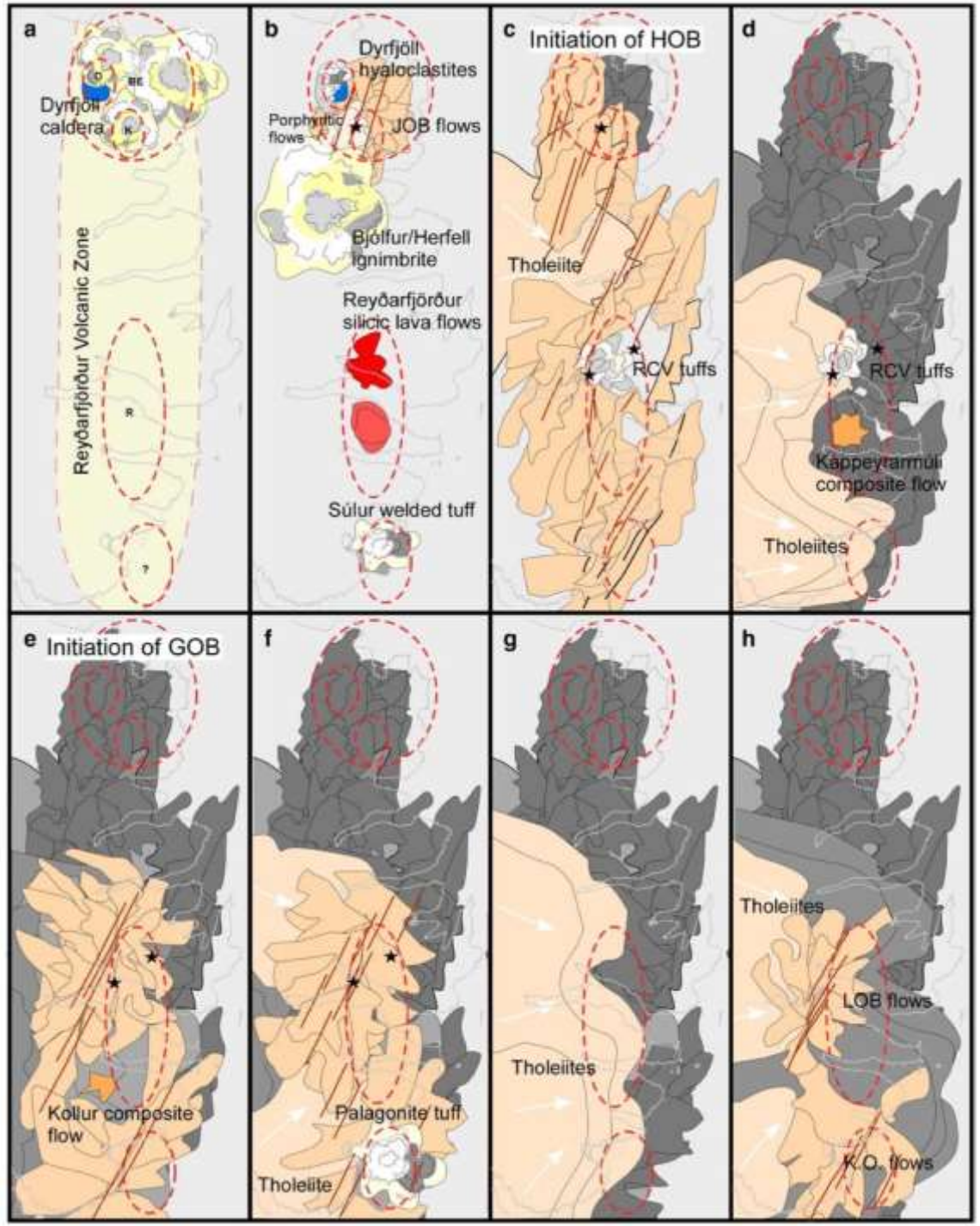
4TH PLANET LOGISTICS

Martin Gasser
Christa Feucht

Moon and Mars habitation in lava tubes: The first explorers will be cave men again


a
Dyrfjöll caldera
Reyðarfjörður Volcanic Zone
b
Dyrfjöll hyaloclastites
Porphyritic flows
JOB flows
Bjólfur/Herfell ignimbrite
Reyðarfjörður silicic lava flows
Súlur welded tuff
c
Initiation of HOB
Tholeiite
RCV tuffs
d
RCV tuffs
Kappeyrarmúli composite flow
Tholeiites
e
Initiation of GOB
Kollur composite flow
f
Palagonite tuff
Tholeiite
g
Tholeiites
h
Tholeiites
LOB flows
K.O. flows

4TH PLANET LOGISTICS

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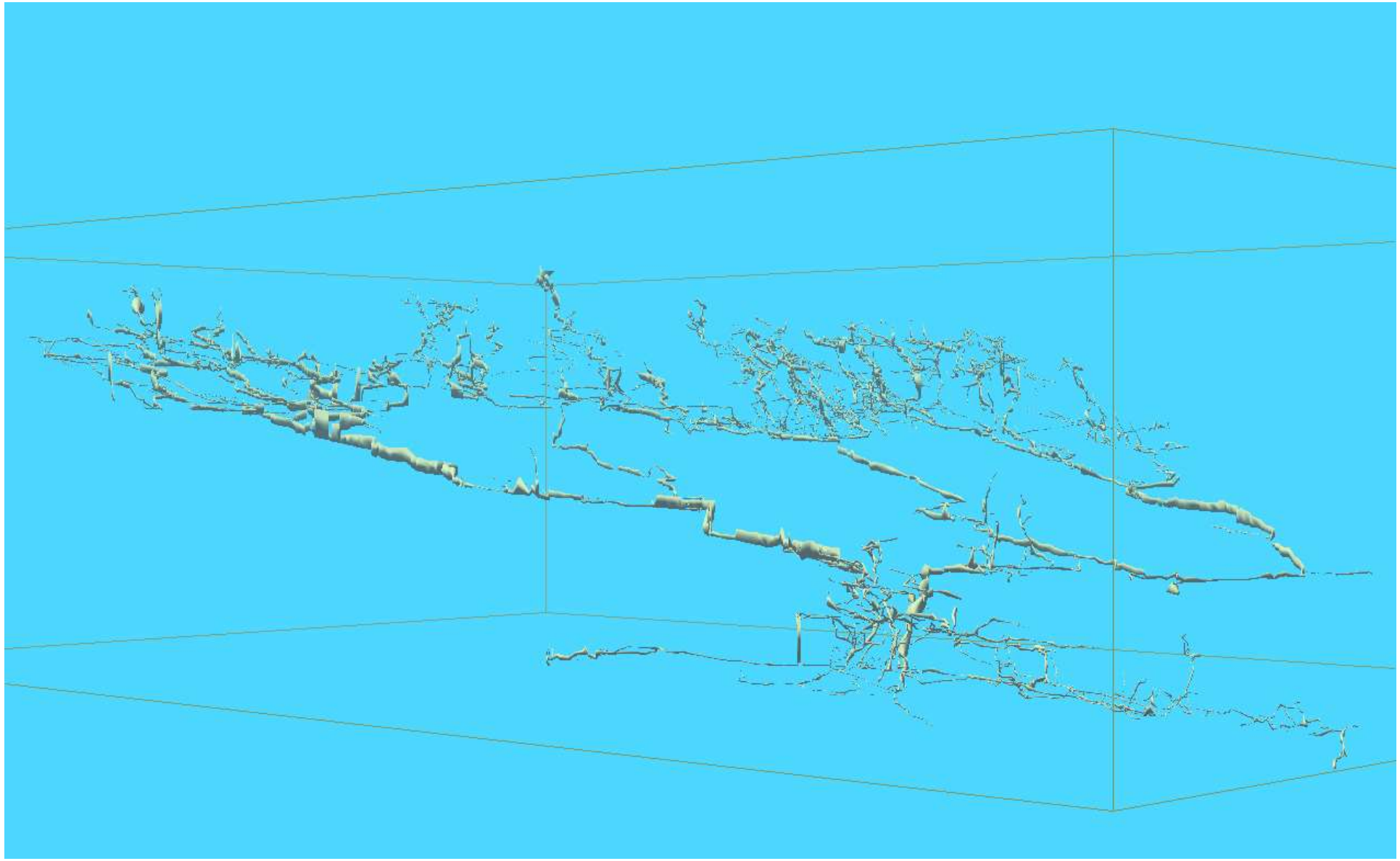
Moon and Mars habitation in lava tubes: The first explorers will be cave men again

