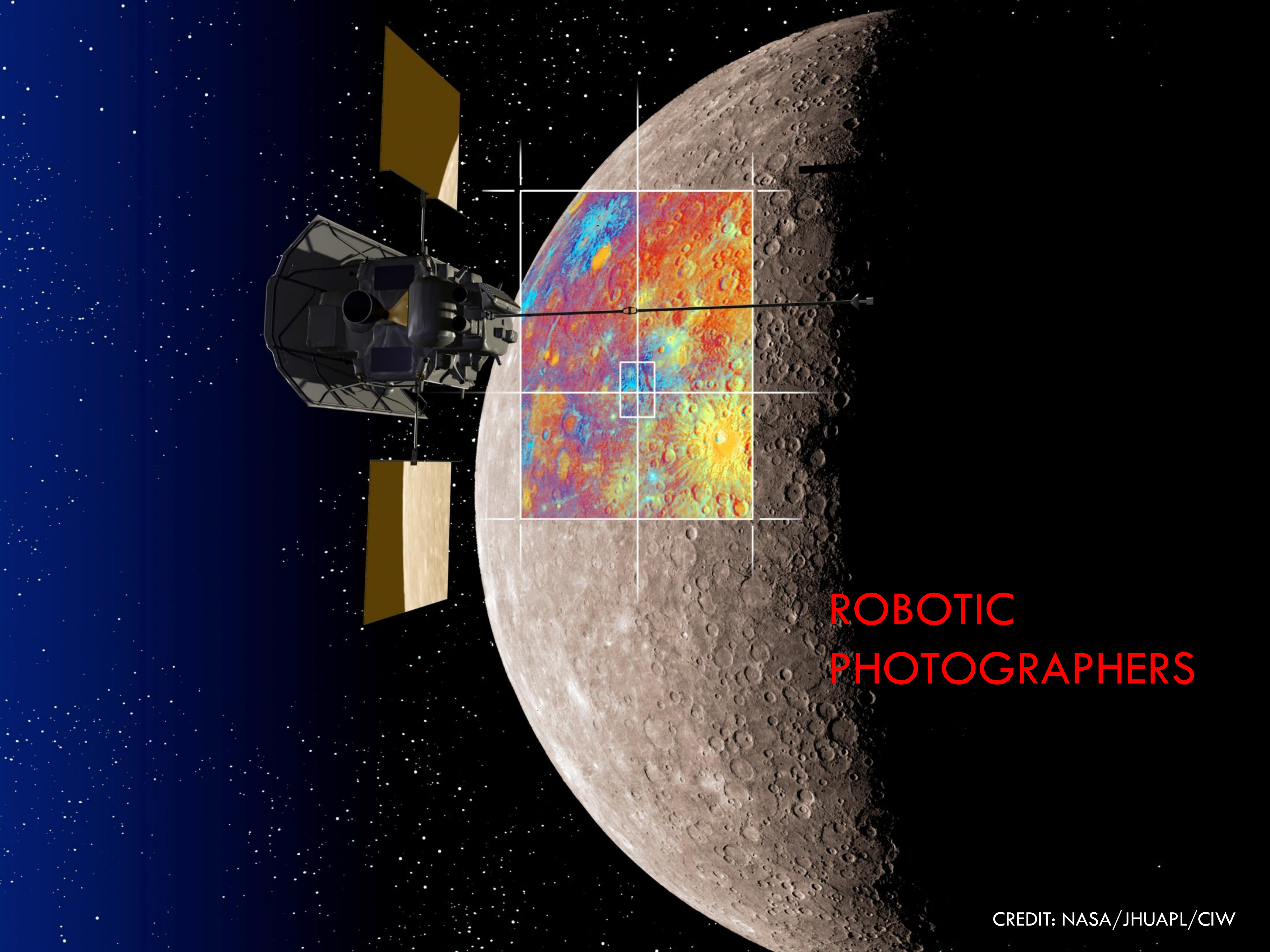


572 km mean diameter

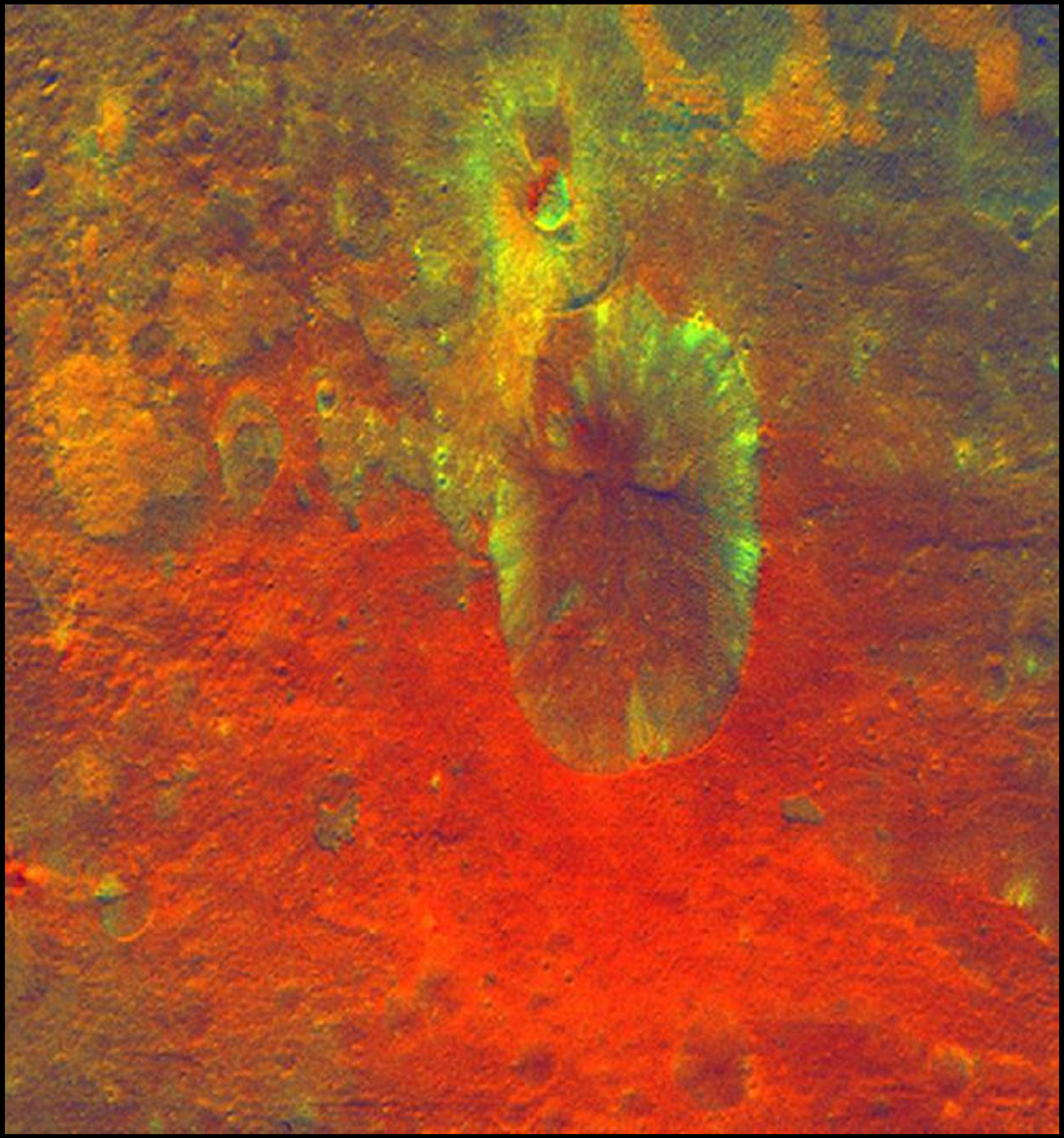
GIANT ASTEROID VESTA

Dawn Mission

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


ROBOTIC
PHOTOGRAPHERS
CREDIT: NASA/JHUAPL/CIW

GEOLOGY & THE ELEMENTS OF ART

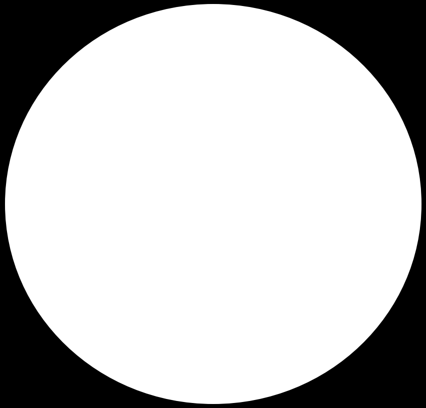


- LINE
- SHAPE
- COLOR
- VALUE
- TEXTURE

GIANT ASTEROID VESTA

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

SHAPE

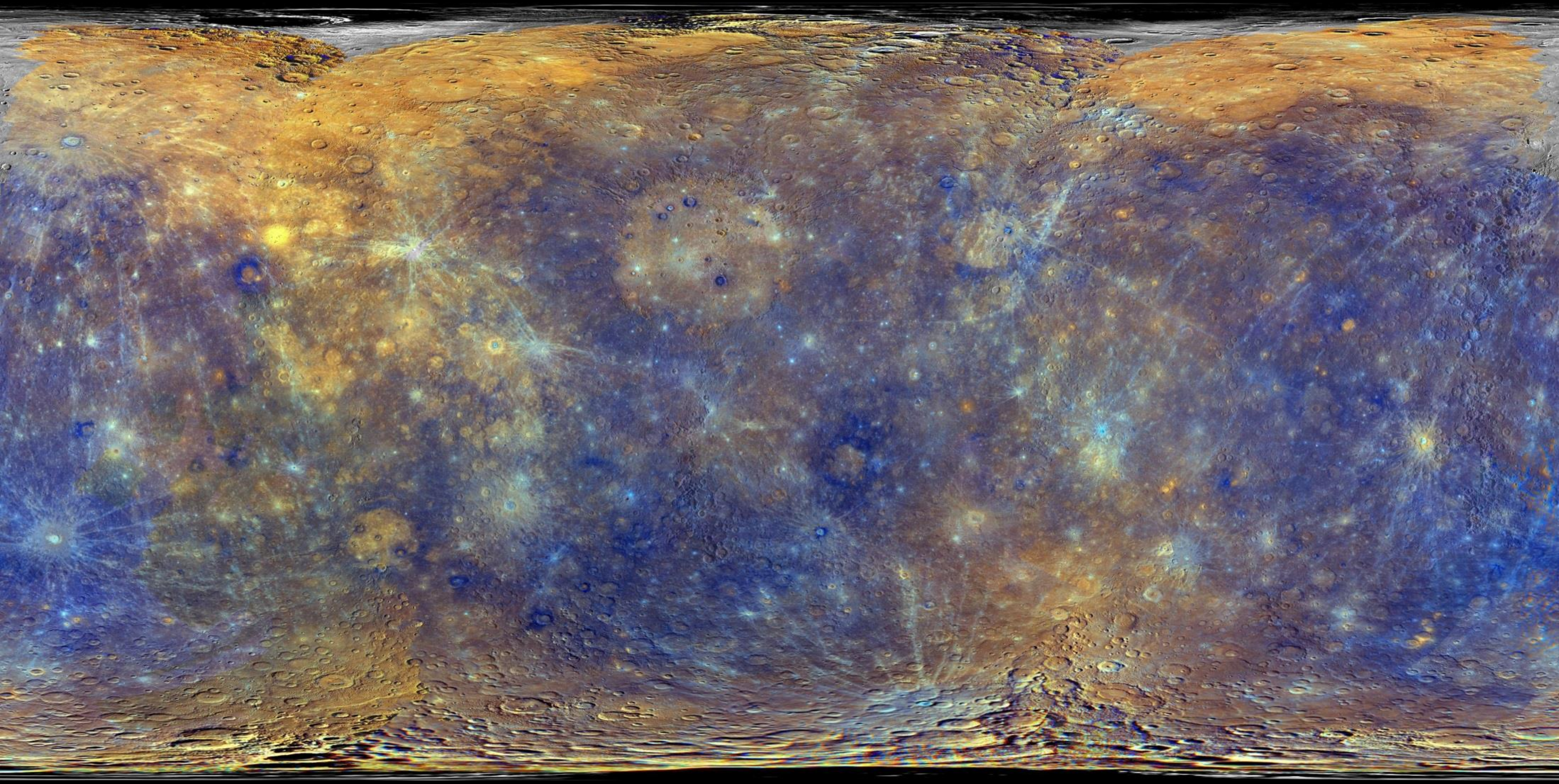


Circle - Craters

MARS

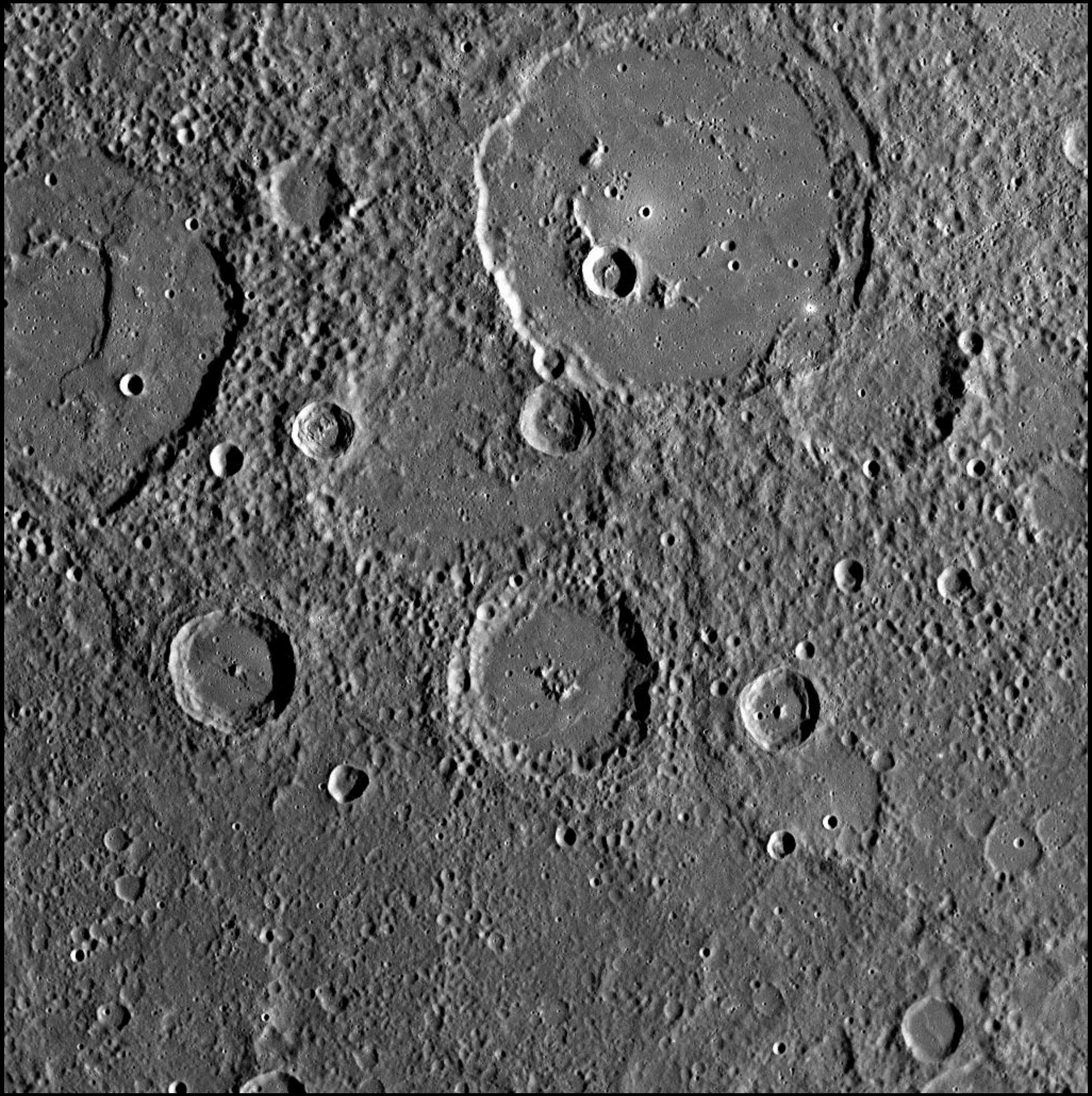
CREDIT: NASA/JPL

CIRCLES: Mercury



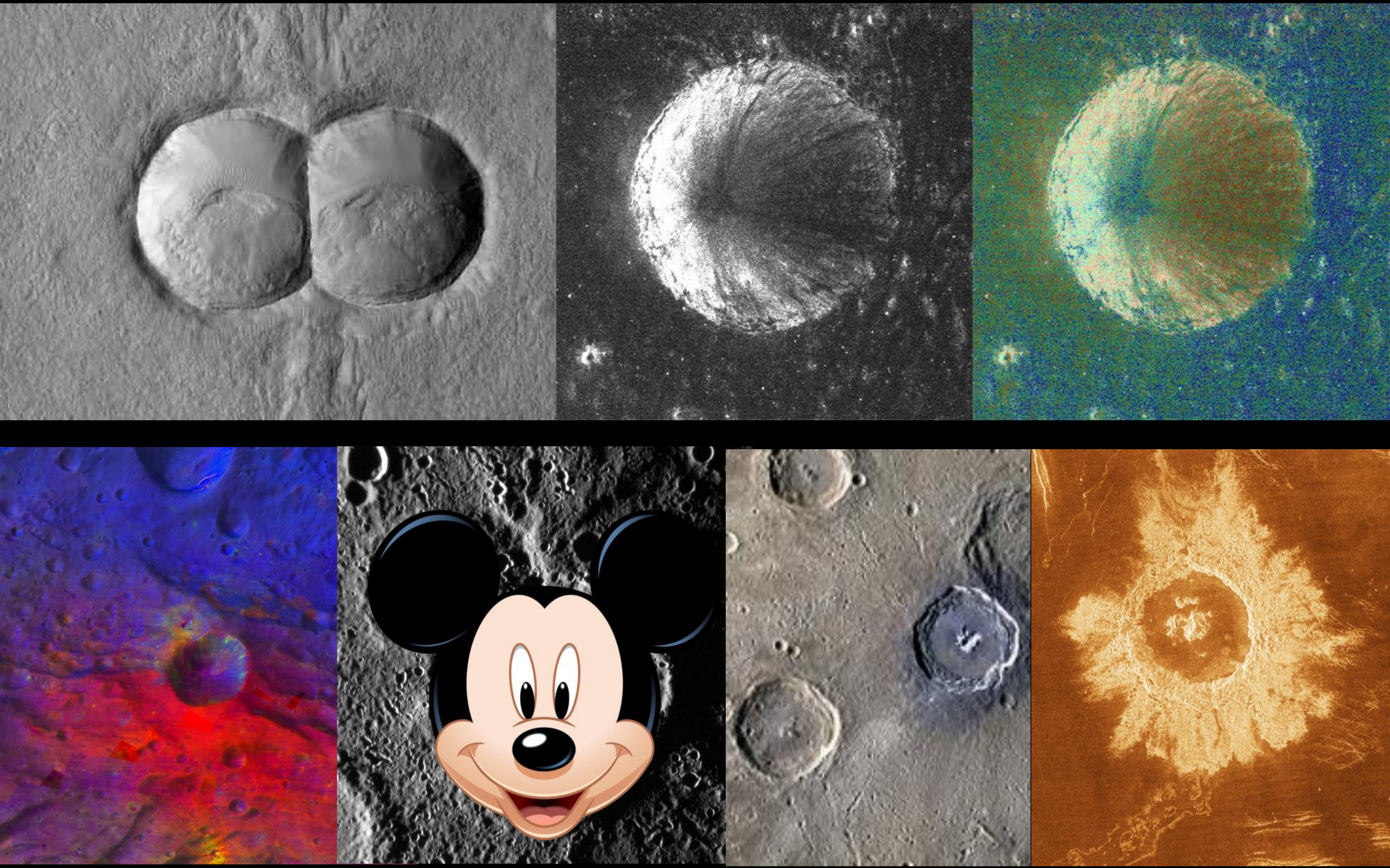
CREDIT: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington

MERCURY



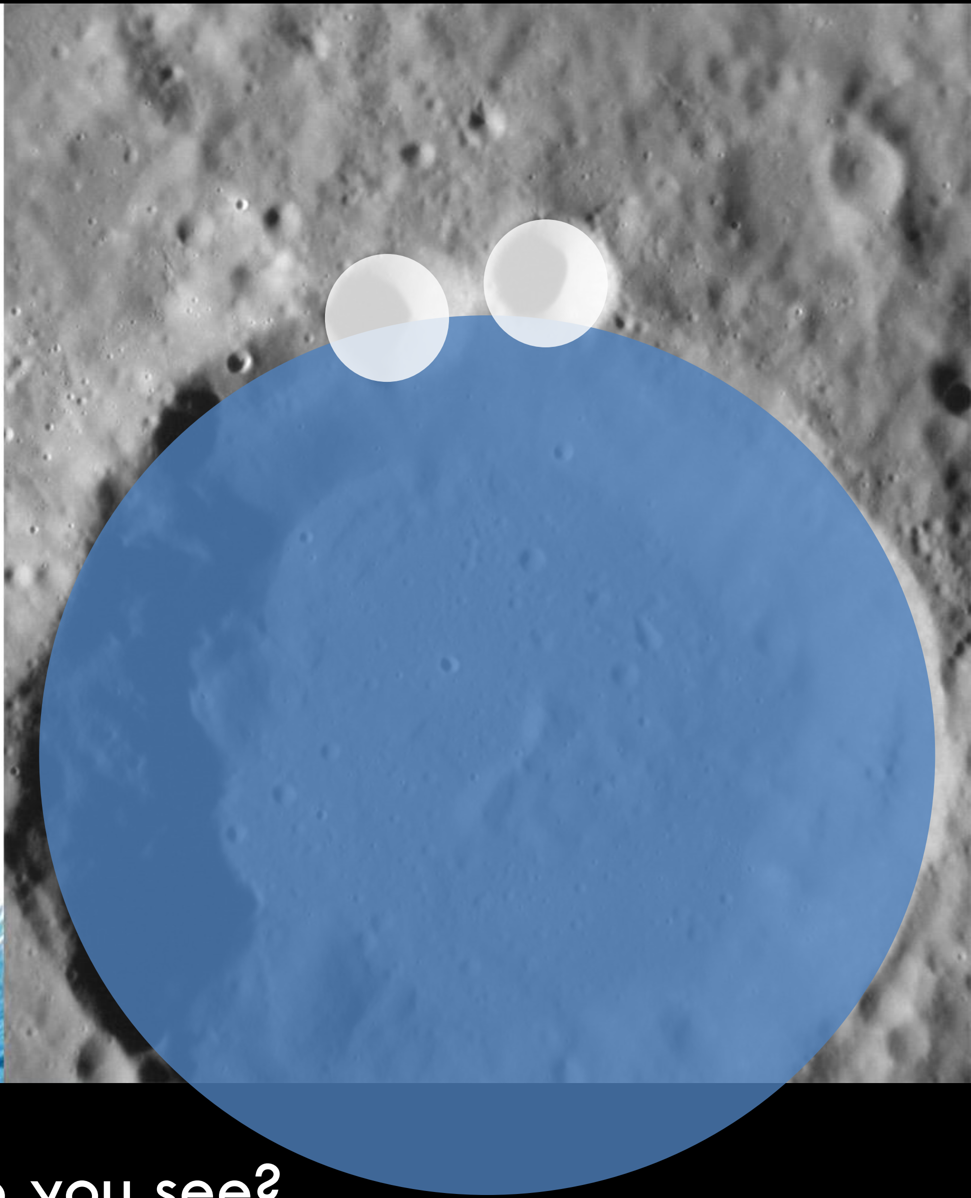
CREDIT: NASA/JHUAPL/CIW

CIRCLES IN THE SOLAR SYSTEM



CREDIT: NASA/JPL

MERCURY



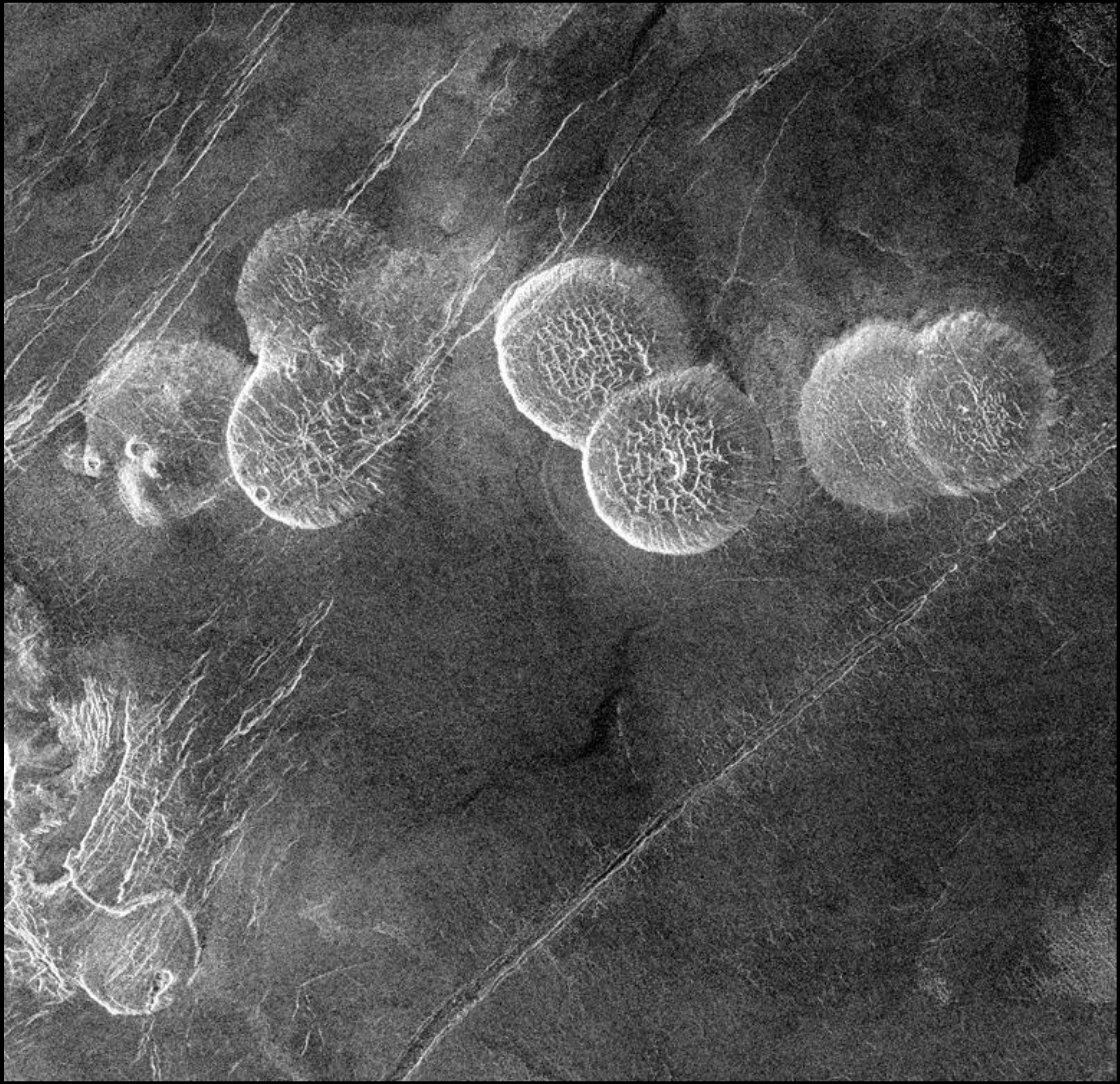
What do you see?

CREDIT: NASA/JPL

EARTH - Kansas

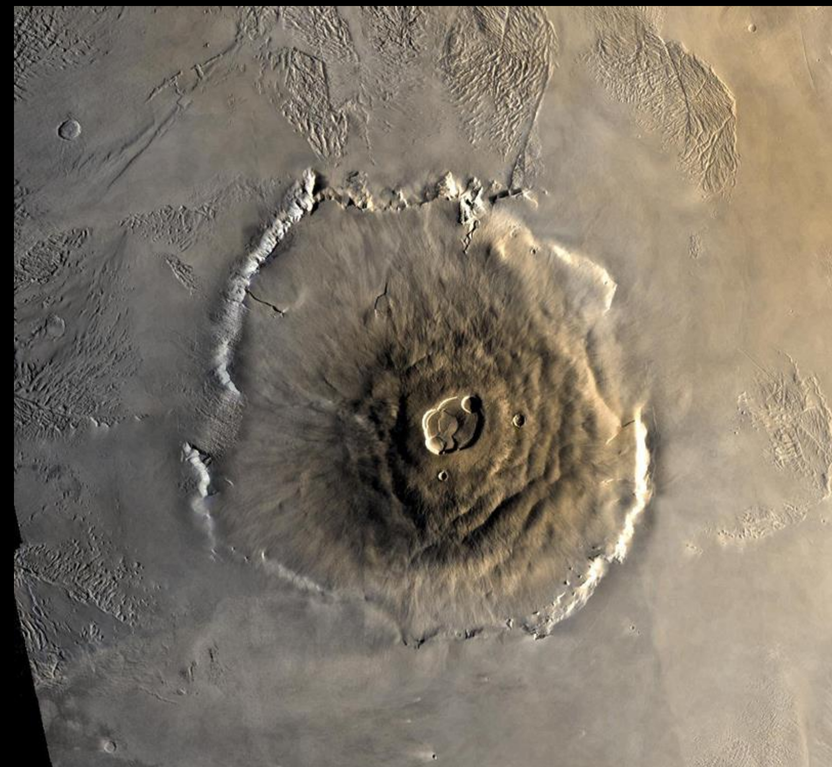
CREDIT: NASA Earth Observatory

VENUS



CREDIT: NASA/JPL

SHAPE



Blobs – Volcanoes (or Lakes)

