Exploring with Drones

Standards (Core Ideas related to the activity):

NGSS:

ETS1.A – Defining and delimiting engineering problems

ETS1.B – Developing possible solutions

ETS 1.C – Optimizing the design solution

Common Core Math:

6-RP.3 – Use ratio and rate reasoning to solve real world problems

7-RP.2 – Recognize and represent proportional relationships between quantities

Objectives:

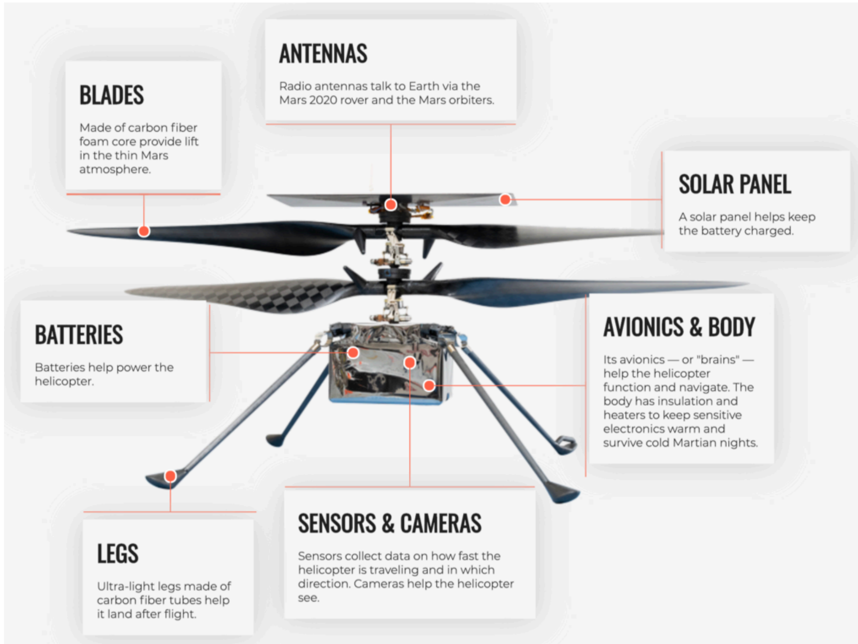
The students will:

- Discuss the role of testing in the development of new technology.
- Define the terms drone, UAS, orbiter and rover.
- Investigate rotary flight.

Background:

Most people think of flying when **drones** are brought up, but drones can operate in the air, on land, or even in the water. In general terms, a drone is anything that can be moved around without an on-board pilot, either **pre-programmed** or **remotely controlled**. A more specific term for flying drones is **UAS** or unmanned aerial systems. These can range in size from as small as 1 inch to as large as a transport plane carrying payloads up to 1.5 metric tons.

The history of unmanned systems goes all the way back to 1898 with Nikola Tesla's patent and demonstration of remote-controlled technologies. In 1918, Orville Wright and Charles Kettering applied the technology to flying machines resulting in the 'Kettering Bug' the first functioning aerial drone. By 1953, the US military was testing pilotless aircraft, and the usage grew from there. Uses of aerial drones are as varied as the drones themselves. Presently, NASA has a rotary-powered drone called Ingenuity on the Perseverance Rover that is due to land on Mars in February of 2021. The atmosphere on Mars is very different from that here on Earth. It is made mostly of carbon dioxide and is extremely thin, so this experiment will tell NASA whether or not powered flight on Mars is possible.



The Ingenuity **rotorcraft** features four specially made carbon-fiber blades, arranged into two rotors that spin in opposite directions at around 2,400 rpm – many times faster than a passenger helicopter on Earth. It also has innovative solar cells, batteries, and other components to deal with the extremely thin and cold atmosphere on Mars. When exploring new worlds, **orbiters** give a view from high overhead while **rovers** are on the surface, so the use of drones would allow for a unique view of the exploration area. In the future, drones could be used to deliver scientific instruments and sensors to places rovers can not go, or even scout the path ahead for rovers or astronauts.

Further in the future, NASA is looking at the possibility of a program called Dragonfly that would include a rotary-drone on Titan (Saturn’s largest moon). Dragonfly is planned for launch in 2026 and arrival in 2034. Since the atmosphere on Titan is very dense, Dragonfly will be able to carry many instruments and sensors. The rotorcraft will fly to dozens of promising locations on Titan looking for prebiotic chemical processes common on both Titan and Earth.

Vocabulary:

- Agriculture – the science and action of growing crops
- Cartography – the creation of maps
- Drone – a pilotless or autonomous vehicle.
- Orbiter – a type of spacecraft that orbits a celestial body but does not land on it.
- Pre-Programmed – a drone that has all instructions loaded before its mission begins.
- Remote-controlled – a drone that can be controlled from another location and receives instructions in real time.
- Rotorcraft – an aircraft that uses rotary blades to provide lift and thrust for flight.
- Rover – a drone that moves directly on a foreign surface.
- Sequential – in a given order
- Topography – mapping the natural features of an area
- UAS – unmanned aerial systems or flight-based drones.

Supplies:

- Pencils
- Rulers
- Pictures of Jezero Crater
- Drop Copter templates
- Scissors
- Paperclips
- Fan

Optional intro or follow up: Have students pick a drone use from the list below and do some research as to how drones are utilized in this area.

In addition to space applications, here on Earth, there are many practical applications using aerial drones. These include:

- Surveying and cartography
- Defense industry
- Emergency Response and disaster management
- Conservation of endangered species and land
- Healthcare
- Agriculture
- Weather
- Waste Management
- Mining
- Entertainment Industry
- Energy sector
- Civil maintenance

Prep:

1. Print the pictures of Jezero Crater included at the end of the lesson plan. Note, students will be writing on one of them. If you would like to laminate them and use dry erase pens, you can reuse the picture.
2. Print templates of drop copters.