Picture: SSS/SGH Bern

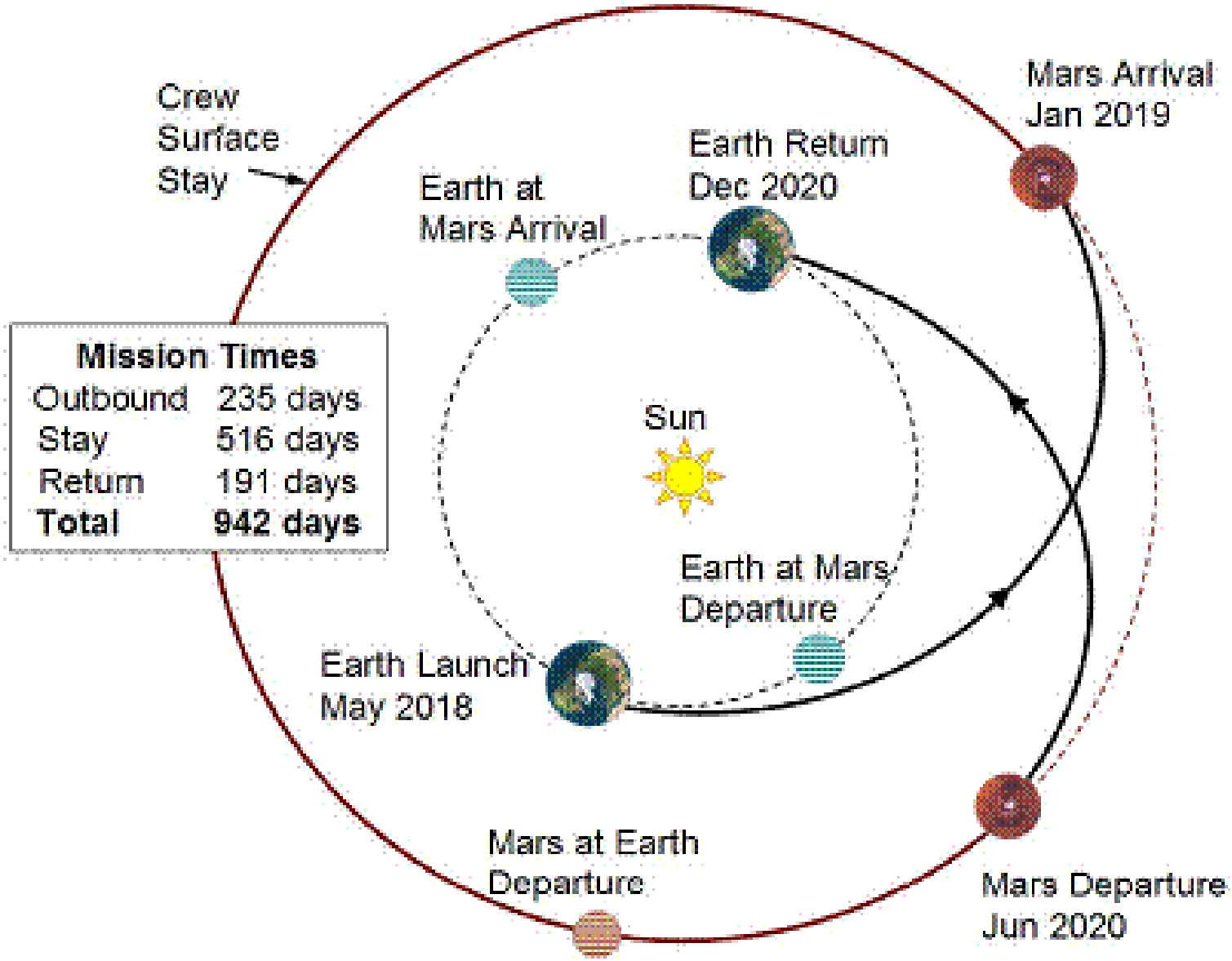


...Réseau der Siebenhengste-Hohgant = 156 km, -1‘340 m

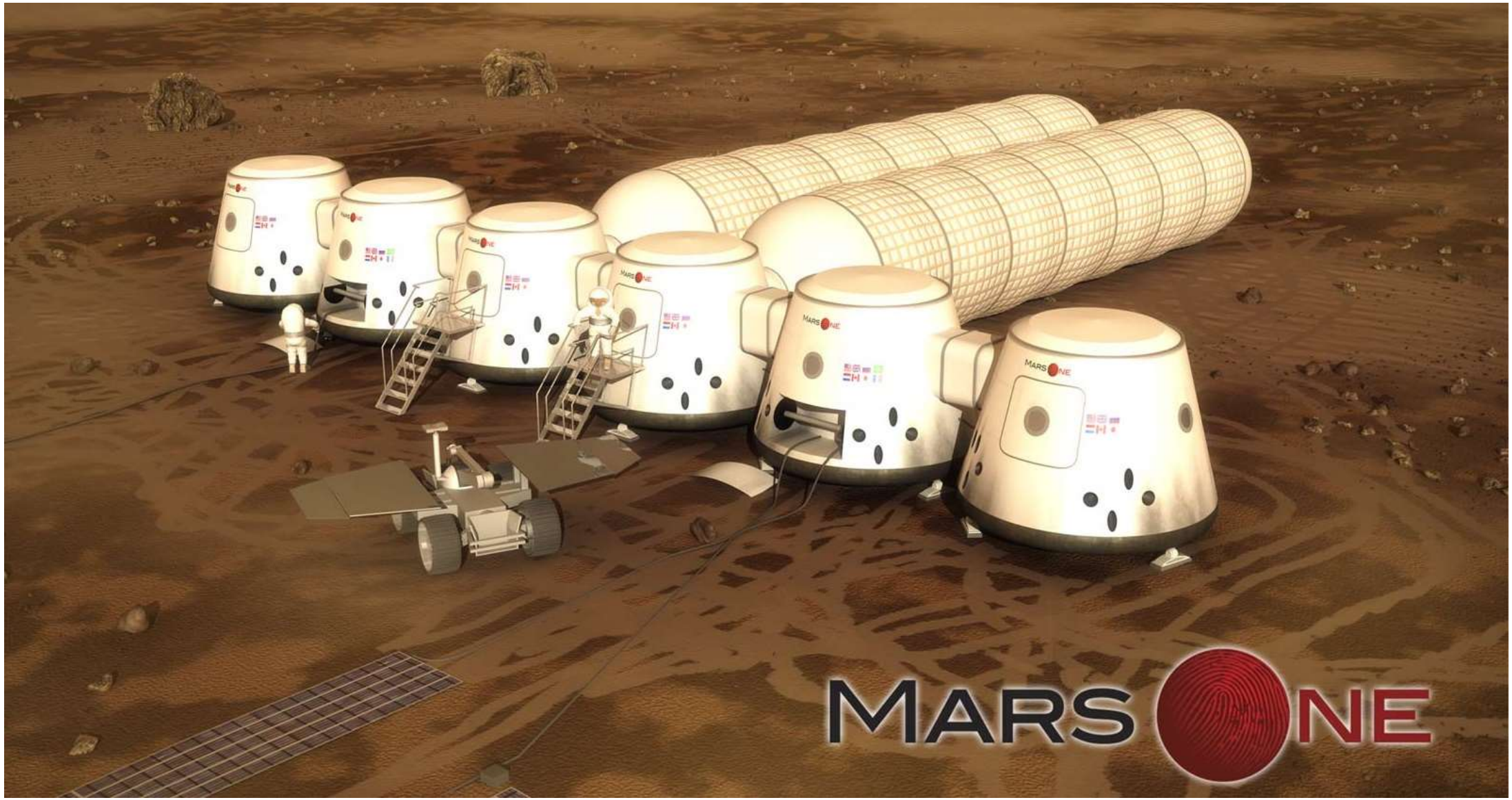
4TH PLANET LOGISTICS

Moon and Mars habitation in lava tubes: The first explorers will be cave men again

- human habitation outlook for Moon and Mars
- lava tubes
- how to find and characterize lava tubes
- technical requirements to get in there
- concept of 4th Planet Logistics

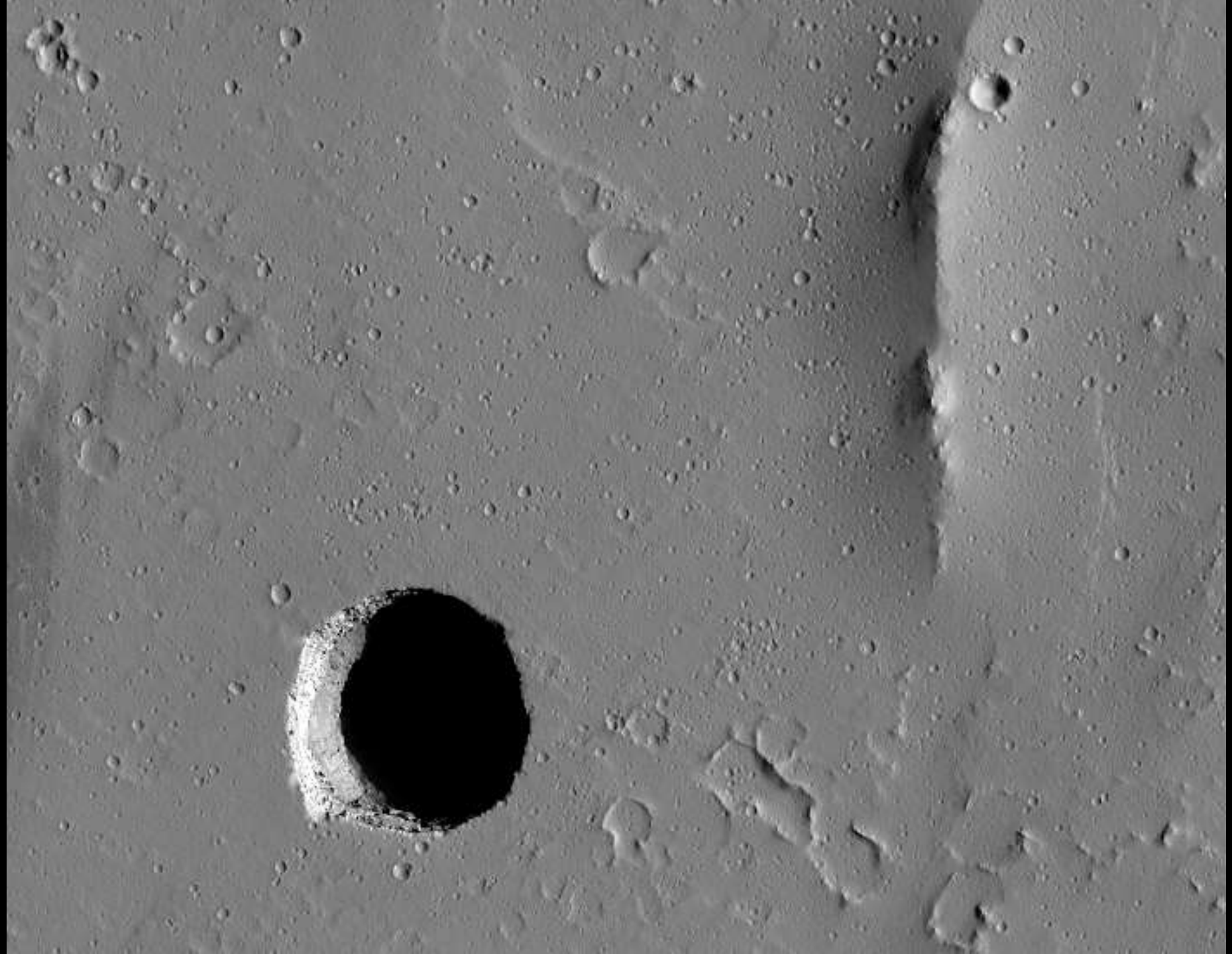

Crew
Surface
Stay
Mars Arrival
Jan 2019
Earth Return
Dec 2020
Earth at
Mars Arrival
Mission Times
Outbound 235 days
Stay 516 days
Return 191 days
Total 942 days
Sun
Earth at Mars
Departure
Earth Launch
May 2018
Mars at Earth
Departure
Mars Departure
Jun 2020


MARS
EXPLORER
www.mondoart.net
NASA

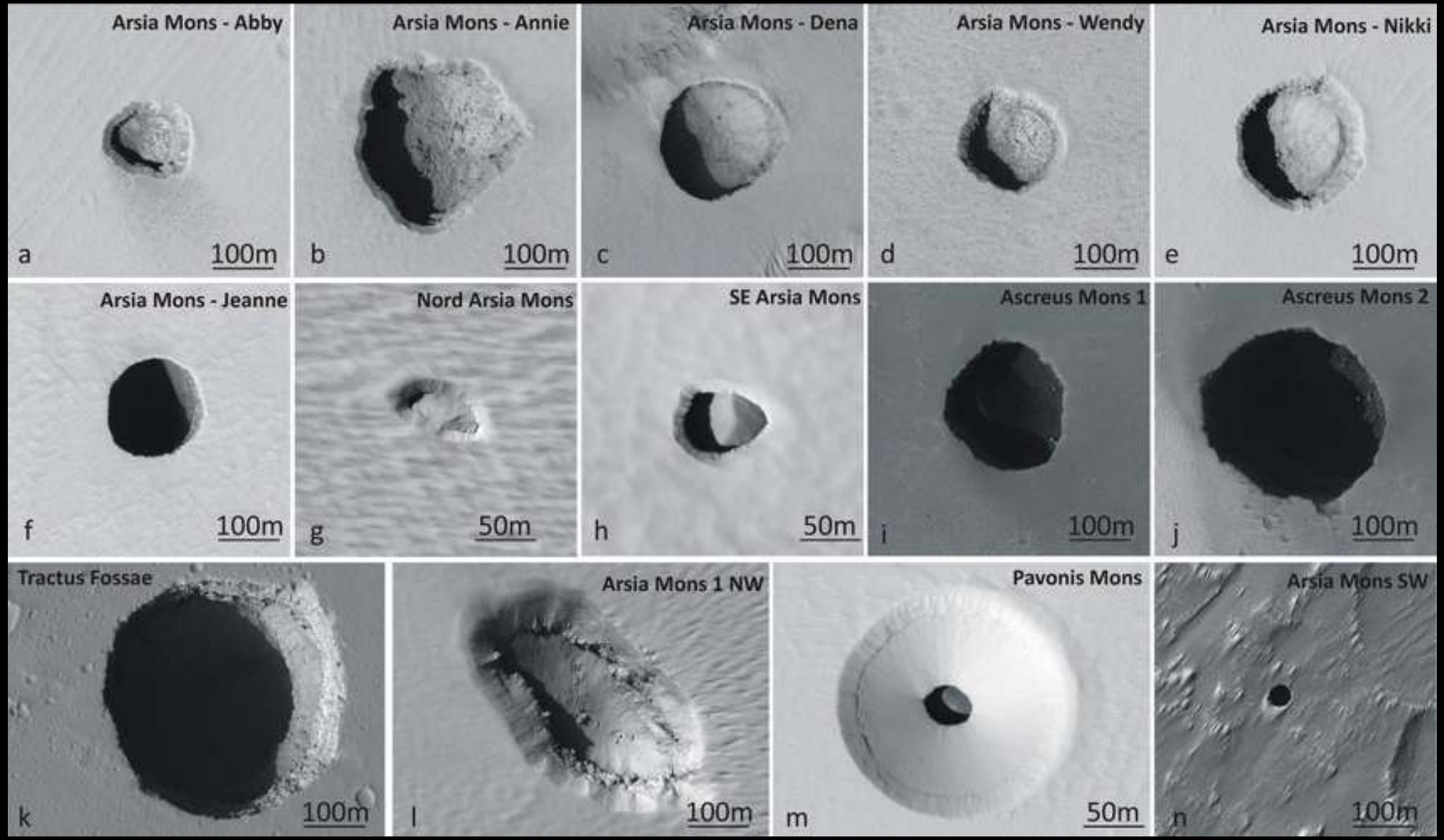

MARS ONE

Why go underground:

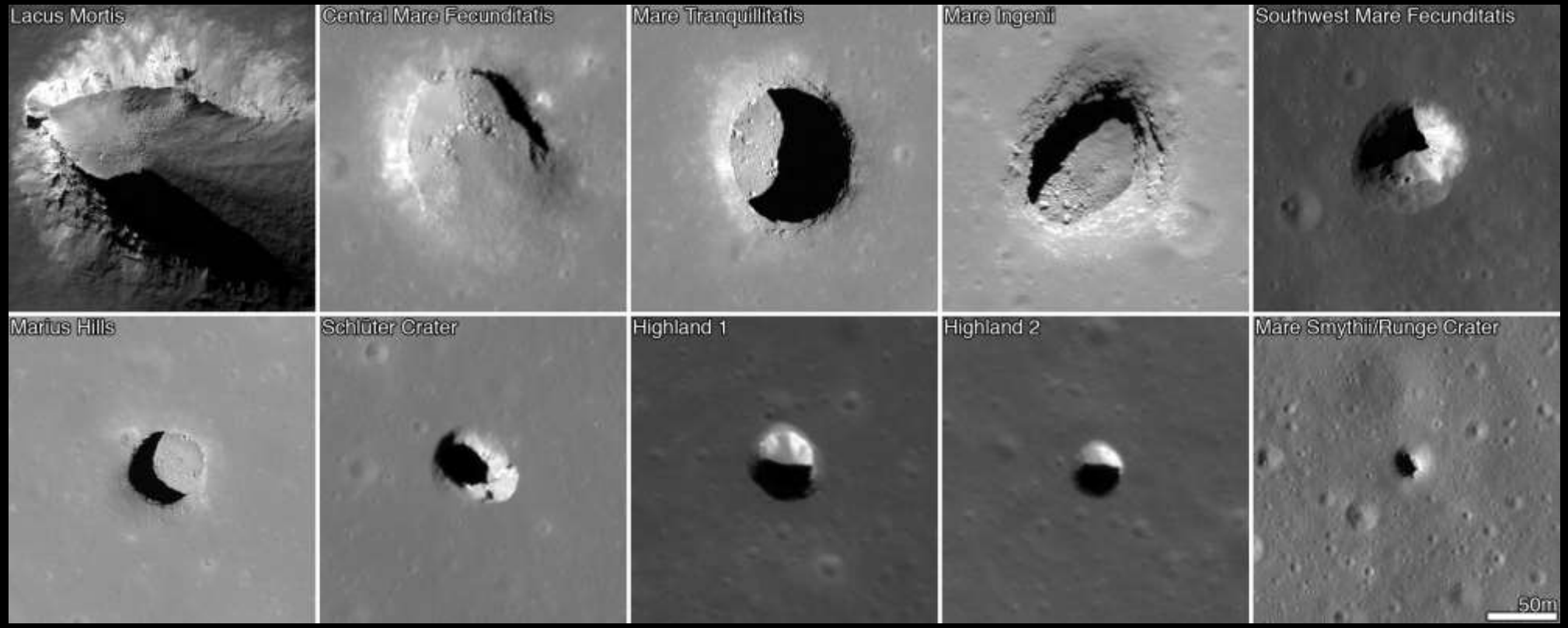
- radiation protection
- dust storm protection
- meteorite protection
- stable temperature
- mass and volume reduction
- possibility for finding life and/or water



MRO


Arsia Mons - Abby
a
100m
Arsia Mons - Annie
b
100m
Arsia Mons - Dena
c
100m
Arsia Mons - Wendy
d
100m
Arsia Mons - Nikki
e
100m
Arsia Mons - Jeanne
f
100m
Nord Arsia Mons
g
50m
SE Arsia Mons
h
50m
Ascreus Mons 1
i
100m
Ascreus Mons 2
j
100m
Tractus Fossae
k
100m
Arsia Mons 1 NW
l
100m
Pavonis Mons
m
50m
Arsia Mons SW
n
100m

LRO…


Lacus Mortis
Central Mare Fecunditatis
Mare Tranquillitatis
Mare Ingenii
Southwest Mare Fecunditatis
Marius Hills
Schlüter Crater
Highland 1
Highland 2
Mare Smythii/Runge Crater
50m

Why go underground:

- **radiation protection**
- dust storm protection
- meteorite protection
- stable temperature
- mass and volume reduction
- possibility for finding life and/or water

Why go underground:

- **radiation protection**

  Transit: 0.66 Sv
  500 days on Mars surface: 0.34 Sv (Curiosity rover data)

  1 Sv ≈ 100 abdominal CT scans ≈ 5% increased risk of fatal cancer

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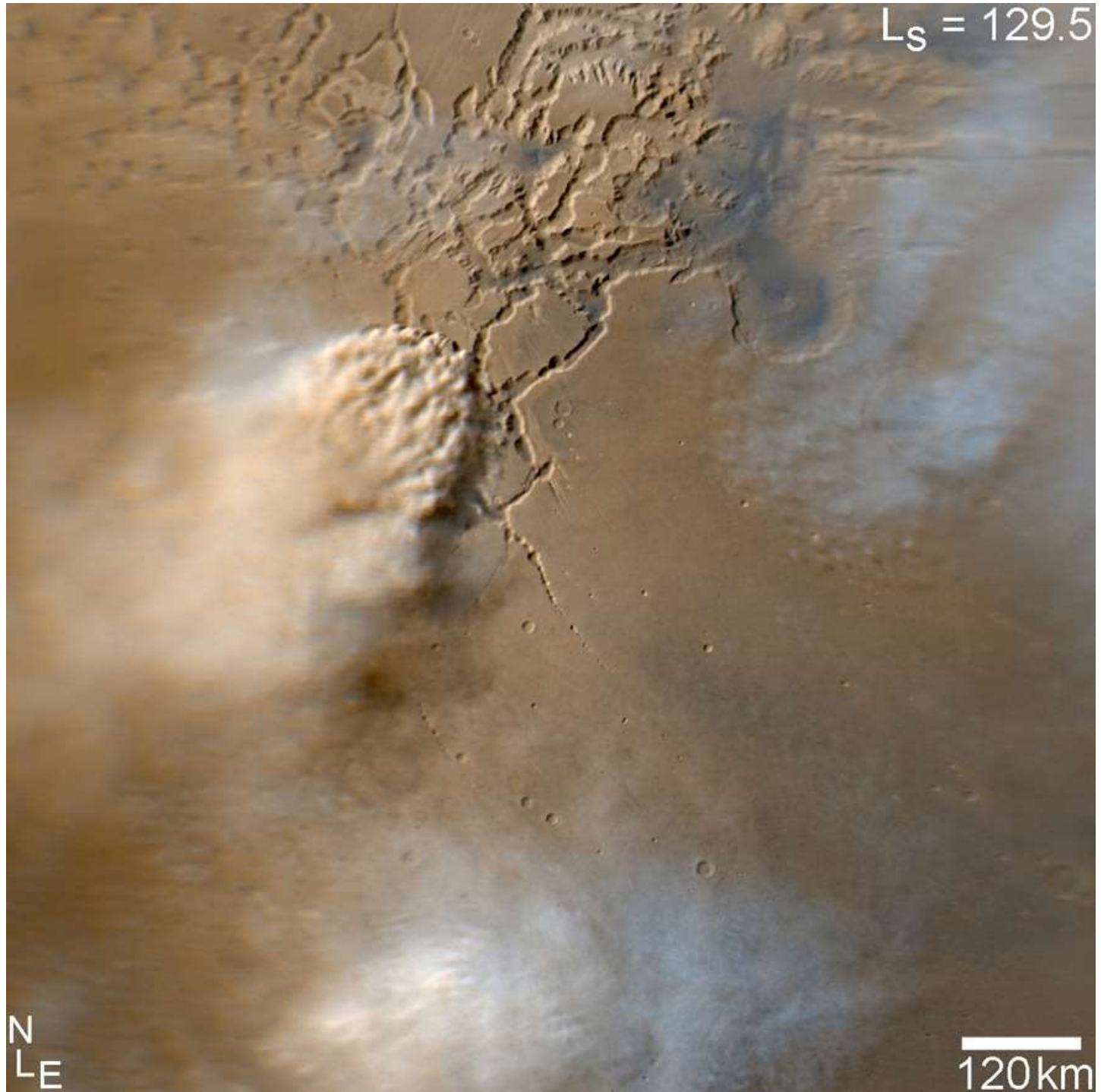