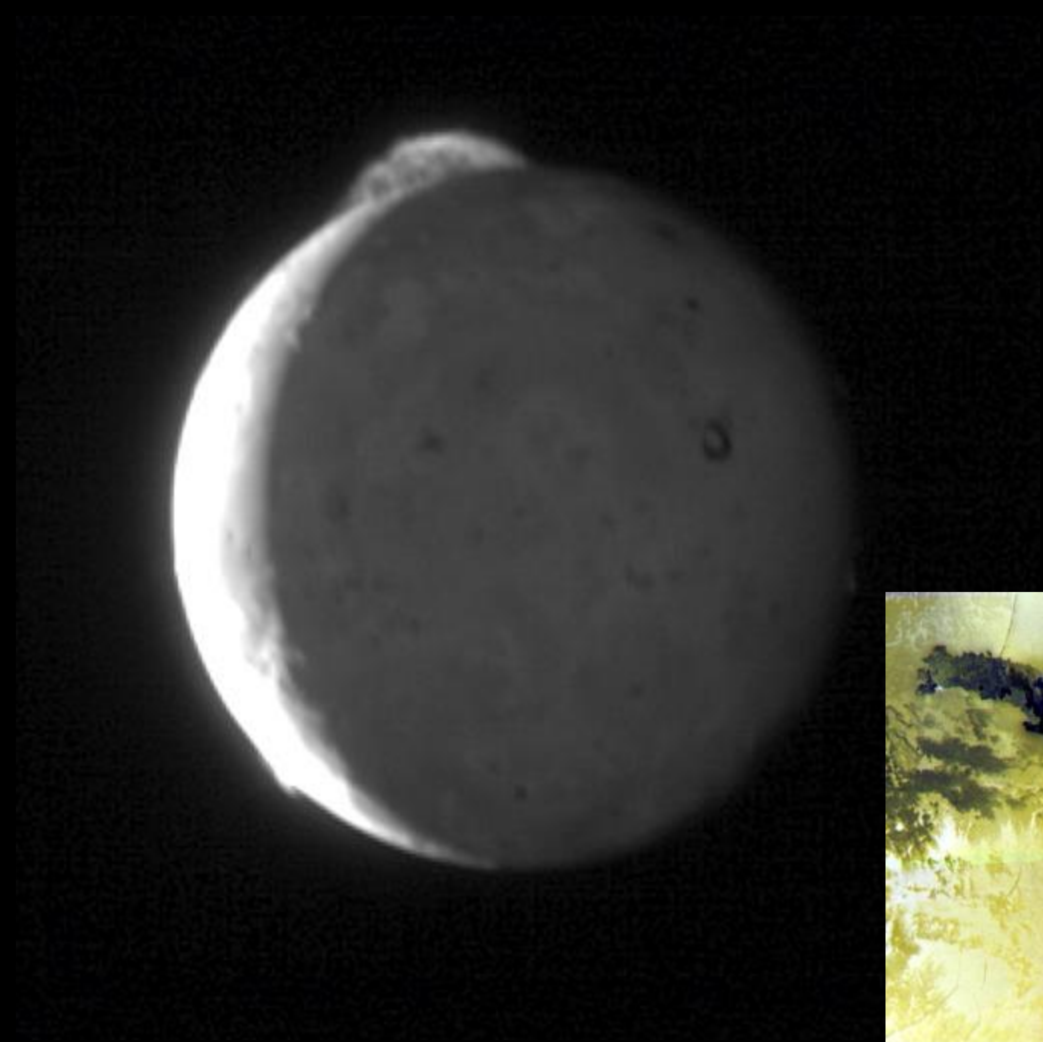
MAR'S OLYMPUS MONS

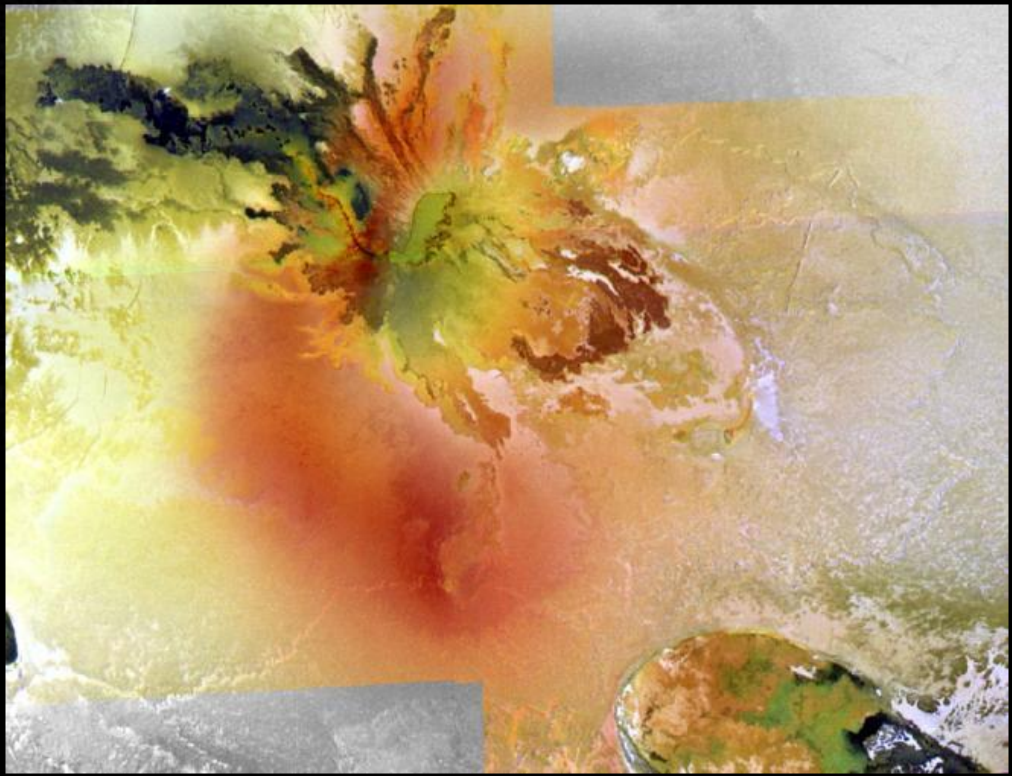
CREDIT: NASA/JPL

Jupiter’s moon, IO

CREDIT: NASA/JPL-Caltech/Univ. of Arizona

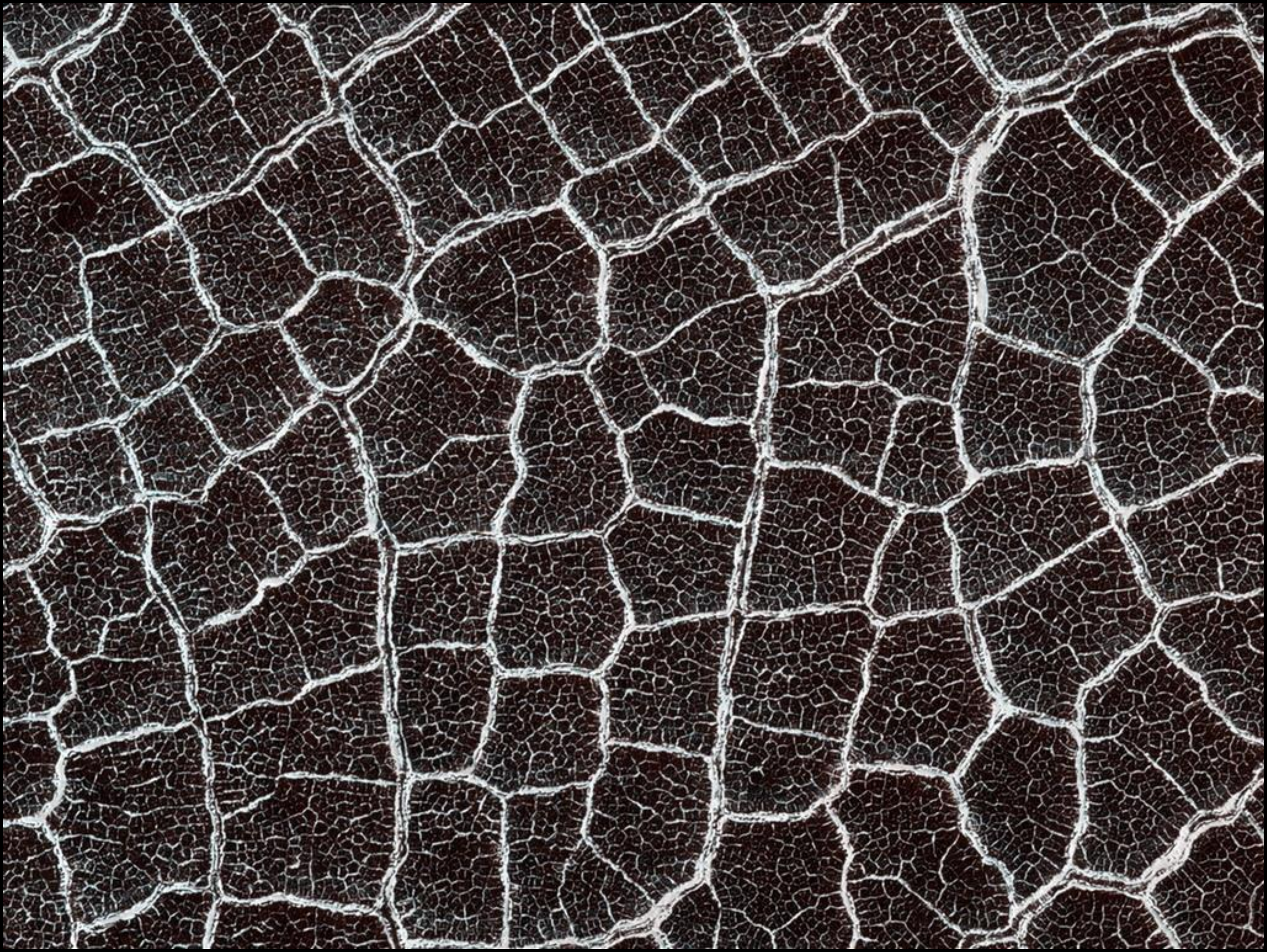
Jupiter’s moon, IO





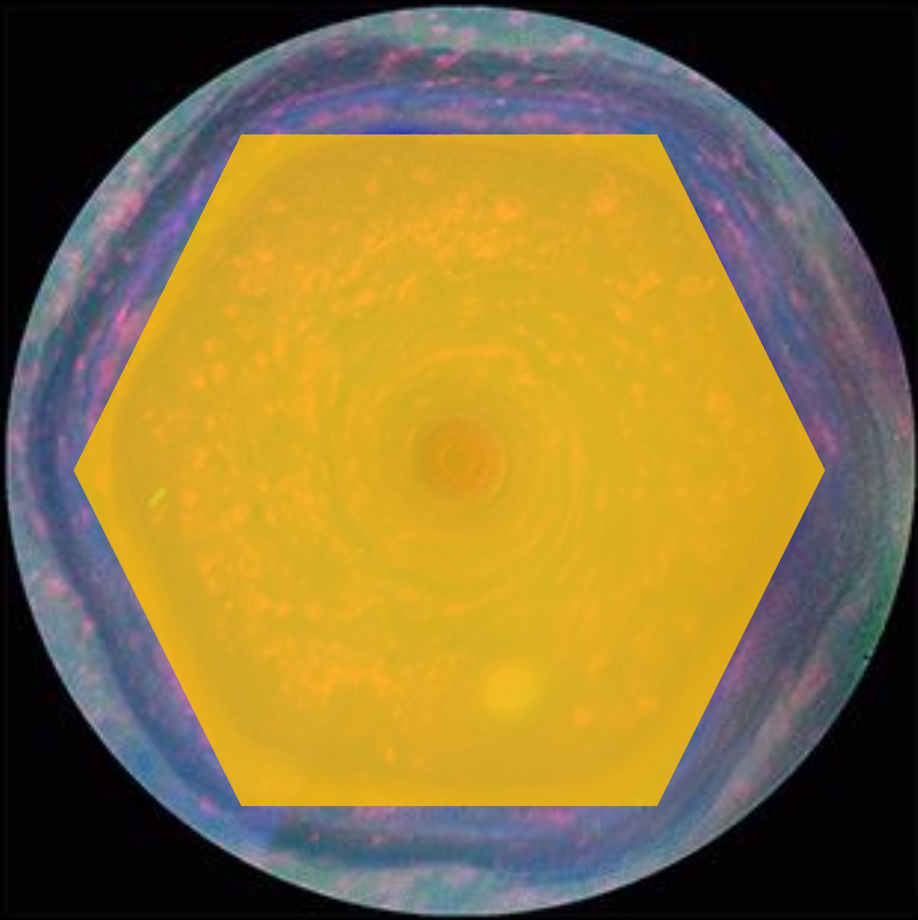
CREDIT: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute & NASA/JPL-Caltech/Univ. of Arizona

MARS: Polygons?



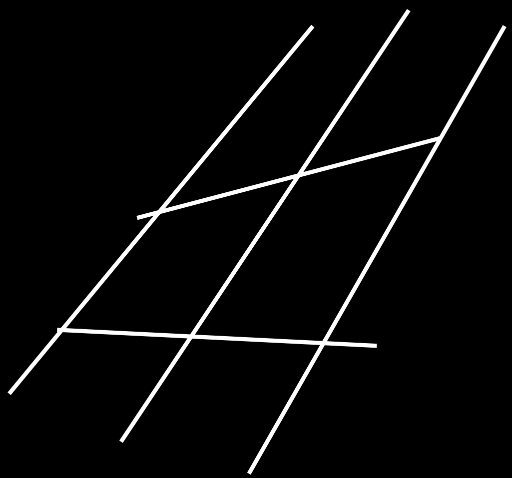
CREDIT: NASA/JPL-Caltech/University of Arizona

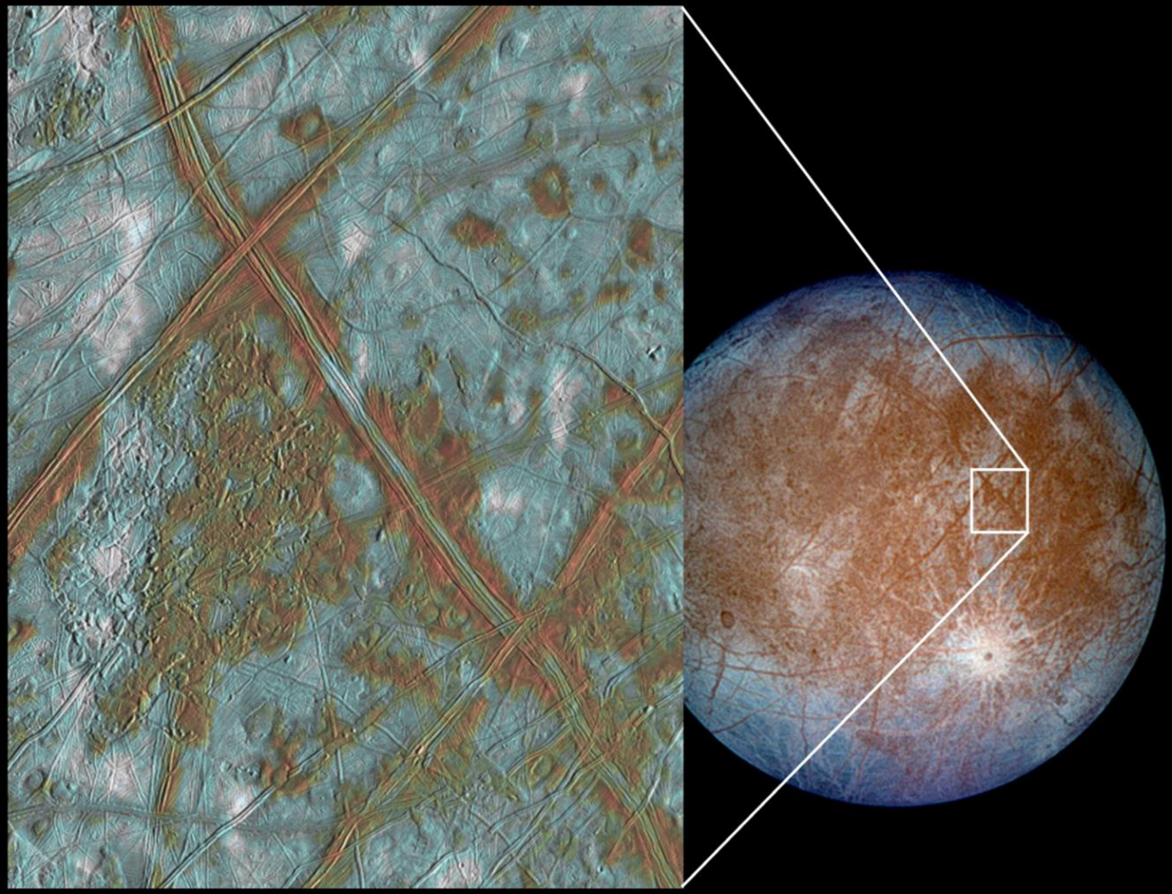
HEXAGON ON SATURN



CREDIT: NASA/JPL-Caltech/SSI/Hampton University

STRAIGHT LINES



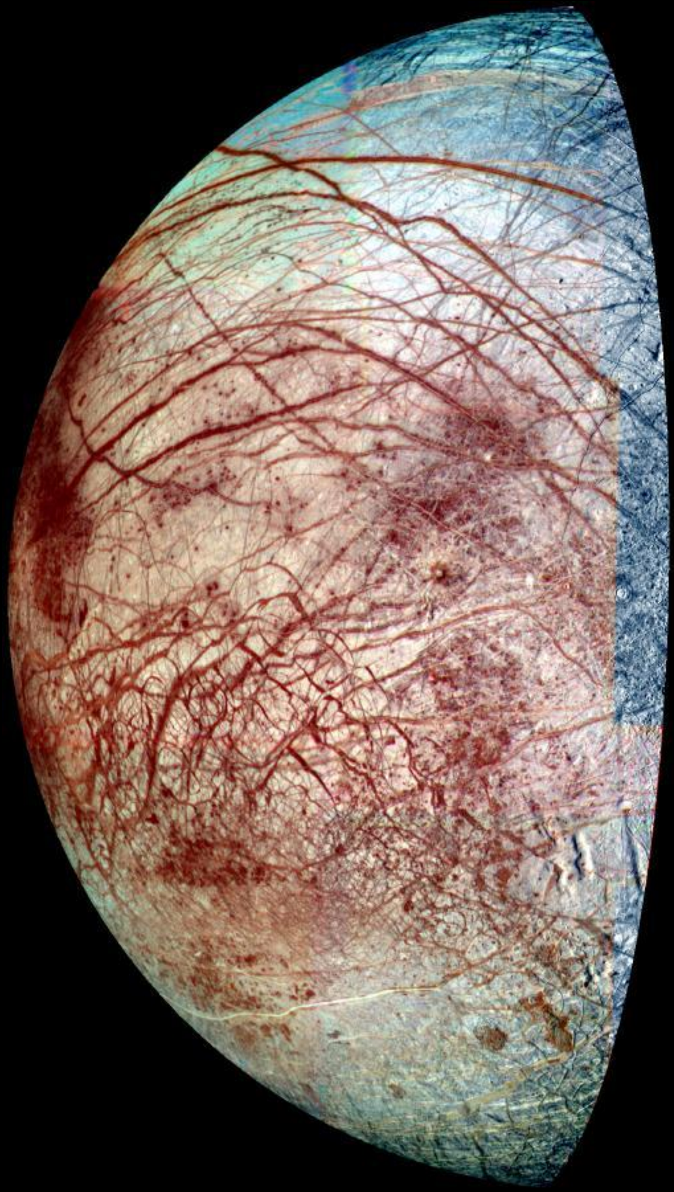


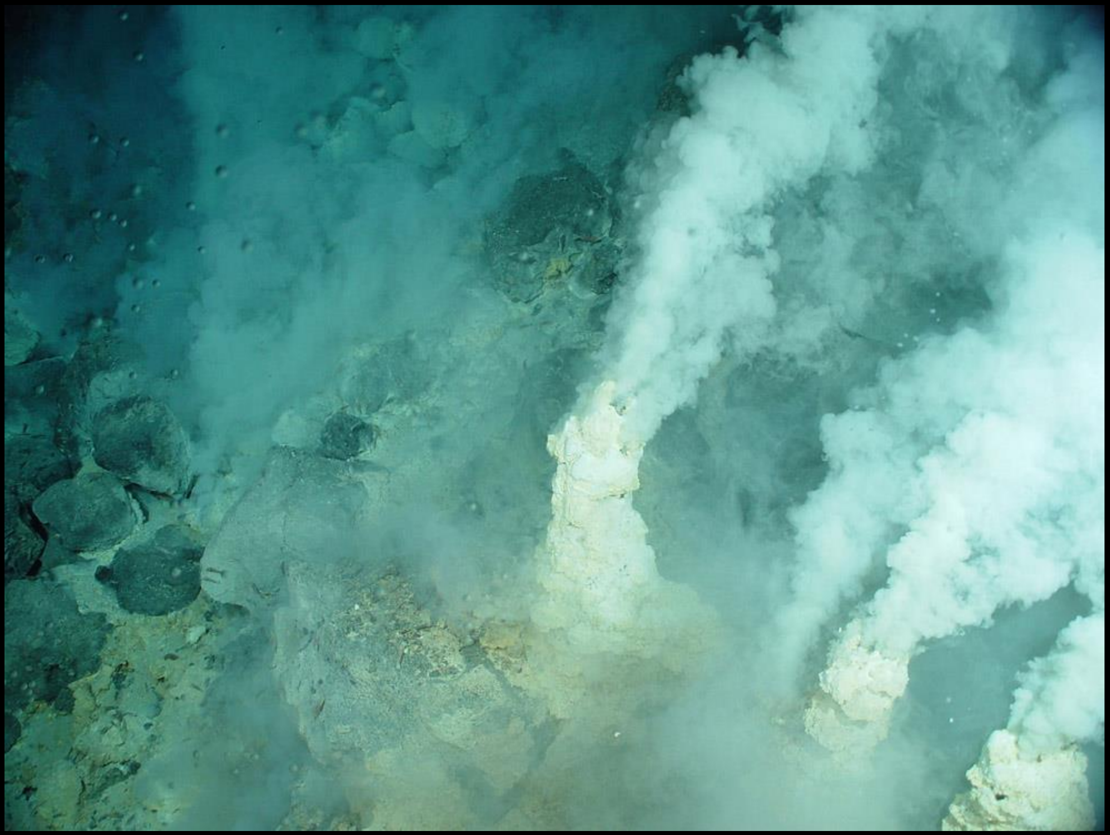
Straight lines – cracks & faults (tectonics activity)

CREDIT: NASA/JPL

EUROPA: Possible Life?

EARTH: Extremophiles!

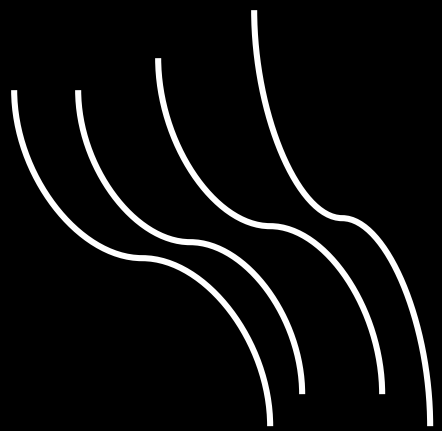


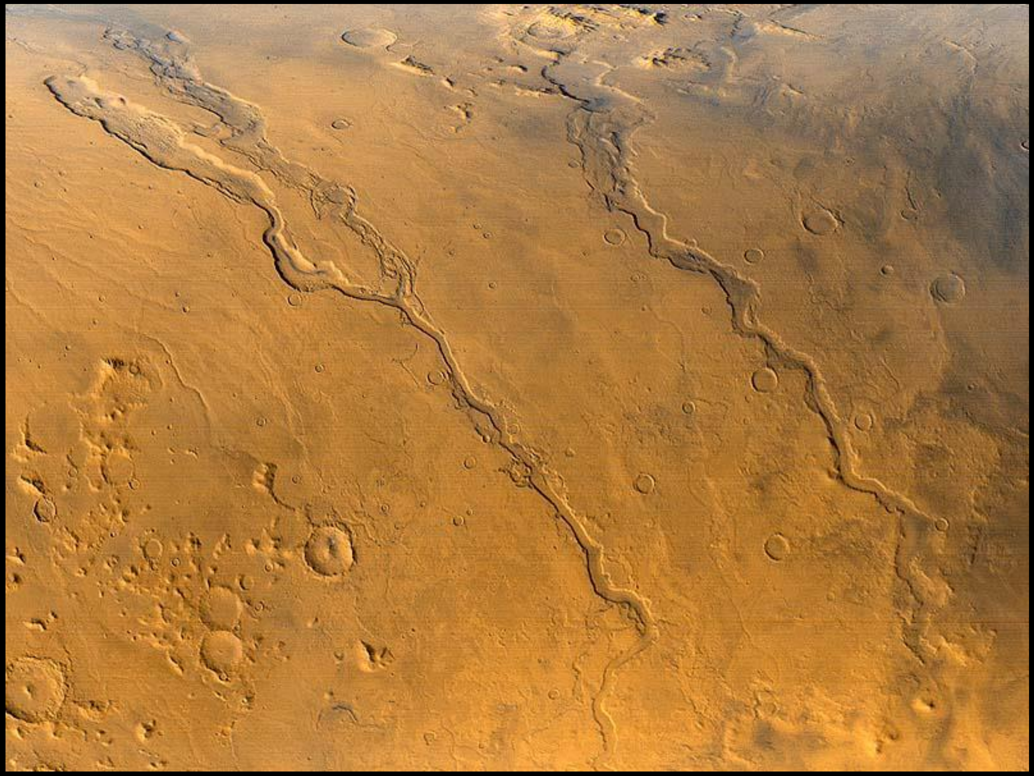


CREDIT: NASA/JPL/University of Arizona

CREDIT: National Geographic

LINE

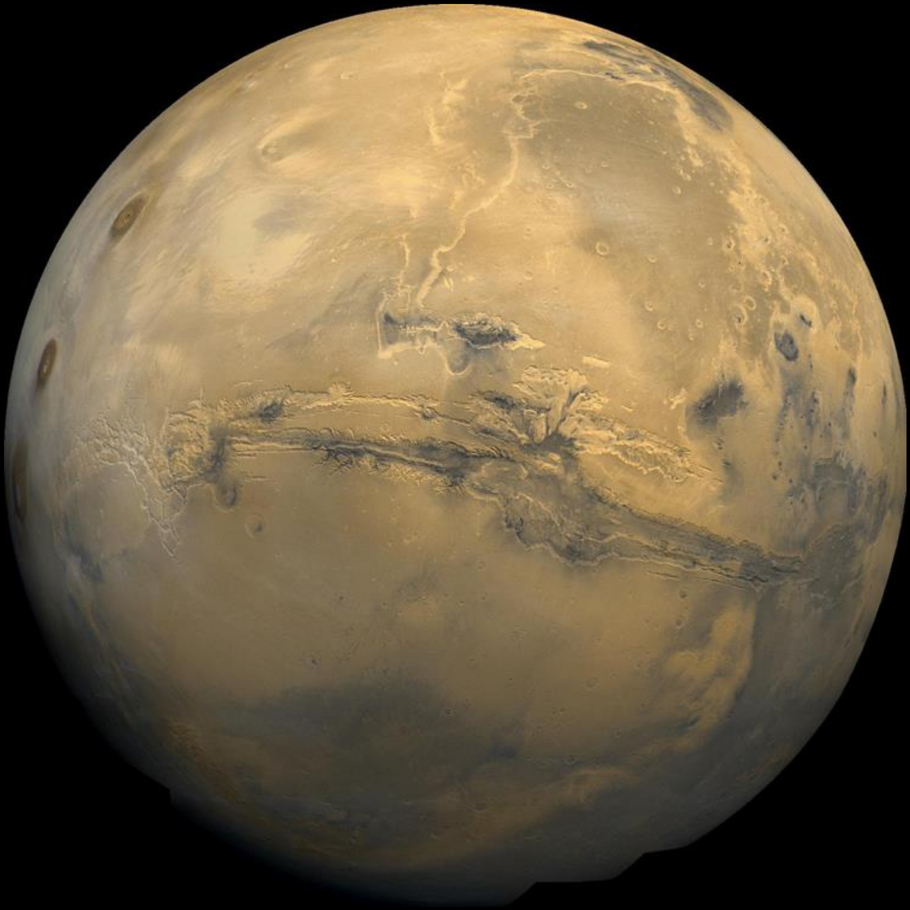




Squiggly lines - erosion (liquid & wind)