Procedures:

1. When Ingenuity is tested in Jezero crater, it will be a series of small flights. Take a look at the following video and discuss the landing site NASA has chosen for the Perseverance Rover. https://mars.nasa.gov/mars2020/mission/science/landing-site/
2. Explain that The Ingenuity Drone is stowed under the 'belly' of the Perseverance Rover. When Perseverance lands in Jezero Crater, Ingenuity will be released to the surface of Mars and then will fly a series of test flights.

3. Hand out the pictures of Jezero Crater and let your students take a look. Some of the pictures are overhead views, some are closer in. One has topography marks to help with orientation, and one is false colored to indicate elevation. Using the maps, ask them to plan 5 flights for the Ingenuity rover. The topography map has the landing radius for Perseverance clearly marked. The true color map will be the easiest to use for this, as scale is marked on the map.
4. Using a pencil and ruler, mark the direction and distance of the flights. The flights should begin somewhere in the original landing radius. They should be short and get longer each time; 150 meters, then 300m, 450m, 600m, and finally 750m. The flights should be sequential, taking off from where the previous flight landed, just like the real Ingenuity will have to do. The students should be able to explain why they took the path they chose. (terrain, possibility of past water, etc.)
5. Next, the students will investigate rotary craft. This part of the lesson is based on JPL's "Make a Paper Mars Helicopter". Give each student a drop-copter template.
6. Have them cut along the dotted lines to cut the copter out.
7. They will then fold the blades in opposite directions along the solid lines. Ask the students why they think this is at an angle and not straight?
8. Have them fold the stem of the copter in, and then up, and use a paperclip to secure.
9. Have the students drop their copter and make notes about the behavior.
10. Since the atmosphere on Mars is a big concern in the flight of ingenuity, use the fan to change the atmospheric conditions. Set the fan to low and have the students do a second drop near the fan. How does that change the behavior of the copter?
11. Have the students do a quick modification to deal with the fan; they can change the weight, or the angle of the blades, or even the size of the copter.
12. Redrop the modified rotorcraft. Have the students note the behavior and any improvements in flight.

Credits:

https://economictimes.indiatimes.com/news/international/world-news/china-successfully-tests-worlds-largest-unmanned-transport-drone/articleshow/66264074.cms

https://www.nasa.gov/feature/jpl/6-things-to-know-about-nasas-ingenuity-mars-helicopter/

https://mars.nasa.gov/technology/helicopter/#Anatomy

https://wingtra.com/drone-mapping-applications/surveying-gis/

https://www.geospatialworld.net/article/what-are-popular-uses-of-drones/

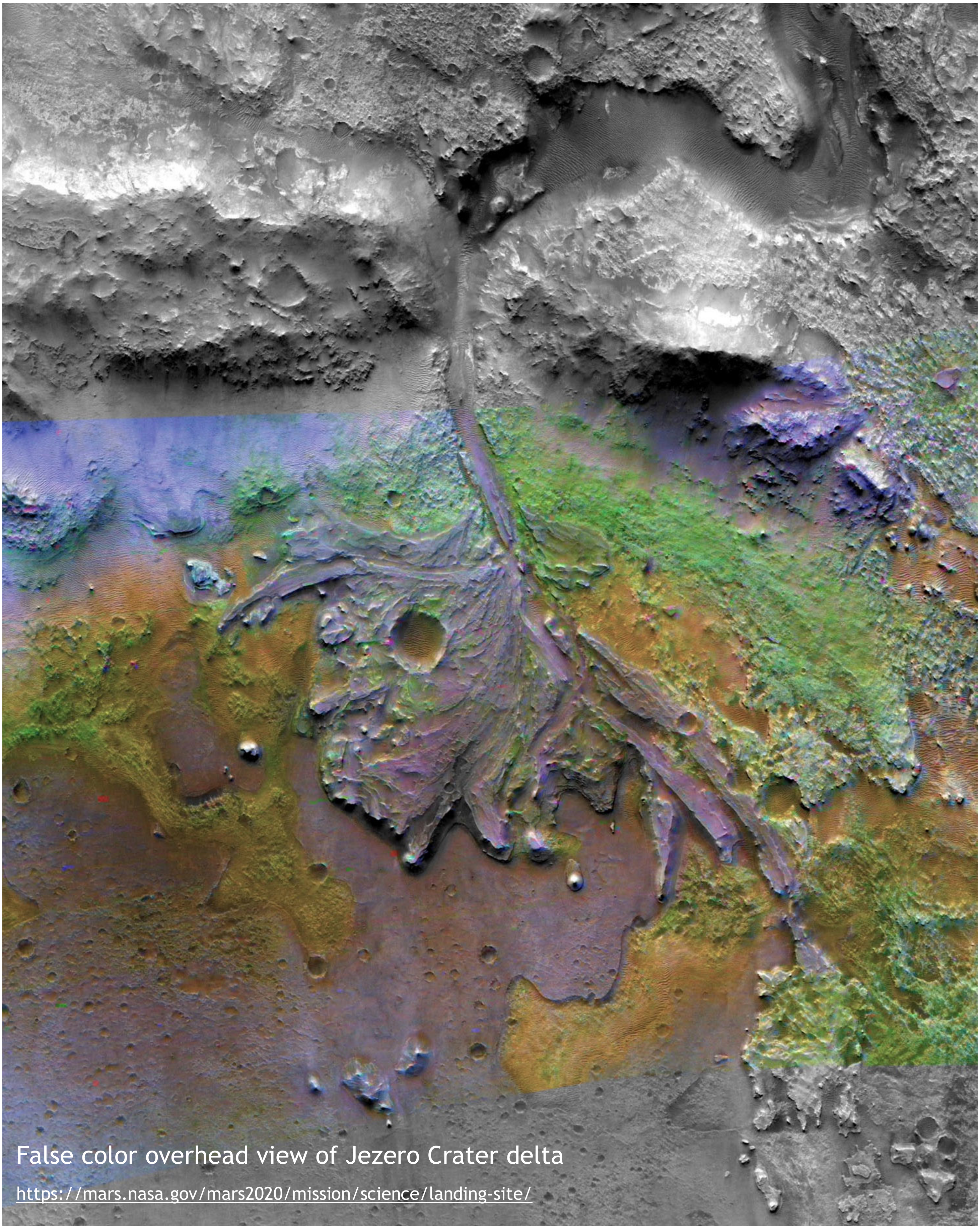
https://dronelife.com/2018/09/14/another-life-saved-by-a-drone-with-thermal-imaging/