4TH PLANET LOGISTICS

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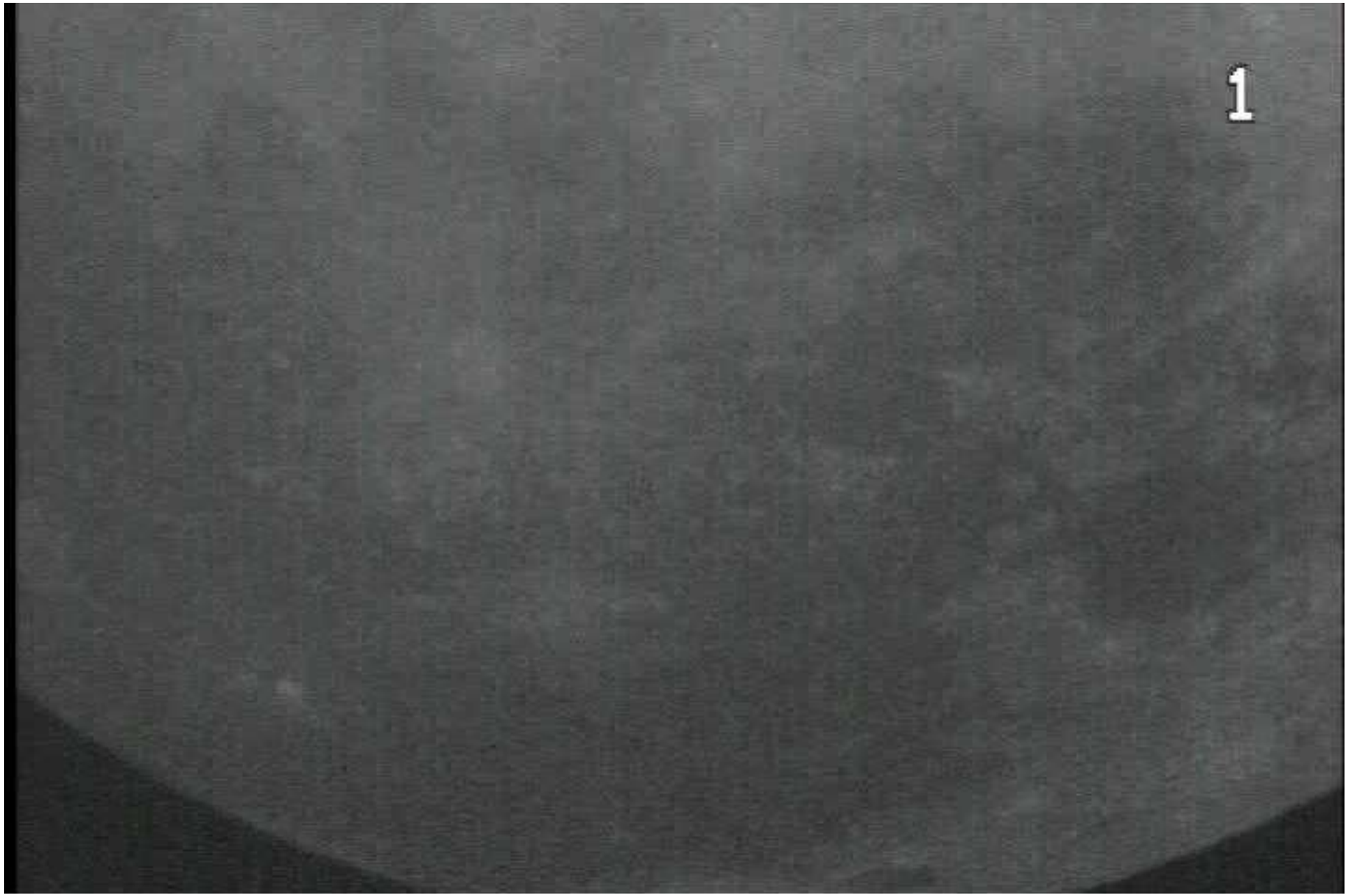
Peru 2007

Photograph:
AFP/Getty Images

Ann Hodges, Alabama 1954

Pictures:
Alabama Museum of Natural History


1


1


1


1


1


1


1


1


1


1


1


1


1


1


1


1


1

LUNAR IMPACT

science @ NASA

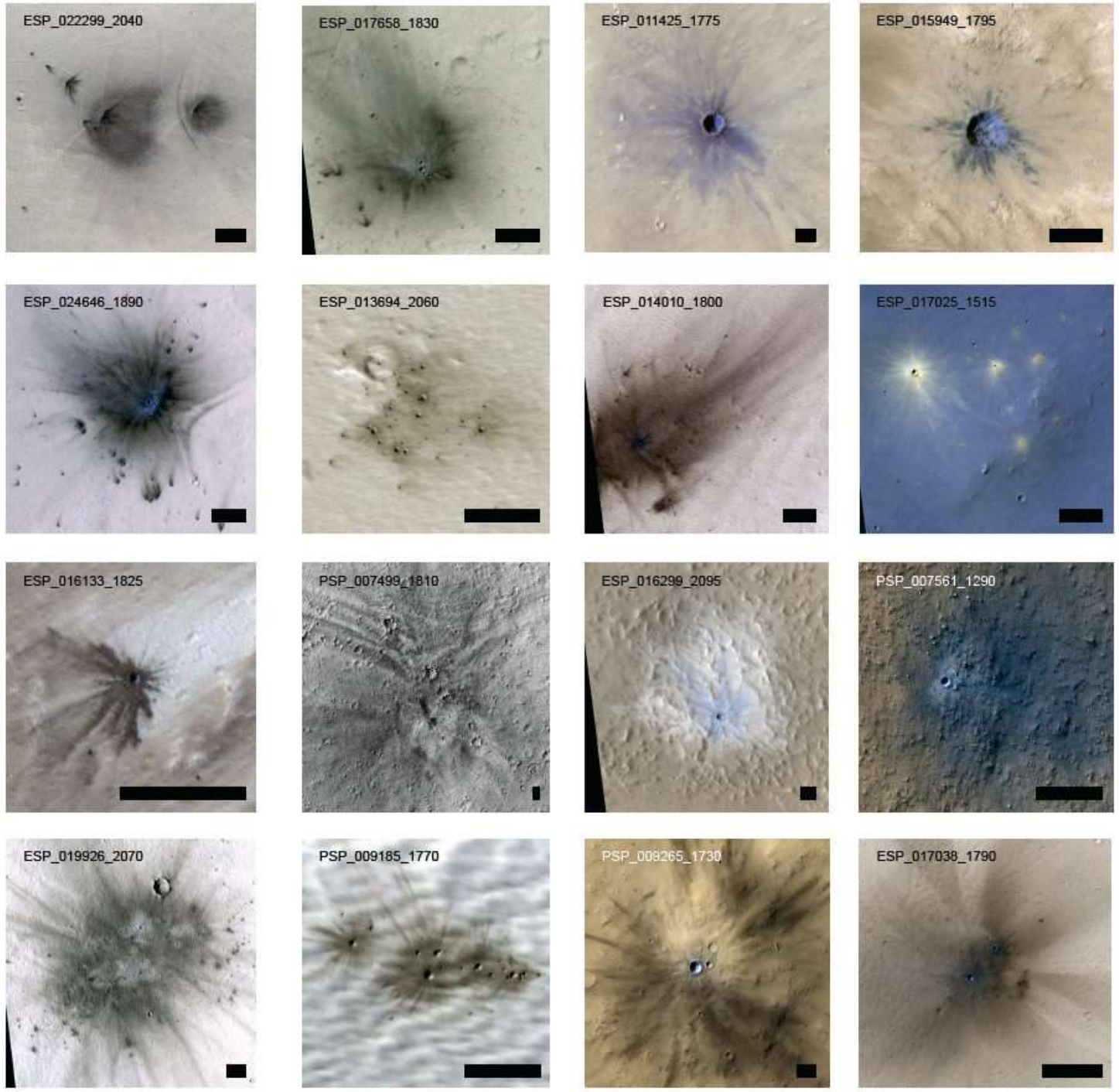
DATE: 03/17/2013

WEIGHT: 40 KILOGRAMS

SIZE: 0.3-0.4 METERS

SPEED: 25 KILOMETERS PER SECOND

EXPLOSION: 5 TONS TNT EQUIVALENT



Mars:
About 200 cratering impacts per year

Credit: NASA/JPL/Univ. of Arizona.

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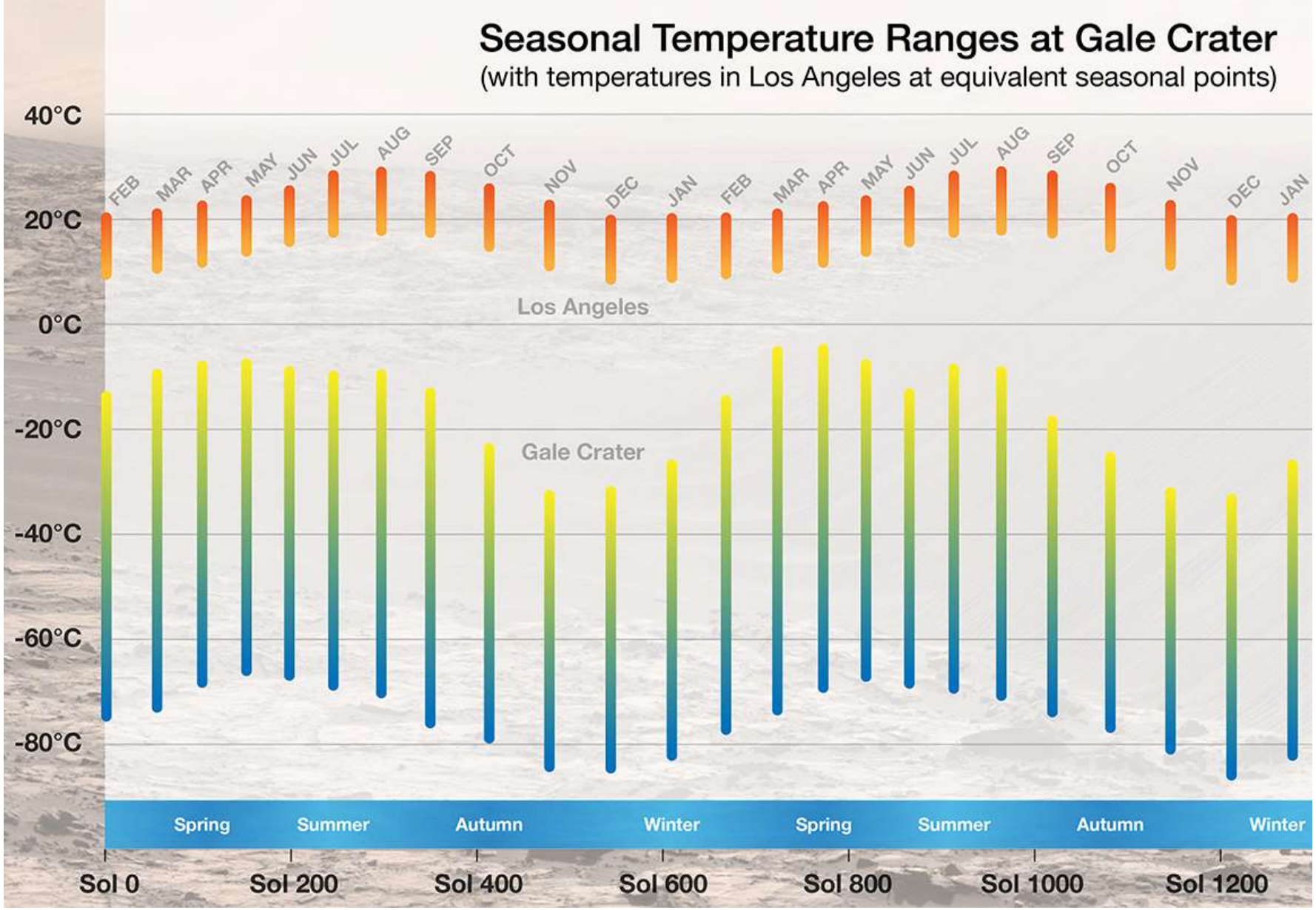
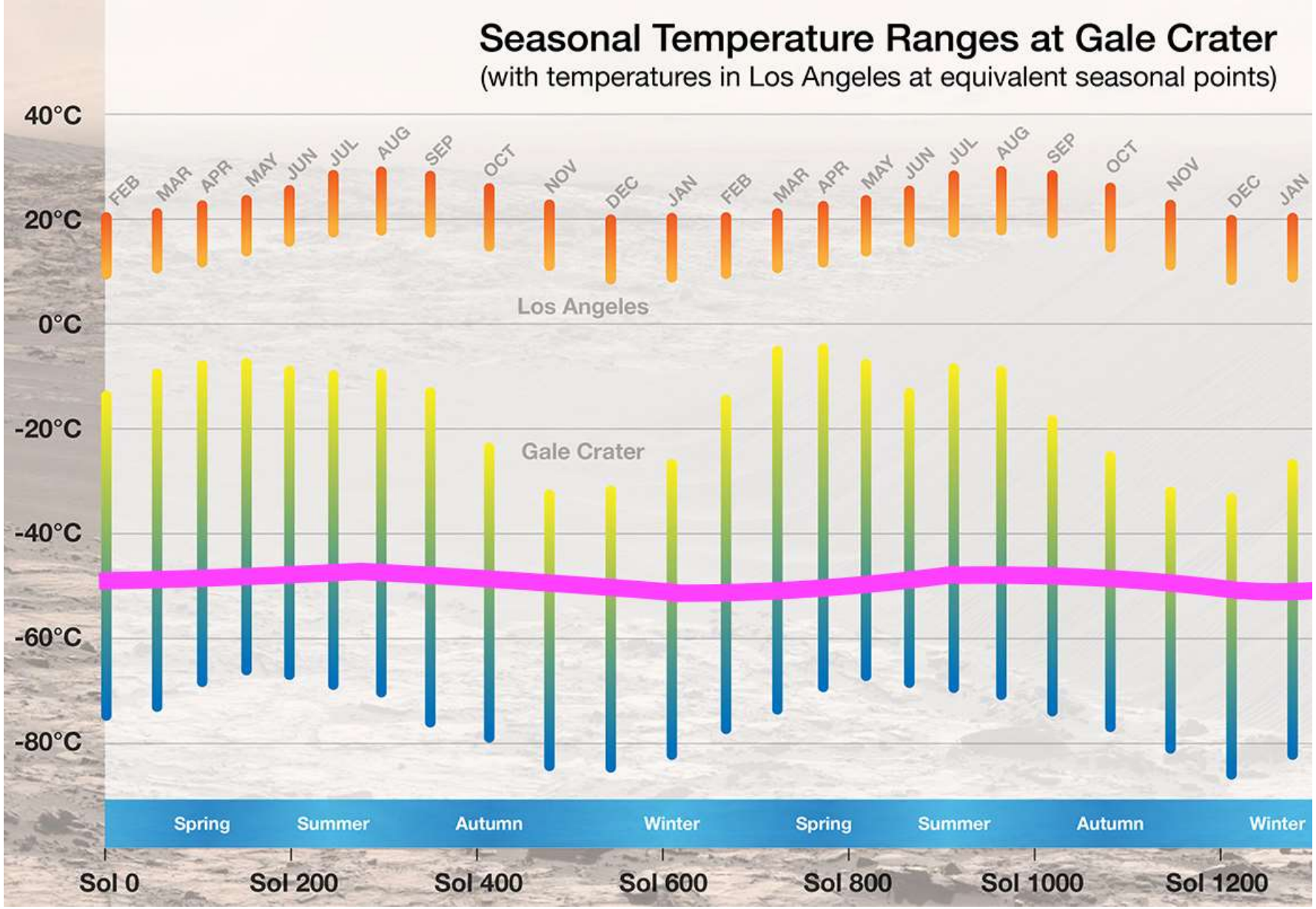