CREDIT: NASA/JPL

FOLLOW THE WATER: Mars



CREDIT: NASA/JPL

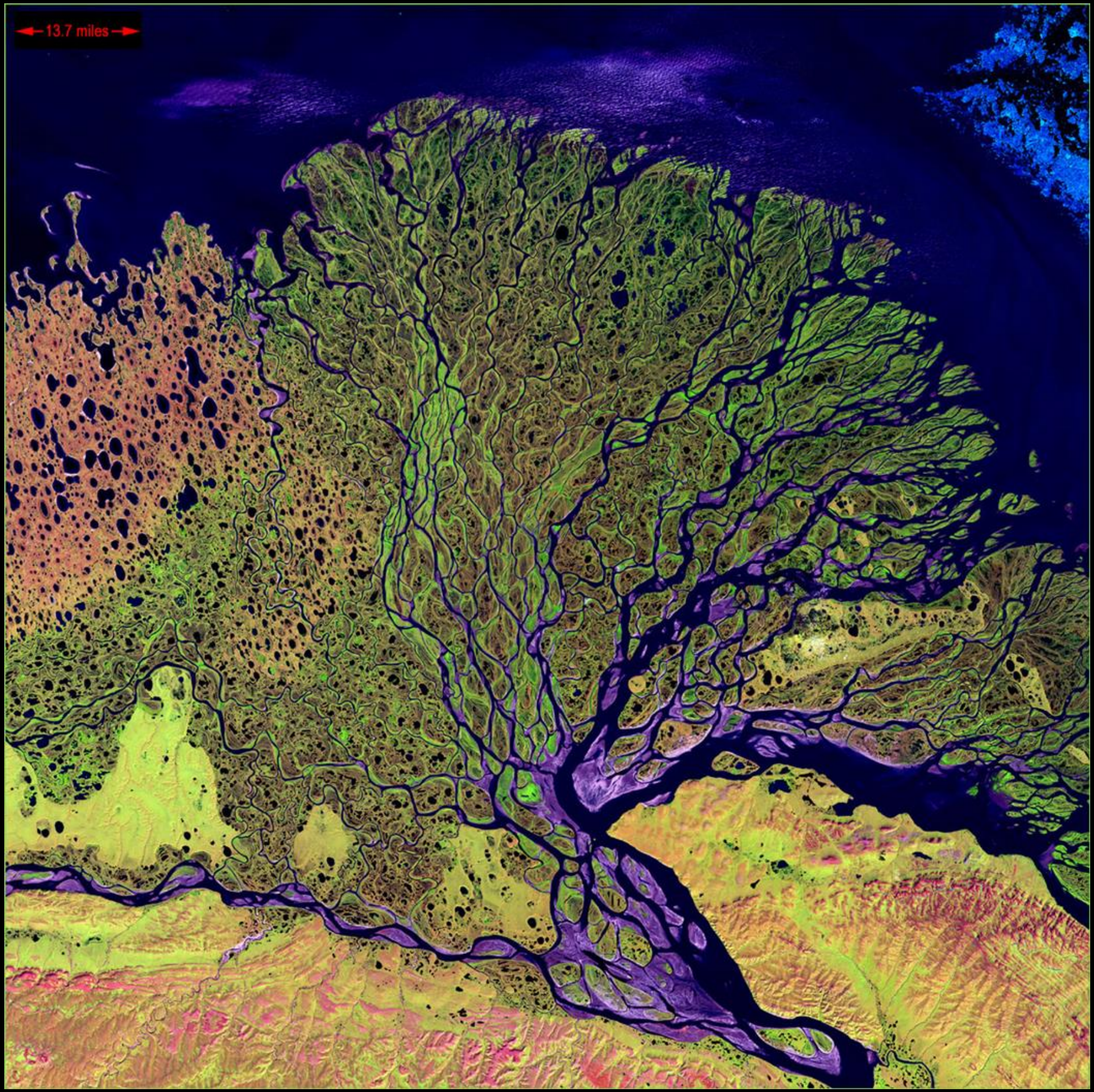
MARS

CREDIT: NASA/JPL-Caltech/Univ. of Arizona

EARTH

CREDIT: NASA

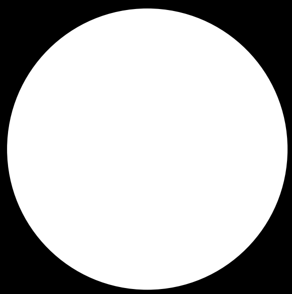
EARTH

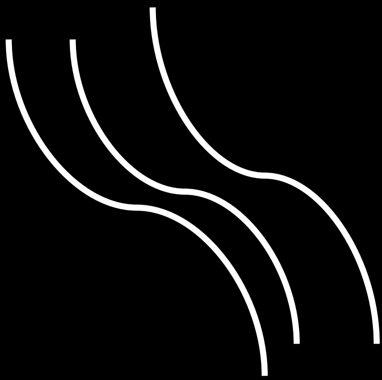


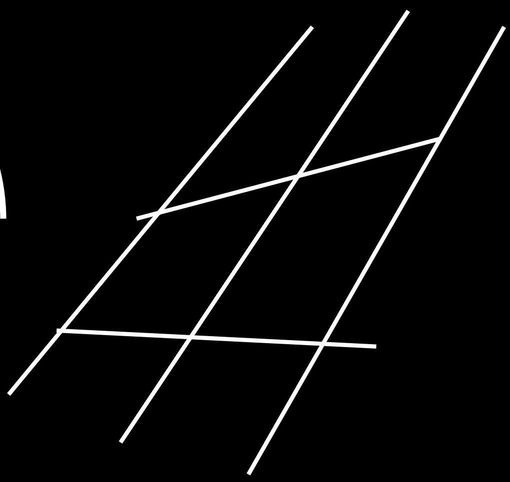
CREDIT: NASA Earth Observatory

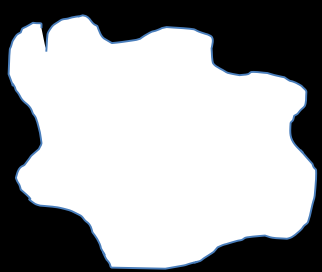
Access for Littler Learners

- Straight Lines
- Squiggly Lines
- Circles
- Blobs



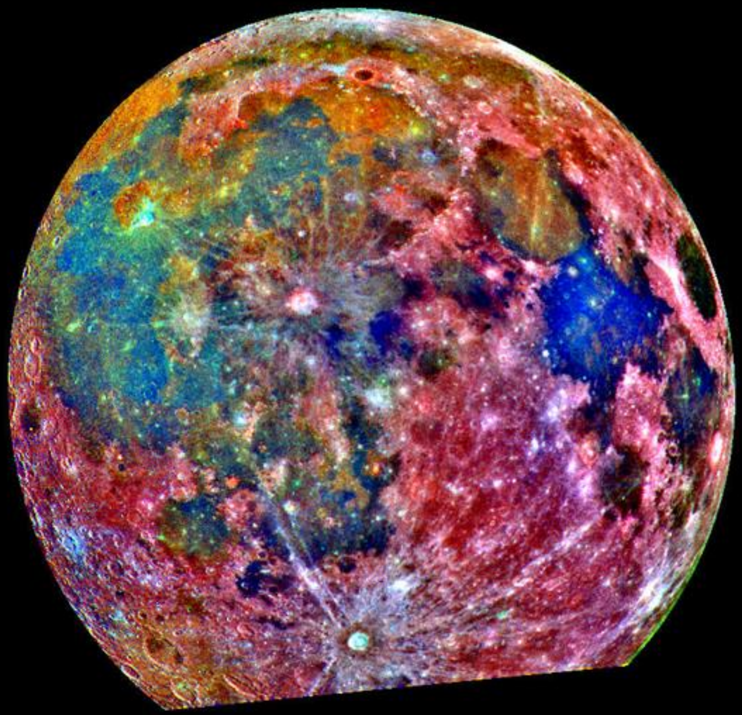






COLOR

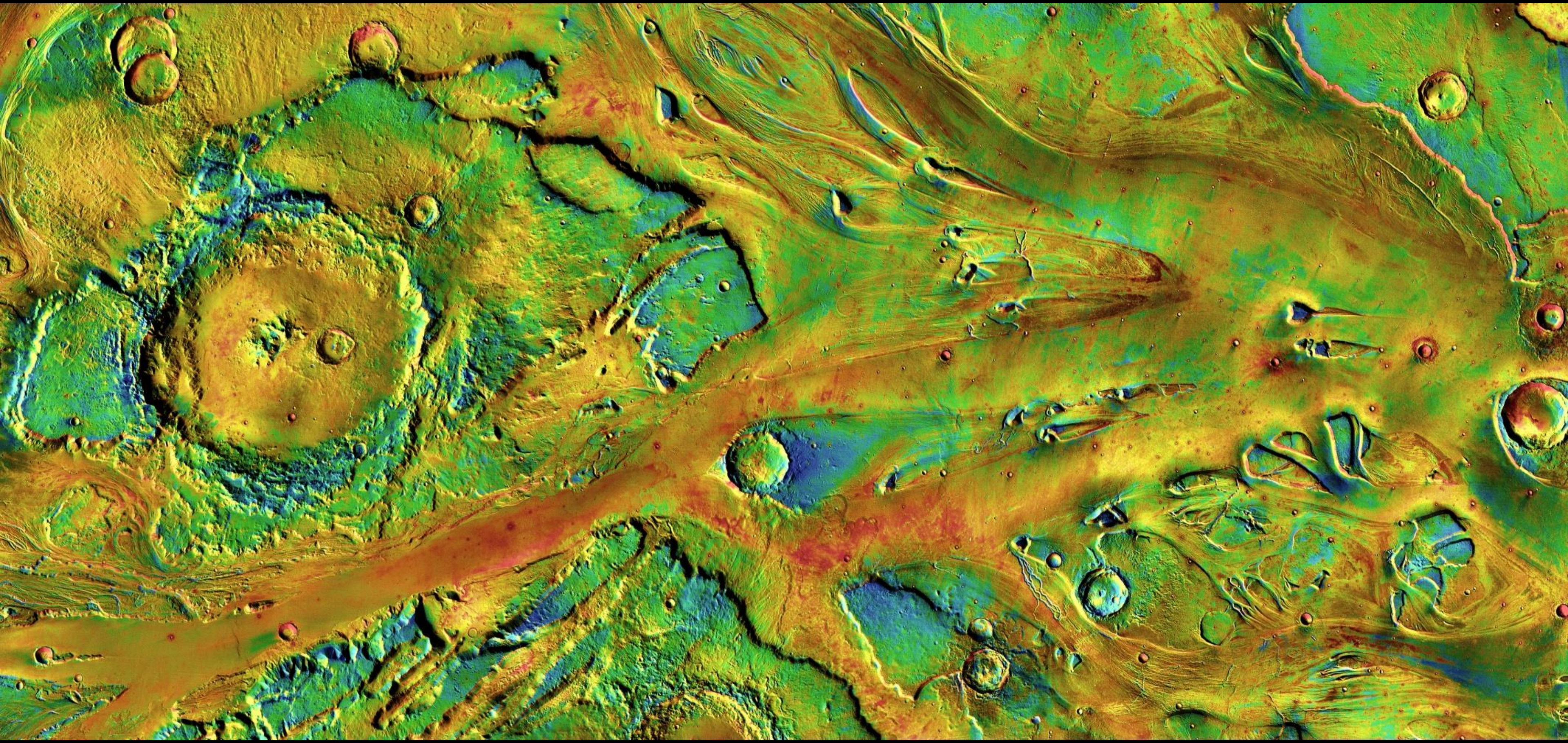
MOON



Color – true and added

CREDIT: NASA/JPL

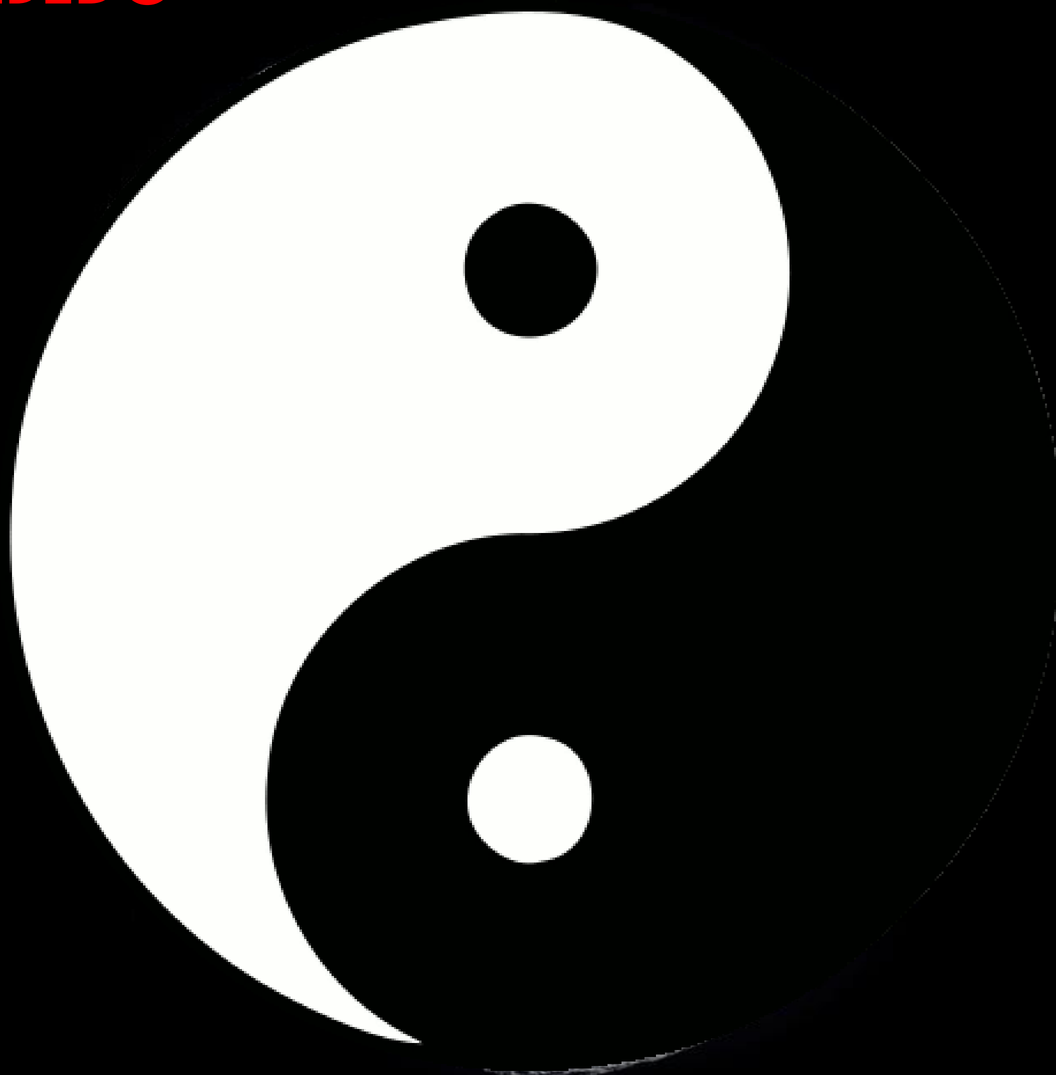
MARS



CREDIT: NASA/JPL-Caltech/University of Arizona/HI-RISE

VALUE / ALBEDO

IAPETUS

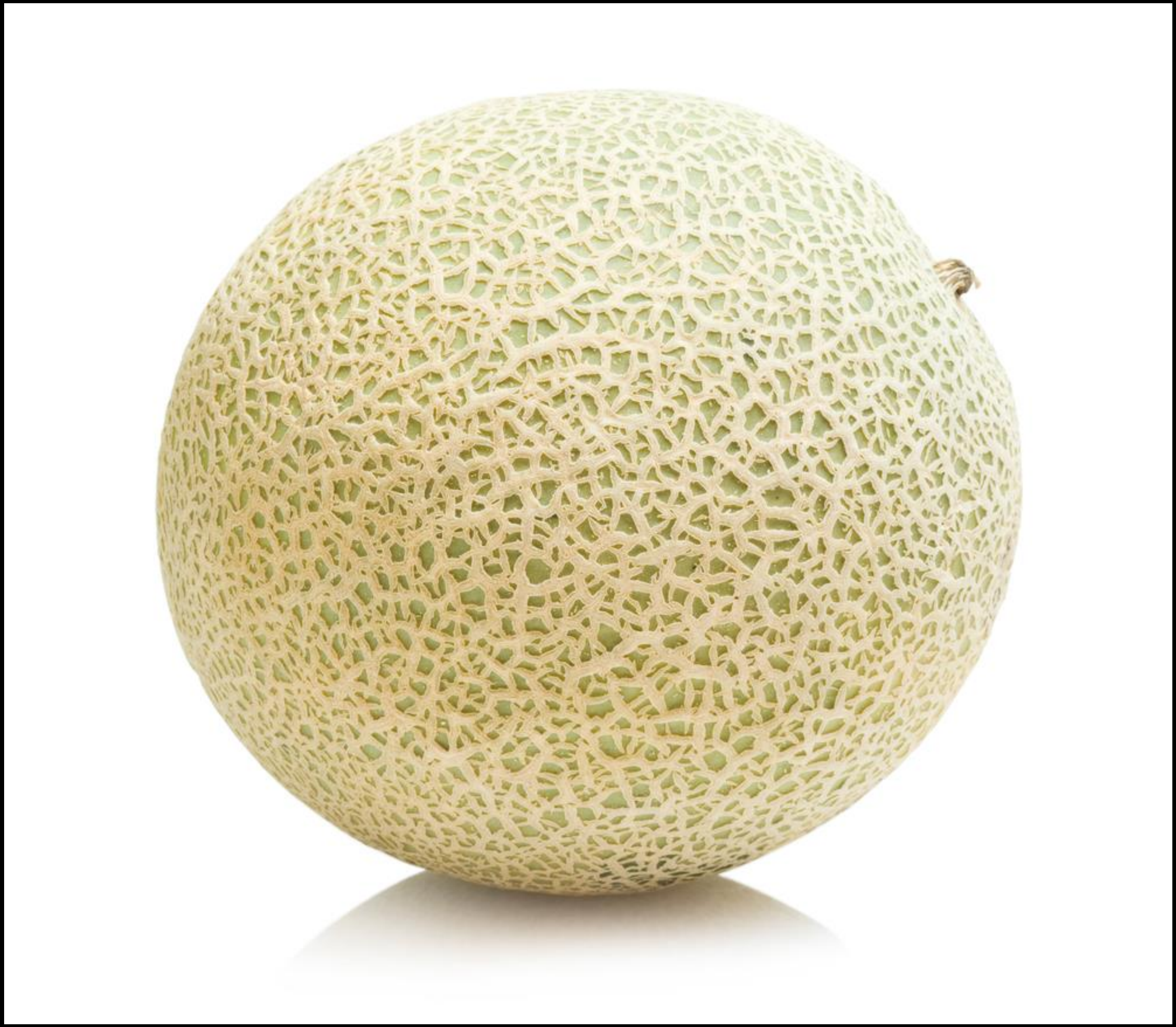


Value – light and dark, shade and highlight

CREDIT: NASA/JPL/Space Science Institute

TEXTURE

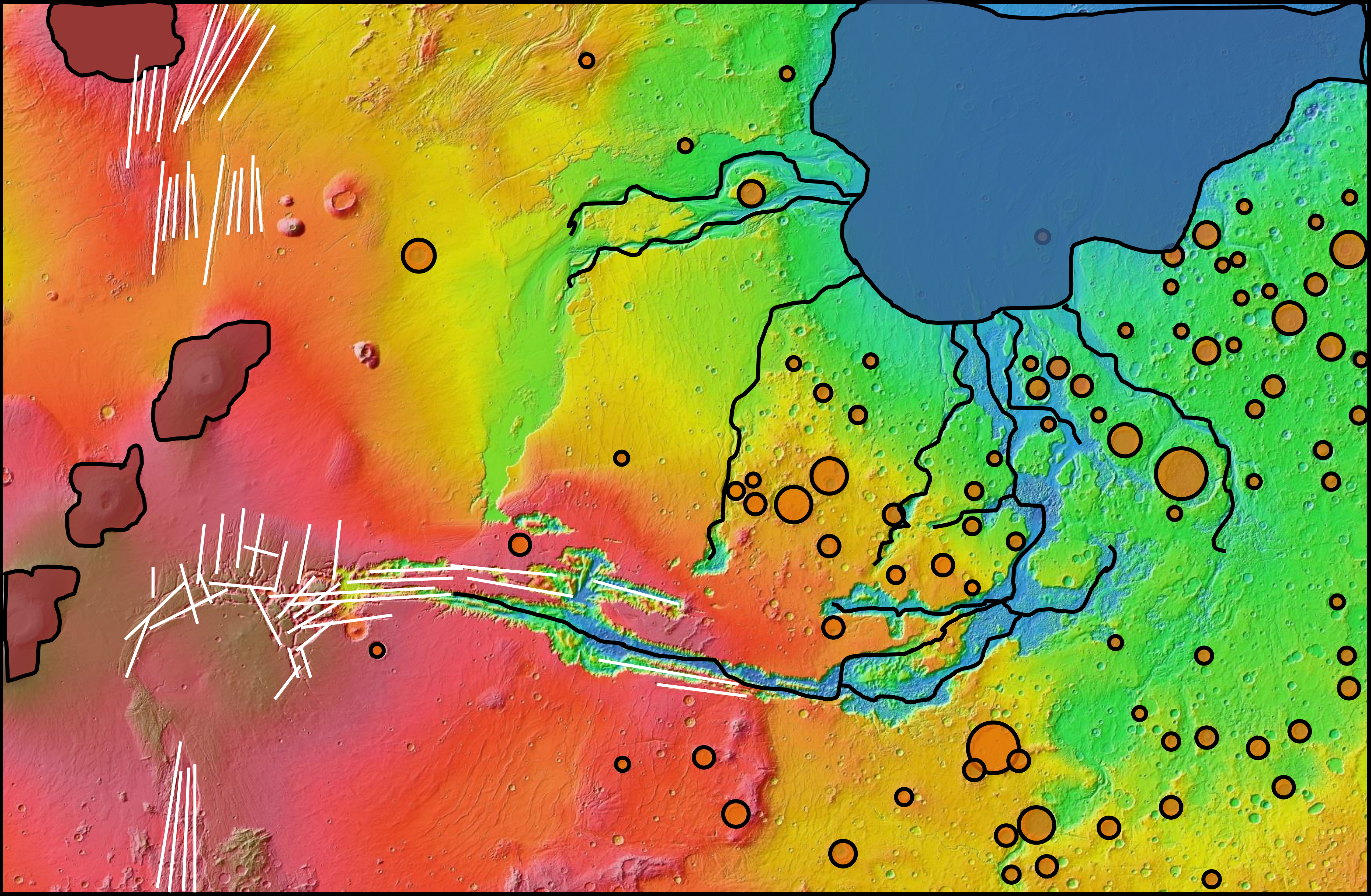
TRITON



Texture – the quality of the surface

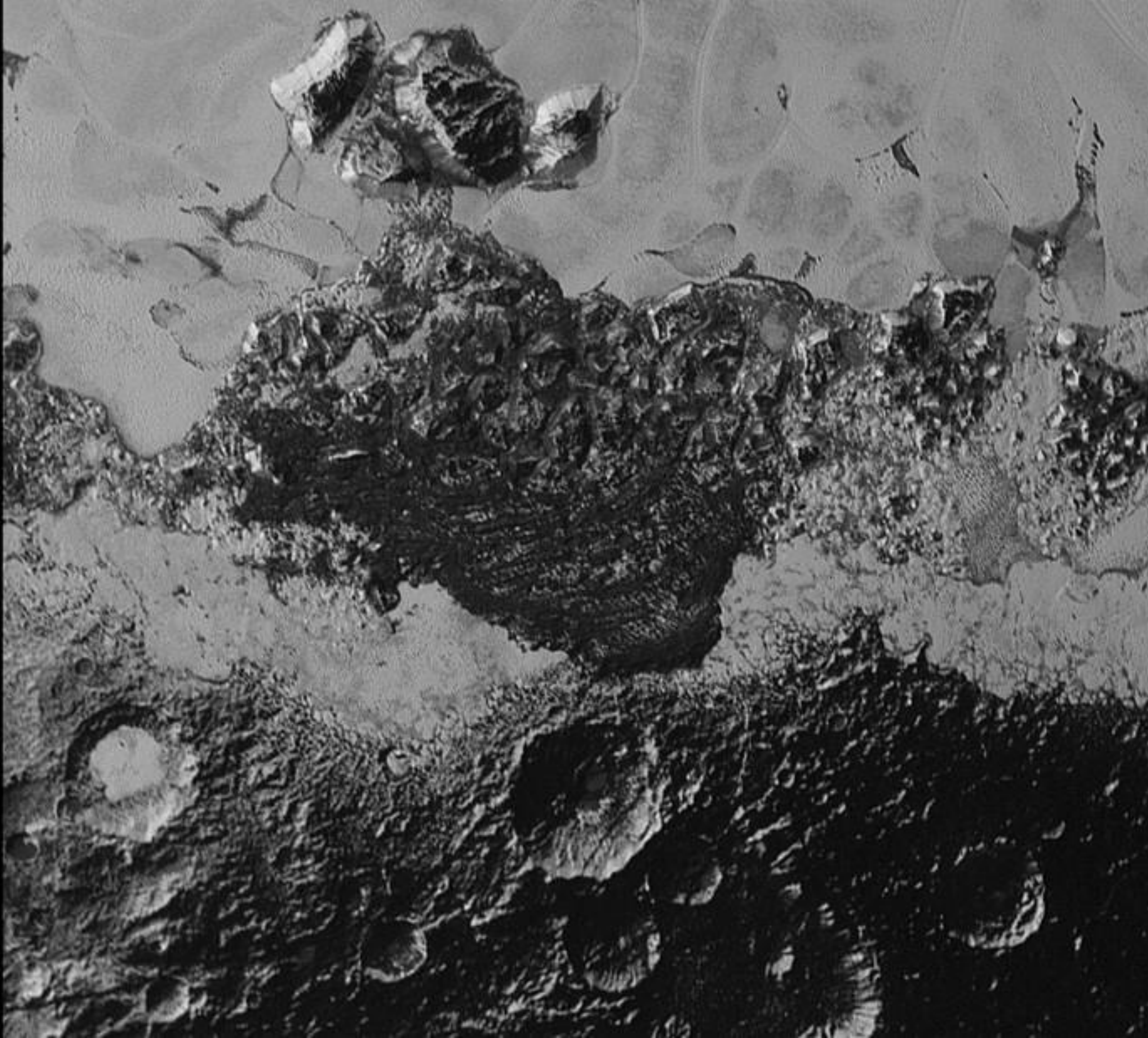
CREDIT: NASA/JPL/USGS

What "stories" do you see on Mars?



CREDIT: NASA/JPL

What Stories Do These Mysterious Worlds Tell?

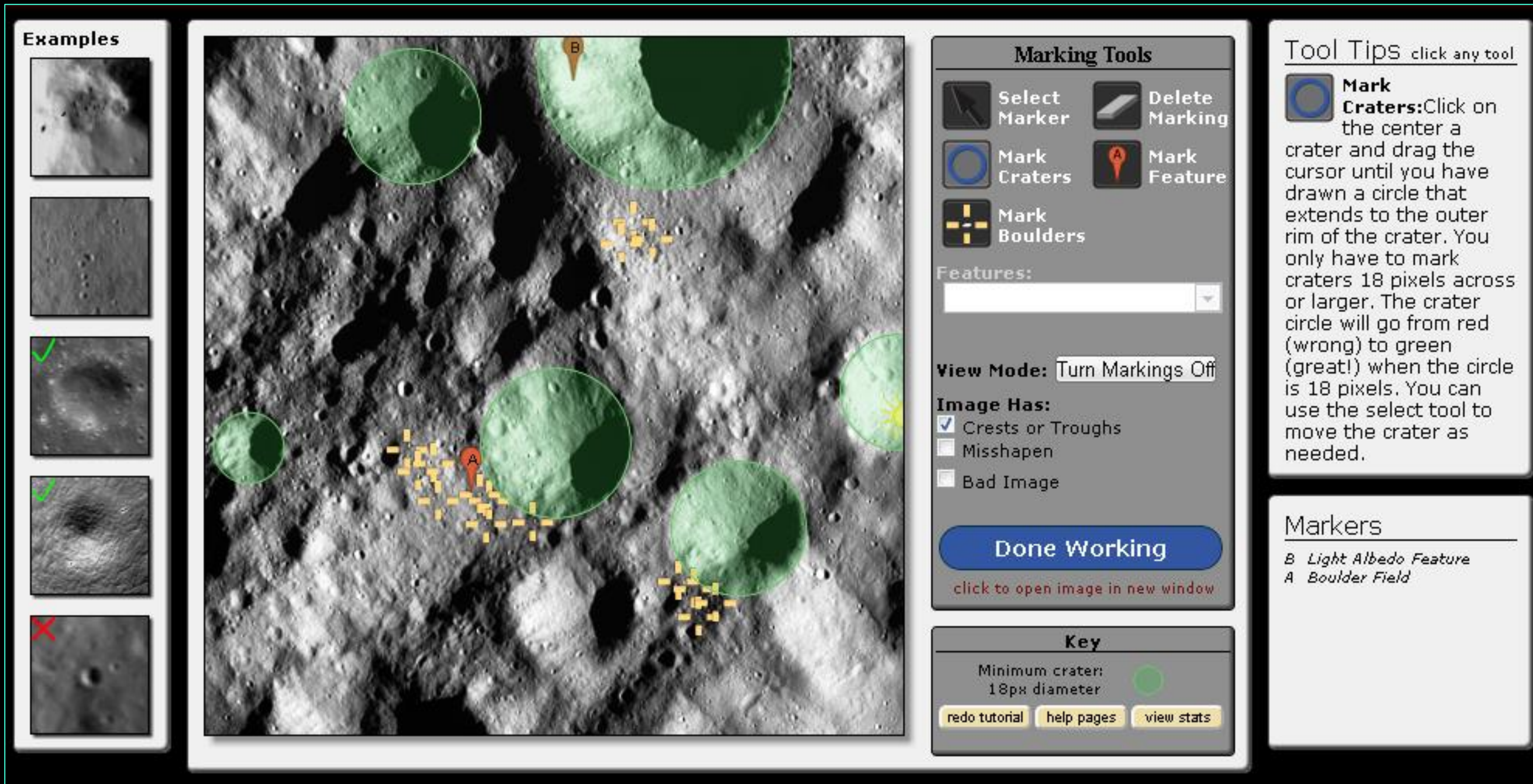


Gallery Walk

– What do you notice? Take a note!

Mapping 1

- Knuckle = ~10 kilometers
- Circle all craters over 5 km
- Count total craters
  - 0-3, blue
  - 4-6, green
  - 7-10, yellow
  - 11+ red



CosmoQuest Citizen Science

I'm a Mapper,

She's a Mapper,

Wouldn't You Like to be a Mapper, too?

CosmoQuest X

Learning Science & Building Community around Citizen Science Collaboration

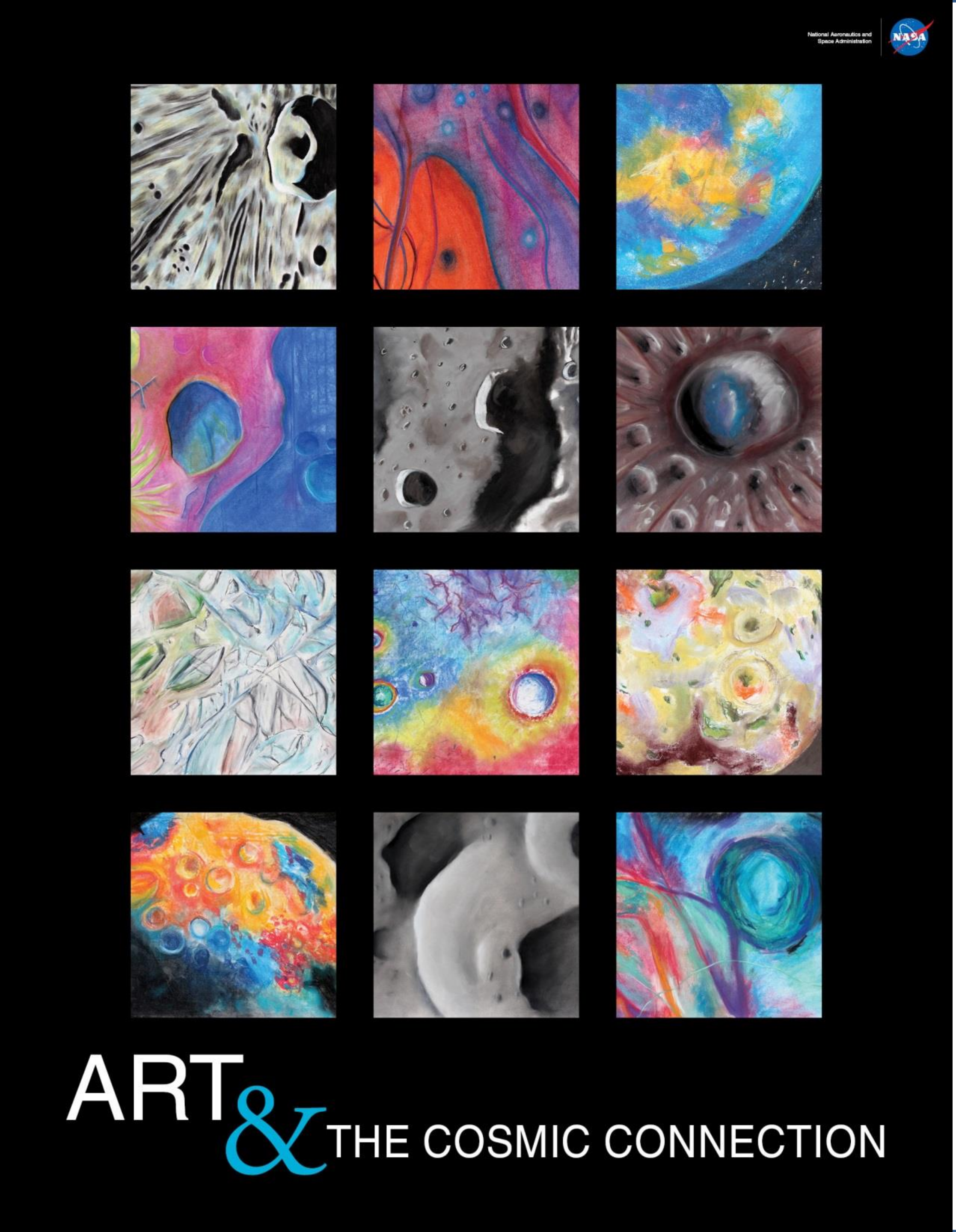
Britney Schmidt (Georgia Tech), Jake Noel-Storr (InSight STEM)
Whitney Cobb (McREL), Sanlyn Buxner (Planetary Science Institute)
Theresa Summer (Astronomical Society of the Pacific)

Astronomical Society of the Pacific
Advancing science literacy through astronomy

Planetary Science Institute
Est. 1972

InsightSTEM Inc.

McREL International



http://discovery.nasa.gov/art/

Instructor's Guide

Day One – Introduction: Why the Moon?

Objective: Students will compare and contrast surface features of the Earth and Moon.

Materials: Six sets of ten black and white pictures of the Earth and Moon surfaces---five representing each surface, large sheets of paper for Venn diagrams

Engage: Earth or Not Earth?
Compare Moon and Earth features by classifying pictures.

- Teams are given 10 pictures – five of black-and-white Earth features, five of Moon features.
- Ask: Which are pictures of the Moon, which are pictures of the Earth, as seen from above?
- Teams separate pictures into Moon group and Earth group, ***discussing their reasoning.***
- Conduct whole group discussion: What clues did you use to identify the picture

Explore: Construct Venn diagram of Earth/Moon.

- Distribute one large piece of paper to each team.
- Teams draw a Venn diagram to show similarities and differences between the geologic features and history of the Earth and Moon.
- Students copy their team's diagram in their Moon Journals.

Explain:
Vocabulary: Terrain, planetary geologist
Concepts

- Features of the Moon have their equivalents on Earth; the form of the features result from similarities and differences between geologic processes.
- Scientists study the Moon to learn more about the processes that shape it. Knowledge gained can be applied to similar structures on Earth as well as other planetary bodies.
- Students copy vocabulary, definitions, and concepts into their Moon Journals.

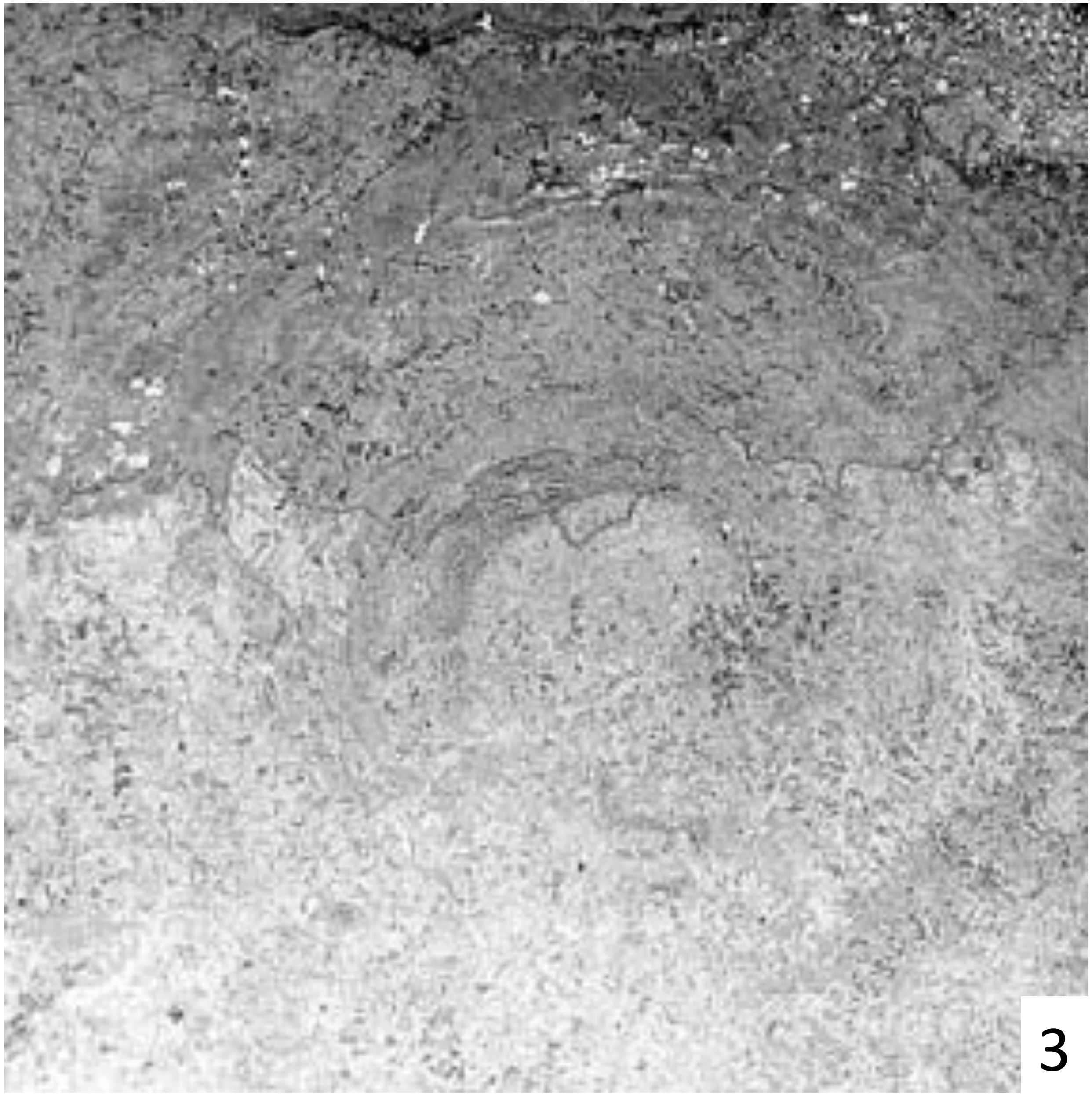
Evaluate: Check completion of Moon Journals.