https://www.theverge.com/2018/5/11/17346414/nasa-mars-2020-helicopter-atmosphere

https://www.nasa.gov/press-release/mars-helicopter-to-fly-on-nasa-s-next-red-planet-rover-mission

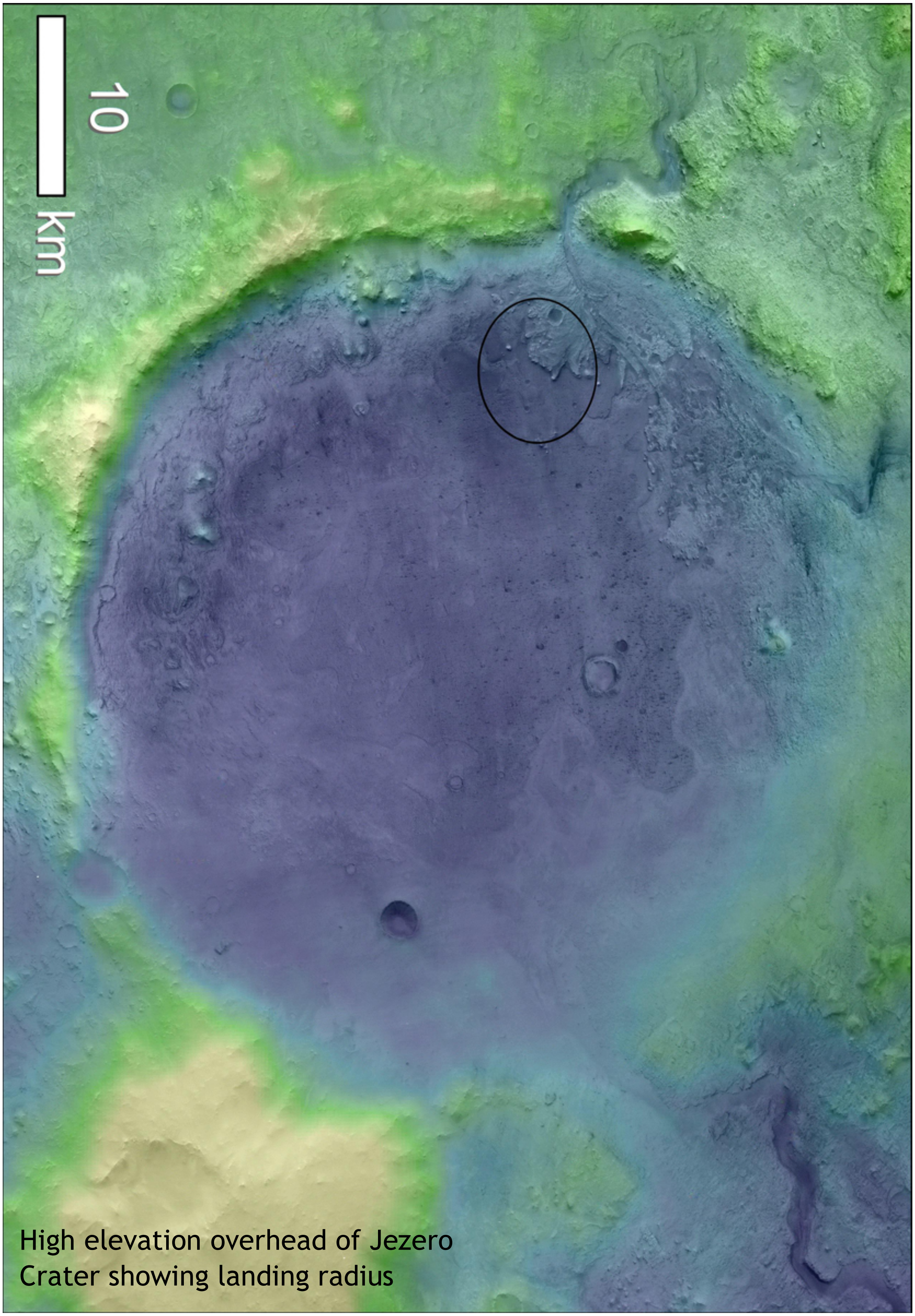
https://www.scientificamerican.com/article/nasas-ingenuity-the-first-ever-off-world-helicopter-is-set-for-a-wright-brothers-moment-on-mars/