- Image: NASA/JPL-Caltech/CAB(CSIC-INTA)



- Image: NASA/JPL-Caltech/CAB(CSIC-INTA)

Caves have a moderate climate: They are warmer than the surface in winter or at night, and cooler than the surface in summer or at daytime.

Picture: Martin Gasser

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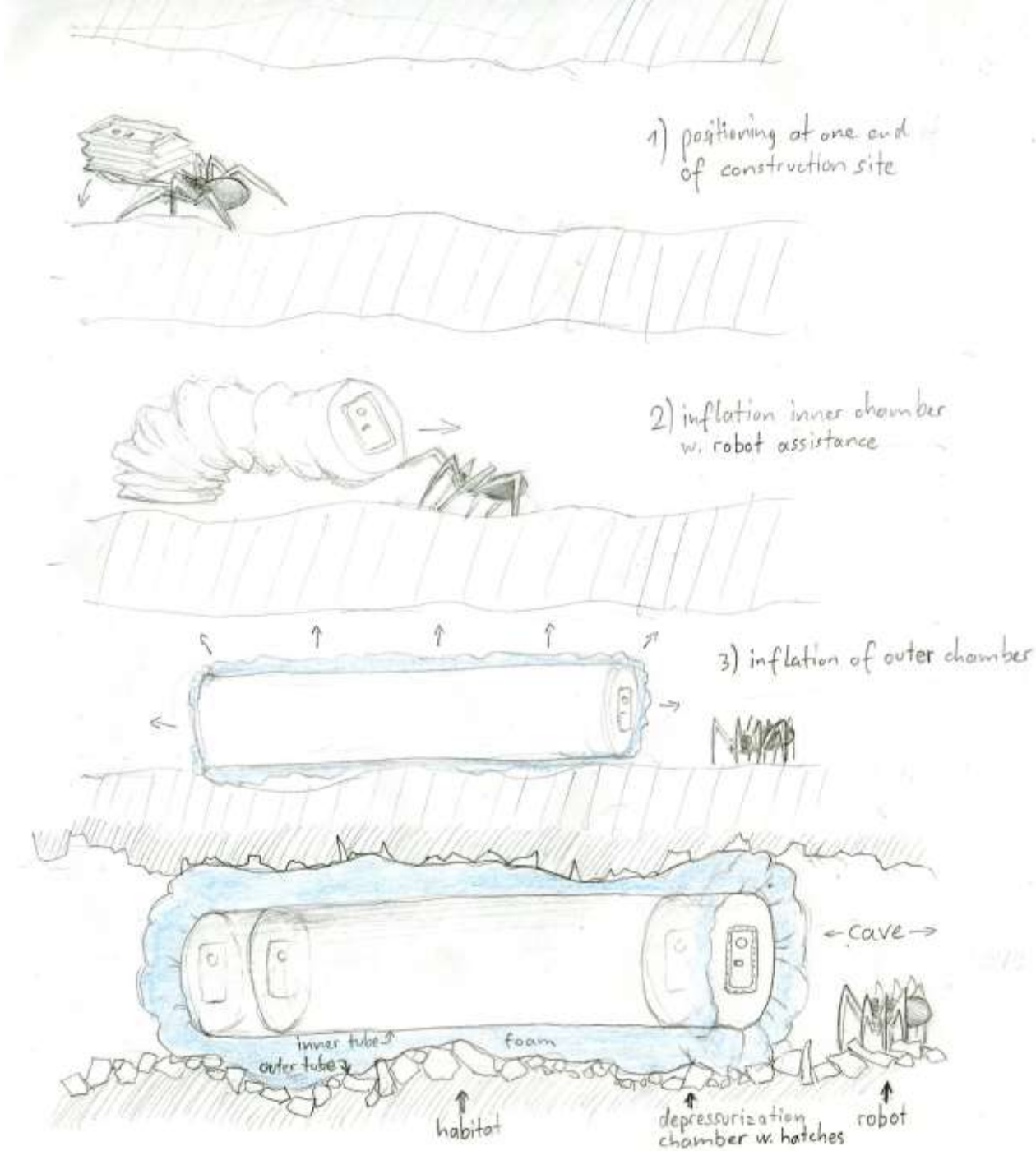
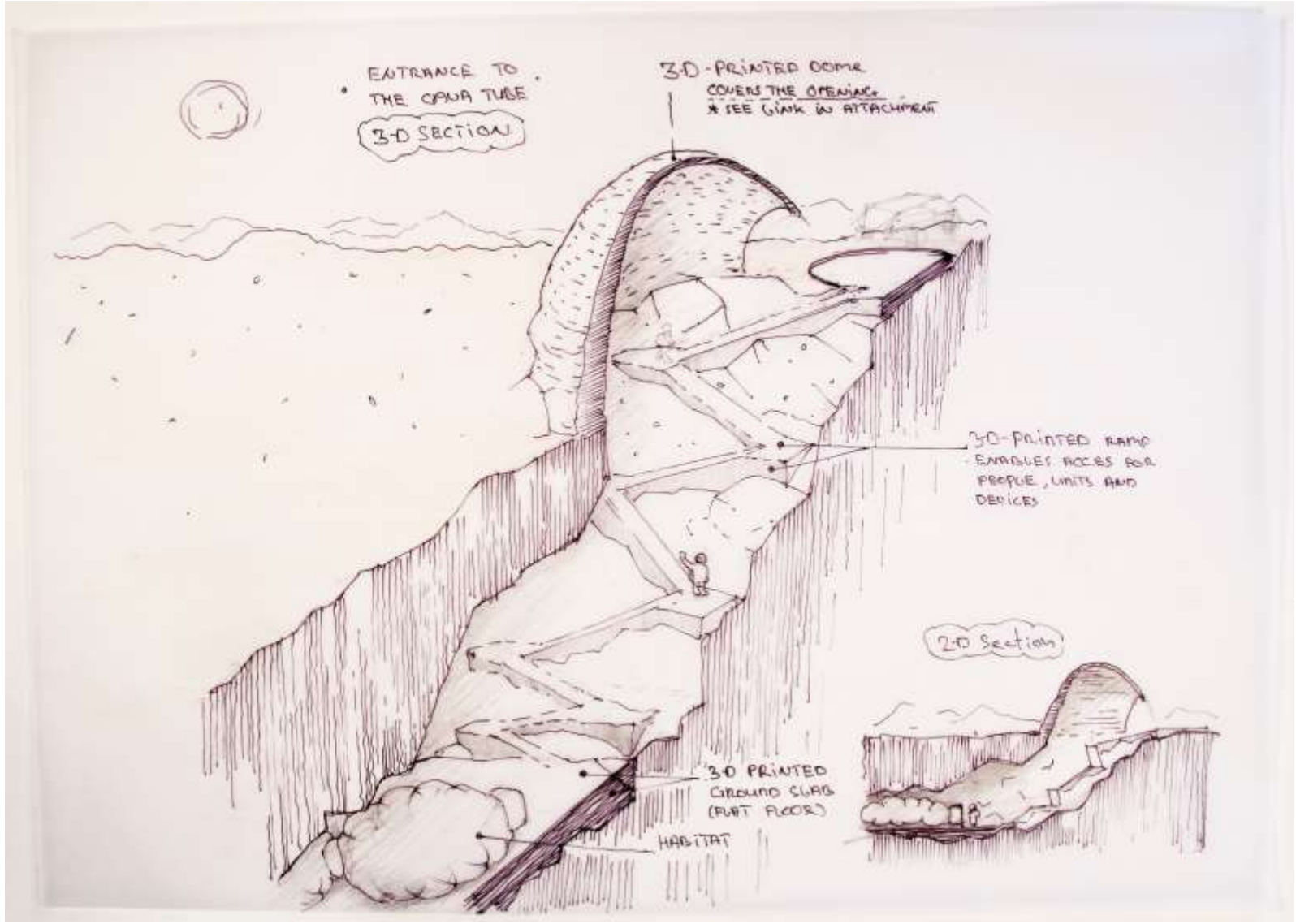

1) positioning at one end of construction site
2) inflation inner chamber w. robot assistance
3) inflation of outer chamber
cave
inner tube
outer tube
foam
habitat
depressurization chamber w. hatches
robot