Elaborate:
Have each student find a picture of a geologic feature on Earth and tape it into a journal page. Students then write a paragraph to explain the processes that might have formed the feature and if this feature might also exist on the Moon.

Technology Links:
How did people first learn about the features on the surface of the Moon? Students can find out by building and using their own telescopes. Several simple homemade telescopes can be found at http://www.nasa.gov/audience/foreducators/informal/features/F_Build_a_Telescope_prt.htm and http://www.universetoday.com/17366/build-a-telescope/. You may choose to ask students to look at the Moon with their new telescopes, binoculars, or just naked eye and record what they see in their journals for the activity on day six.

Interdisciplinary Link:
Link to Language Arts - Research legends about "The Man in the Moon" and other lunar legends

****REMINDER:** Ask students to bring three or more natural rock samples, (not brick, concrete, or other manufactured rocks), from home for tomorrow's class.



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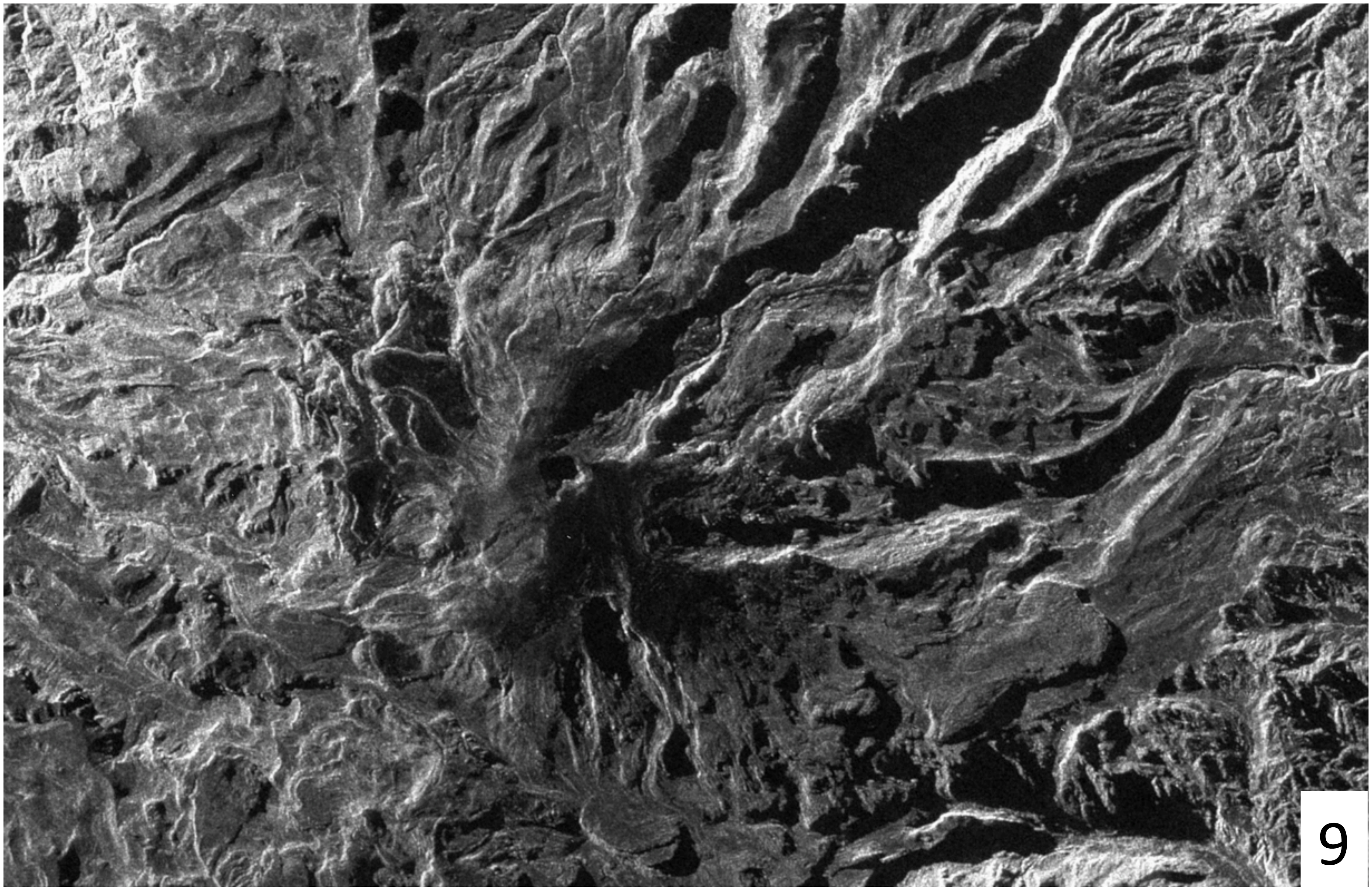

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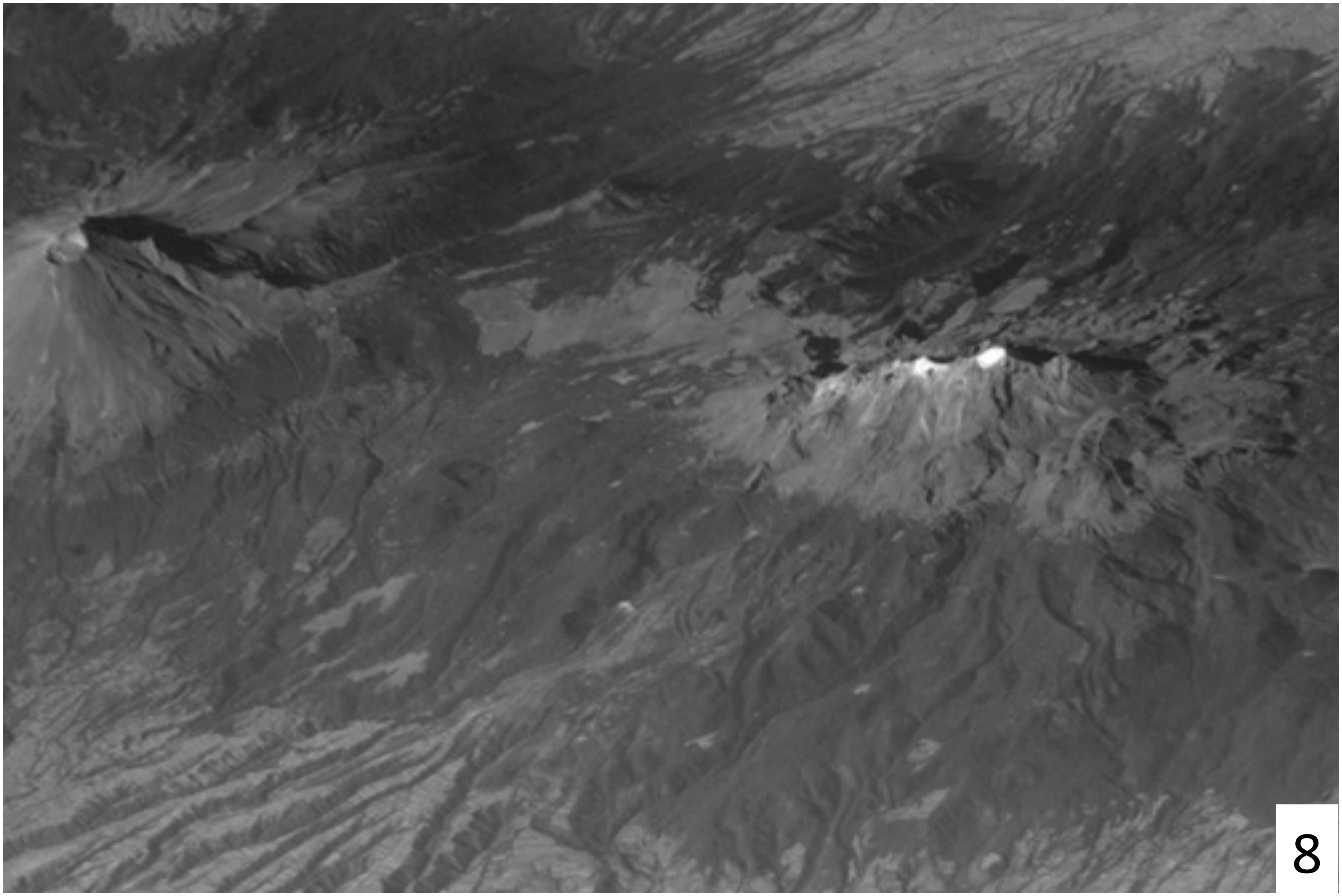

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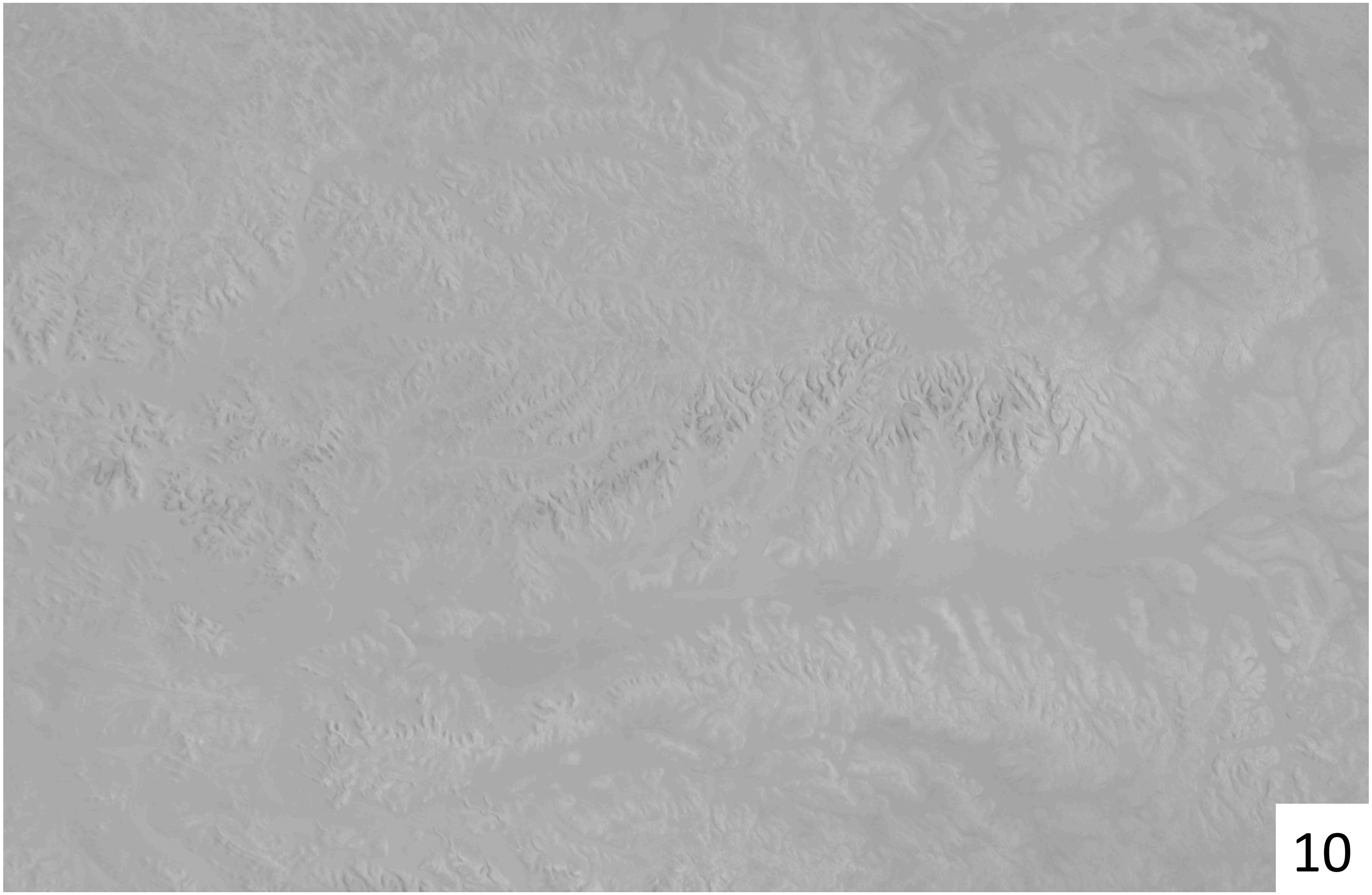

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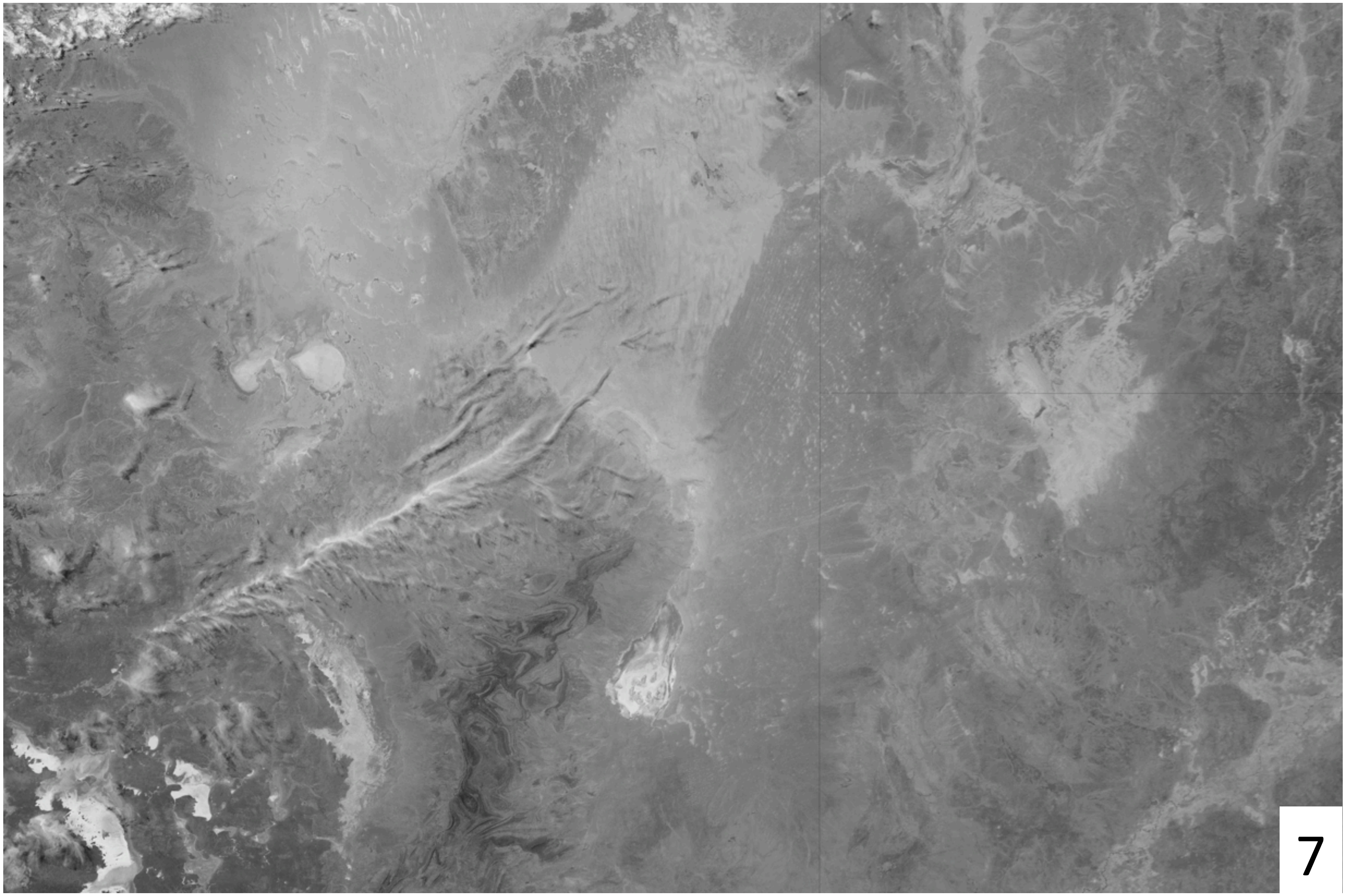
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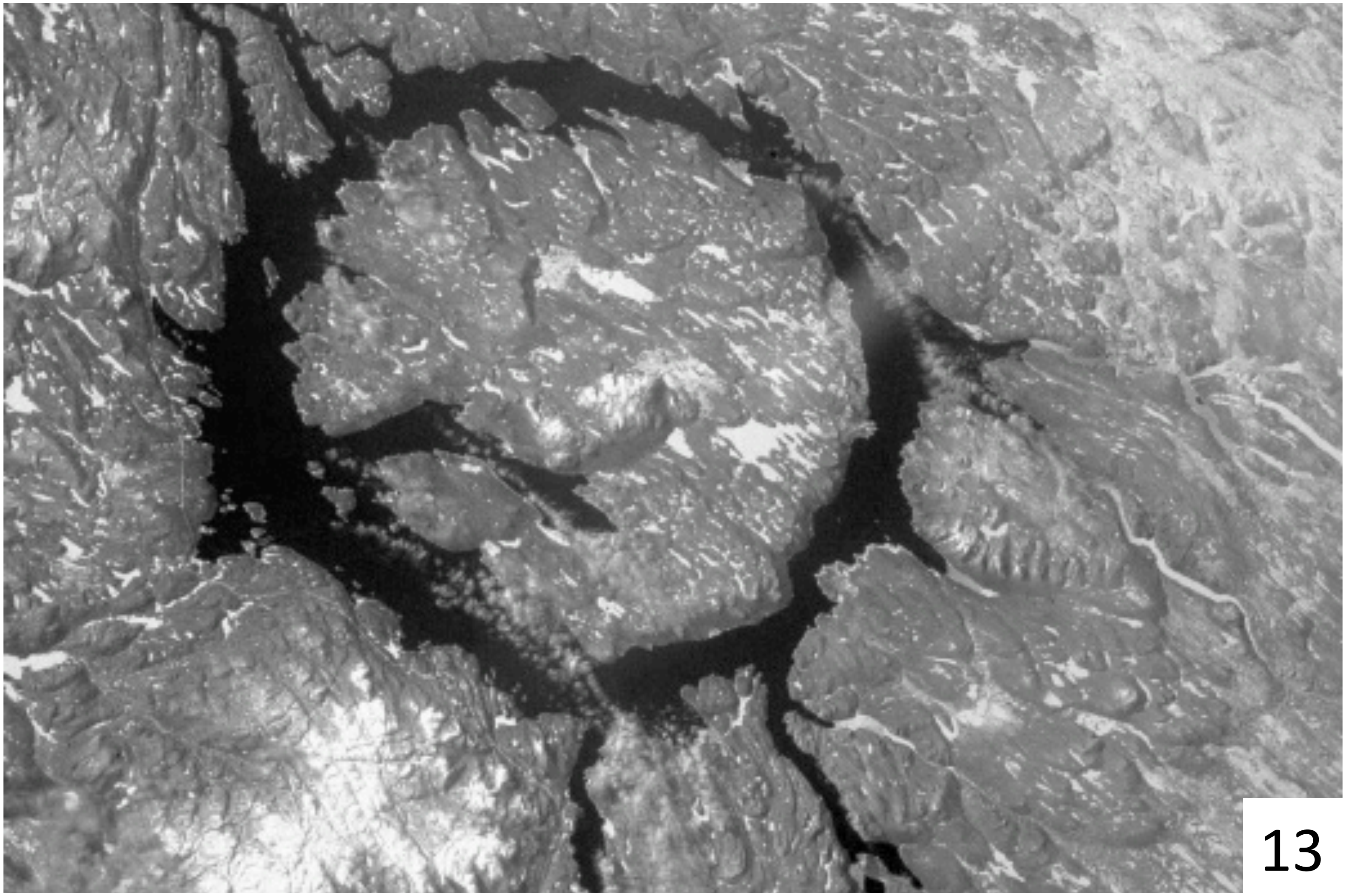

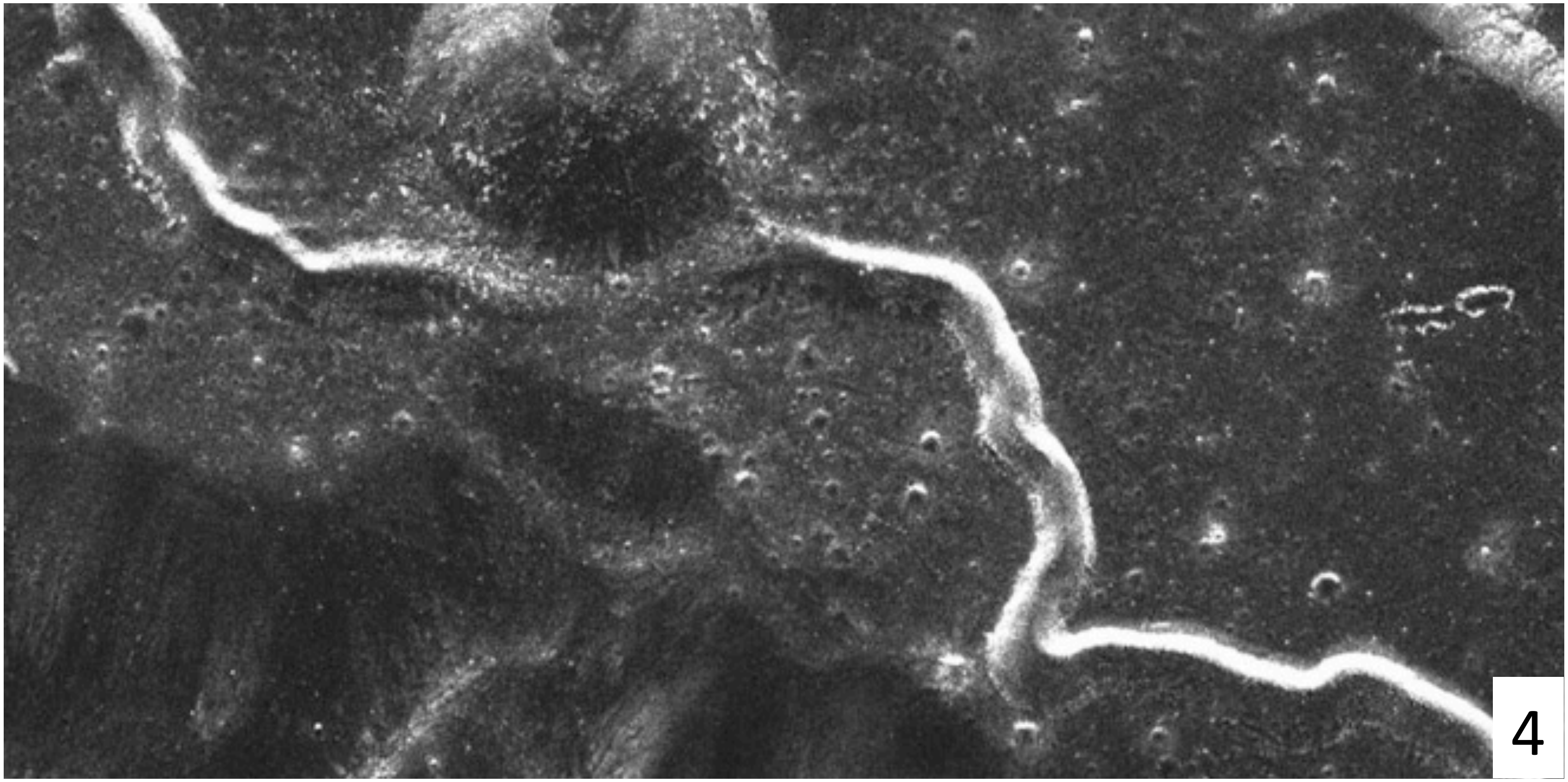
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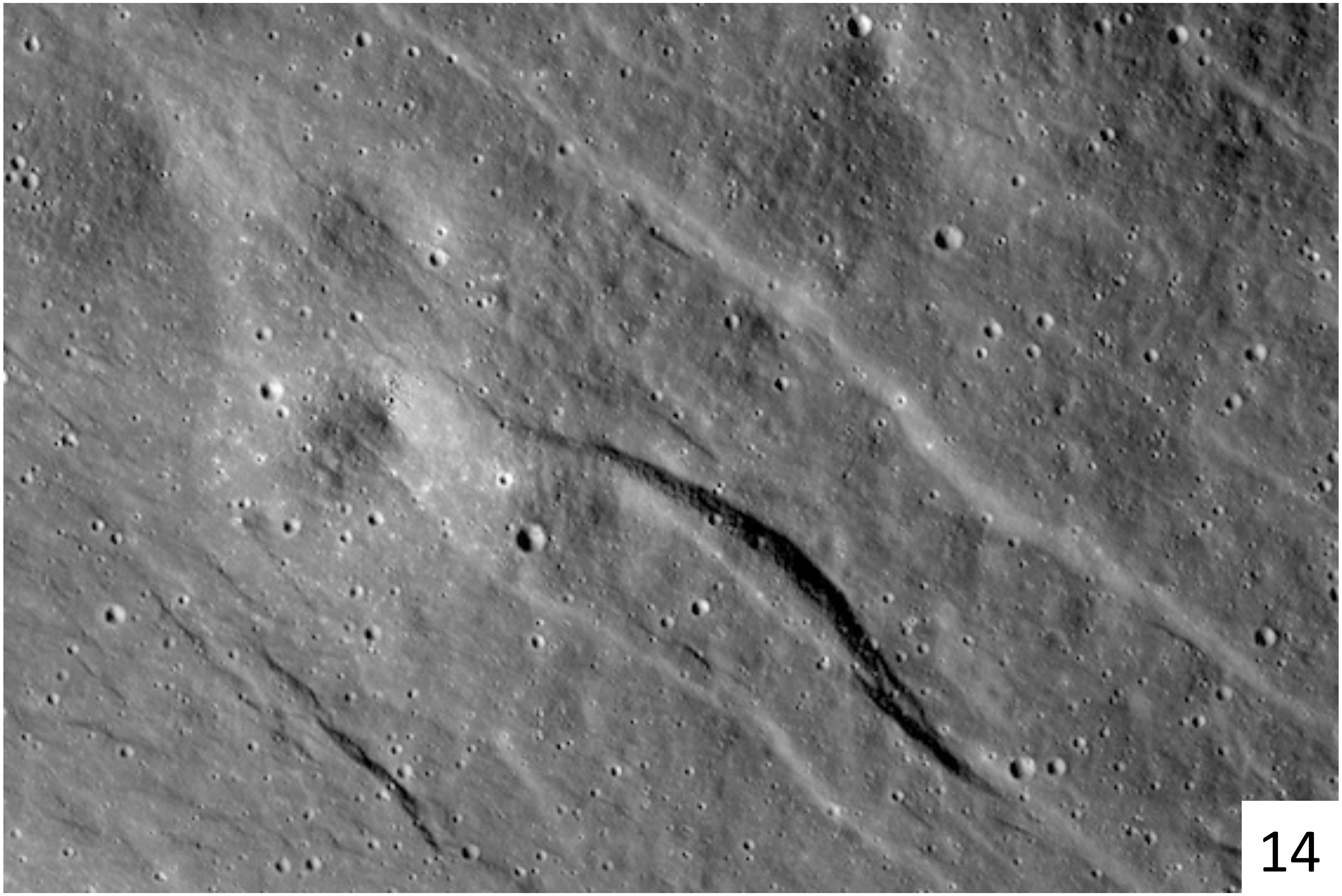

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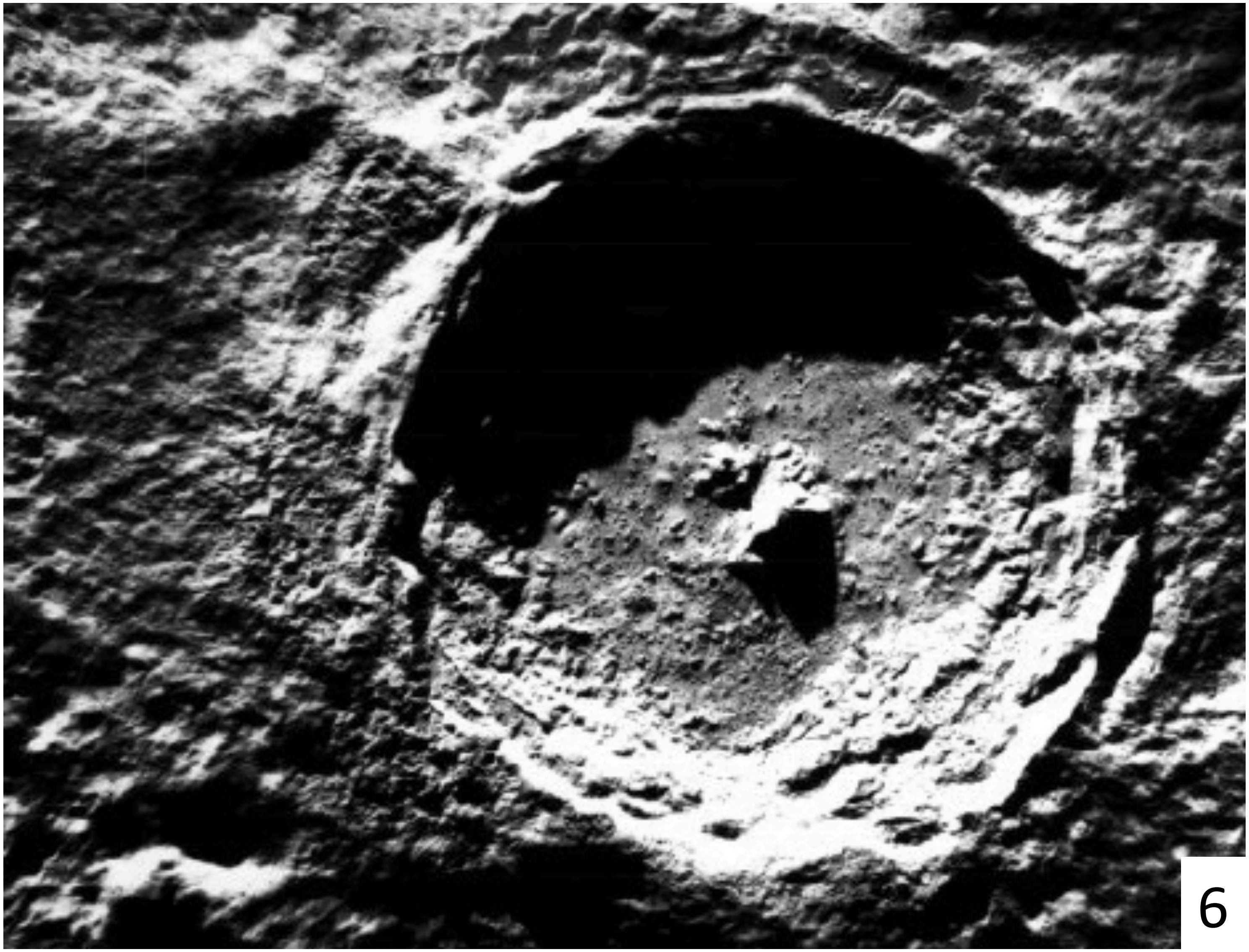