https://www.jpl.nasa.gov/edu/teach/activity/make-a-paper-mars-helicopter/

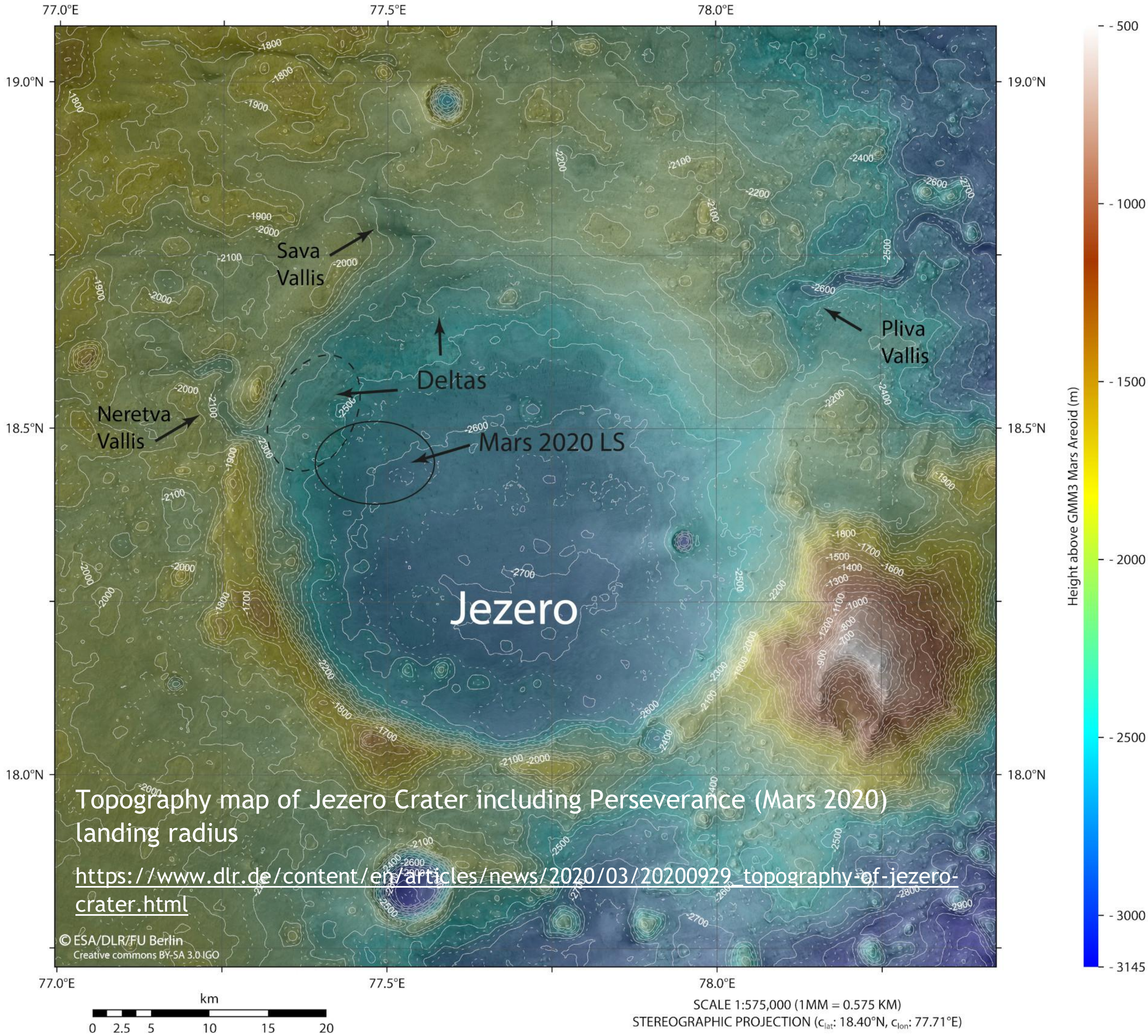


False color overhead view of Jezero Crater delta

https://mars.nasa.gov/mars2020/mission/science/landing-site/