Human habitation outlook for Moon & Mars



Courtesy of Architect Dmitry Zhuikov, zaarchitects.com

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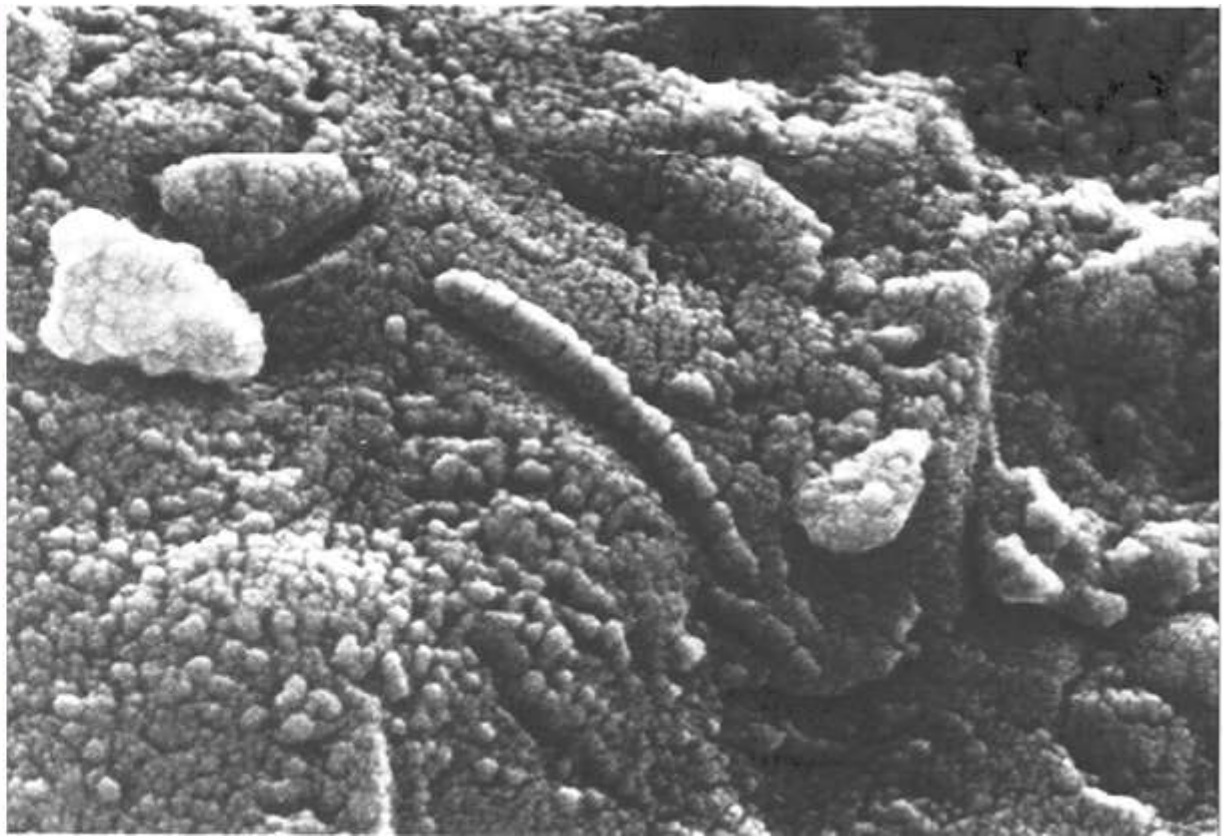

D. S. McKay et.al.: ***Search for past life on Mars: Possible relic biogenic activity in martian meteorite ALH 84001***.
In: *Science*, Vol. 273 (1996), S. 924–930

Vestigial life – extinct on the surface, but surviving in caves.

For example: New endemic invertebrates discovered in lava tubes on Rapa Nui

(Jut Wynne, Northern Arizona University)

Vast biodiversity of subsurface (bacterial) life:

-- Big genetic difference to surface life
-- Big genetic difference to other cave bacteria

(Penelope Boston, NASA & New Mexico Tech)

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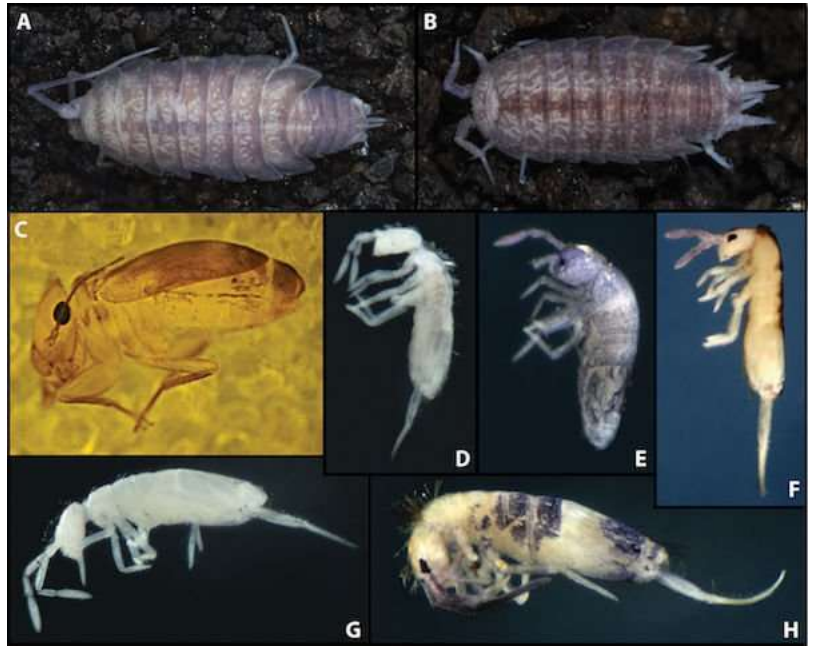

Image: Wynne et. al.

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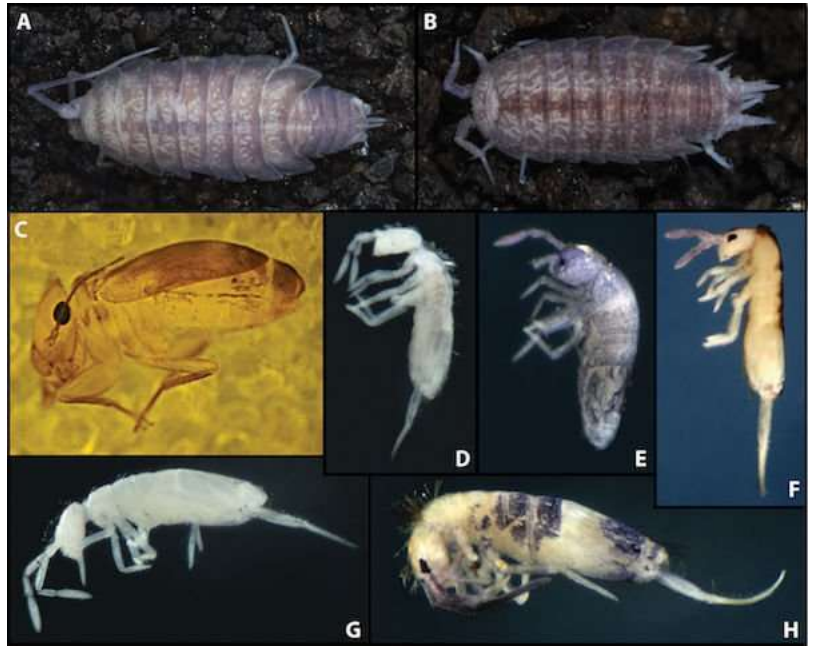

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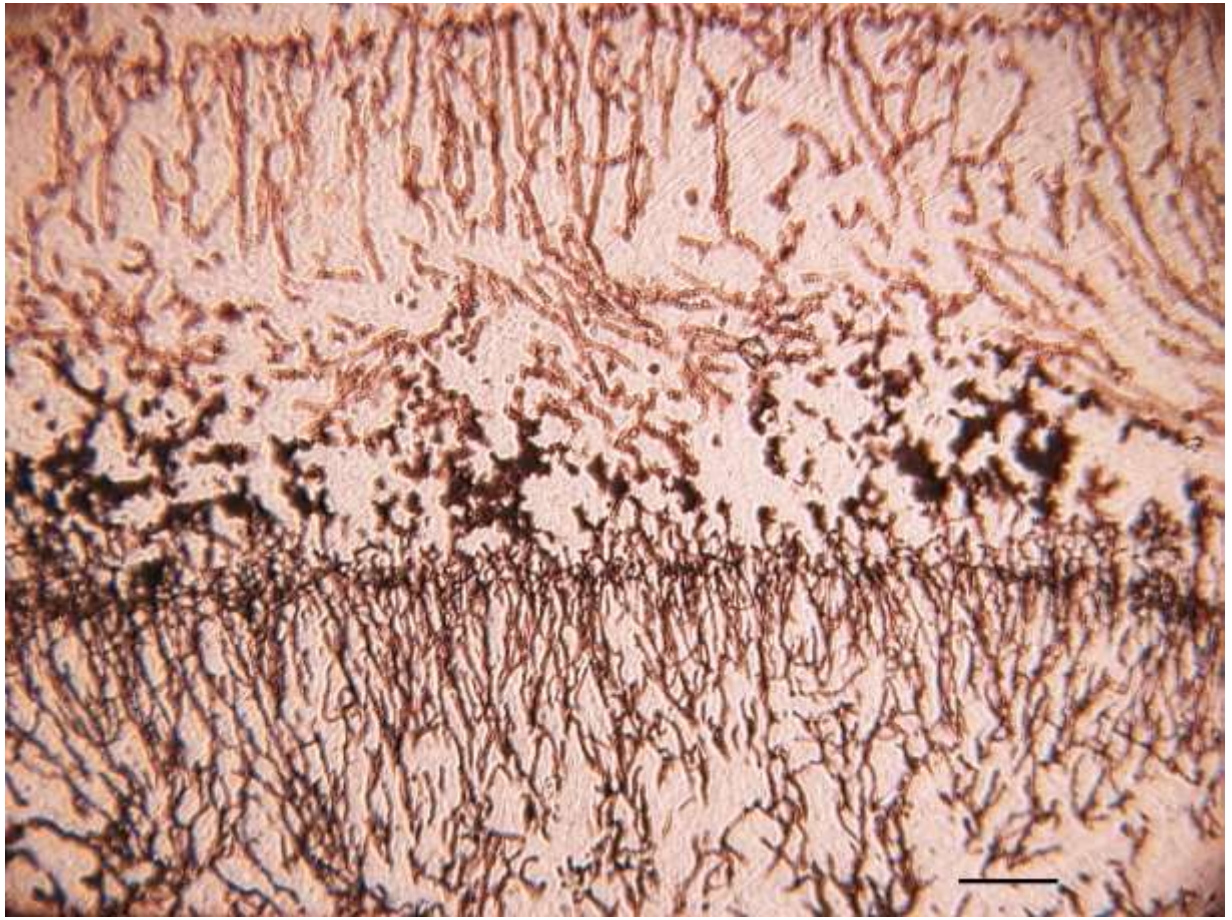
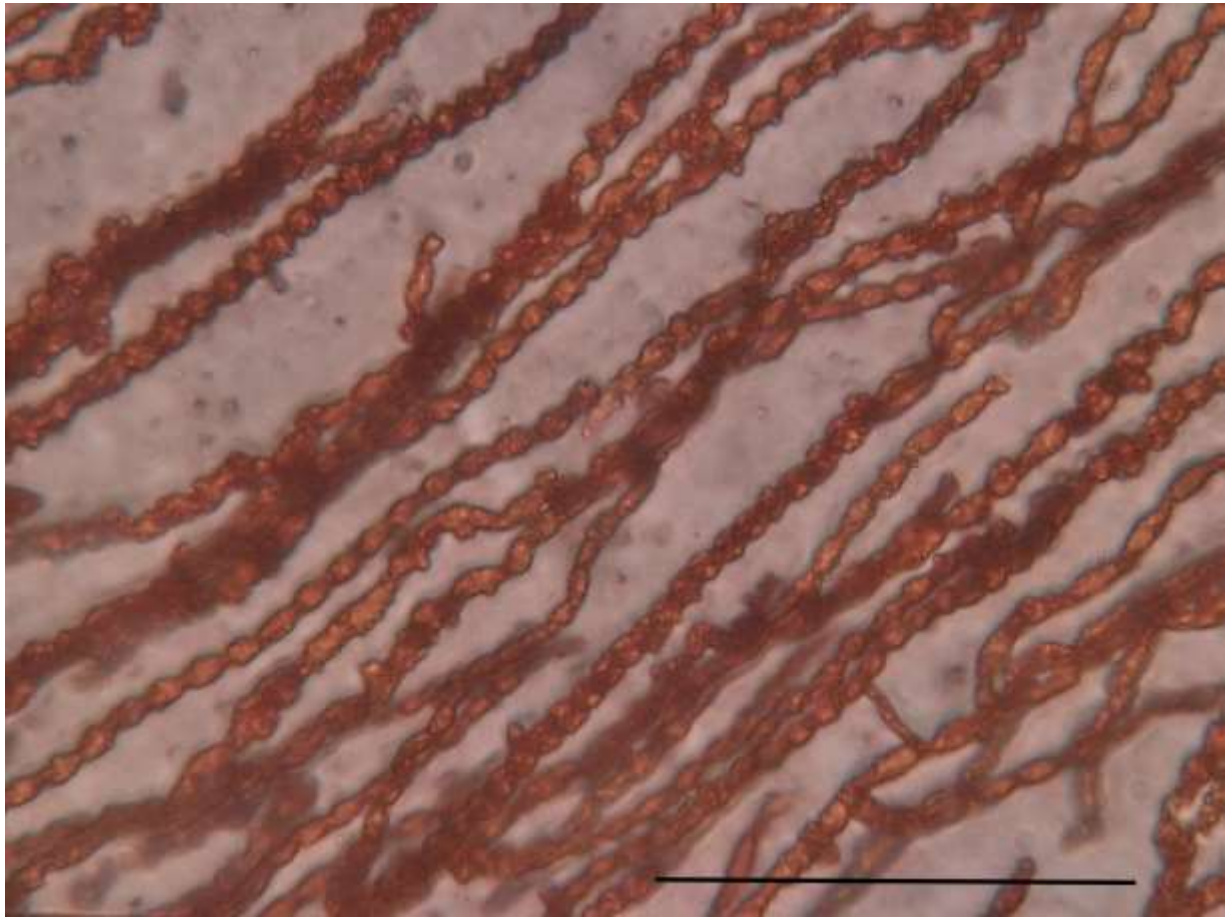
Image: Boston et. al.