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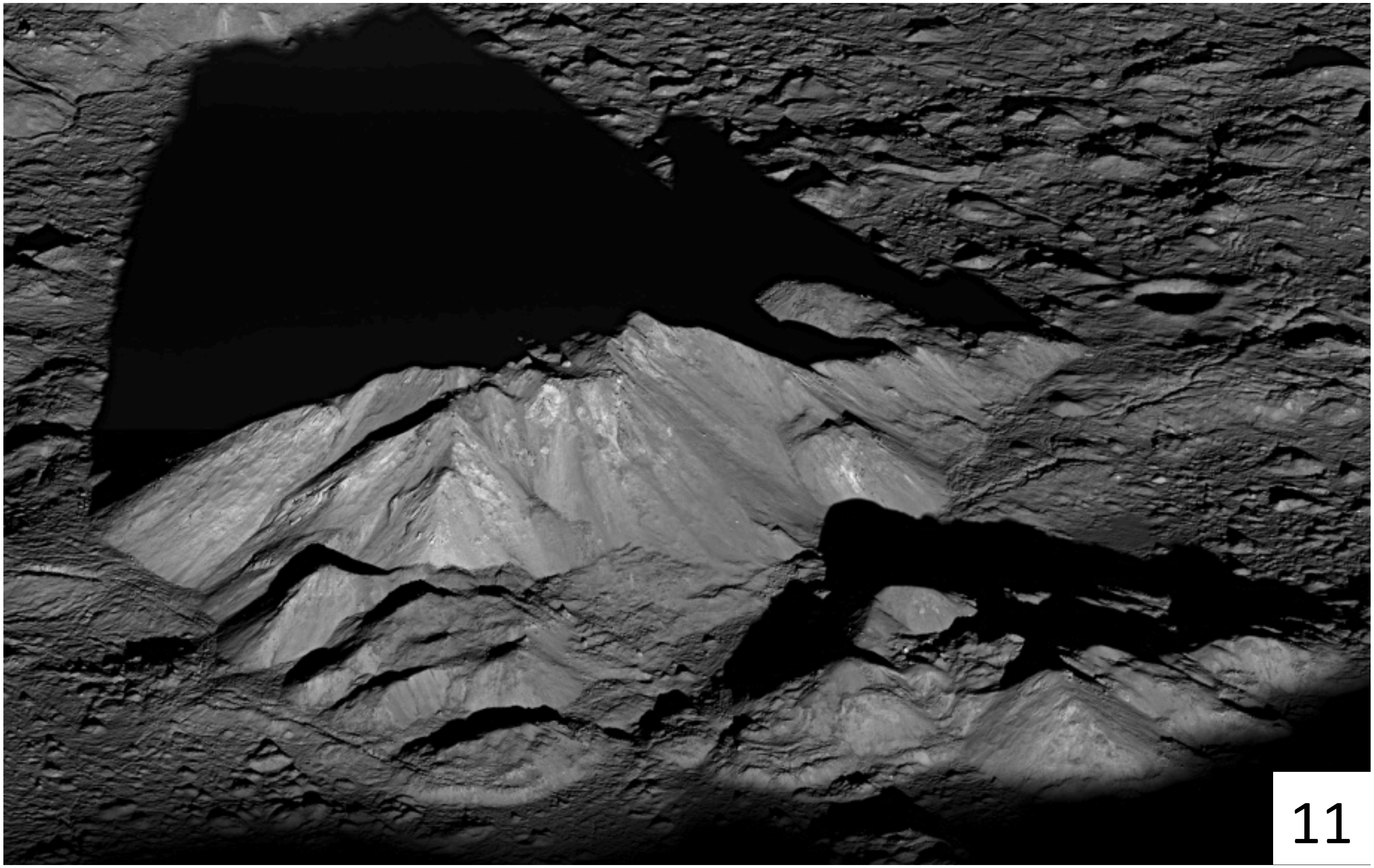
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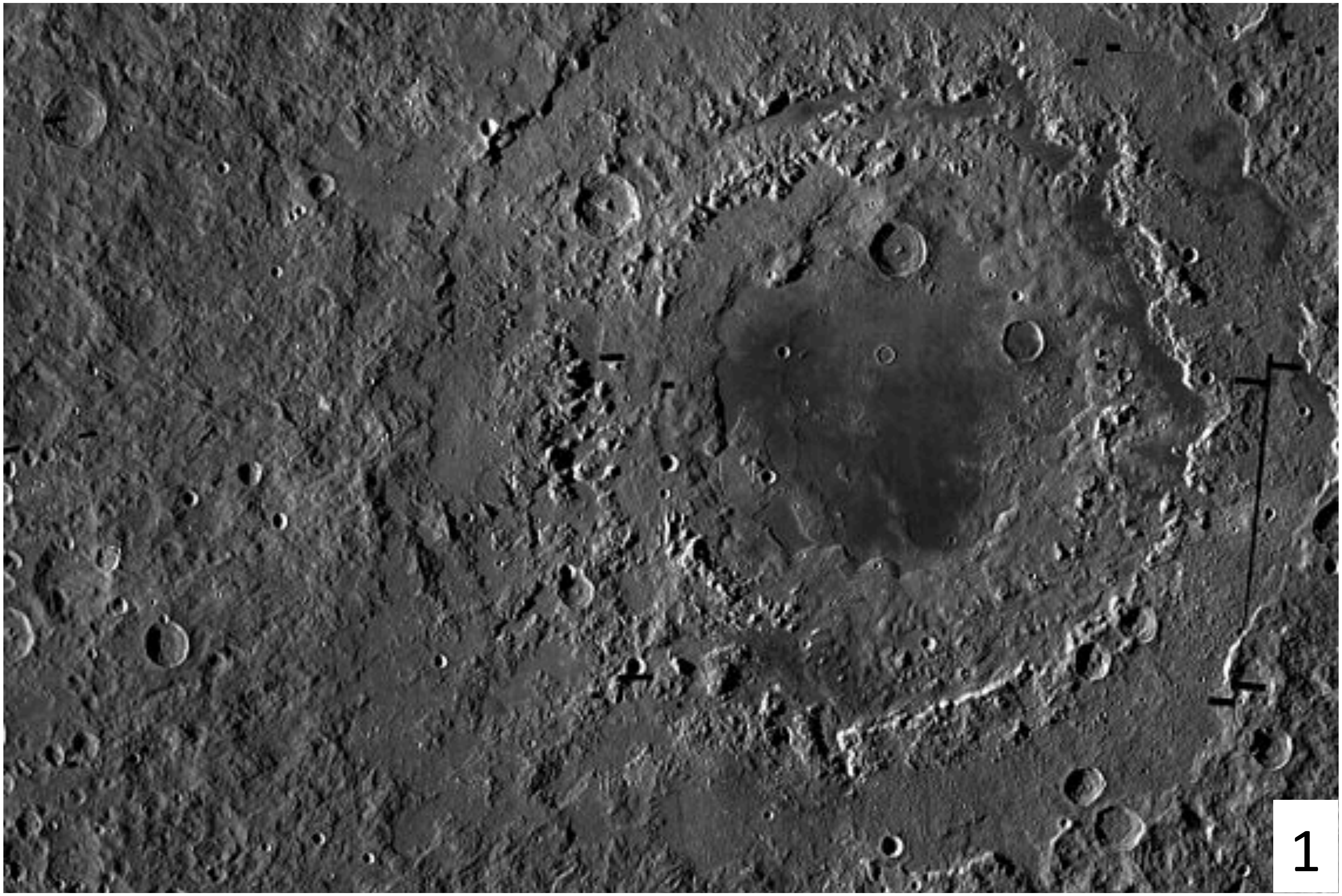
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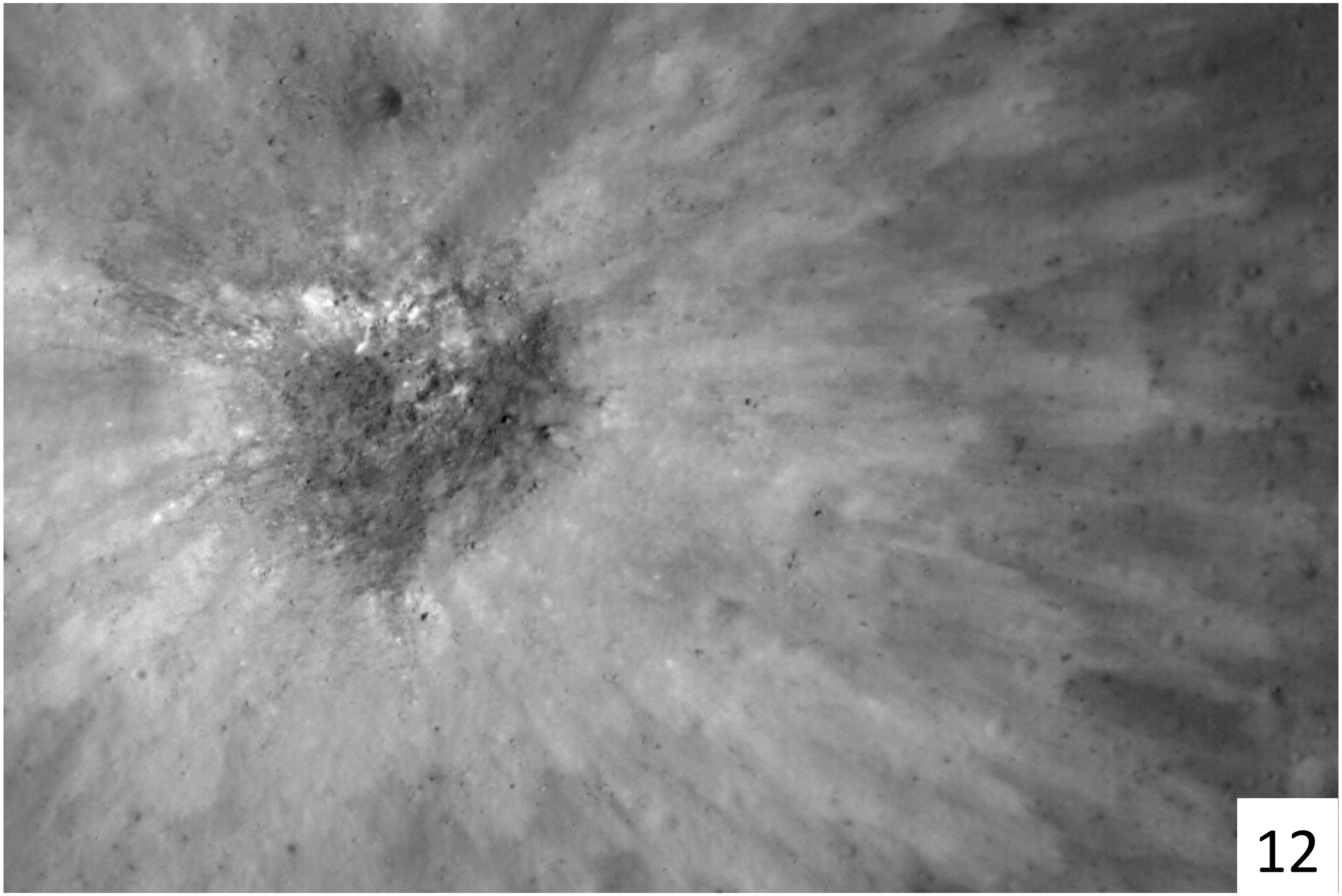
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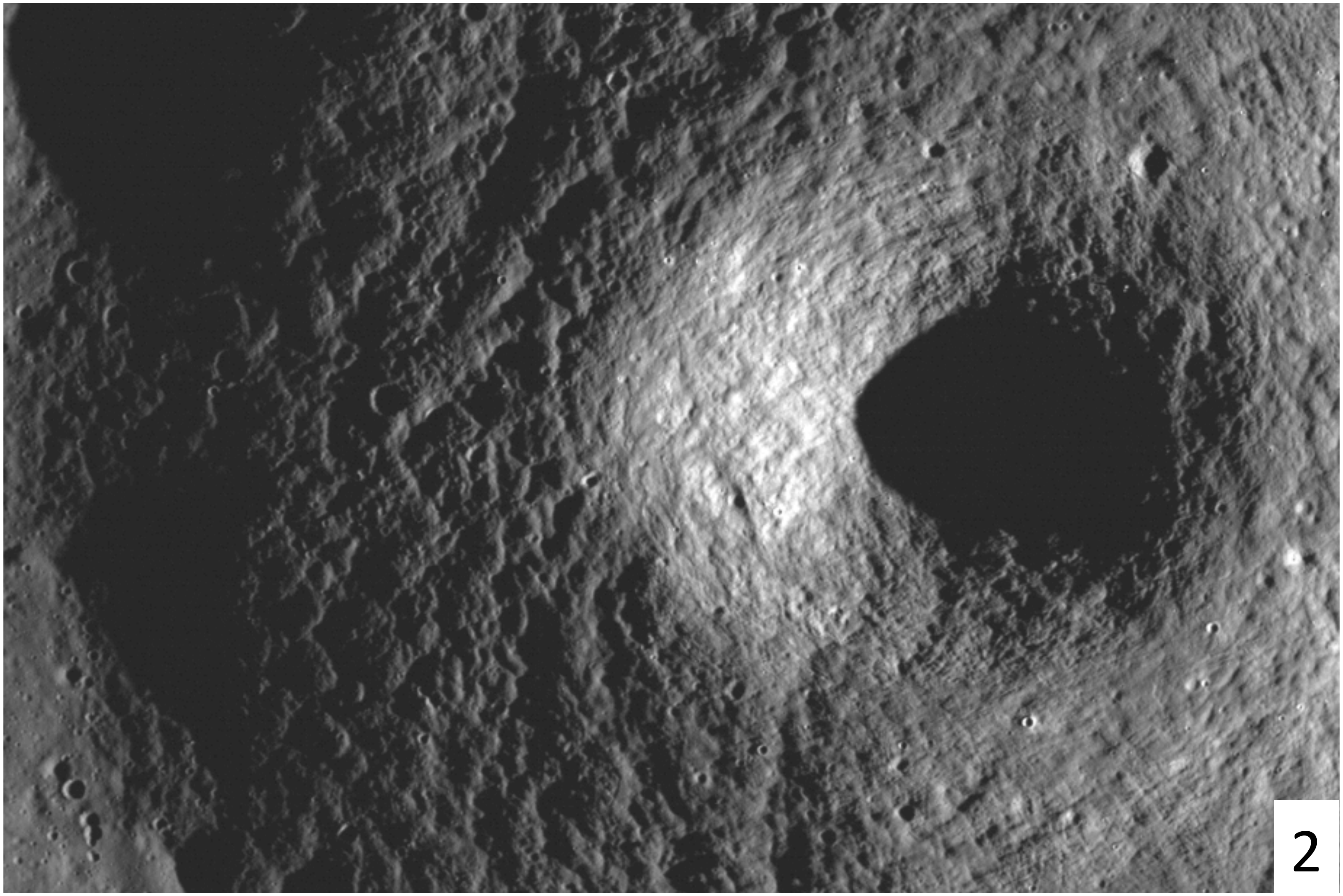

2

Key (order of slides)

3 – Earth - Vredefort Dome (South Africa) - http://upload.wikimedia.org/wikipedia/commons/c/c3/Vredefort_crater.jpg

9 – Earth - Nevado del Ruiz (Columbia) - http://upload.wikimedia.org/wikipedia/commons/0/0f/Nevado_del_Ruiz_-_radar_image_from_space.jpg

5 – Earth - Barringer Crater (United States) - http://ut-images.s3.amazonaws.com/wp-content/uploads/2008/11/barringer-meteorite-crater.jpg

8 – Earth - Volcanoes (Mexico) - http://www.nasa.gov/images/content/114750main_image_feature_328_ys_4.jpg

10 – Earth - Erosion (Libya) - http://www.nasa.gov/images/content/285297main_iss017e013789_high.jpg

7 – Earth - Tirari Desert (Australia) - http://upload.wikimedia.org/wikipedia/commons/1/12/Tirari_Desert_-_NASA_-_satellite_2006.jpg

13 – Earth - Manicouagan Reservoir (Canada) - https://dl.dropbox.com/u/19254794/TERRALUNA%20manicouagan-reservoir.jpg

4 - Lunar rille - http://www.nasa.gov/images/content/463898main2_LRO_Rille_670.jpg

14 - Lunar graben - http://www.nasa.gov/images/content/623732main_video_graben_image_lgweb.jpg

6 - Lunar crater (Tycho) - http://upload.wikimedia.org/wikipedia/commons/f/f8/Tycho_crater_on_the_Moon.jpg

11 - Lunar crater central peak (Tycho) - http://apod.nasa.gov/apod/ap110706.html

1 - Lunar mare (Orientale) - http://en.wikipedia.org/wiki/File:Orientale_lro.jpg

12 - Lunar ejecta from young crater - http://www.nasa.gov/images/content/424832main_murchison_lg.jpg

2 - Lunar volcanic pit crater - http://lroc.sese.asu.edu/news/uploads/LROCiotw/M131488521RE-2_thumb.png

Key (numerical order)

1 - Lunar mare (Orientale) - http://en.wikipedia.org/wiki/File:Orientale_lro.jpg

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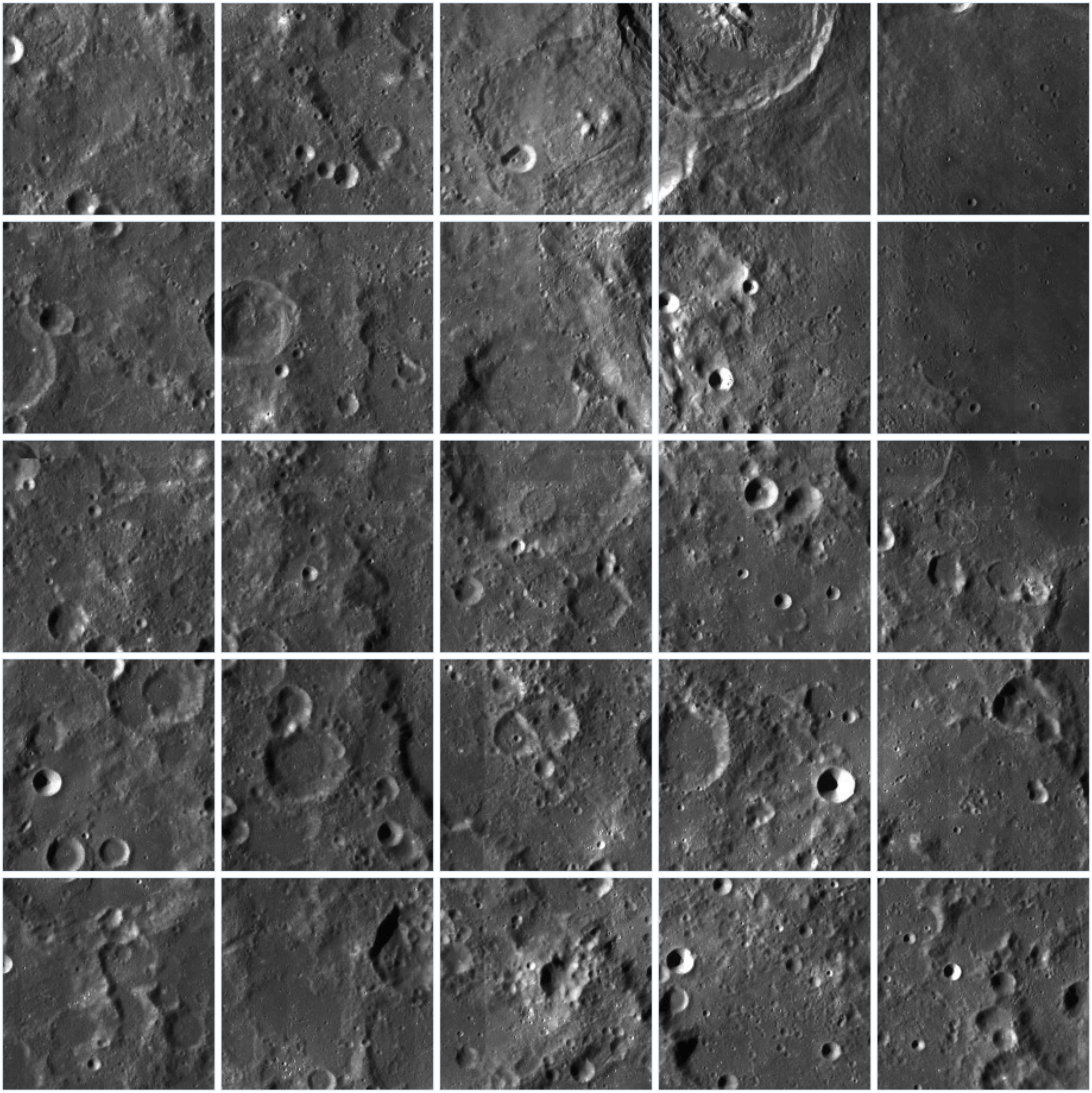
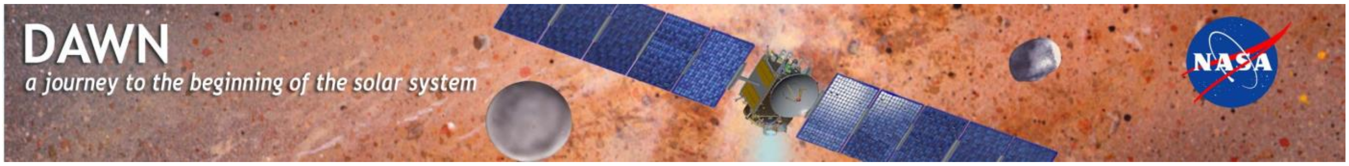




History and Discovery of Asteroids

In Search Of…

ACTIVITY

PART 1: OVERVIEW

The Hunt for the Missing Planet
The Titius-Bode rule resulted in the need to discover a “missing planet” between the orbits of Mars and Jupiter. Baron von Zach had spent years searching for this planet. The method that von Zach used was tedious. Using a telescope, each star that was not on von Zach’s star chart was checked on successive nights to determine if it had moved. If the position of the star moved with respect to the other “known” stars on his chart, it could be the missing planet. Since the star charts at the time were not accurate, many had to be checked and double-checked. Von Zach was not successful in finding the missing planet.

The Celestial Police
In the late 1790s, von Zach met with French astronomers Joseph Lalande and Johann Bode and determined that a more systematic approach was in order. In 1800, von Zach held a meeting with Johann Schröter, Karl Harding, Heinrich Olbers, Ferdinand von Ende, and Johann Gildemeister to determine a plan. Since all of the known planets were located along the **ecliptic**, this section of the sky was divided up into 24 zones. The astronomers dubbed themselves the “Celestial Police,” whose goal was to find this elusive planet. Each member of the newly formed group was to observe and record one zone in detail. They soon realized that they needed to recruit additional police officers for the task. They invited other European astronomers to participate. “Each member was to draw up a star chart for his zone, extending to the smallest telescopic stars, and through repeated examination of the sky was to confirm the unchanging state of his district, or the presence of each wandering foreign guest.” (Hoskin, 1992). http://www.astropa.unipa.it/versione_inglese/Hystory/BODE%27S_LAW.htm

PART 2: GROUP ACTIVITY

Astronomers Most Wanted
Now it’s your turn. View the following star maps and try to find the missing planet. Answer the question, “How can I find a missing planet amongst the stars?” This is the same type of question that the Celestial Police asked. There are four star charts that make up half of the nighttime sky. There is one missing planet found in these charts. You will be able to identify the missing planet by finding the “star” (dot) that moves with respect to the constellations from one night to the next.

Share Your Finding
Once you have found the missing planet, respond in writing to the questions below:

1. What strategy did you use to find the “missing planet”?

2. Did you find the “missing planet”? If so, how do you know that you found it? In not, why are you certain that the missing planet is not in your quadrant of the sky?

3. After sharing your findings within your group, use the space below to draw a simple diagram of the path that the missing planet follows.

4. Next, in your diagram above, make a prediction as to the path that this body will continue to follow over the next week. Indicate your predicted path with a dotted line. Justify your prediction in writing below.

PART 3: EXTENSION ACTIVITY

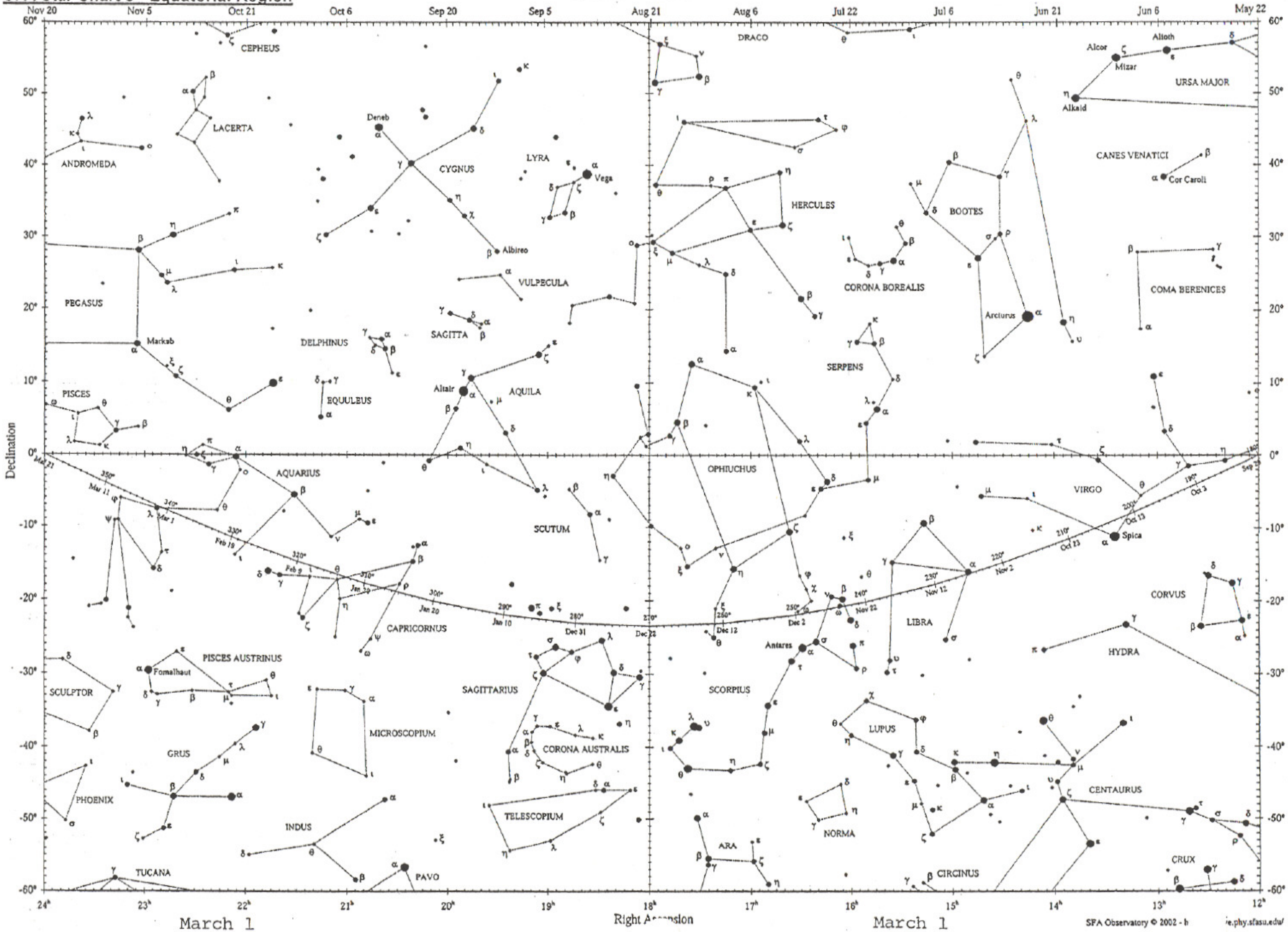
Failure?
The Celestial Police failed at their systematic attempt at finding the missing planet. It was the newest member of these sky cops, an Italian monk, Giuseppe Piazzi, who finally discovered a small new world. However, he was not sure what he discovered! Learn more about this discovery by reading “It Was a Dark and Starry Night.”