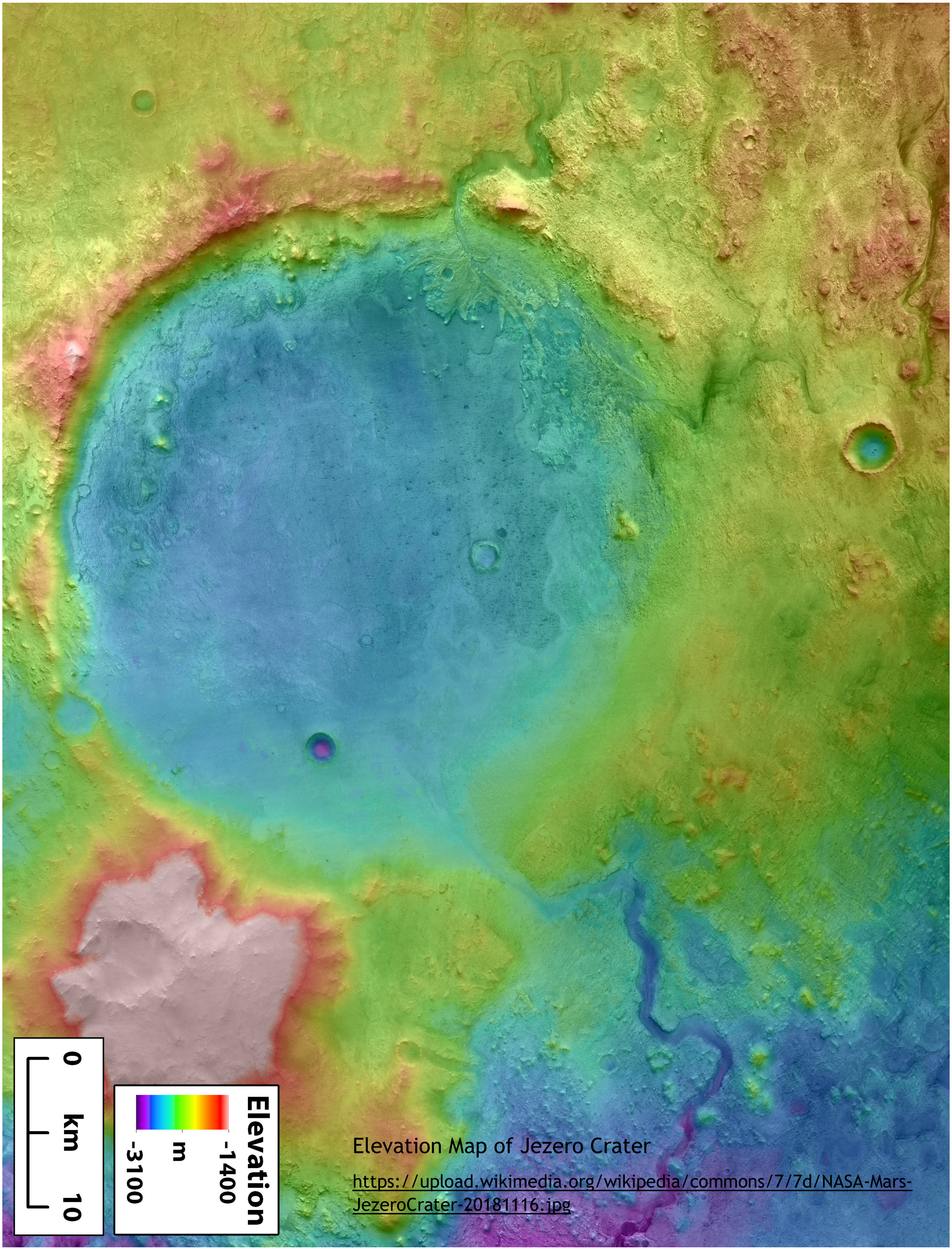


High elevation overhead of Jezero
Crater showing landing radius



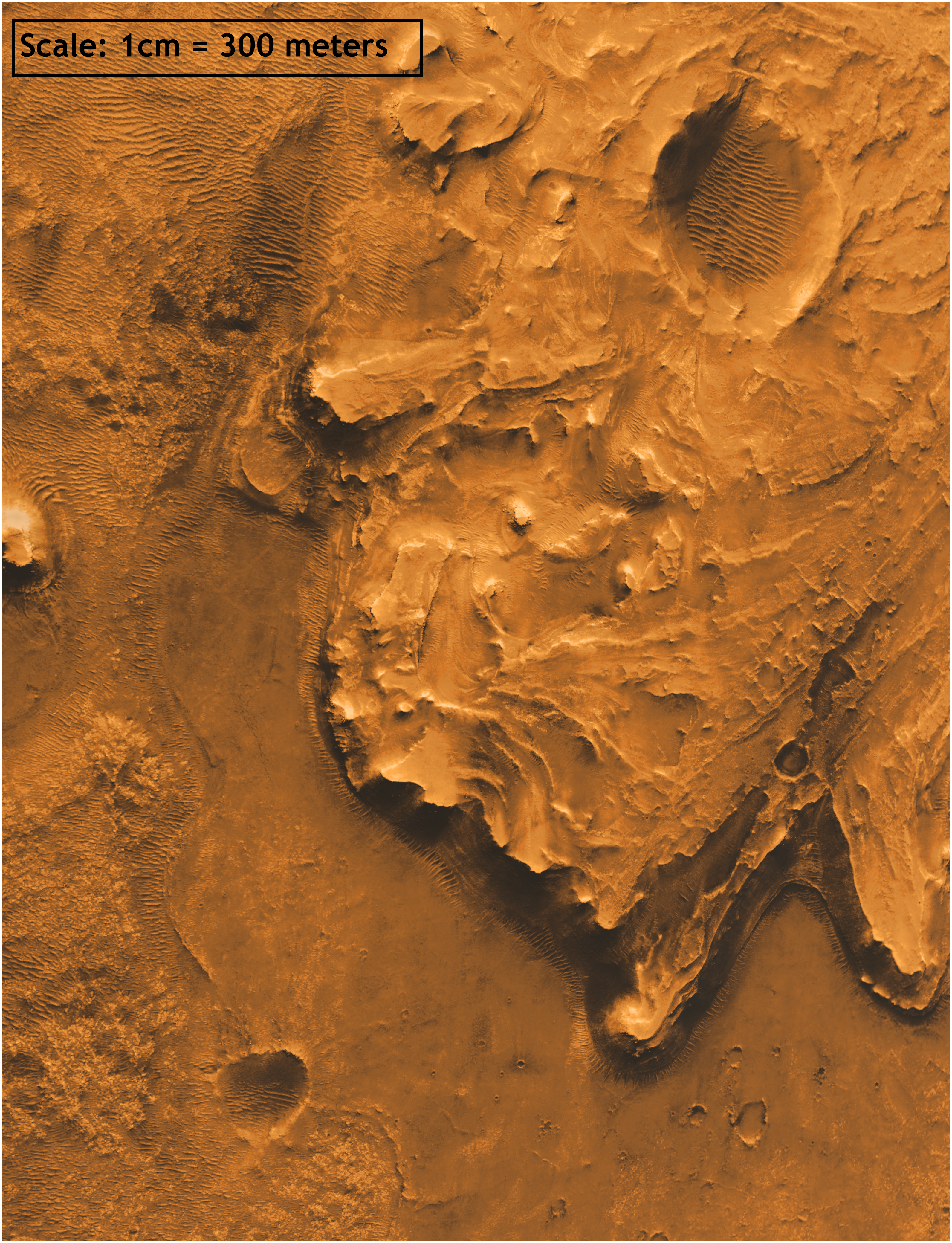
Topography map of Jezero Crater including Perseverance (Mars 2020) landing radius