Chert biosignatures

Chert biosignatures



Chert biosignatures



Lava tubes

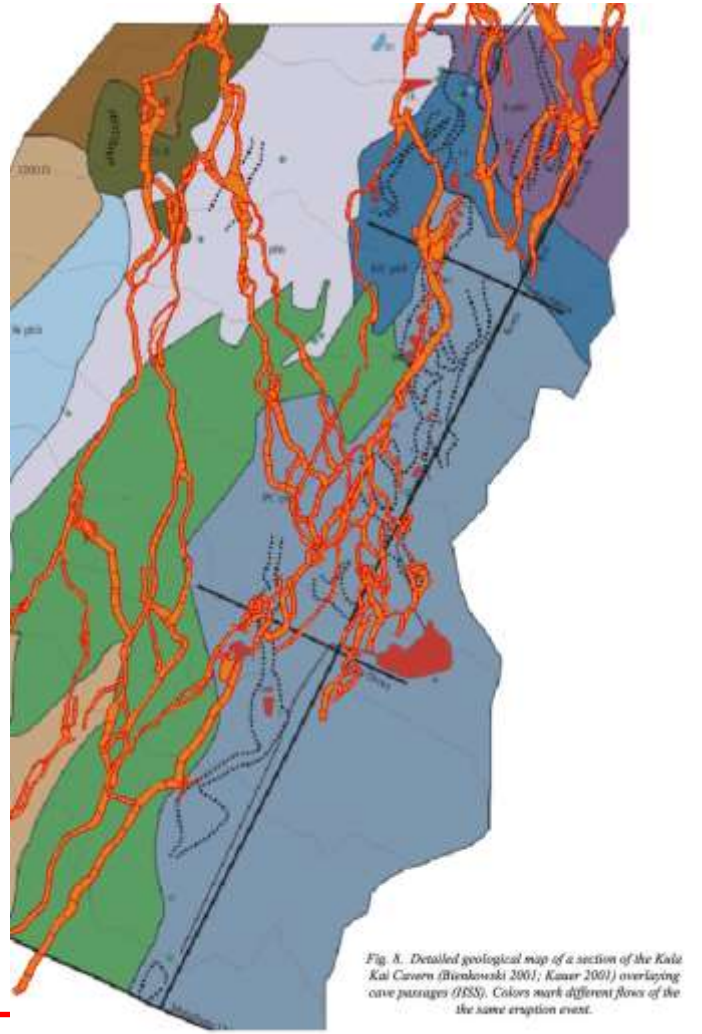


Fig. 8. Detailed geological map of a section of the Kula Kai Cavern (Bienkowski 2001; Kauer 2001) overlaying cave passages (HSS). Colors mark different flows of the the same eruption event.

Lava tubes, not tectonic cracks

Lava tubes, not tectonic cracks

Active lava tube (pyroduct). Mauna Ulu, Hawaii, 1970

Picture: Jeffrey Judd, USGS

Similar pyroduct, 1100 years old. Surtshellir, Iceland.

Picture: Martin Gasser

More info: http://volcano.oregonstate.edu/lava-tubes

Surtshellir lava tube, Iceland

Picture: Christa Feucht

Raufarhólshellir lava tube, Iceland

Picture: Eyfi

A collapse feature on a tectonic fissure: Wood Valley Pit Crater, Hawaii.

Two pits in the flanks of Arsia Mons volcano.

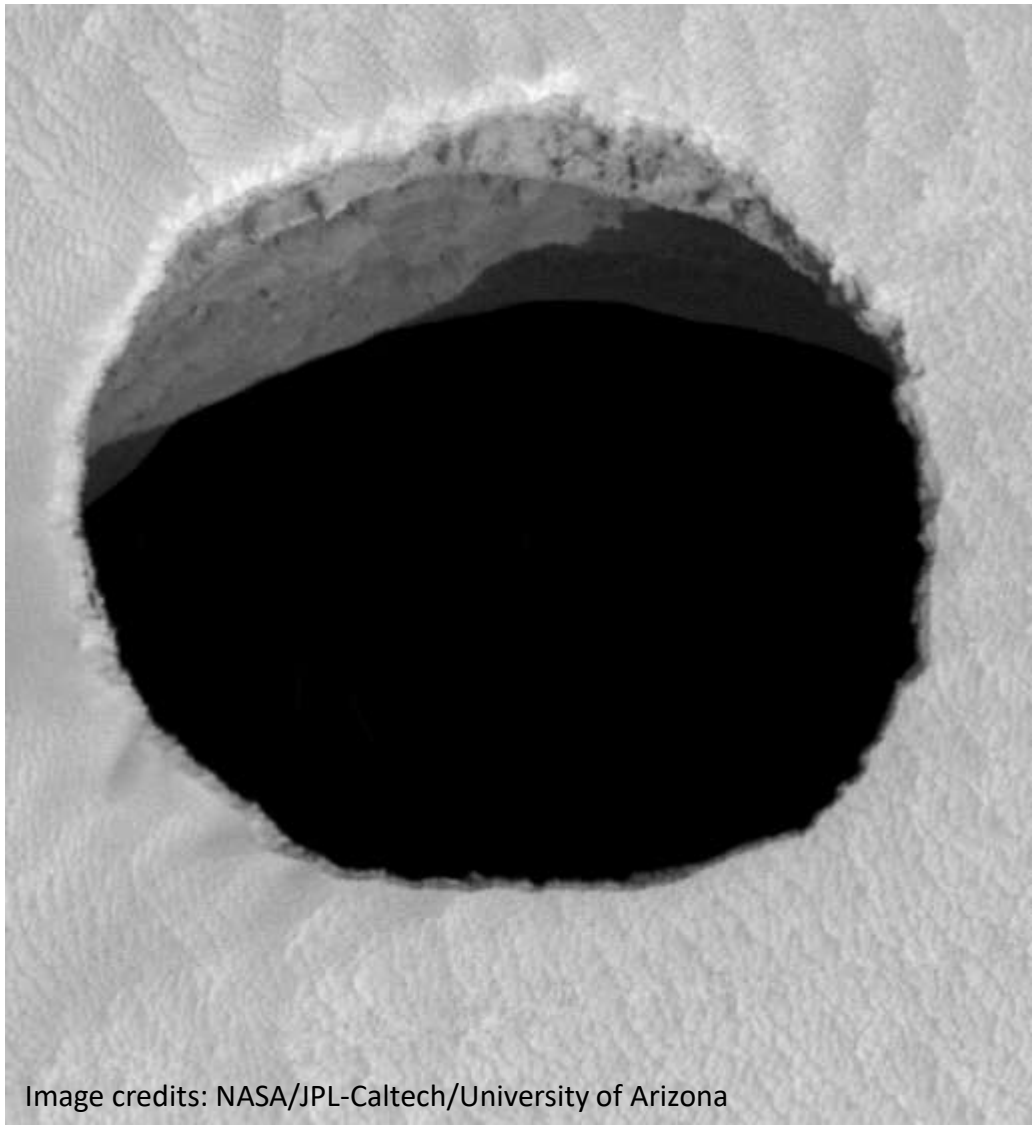


Image credits: NASA/JPL-Caltech/University of Arizona

How to find and characterize lava tubes

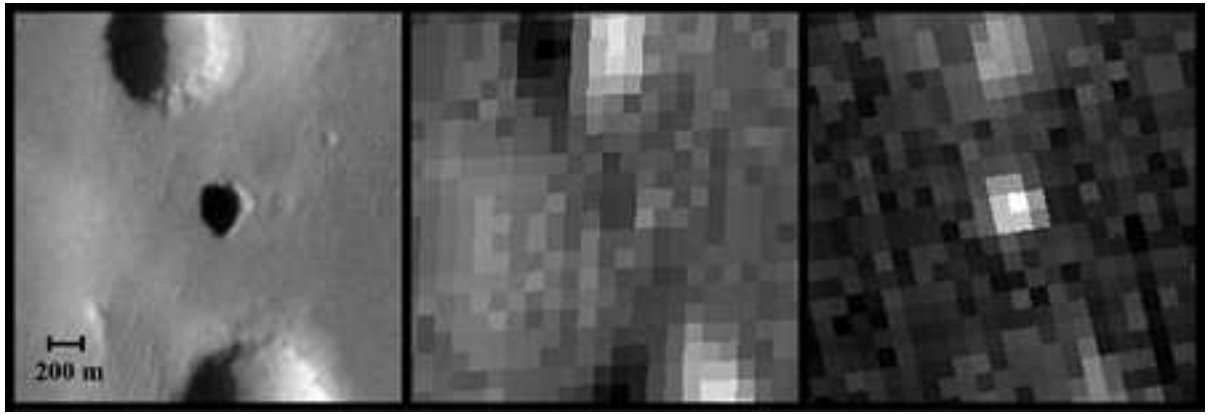


Image: Cushing, Titus, Wynne, Christensen: THEMIS observes possible cave skylights on Mars