March 1

MARCH 1

SFA Star Chart 3 - Equatorial Region

Local Meridian for 8 PM



March 1

March 1

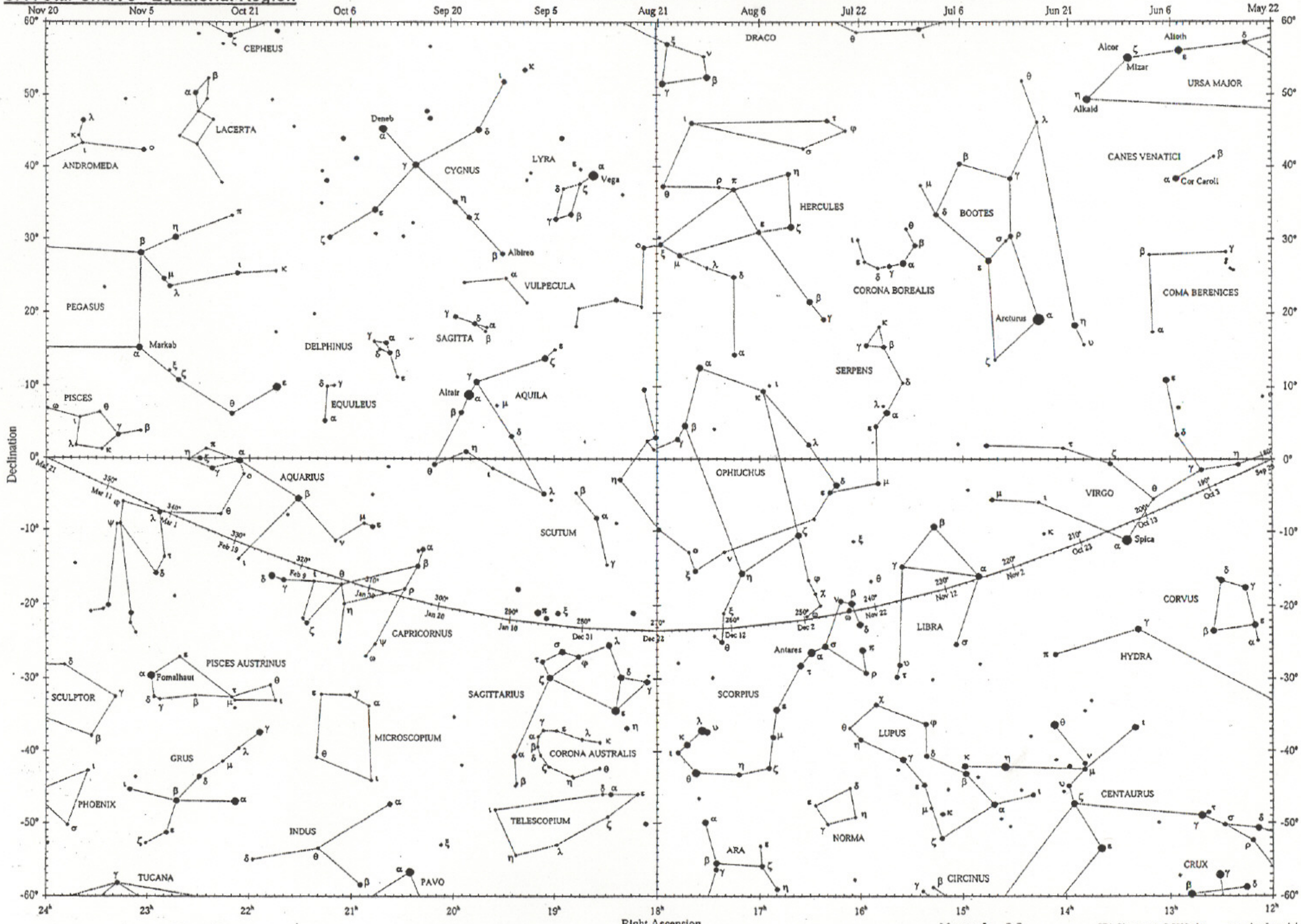
SFA Observatory © 2002 - h ... e.phy.sfasu.edu/

March 11

MARCH 11

SFA Star Chart 3 - Equatorial Region

Local Meridian for 8 PM



March 11

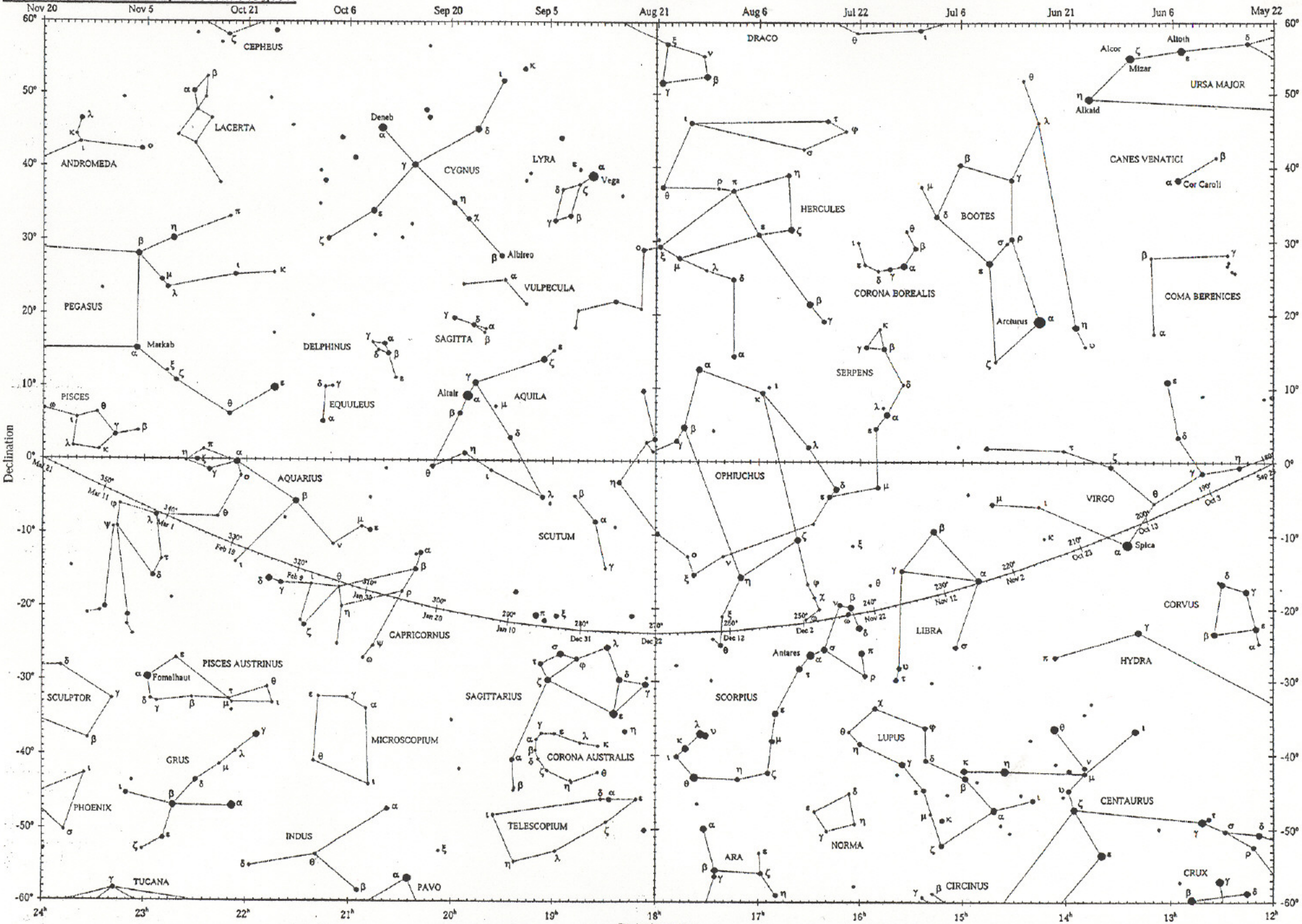
March 11

March 21

MARCH 21

SFA Star Chart 3 - Equatorial Region

Local Meridian for 8 PM



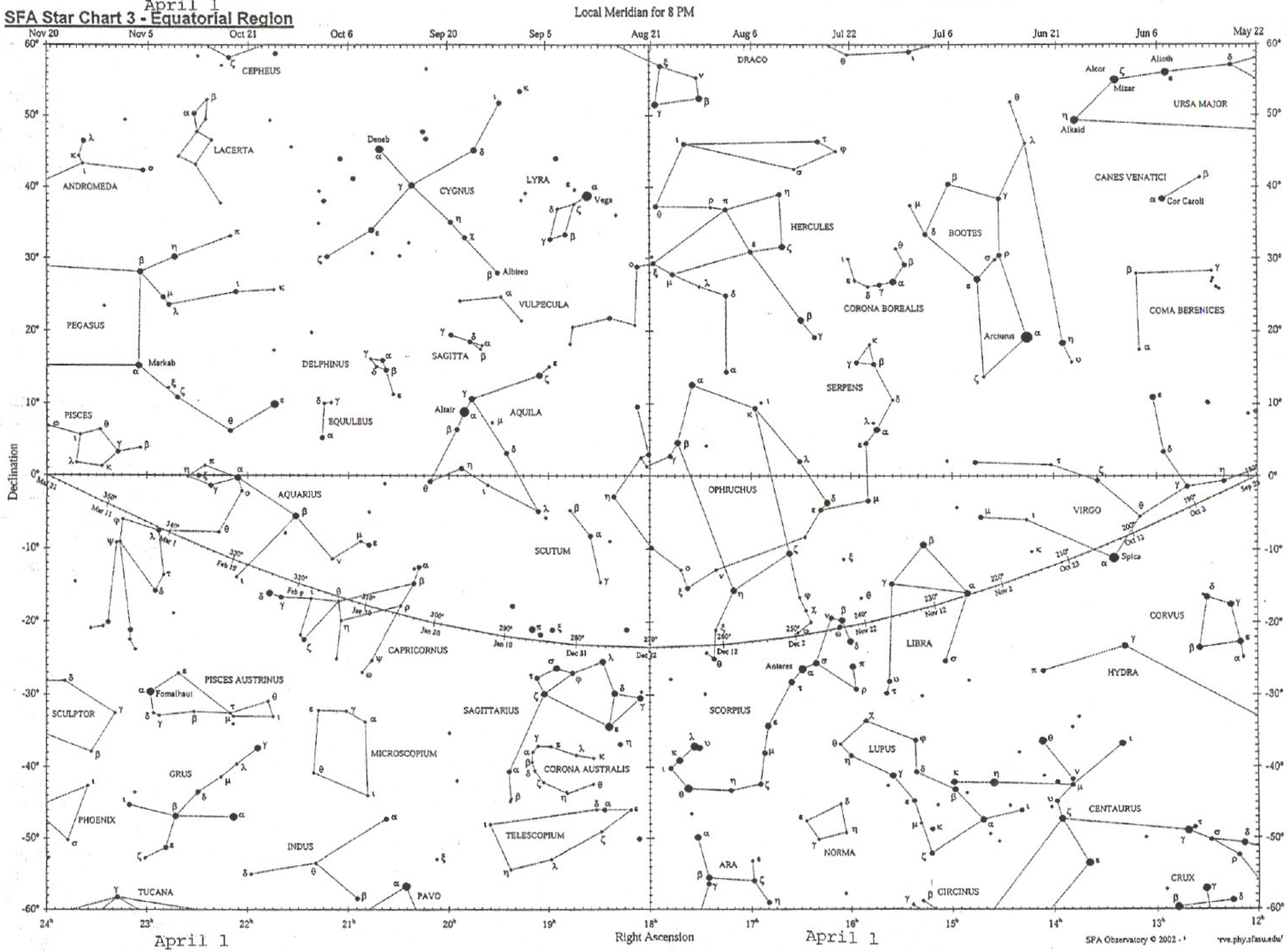
March 21

March 21

April 1

APRIL 1

SFA Star Chart 3 - Equatorial Region



April 1

April 1

ART & THE COSMIC CONNECTION

Elements of Art Inspire Planetary Image Analysis

Created by Monica & Tyler Aiello, Artists & Educators

for NASA's Discovery and New Frontiers Programs

Cool new images arrive from NASA missions to planets, asteroids, comets, moons. What do they tell us? Using the elements of art—shape, line, color, texture, value—make sense of what you see, honing observation skills and inspiring questions. Learners of all ages create a beautiful piece of art while learning to recognize the geology on planetary surfaces. We start with what we know here on Earth and use that awareness to help us interpret features on distant objects in the solar system. *Art & the Comic Connection* offers a terrific bridge between Earth and Space Science, as well as a wonderful dive into the potential of science to inspire art—and art to empower science!

PROGRAM OVERVIEW

For the past three decades, NASA has sent many space missions to the planets, moons and small bodies of our solar system. Spacecraft have acted as robotic explorers, capturing images of mysterious alien landscapes using a range of instruments: spectrometers, gamma ray neutron detectors, cameras. These pictures are studied using a variety of techniques including visual analysis, or "looking to understand." Similarly, visual artists depend on their sense of sight to guide their creativity. Both artists and scientists are keen observers of the natural world and engage in creative problem solving.

Artists utilize a system of concepts to make sense of visual information called the elements of art—line, shape, color, value, and texture. Planetary scientists utilize analogous concepts, and the elements of art can be a valuable tool in planetary image analysis. Fusing art and science education proves an exciting and effective method for inspiring students to explore both disciplines.

PROGRAM FEATURES:

Flexible, can be scaled for K-12 students and informal education settings of all kinds.

***Art & the Cosmic Connection* PowerPoint Presentation**

- Easy to follow presentation notes and science notes for expanded content

- Pastel Art Activity to engage students and reinforce concepts

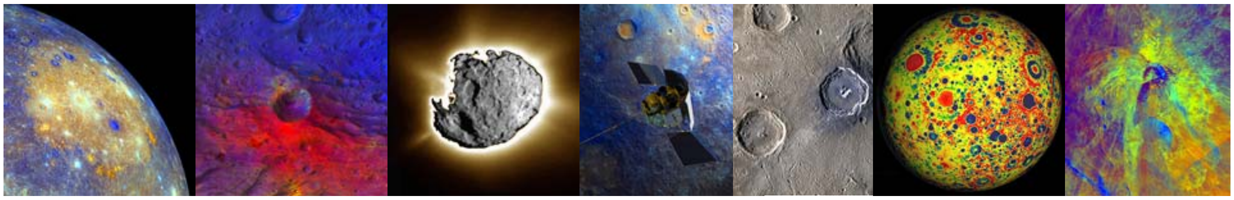
- Beautiful and inspiring NASA images you can print

- **NASA images correlate with current and recent missions to highlight space exploration**
- **Downloadable from the NASA Discovery Program website**

- Program can be a one day or two day activity

-Works with both science and art curricula, providing opportunities for cross-curricular collaboration

-Curriculum has proven success with both youth and adults via schools, universities and museums



Courtesy NASA/JPL

PRESENTATION + ART ACTIVITY

Art & the Cosmic Connection is a 2-part interdisciplinary program developed by artists and educators Monica & Tyler Aiello. Learn more about their work at http://www.studioaiello.net. Designed to engage students in space science education by becoming artist explorers, the project incorporates the use of the elements of art as a tool to investigate and interpret the mysterious surfaces of our celestial neighbors. Students learn to analyze images of planets and smaller bodies such as moons, comets and asteroids with basic art concepts which parallel scientific practice. The project includes a PowerPoint presentation and pastel art activity which teachers can incorporate into their classroom curriculum or out-of-school time program. The project is scalable for different grade levels and blends artistic concepts with the investigation of planetary studies and storytelling. Utilizing art-making as a vehicle for scientific inquiry both inspires and engages students—preparing them for a more rigorous exploration of space science and art theory, while gaining a broader perspective of their own planet, Earth.

MATERIALS & SUPPLIES

- PowerPoint presentation

- NASA image prints

- Artist drawing paper

- Soft pastels or other drawing media

- Gummy erasers

- Hand wipes

- Q tips

- Fixative, either artists' or hair spray (prone to wrinkling the paper) (optional but very helpful)

LEARNING OBJECTIVES

Space Science

- Explore the basic structure of the solar system
- Appreciate the diverse planets and small bodies within the solar system, including moons, dwarf planets, asteroids, comets, and Kuiper Belt Objects (KBOs are similar to main asteroid belt objects, beyond the orbit of Neptune)
- Introduce current and recent NASA space missions
- Appreciate the concept of remote sensing and how it is used in scientific research
- Apply the Elements of Art (shape, line, color, value, texture) to planetary image analysis and learn how they can be used to recognize geologic processes in Earth science
- Learn about basic geologic processes including impact cratering, volcanism, erosion, and tectonic activity
- Begin to interpret more complex geologic stories
- Create a beautiful piece of artwork inspired by planetary images!

BACKGROUND INFORMATION

CORE CURRICULM CONCEPT: Art Elements Correspond to Geological Features

The elements of art—shape, line, color, value, texture—offer an amazing way to make sense of the geology of planetary surfaces. The core curriculum connects the elements of art to planetary image analysis. This simple concept shows how basic art forms can be sign posts for specific geologic processes – art depicts geology. The Elements of Art can provide a road map for students to interpret planetary images. When there are exceptions to these rules, or if these rules have multiple interpretations, students can learn to use other factors to infer results, just like scientists. As these concepts build, students can combine these elements to understand more complex images, thus discovering geologic narratives and engaging in storytelling.

SLIDE/PRESENTATION RECOMMENDATIONS

GRADES 3-5
Break the presentation into several lessons.

Lesson 1 60 120 min
Introduction to the Solar System: Slides 1-13
- **Have student teams create a KWL chart, and then build one for the entire class.**
- **Explore books to help students develop understanding of celestial bodies**

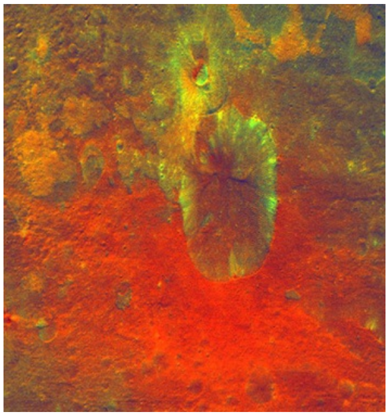
Lesson 2 60 120 min
- **Have each child choose a favorite image. Introduce the elements of art**
- **Choose 2-3 examples of each element of art from Slides 14-58 to illustrate concepts, hiding the rest.**

Pastel Art Activity
- **Suggest a focus on just shape, color, and line to start.**
- **Children are able to appreciate value and texture, too, but try it in context of kids' art creation to keep from overwhelming them with content/talk.**

GRADES 6-10
90-120 min
- **Encourage students to engage actively in the PowerPoint; noting features and writing down ideas are ways to keep participation lively.**
- **Use the PwPt notes to familiarize yourself with the content ahead of the presentation.**
- **Encourage interested students to use the many PwPt links to investigate further.**
- **It is also effective to have small discussions with students about art elements in their particular images in lieu of an extended presentation – the art making leads to rich scientific discourse!**

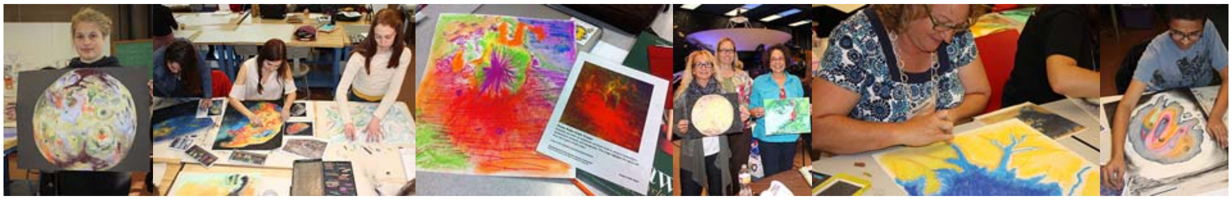
Elements of Art and their Geology Matches

- **Circle:** When circles are viewed on a planetary image, it often indicates an impact feature, a crater. The size, shape, ejecta blanket (stuff thrown away or ejected from the impact site, material from both the impactor and the area impacted) and number of craters give important clues as to the history of a planetary body. Sometimes circular features are volcanic or tectonic in origin, such as volcanic pancake domes found on Venus, for example.
- **Blobs:** Organic shapes, or blobs, can often be interpreted in two ways. Blobs frequently mean that one is viewing volcanic processes and lava flows. Blobby shapes can also indicate existing bodies of surface liquid (rivers and seas) or ancient bodies of liquid that left remnants of dried beds.
- **Straight Lines:** The presence of straight lines on a planetary body is often indicative of tectonic activity, including faults, ridges, cracks and mountains. On Earth tectonic activity is thought of as a land phenomenon; it can also be present in icy worlds.
- **Squiggly Lines:** The presence of squiggly lines on the surface often tells us forces of erosion are at work, including that of liquid and wind.
- **Color:** In addition to visible light, scientists image planetary bodies in many different frequencies of the electromagnetic spectrum (infrared, radio waves, X-ray, ultraviolet, etc.) They also create colorized images, adding and often exaggerating color differences to show subtle differences that the eye cannot detect otherwise, highlighting distinct aspects of a planet: topography, mineral composition, even gravity! Light and color are critical tools in interpreting and understanding planetary surfaces.
- **Value:** Value is the contrast of light and dark. Its scientific counterpart is called *albedo* - the measure of the reflectivity of a surface (think of snow vs. charcoal—which reflects more light?). Value/Albedo is a critical tool for understanding a planetary body.
- **Texture:** Implied texture is the tactile quality of a two-dimensional surface which we can see with our eyes, yet not touch. Images of planetary bodies are replete with various textures corresponding to eons of geologic history. Geologic processes build over time to create complex textures which can be deciphered with the aid of the other art elements.



TEACHING PART 1: Art & the Cosmic Connection PowerPoint Presentation

The presentation uses many beautiful NASA planetary images to illustrate concepts. It is flexible and scalable for various ages, experience levels, and time requirements. To prepare, teachers are encouraged to review the PowerPoint and make appropriate revisions for their particular students (see sidebar page 3), depending on the curriculum you would like to cover. The PowerPoint includes extensive ***Presentation Notes*** to guide teachers through the curriculum. The notes serve as a basic script and also include question prompts to encourage class discussion. There is also a ***Science Notes*** section with links to NASA web resources for educators who wish to expand their lesson plans.



Courtesy McREL

Show the PowerPoint
After reviewing the PowerPoint and the *Presentation Notes*, show the PowerPoint presentation to your students. The PowerPoint has an introduction to the solar system, an overview of remote sensing and space exploration, and the core concept that describes planetary image analysis using the elements of art.

Getting Started: What Do You Know About the Solar System?
Begin by making a KWL (Know, Wonder, Learn) table on the board or chart paper. Take notes (or invite students to) on the chart paper as students answer the following about the solar system:

- What do we ***know***?
- What do we ***wonder*** about?
- What have we ***learned***?

This forms a baseline of classroom knowledge, helps you be aware of your students' prior knowledge, and promotes inquiry. The KWL can be done in pairs or small groups initially to engage participants actively.

- ➢ If a student states something others are uncertain about, or you believe is inaccurate, post it in the Wonder section to return to for verification later.

Avoid major discussion of the structure of the solar system (including the inner terrestrial planets, outer gas giants, and small bodies including moons, asteroids, comets, dwarf planets, and Kuiper Belt Objects [or KBOs]) until after the main presentation. Images there will help support your discussion.

- Make special note that our activity focuses on worlds with visible geology. Thus, the presentation does not focus on the gas giants themselves, but does appreciate their marvelous moons!

Introduction: Science Inspires Art
The beginning of the presentation briefly introduces students to the painting and sculpture of project authors, Monica and Tyler Aiello. The husband and wife artist team collaborate with NASA and the scientific community in the development of their artwork and educational programs. Students are intrigued to view professional artists inspired by science, and are encouraged to become "artist explorers."

Remote Sensing & Space Exploration
A brief discussion of remote sensing incorporated in the PowerPoint explains how NASA sends robotic explorers to planetary bodies and takes pictures of their surfaces. The images used are shown from the aerial or "birds-eye" view. The planetary images provided correlate to recent and current NASA missions to provide an opportunity to build student interest and excitement in space exploration. The beautiful and often unfamiliar images keep students engaged with the content.

Elements of Art & Planetary Image Analysis
The core concept section relates how the Elements of Arts can be used to interpret planetary images. It is useful to have students define (or for the educator to review) the definitions of the Elements of Art. The remainder of the presentation includes sections for each of the Elements of Art and illustrates the how these relate to specific geological processes using examples of gorgeous NASA images.

- Circle – Crater
- Blobs – Volcanoes or Lakes
- Straight Lines – Tectonic Activity
- Squiggly Lines – Erosion
- Color, Value, Texture – Critical Scientific Tools

TEACHING PART 2: Art Activity

The *Pastel Art Activity* is designed to be a simple, yet fun and engaging way for students to explore the concepts they've learned from the PowerPoint presentation. Students enjoy making art in science class or exploring science in art class, depending upon how the project is taught. This reinforces the connections between the arts and the sciences and engages the students in an interdisciplinary learning environment. The art project can be taught during the same session as the presentation or in subsequent sessions.

Time Recommendations

Grades K-5: two or three 45-minute periods
Grades 6-12: one or two 45-60 minute periods

Supplies

- **Drawing paper –** A larger-sized, fine artist drawing paper is recommended, budgets allowing (22"x28" is great, at least 9"x12"). Students enjoy working with fine art materials and tend to take their projects more seriously. The drawing paper should be appropriate for the drawing media.
- **Drawing media –** Soft pastels are recommended for their ease of use and blend-ability. However, they should not be ingested. Water colors, crayons, markers and pencils are more appropriate for K-2 students.
- **NASA Planetary Prints –** Download from the NASA Discovery Program website, http://discovery.nasa.gov. The prints inspire the students' artworks.
  - Images are both in black and white and in color. Slipping them into sheet protectors is essential for future use; laminating them is more costly but more durable.
- **Gummy erasers –** Can be used effectively with soft pastels to lift pigment and create highlights
- **Q-tips –** Are a great blending tool
- **Cleaning or Hand Wipes –** Pastels are messy but easy to clean up, especially with cleaning wipes
- **Fixative (optional)** - A pastel spray fix can be used; however, it is toxic and should only be used by a teacher or with older or experienced students, and by all in a ventilated area. For other students, aerosol hairspray can be used. A light coating will help fix the pastel pigment to the drawing paper.
  - Drawings can also be spray-fixed between layers if they get too heavily loaded with pigment or muddy so that students may work on top of the drawing. This process should be completed or supervised by the educator. A fixative is not necessary.

Implementing the Art Activity

- Have all students select a NASA planetary image to work from; pass out paper.
- Ask students to make pastel drawings inspired by their image.
- Discuss or share images prior to the project, if desired.
- Ask students to pay special attention to the Elements of Art and how they relate to interpreting the geologic history of their image. They may choose to focus on one or two images.
- Explain that students do not have to make their artwork exactly like their image. They are making "art" and should feel free to interpret their image by altering their composition, cropping, color, orientation, etc. This is effectively done using question prompts, such as, *"Do you have to make your artwork black and white like your image? No, feel free to explore color!" or, "Focus on the details that intrigue you."*
- Encourage artists to explain their interpretation. For example, a student may have noticed especially bright areas and picked them out in a certain color.

> **TIP:** Distribute drawing supplies AFTER you explain the assignment above so that students do not work ahead or get distracted. ☺

Artists and activity authors at work, Monica & Tyler Aiello

Wrap Up and Formative Assessment

- At the conclusion of the art activity, display artwork and discuss the project. Here are two possible approaches.
  a) Conduct a **gallery walk**, where student art is hung up, with its inspiring image beside it, and students spend time viewing all. Ask all present, kids and adults, to offer observations about what strikes them about the drawing on sticky notes to leave for the artist.
     - Examples: "Really nice example of texture!" "What is your interpretation of that feature?" "Your blending really made those colors pop out!"
  b) Break students into small groups (mix up the class so kids see others' work). Ask students to do a **think-pair-share**, where they write about their experience for a couple of minutes on a sticky note, share their ideas with a partner, and then with a small group.
     - Reflect on the selected planetary image: interpret the geology of their image, and discuss how they used that image to inspire their artwork.
- Ask students to share something new they have learned from the activity with the entire group.
- Conclude by returning to the KWL chart to record:
  - What have we ***learned***?
  - What do we ***wonder* –** what **new** questions do we have?
- Clean up studio or classroom.

Storytelling & Geologic History

- Interspersed within the Elements of Art sections are images with multiple art elements/geologic features. These examples provide students with the opportunity to combine what they have learned to decipher more complex geologic history *(i.e., circles and blobs might be interpreted as craters and volcanoes)*.

NATIONAL EDUCATION STANDARDS
ART & THE COSMIC CONNECTION
Elements of Art Inspire Planetary Image Analysis

SCIENCE
Source:
http://www.nap.edu/openbook.php?record_id=4962

K-4
Earth and Space Science
- Objects in the Sky
- Changes in the Earth and Sky

History and Nature of Science
- Science as Human Endeavor

5-8
Unifying Concepts and Processes
- Evidence, models and explanation
- Form and Function

Earth and Space Science
- Structure of the Earth System
- Earth in the Solar System

ART
Visual Arts
K-4 **Source: http://artsedge.kennedy-center.org/teach/standards/standards_k4.cfm**
- Content Standard #1: Understanding and applying media, techniques, and processes
- Content Standard #2: Using knowledge of structures and functions
- Content Standard #5: Reflecting upon and assessing the characteristics and merits of their work and the work of others
- Content Standard #6: Making connections between visual arts and other disciplines

5-8 **Source: http://artsedge.kennedy-center.org/teach/standards/standards_58.cfm#04**
- Content Standard #1: Understanding and applying media, techniques, and processes
- Content Standard #3: Choosing and evaluating a range of subject matter, symbols, and ideas
- Content Standard #5: Reflecting upon and assessing the characteristics and merits of their work and the work of others
- Content Standard #6: Making connections between visual arts and other disciplines

Instructor's Guide

Day Eight – Mapping 1

Objective:
Students will identify and measure features of craters to determine relative ages of the lunar surface.

Construct explanations for patterns in geologic evidence to determine the relative ages of a sequence of events that have occurred in Earth's past.

Materials:
Black and white pictures of the lunar surface (4"x6") (we provide a set here: https://www.dropbox.com/s/zdgxkpz28raxjr0/CraterAge_Images_small.pdf), scale (https://www.dropbox.com/s/zxvwlpt32gbxmir/crater%20scale.pdf), grid (https://www.dropbox.com/s/rghy654l6xt7ujq/lunar%20surface%20age%20sample%20grid.pdf), overview image (https://www.dropbox.com/s/xj0567p2lwfonkb/Screen%20Shot%202012-11-16%20at%203.56.01%20PM.png), markers, (preferably silver Sharpies), tape, large poster board, colored cellophane or see-through plastic folders in four colors: blue, green, yellow, red

Background:
The most obvious features on the Moon are the craters, or scars left from impacting rocks that have crashed into the Moon since its formation. We do not see many craters on Earth because active geologic processes and erosion erase these features rather quickly. On the Moon, however, there are no active tectonic processes and no weathering due to wind and water, so a record of these impacts is preserved.

It follows that, given a fairly steady rate of impacts, that the older a surface is, the more craters it will have. Although the cratering rate is not strictly steady over all of geologic time, lunar geologists do use the density of craters over a given surface to determine *relative ages*, that is, to tell which surfaces are older and which are younger.

This activity uses images from the Lunar Reconnaissance Orbiter. You will have your students count the craters above a certain size (5 km) there are in each image. Each group will then classify the images by number of craters. This establishes the relative age of that area of the surface. The pictures will come together at the end to make one large map to illustrate how the surface age changes over a larger area of the Moon.

Engage:
Share the video "Lunar Craters Through 8" Telescope" at http://www.youtube.com/watch?v=k4YLMASou78 or "Lunar Moon Crater Copernicus Close Up at http://www.youtube.com/watch?v=AYa1LyVWiaQ

Explore:
Lunar Surface Age Activity – Students may work individually or with partners to trace and count craters on 3-5 lunar surface pictures.

1. Hand out the pictures of the lunar surface to your students. These images will be marked so that you can put them back together at the end of the activity.
2. Ask the students to find and circle all of the craters in their image with the silver Sharpie. Provide each student with the attached scale marker. They should only worry about circling craters that are larger than one square on the scale. This square represents 5 km.
3. Have the students count up the number of craters in their pictures and cover each one with a colored square of cellophane or a plastic see-through folder based on the following guide:

    a. 0-3, blue
    b. 4-6, green
    c. 7-10, yellow
    d. 11+ red
4. Have the students work together to arrange the colored pictures back into one large image on poster board based on the markings to facilitate analysis of the Moon's history.

Explain:

Discussion/connections

- What observations can you make about the section of the Moon that we've put together?
- Which color represents the oldest surface?
- Which is the youngest?
- What does the large image tell you about the age of the surface in this area?

Vocabulary

- Lunar Reconnaissance Orbiter, crater, impactor, asteroid
- Students will add and define LRO in their Moon Journals.

Concept

- The surface of the moon can be mapped using images from the LRO.
- Individual craters have characteristics dependent on the history of their formation
- Characteristics of craters give clues to their relative age

Evaluate:

Students can hand in their completed lunar surface pictures for assessment.