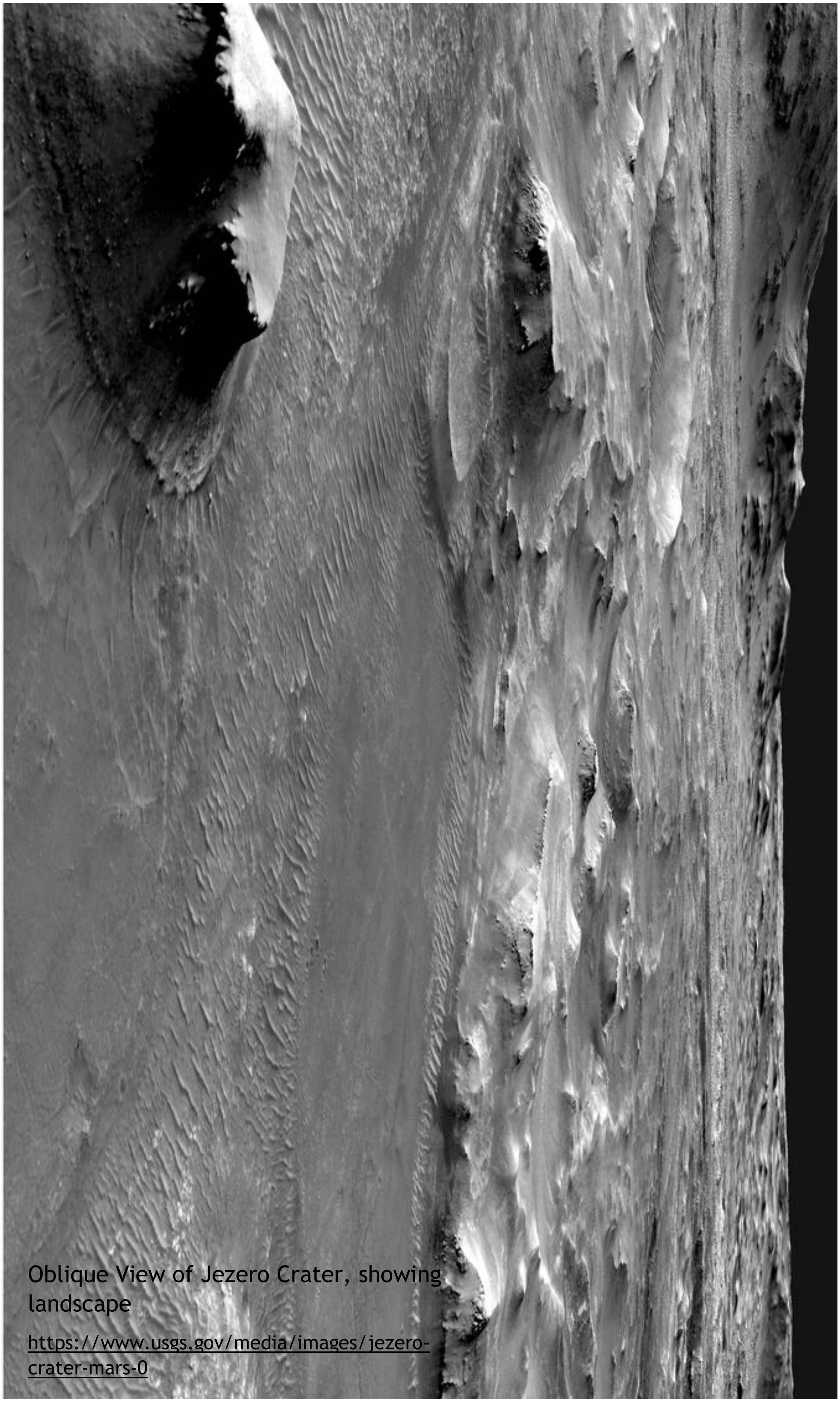
https://www.dlr.de/content/en/articles/news/2020/03/20200929_topography-of-jezero-crater.html