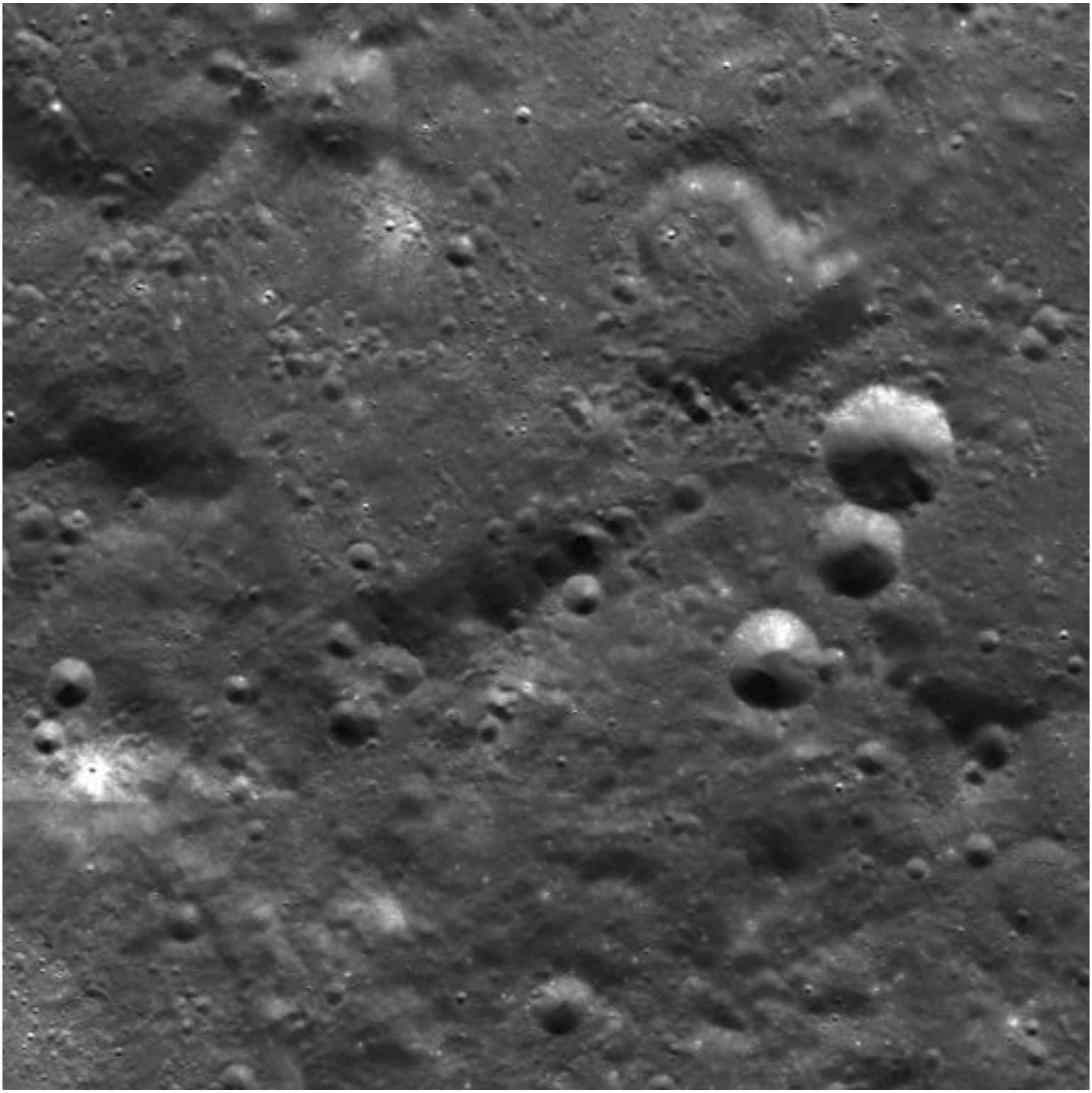
Elaborate:

Students may work with other surface pictures to improve their identification skills. Professional scientists take these relative ages and put them on an absolute age scale by using radioisotope moon rocks that came back from Apollo and other missions

Interdisciplinary Link:

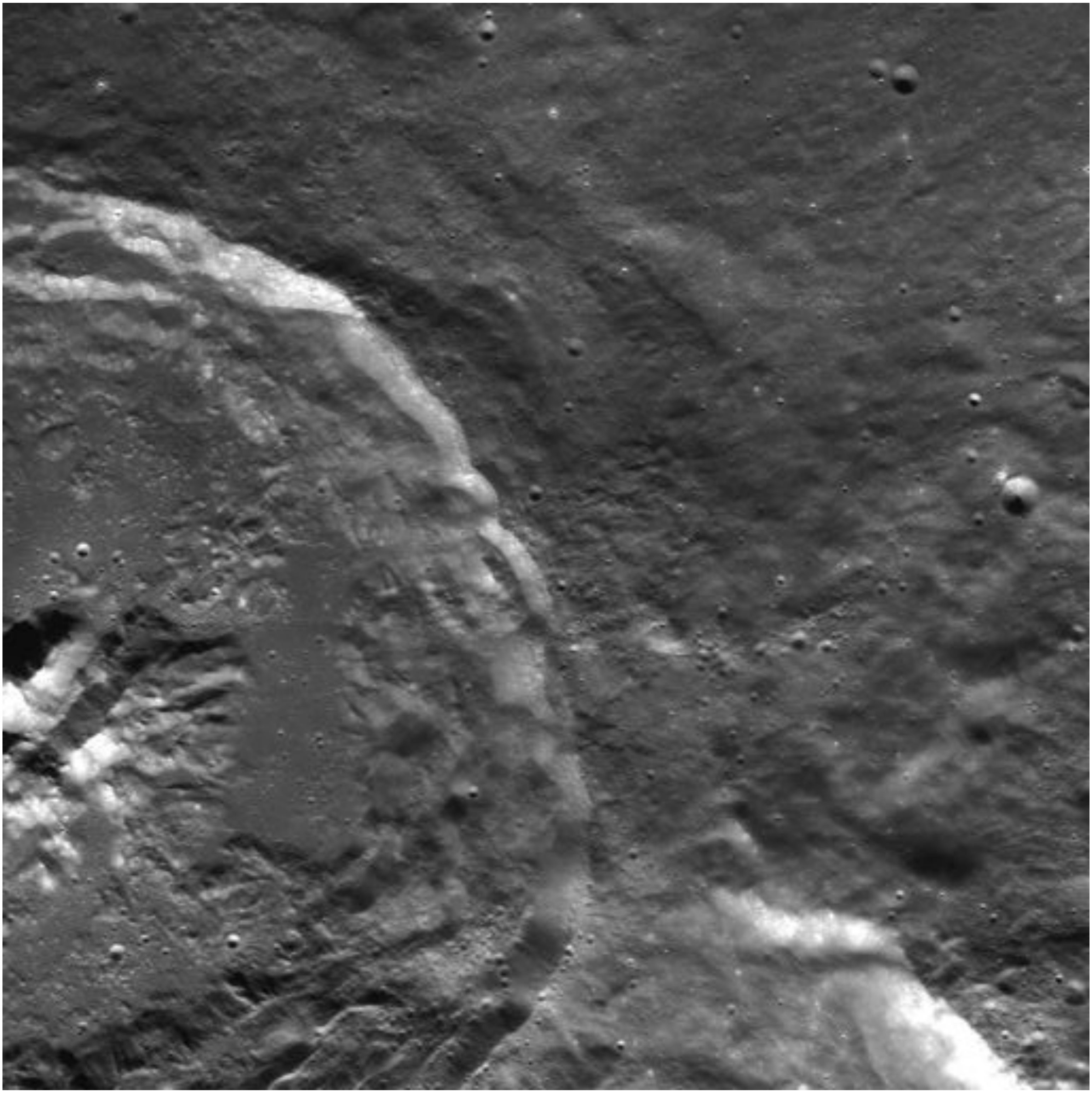
Link to Social Studies – Research the history of people who have mapped the Moon
Link to Math – Graph the frequencies of the diameters of craters.

A1



B1

C1



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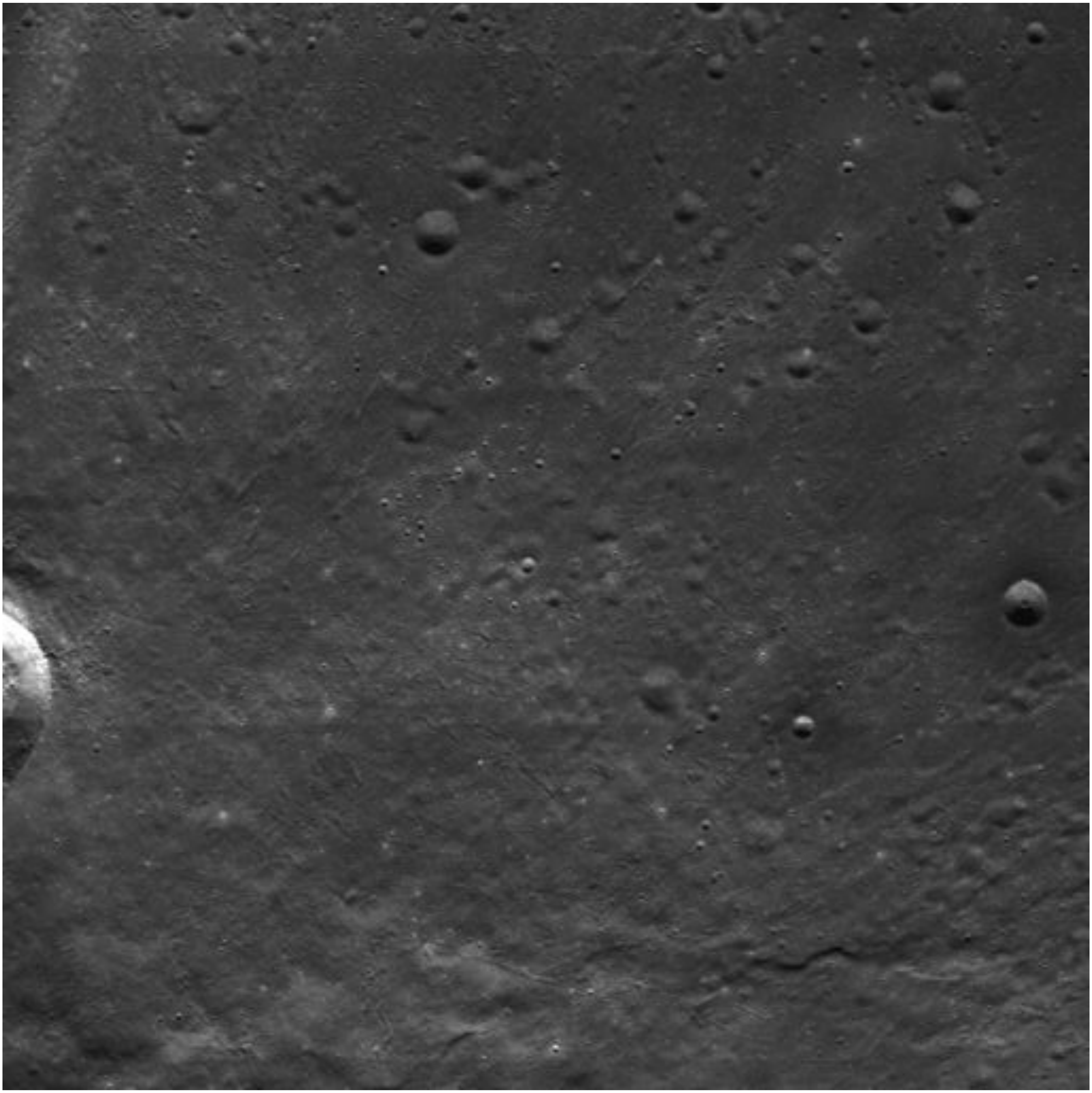
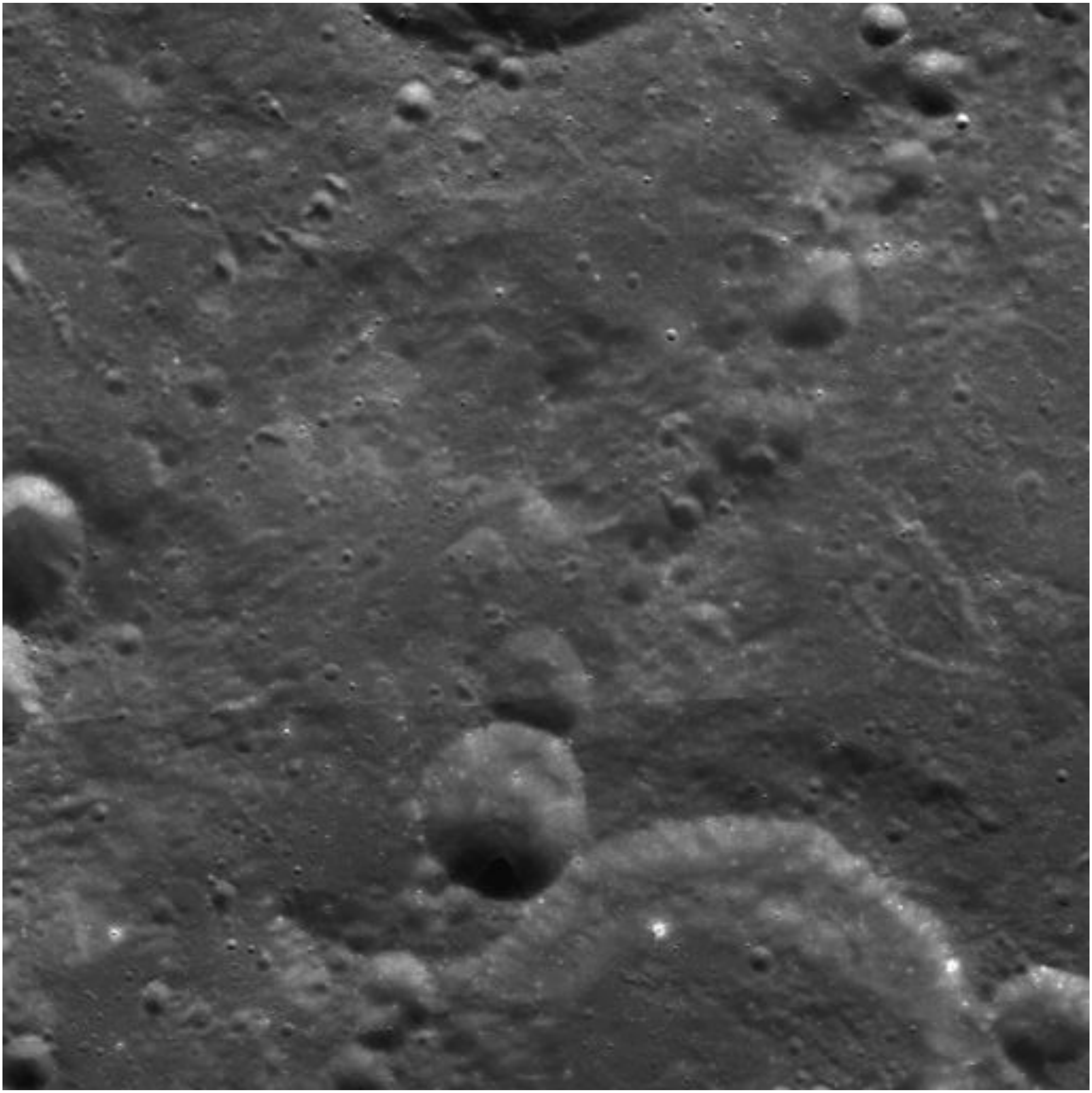


E1



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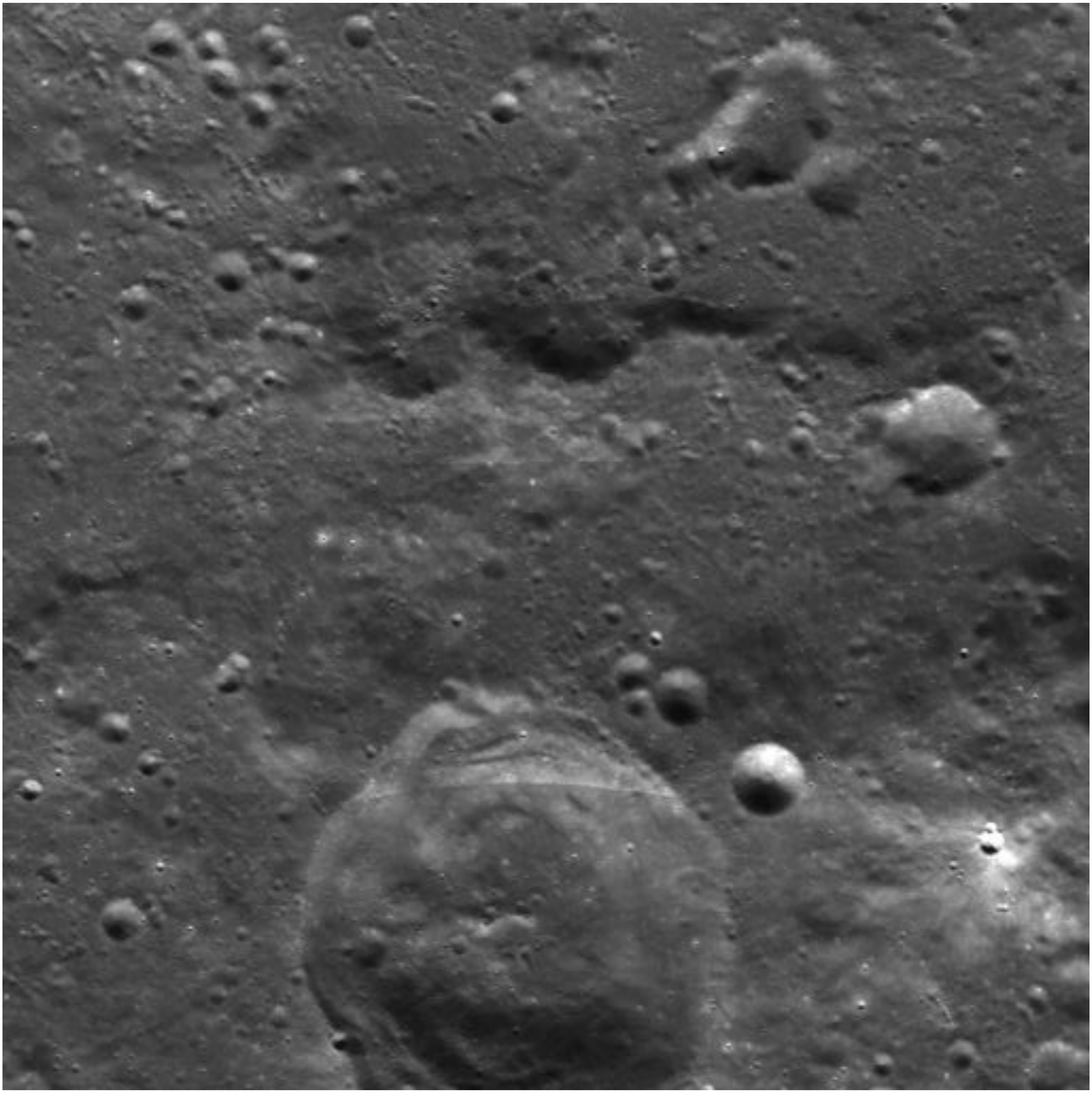

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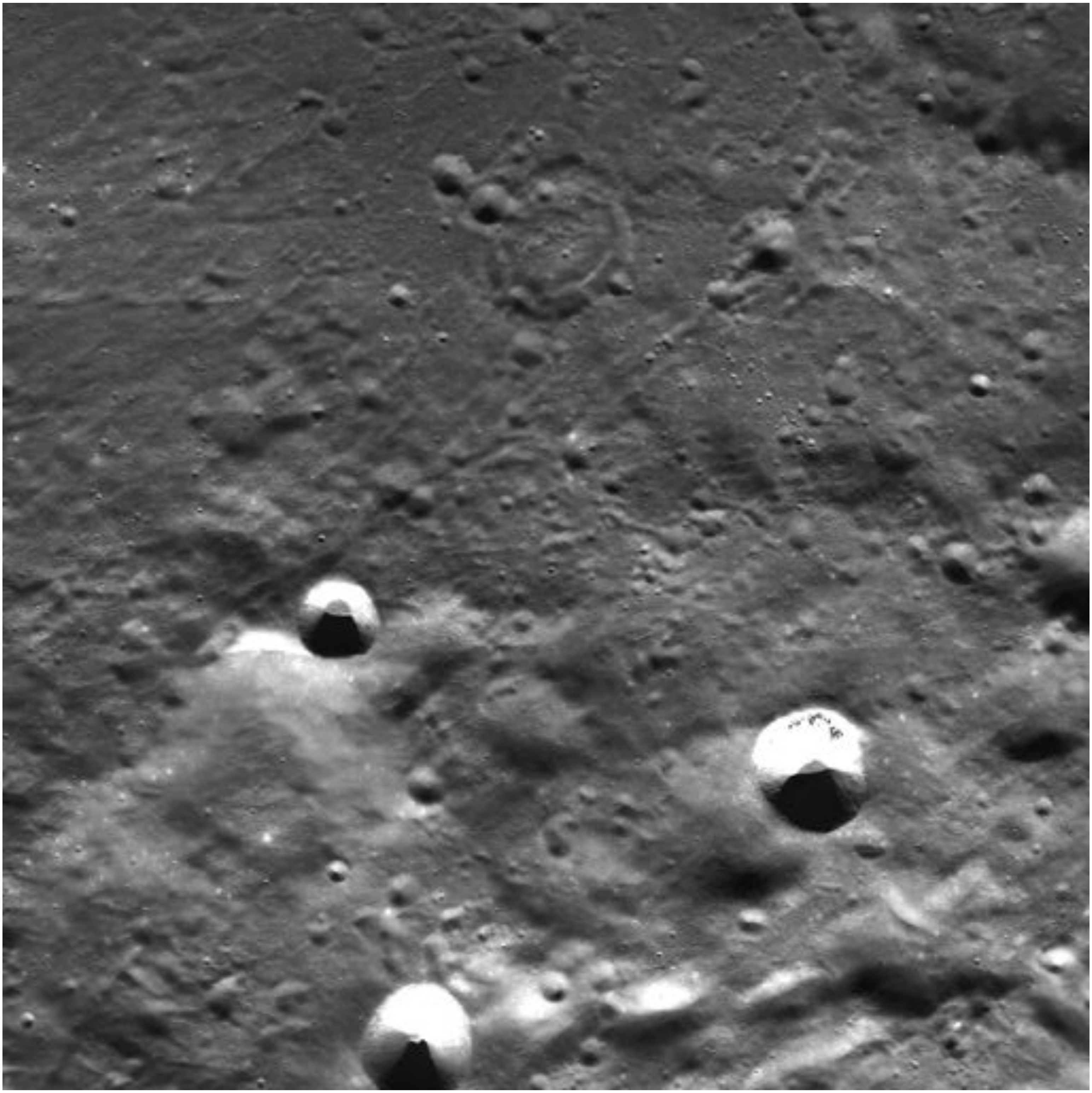

D2

E2

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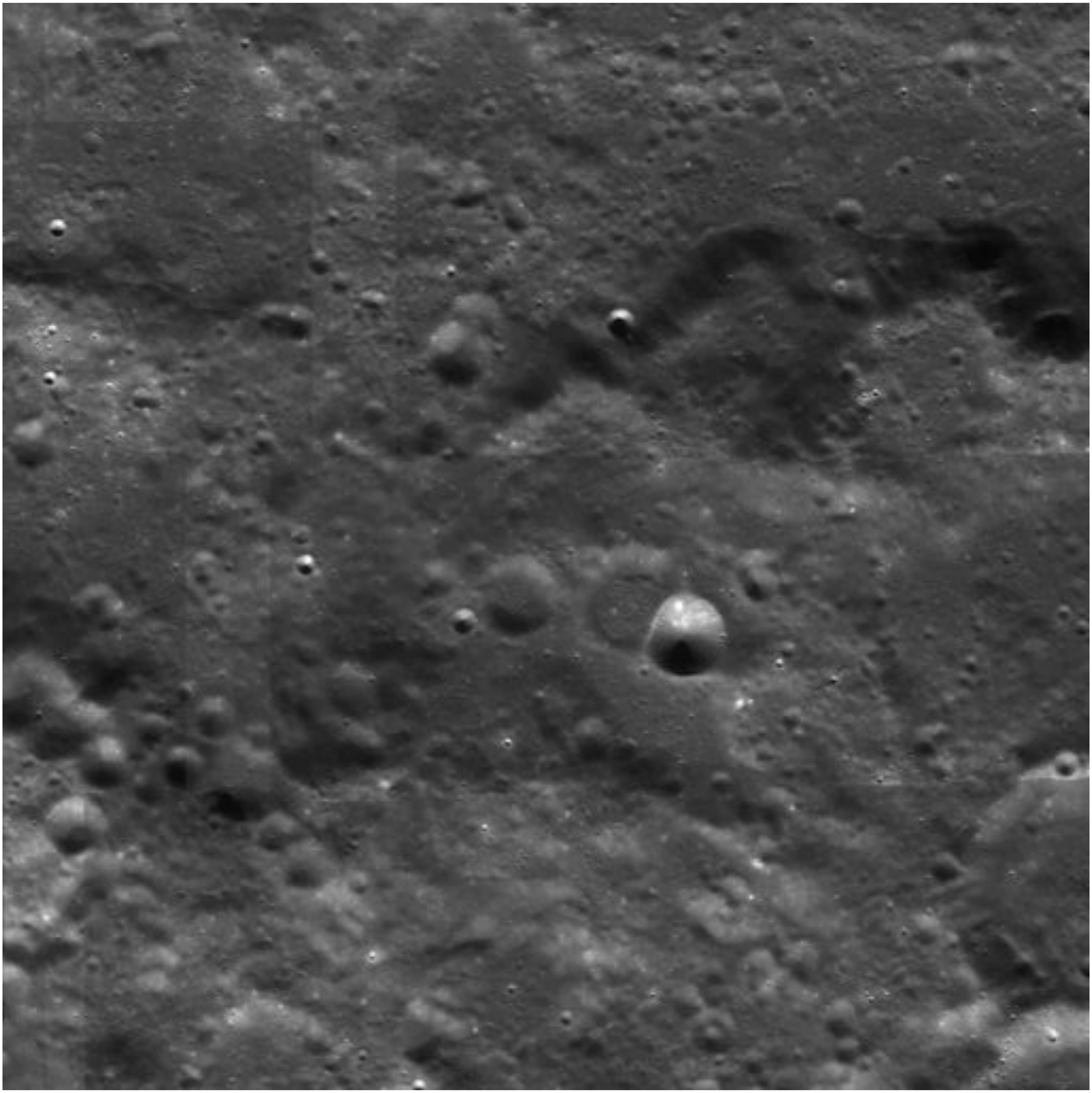

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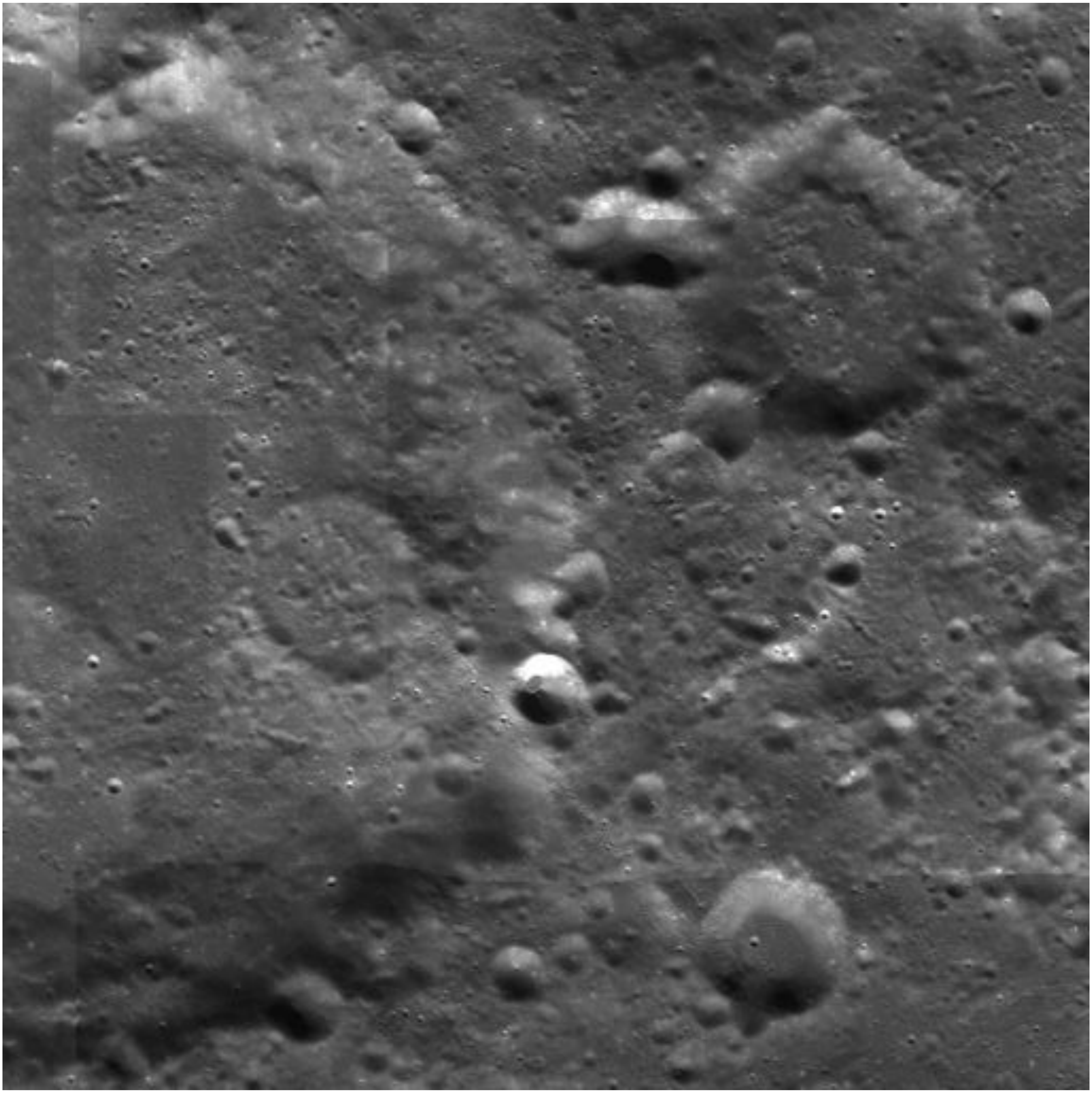

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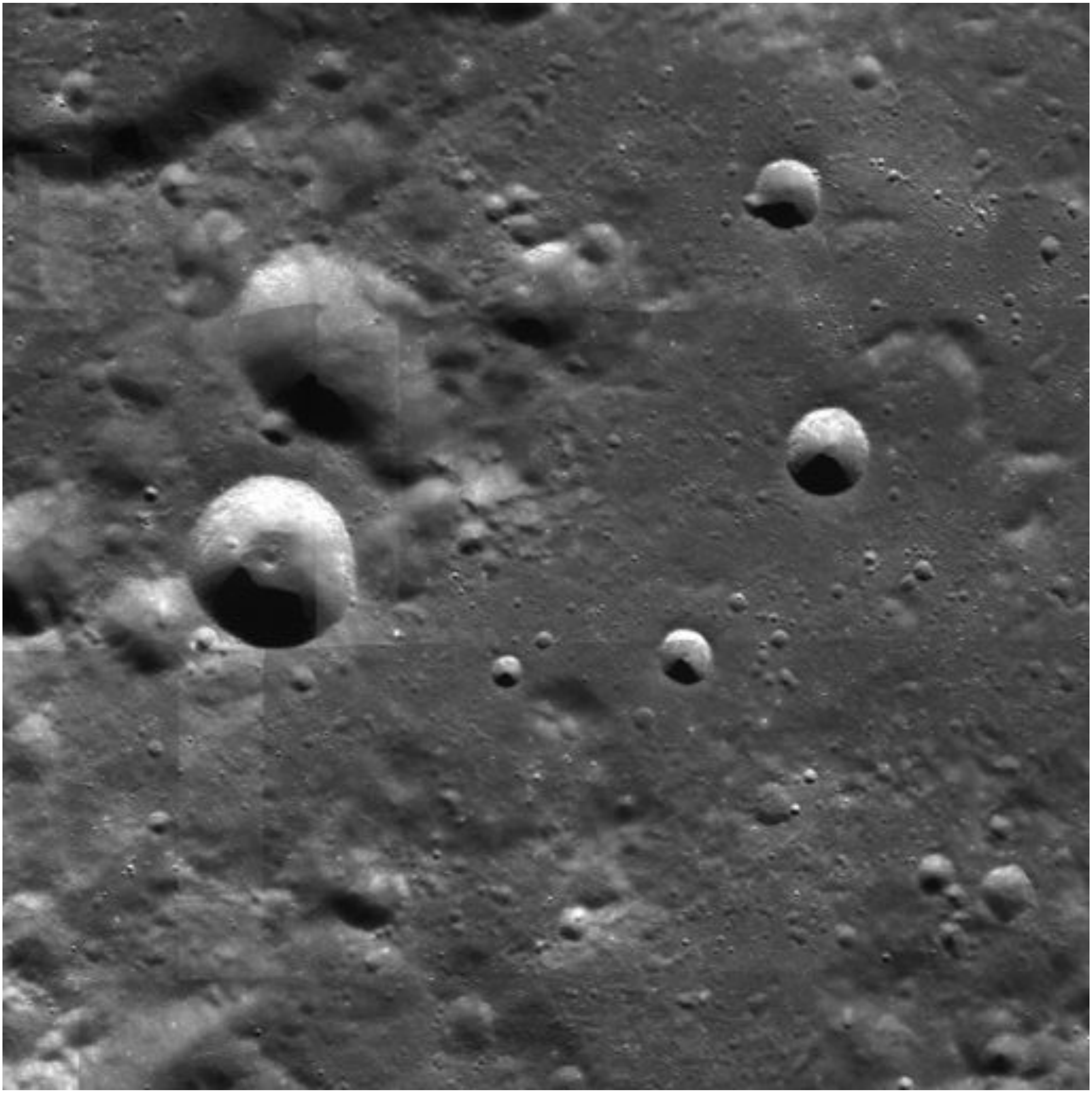

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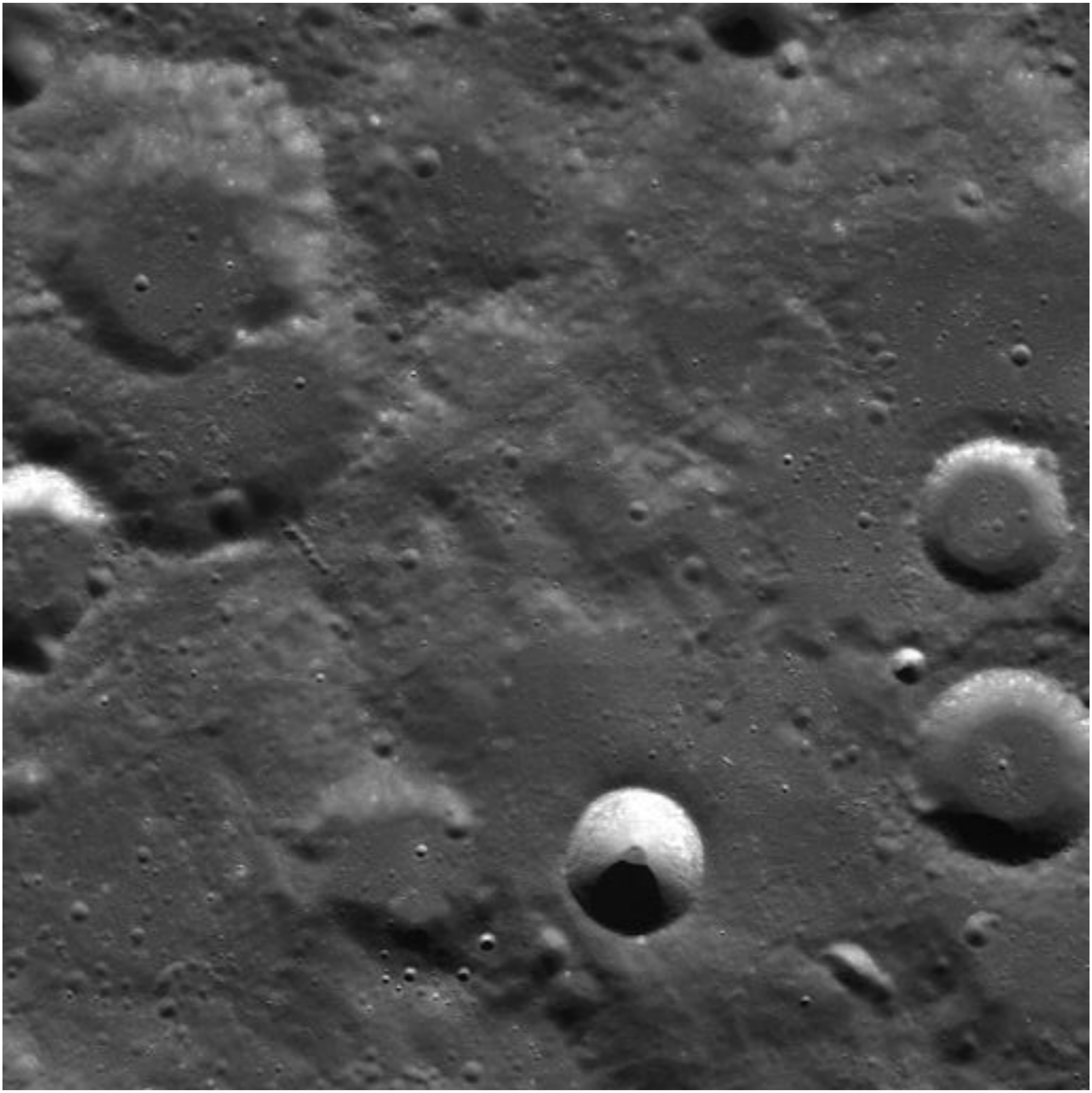
E3



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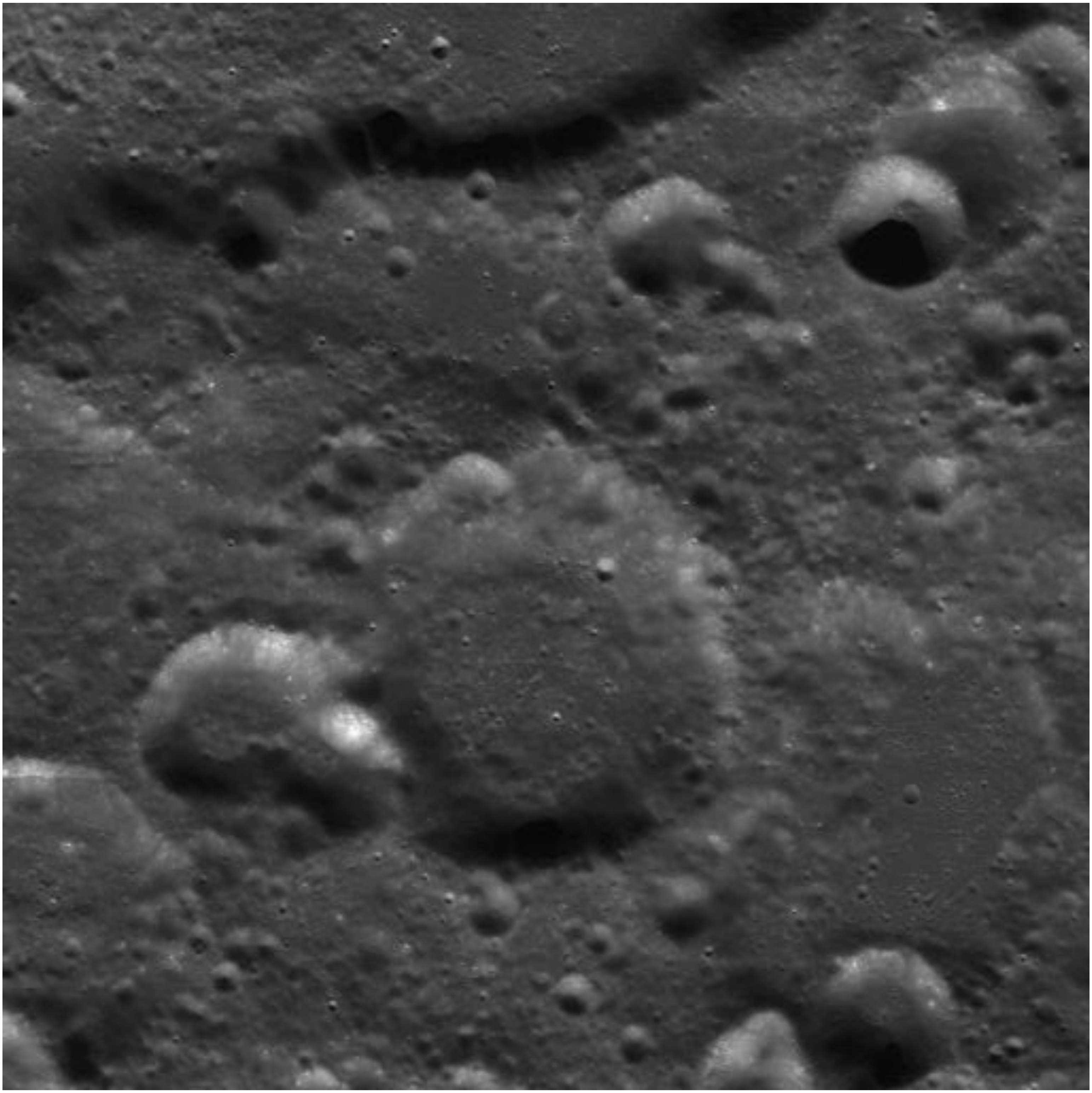

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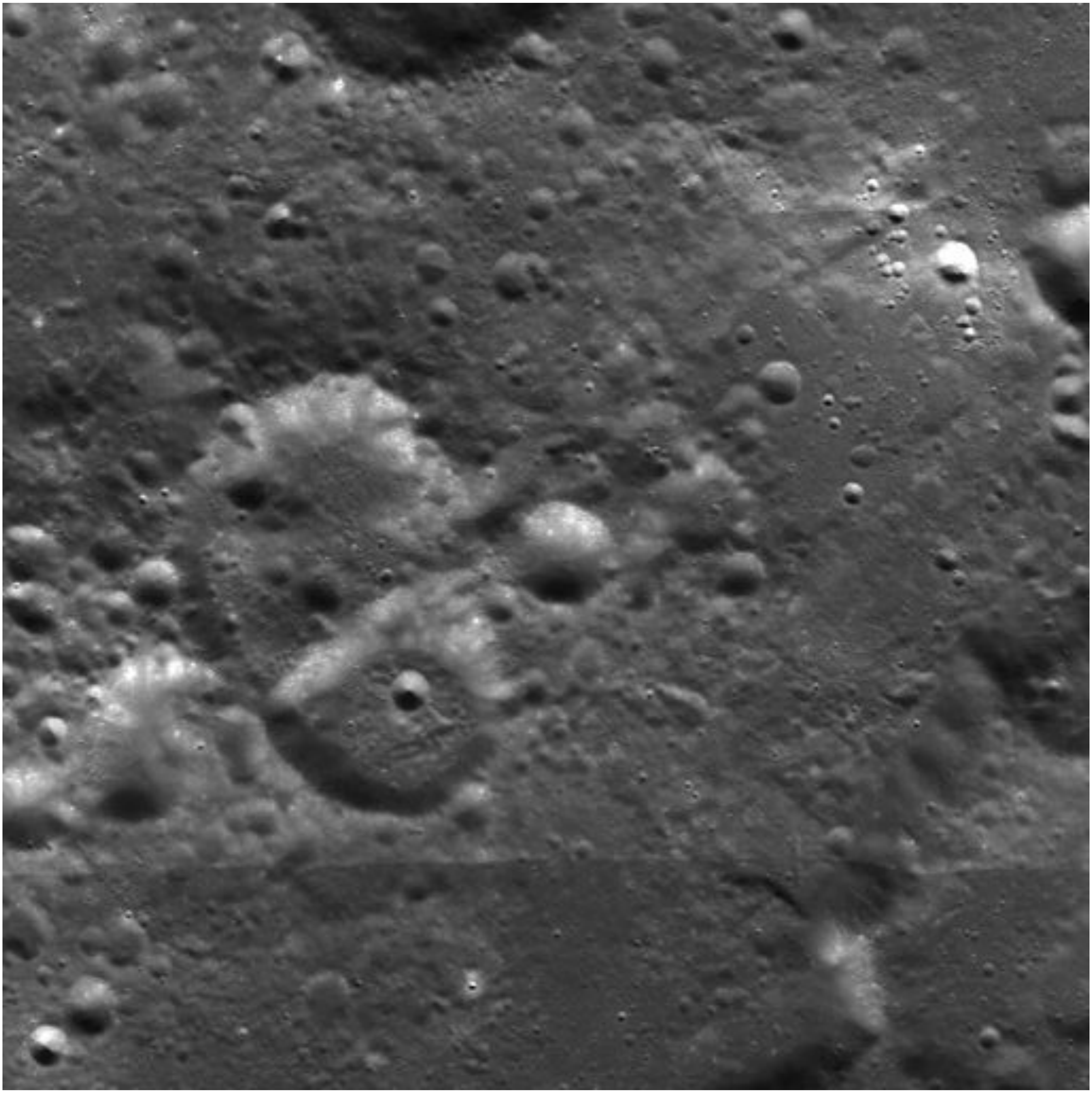

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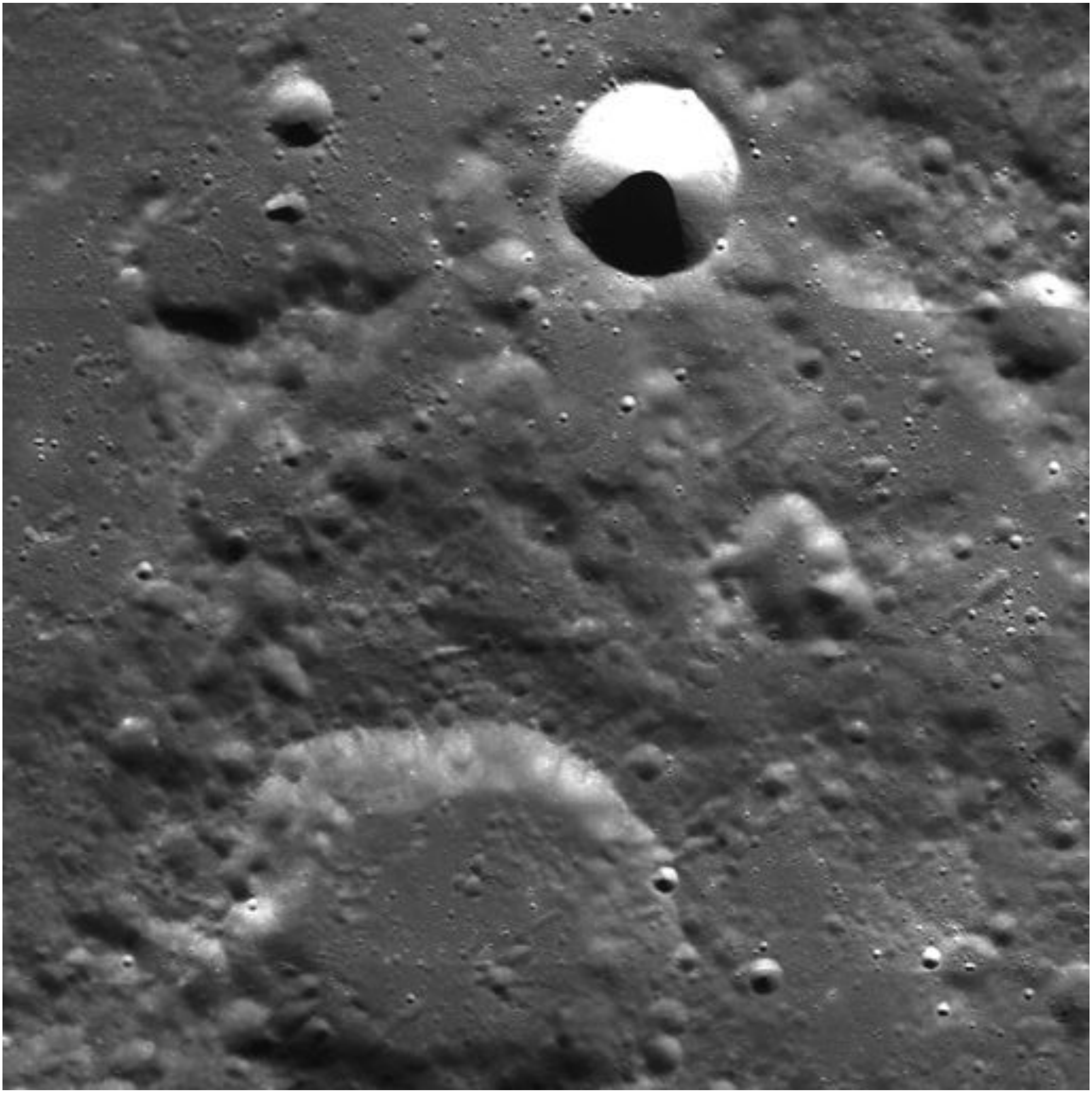
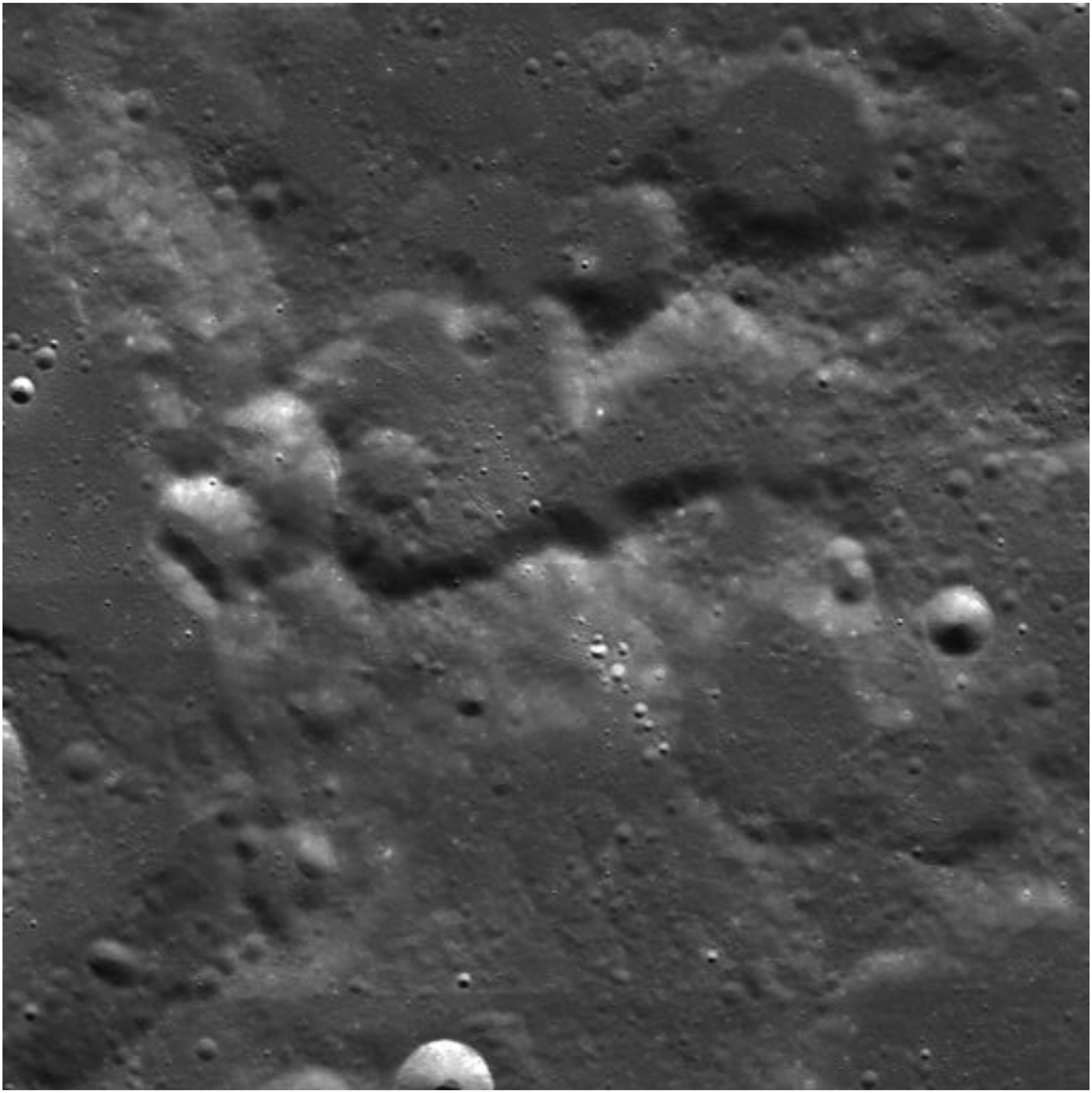


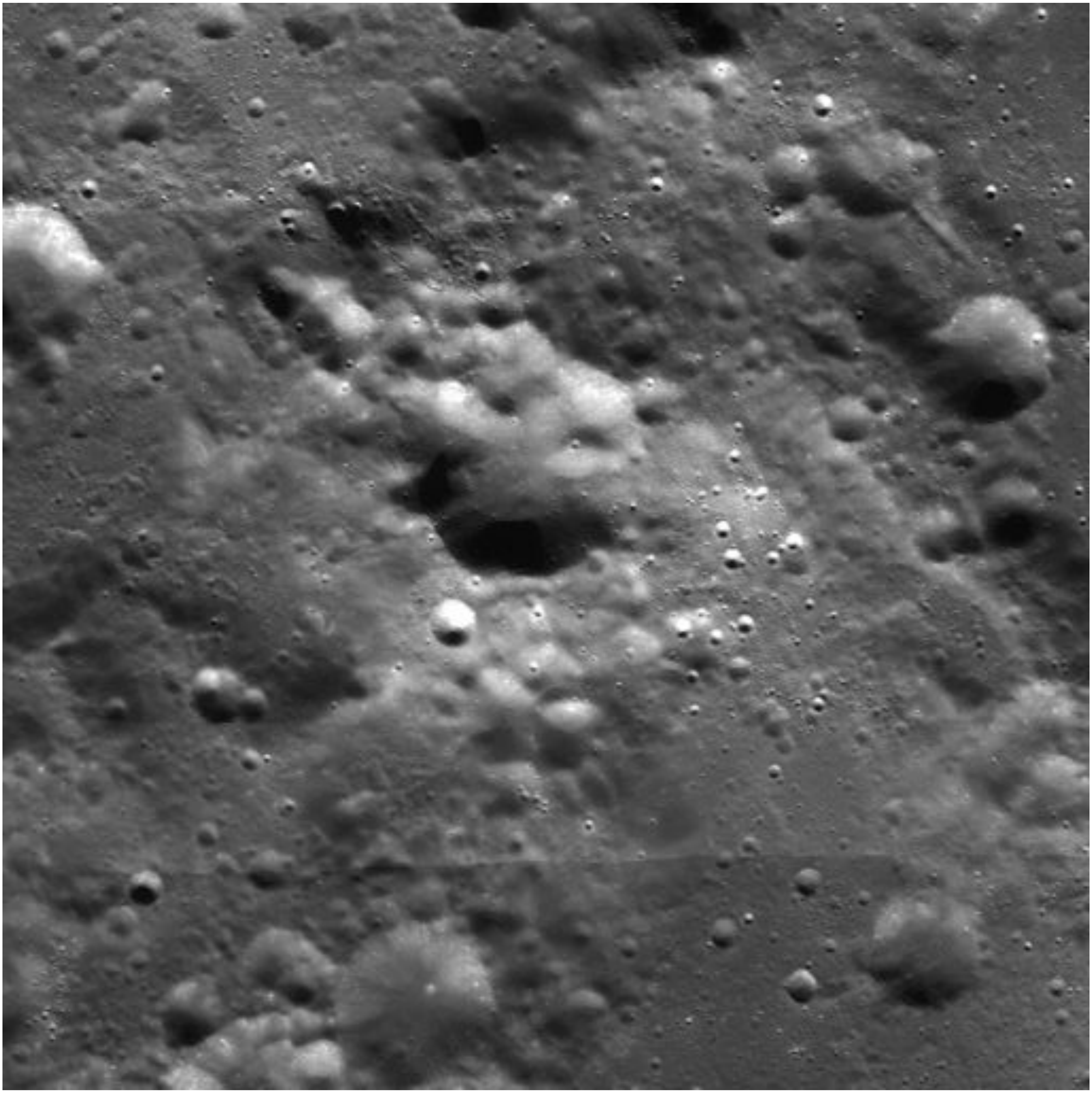
D4

E4



A5

B5



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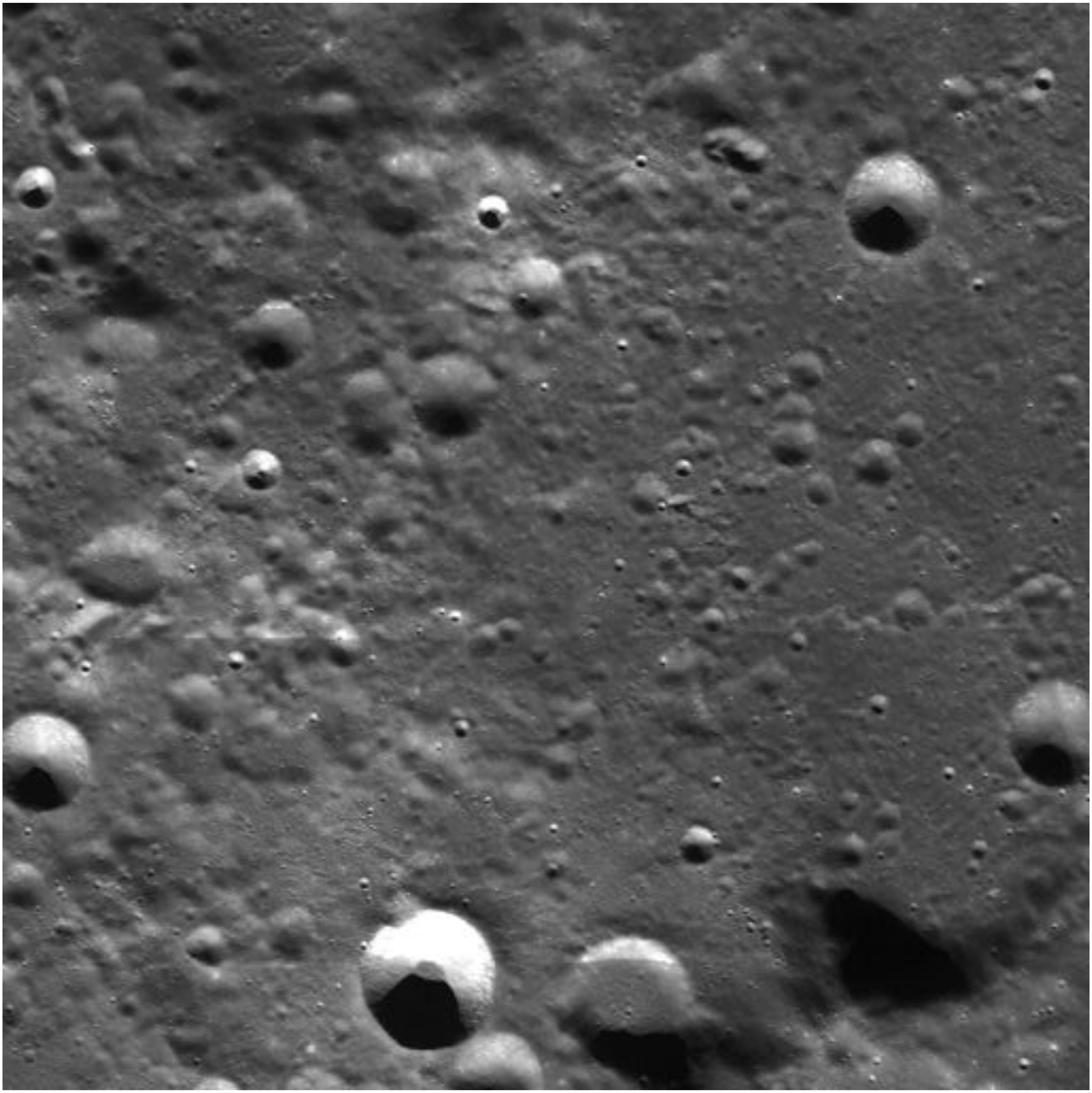

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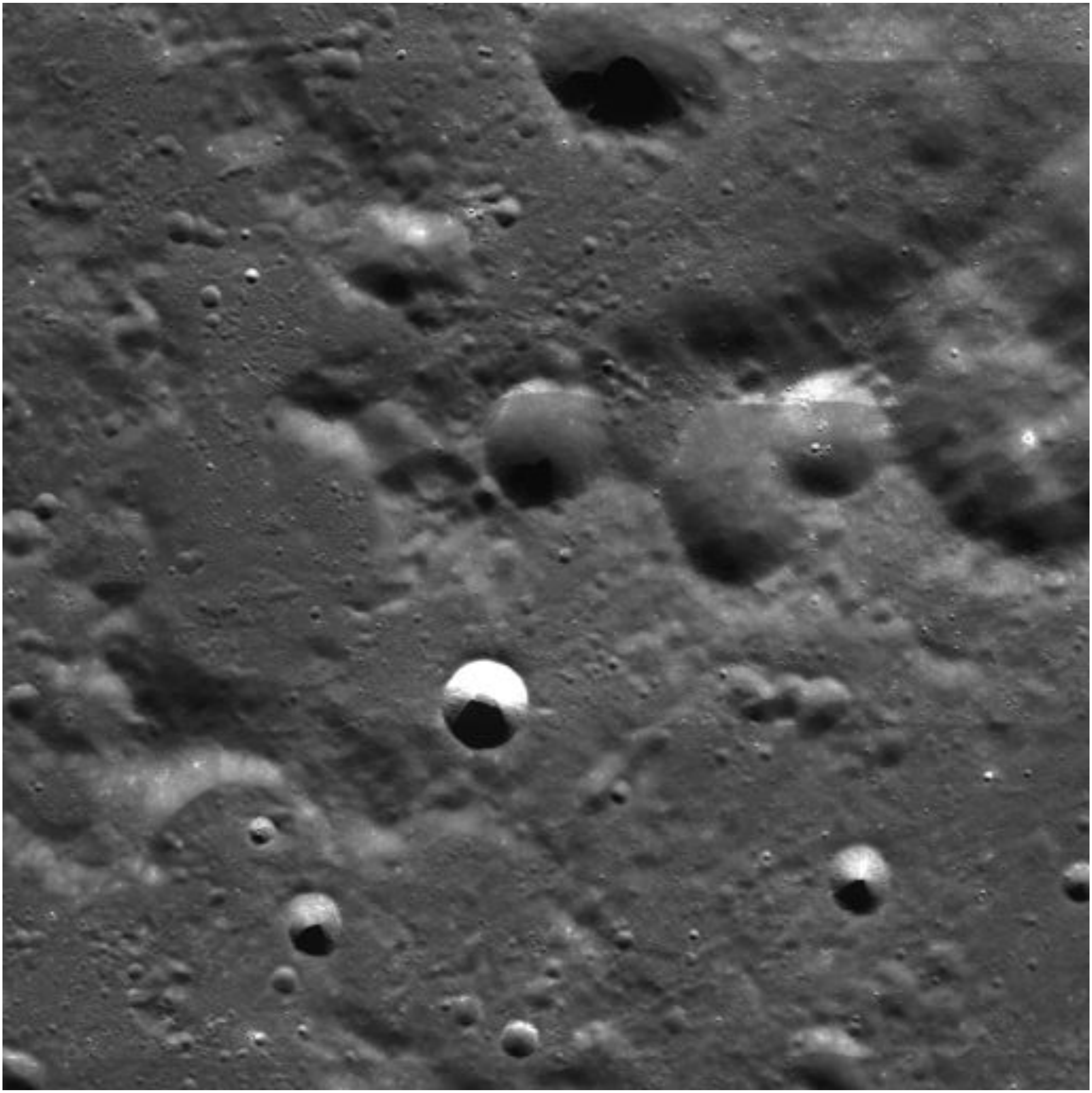

E5

TERRALUNA Day Eight:

Lunar Surface Age Activity Grid for
Assembly of Lunar Surface Map

Coordinates are on bottom of each
lunar surface picture.

A1	B1	C1	D1	E1
A2	B2	C2	D2	E2
A3	B3	C3	D3	E3
A4	B4	C4	D4	E4
A5	B5	C5	D5	E5

Vegetable Light Curves

Developer: John Ristvey, McREL
Audience: 8-12 Formal Education Teachers
Format: Website
Final Recommendation: Recommended, revisions next update.

The panel recommended this product as is for use by its intended audience.
Comments in the attached summary and in the individual review reports should be taken into consideration the next time the product is updated or reprinted.

Vegetable Light Curves

Following is the summary of the individual reviews that was distributed to the reviewers prior to the panel discussion by telecon. This information was used to guide the panel discussion; it is included here to provide a complete report of the review process.

Reviewer	Overall Rating	Recommendation
Education Reviewer	Outstanding	Recommended
Education Reviewer	Outstanding	Recommended
Education Reviewer	Very Good	Recommended, revisions next update.
Science Reviewer	Very Good	Recommended, revisions next update
Science Reviewer	Very Good	Minor Revisions

Strengths

- The product uses a hands-on activity, group exercise and provides ample opportunity to address common misconceptions with students.
- The product fits nicely with NASA's SMD Planetary Science Division content.
- The student activity sheet asks thought-provoking, activity-related questions, which will help develop student understanding of light curves and their applications.
- The teacher guide provides a list of standards that are appropriately related and supported by the activity.
- The product is well suited for 8-12th grade students (Note: one reviewer felt parts may be difficult for 8th graders). The addition of a quantitative extension allows the activity to be used by upper level (11-12) students as well.
- The addition of alternative materials (cucumber, carrot, sweet potato) and modeling (types of motors or stick) makes the activity possible in just about any classroom setting.
- The design quality is clear, easy-to-understand and follow.
- The Teacher's Guide provides ample links to online as well as print resources.

Weaknesses

- The assembly instructions could use more illustrations.
- One reviewer could not load the following sites listed in the Vignettes pdf:
    - http://cfao.ucolick.org/ took the Reviewer to a commercial web site (Note: IGES had no trouble accessing)
    - Browser cannot find: http://cobalt.golden.net/~kwastro/Stellar%20Magnitude%20System.htm/ or http://www.ast.cam.ac.uk/HST/press/oposite.stsci.edu/pubinfo/PR/97/27/vesta.mov
- One reviewer felt the teacher guide was lacking sufficient introductory information about the purpose of the activity. This reviewer felt teachers unfamiliar with the subject need to read several pages to understand what this activity is going to accomplish.

Suggestions/Comments

- Specific scoring criteria are not provided, but teachers should have sufficient information between the questions and explanations provided in the Teacher's Guide to develop their own grading system.
- The addition of a specific example with numbers in the teacher guide for the "Quantitative Extensions" may be helpful to guide teachers since each student group will have different answers.
- Adding a summative assessment piece (to augment assessment questions) would be a good addition.
- Consider linking directly to the "I Can See You More Clearly Now" vignette mentioned on page 5, #5 of the Teacher's Guide.
- The design could be improved by more illustrations. For example, consider adding a photograph to the "Quantitative Extensions" section of the degree marked paper with a potato oriented on it for visual clarity (as was done in the Assembly Instructions with the motor and potato setup).
    - One reviewer suggested considering the value of the addition of a few short movies showing procedures. Specifically, the reviewer felt students might find the prompt on student activity sheet, section 4, question #4, to be difficult to understand (could use a picture, diagram, or movie to further explain).
    - Another reviewer thinks the Assembly Instructions
- Although learning technologies are not required for this activity, teachers who have graphing and modeling programs available for student use could easily integrate them.
- In "history and discovery" one reviewer was curious as to why WWII had so much of an effect but WWI didn't.
- One reviewer was surprised not to find references to the Galileo spacecraft asteroid flybys.