Elevation Map of Jezero Crater

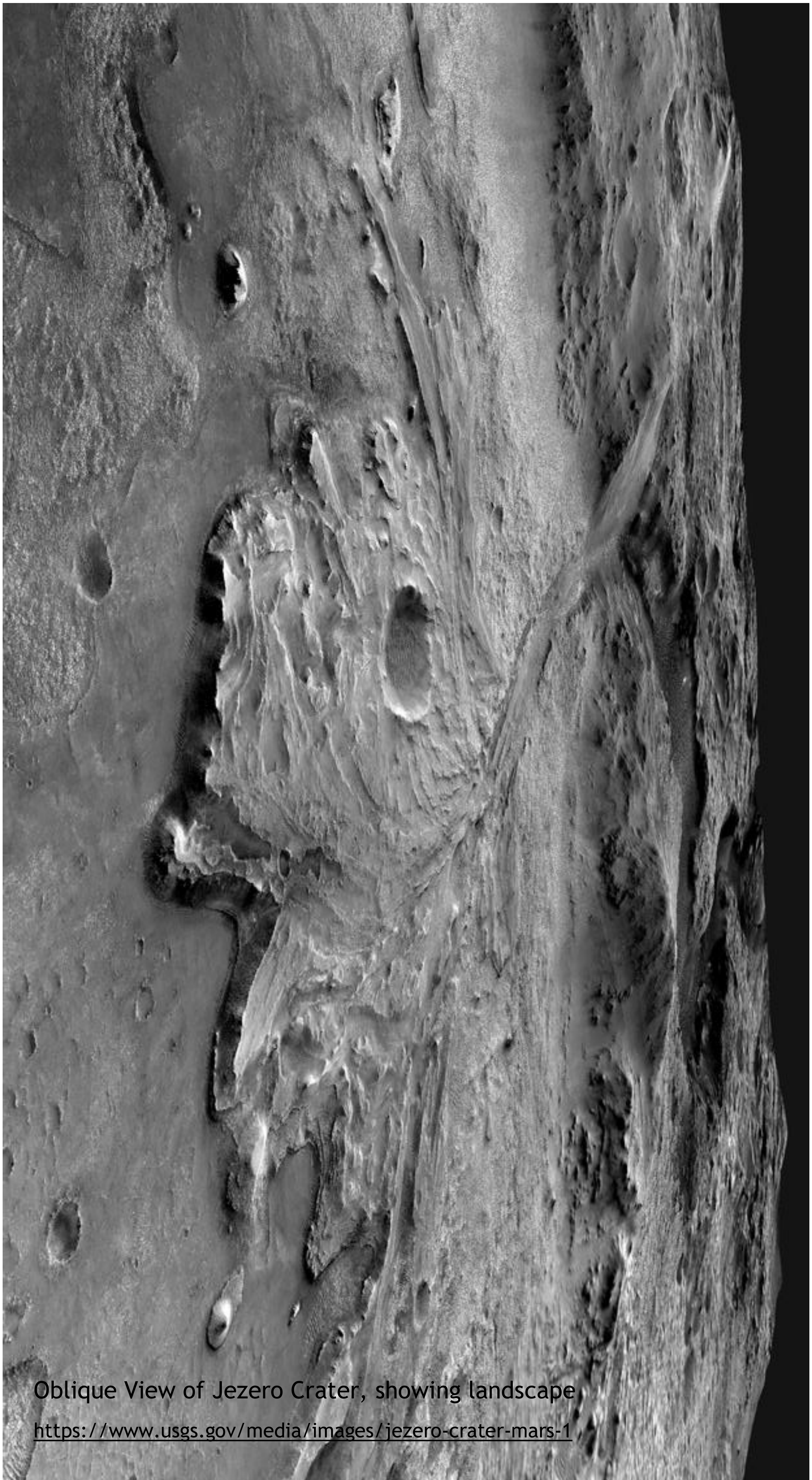
https://upload.wikimedia.org/wikipedia/commons/7/7d/NASA-Mars-JezeroCrater-20181116.jpg


Scale: 1cm = 300 meters



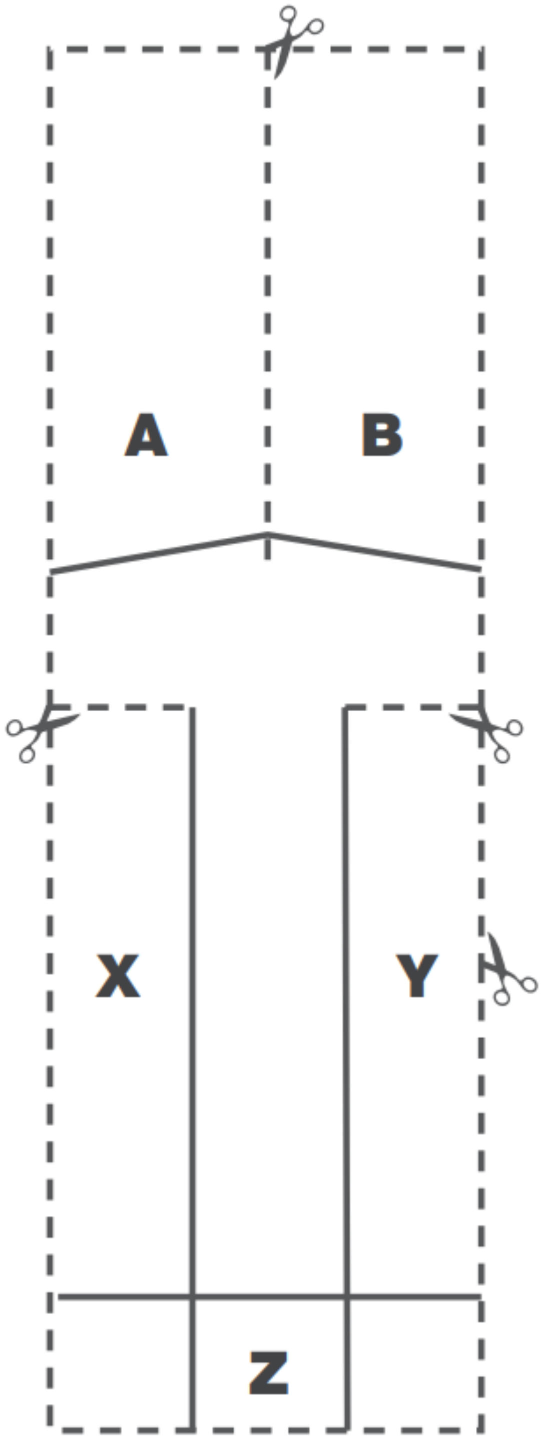
Oblique View of Jezero Crater, showing landscape

https://www.usgs.gov/media/images/jezero-crater-mars-0



Oblique View of Jezero Crater, showing landscape

https://www.usgs.gov/media/images/jezero-crater-mars-1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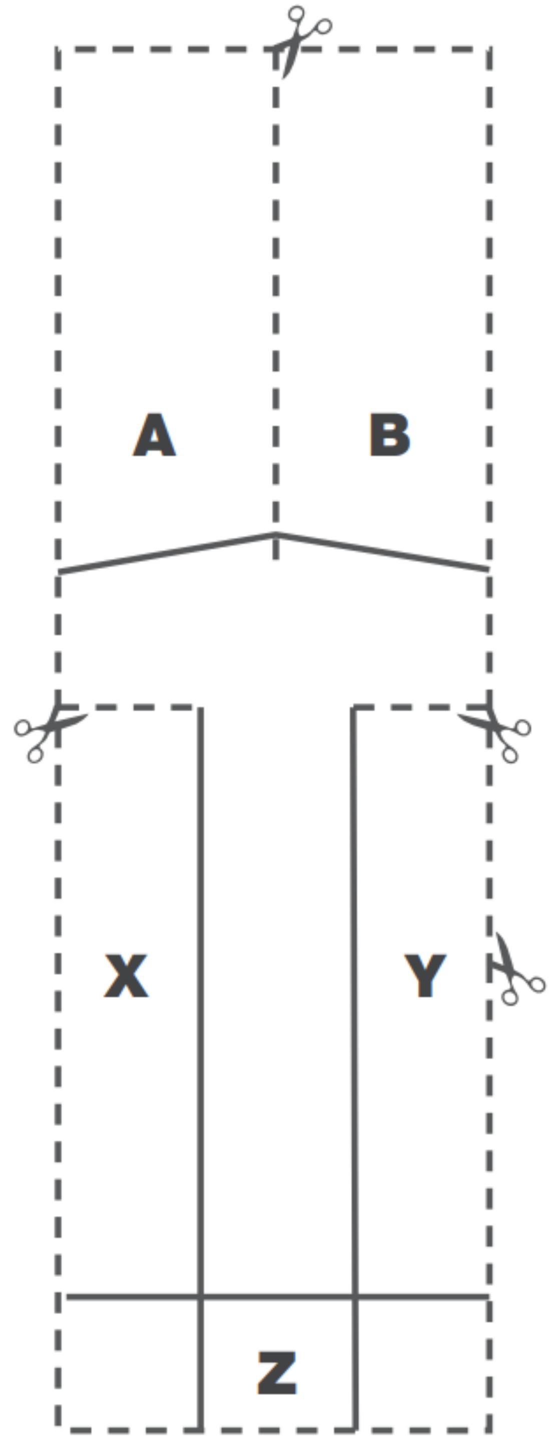
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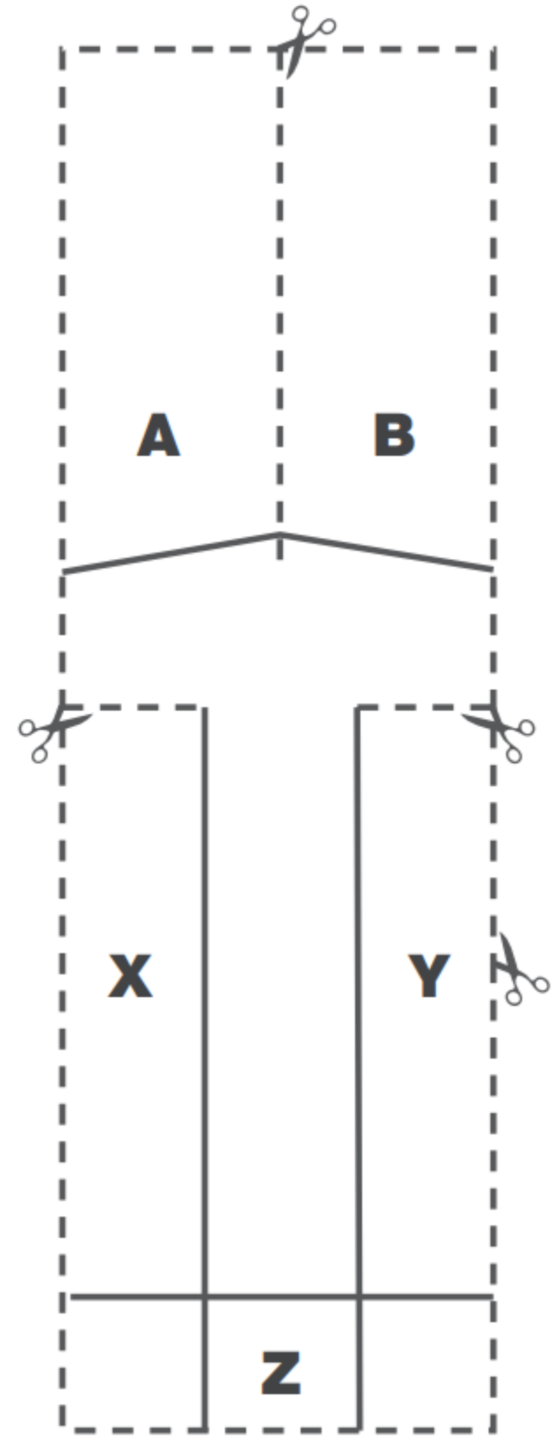
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