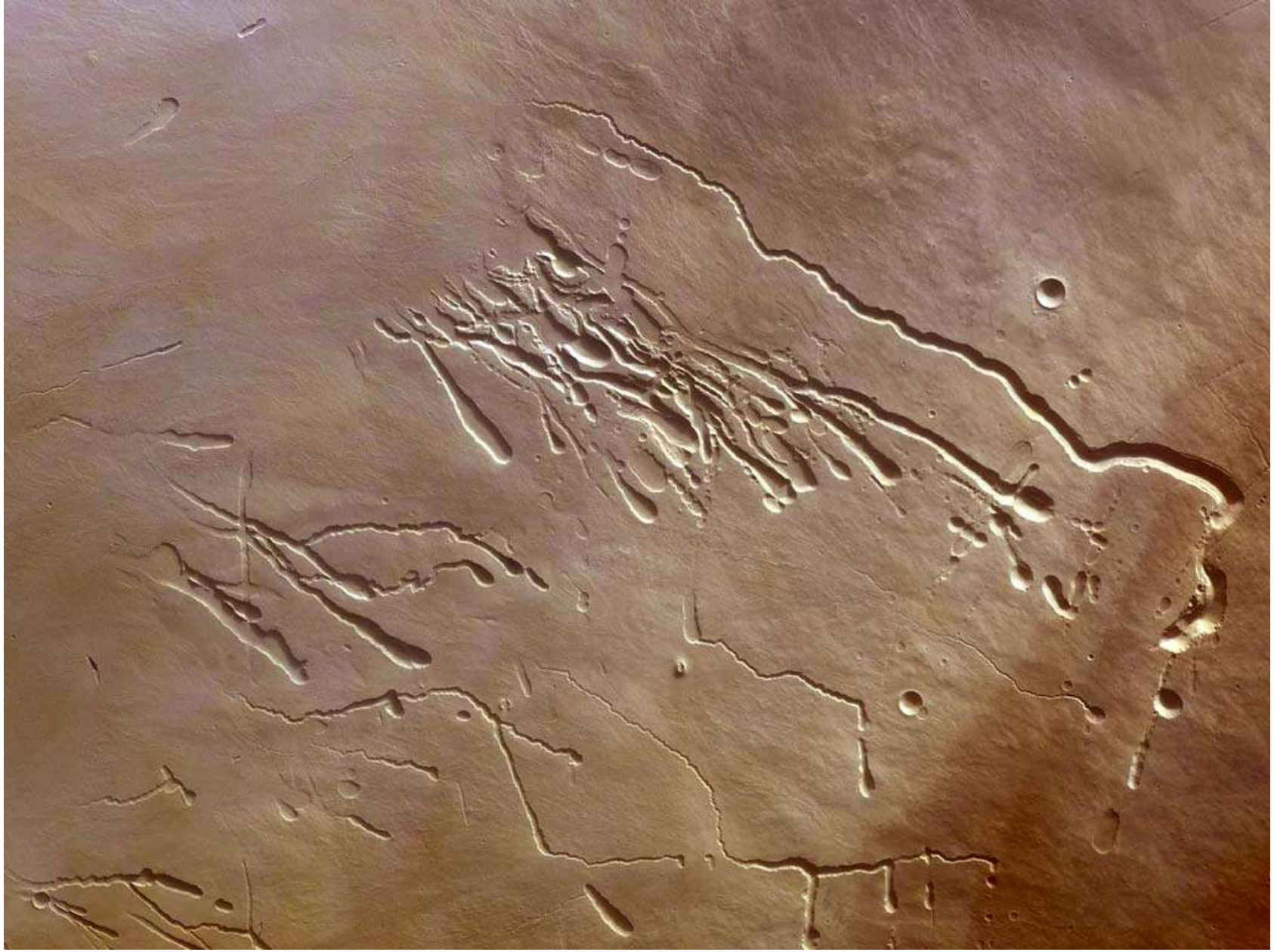


Image credit: ESA/DLR/FU Berlin (G. Neukum)

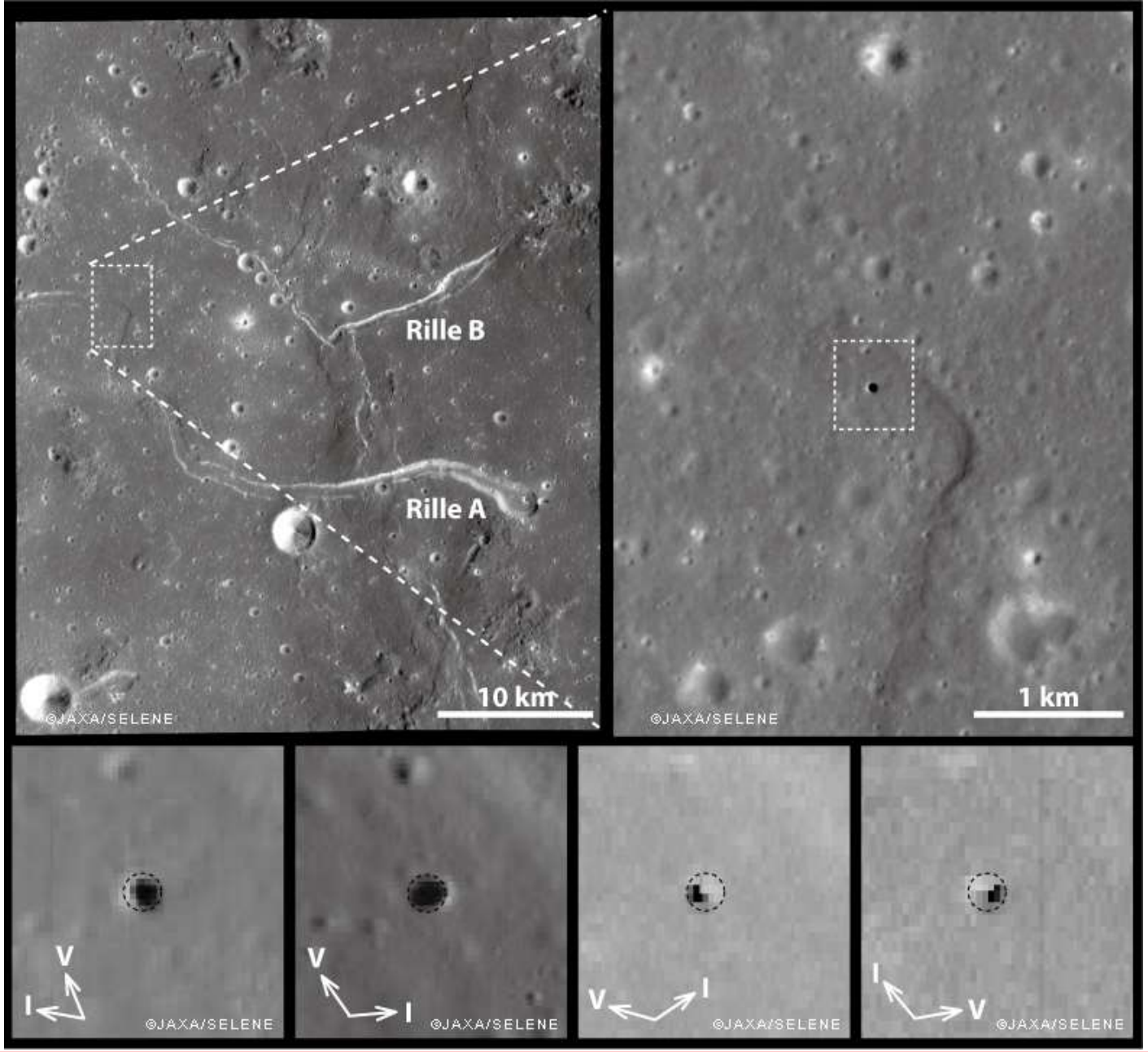
Rilles: Ancient lava channels or collapsed lava tubes

Hadley Rille on Moon

Picture: NASA

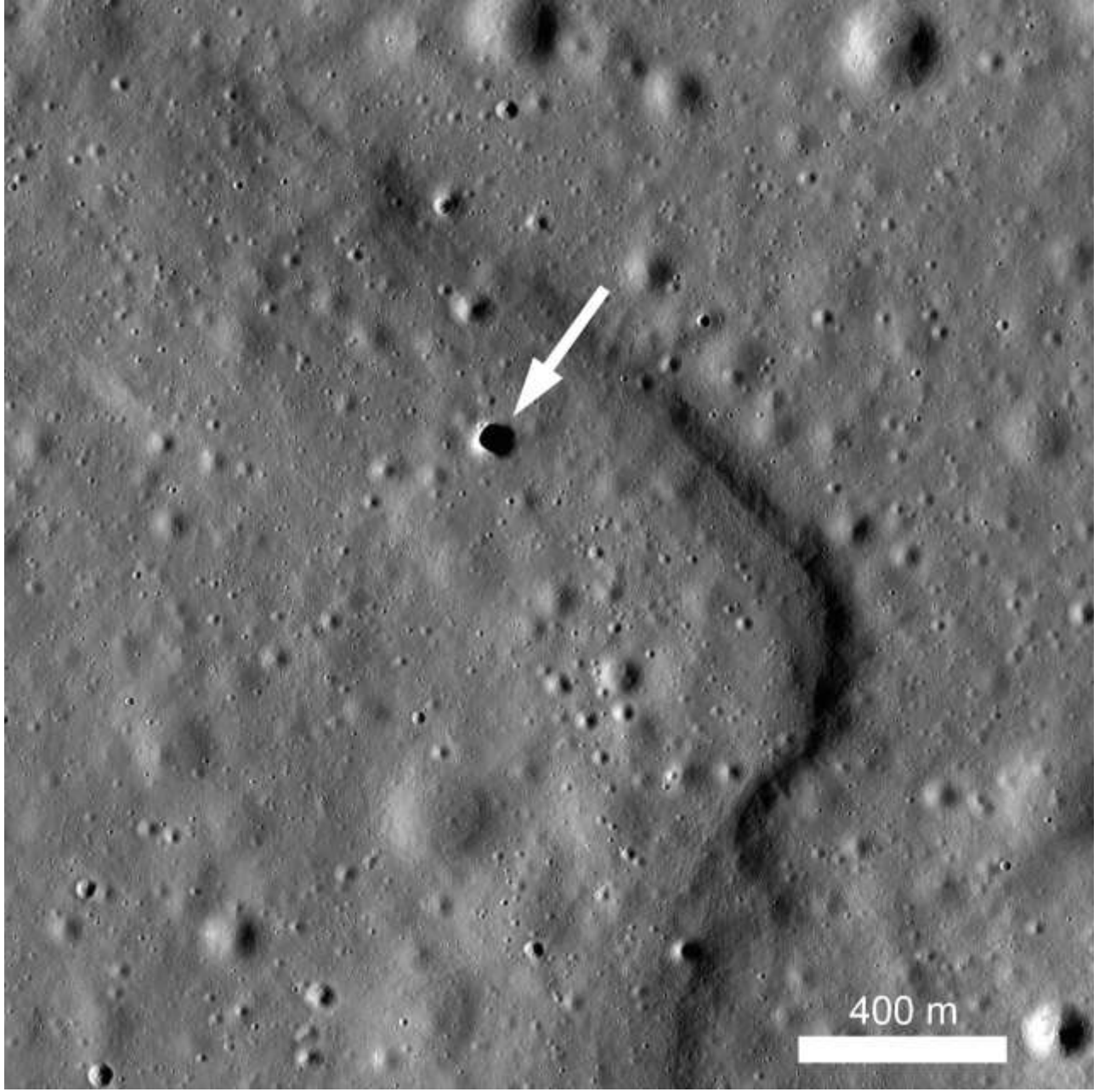
Picture: Martin Gasser

Rille on Earth



4TH PLANET LOGISTICS

Marius Hills pit in Oceanus Procellarum, discovery pictures of Kaguya space probe, SELENE mission.



4TH PLANET LOGISTICS

Marius Hills pit with associated rille.

Image credit: NASA/GSFC/Arizona State University

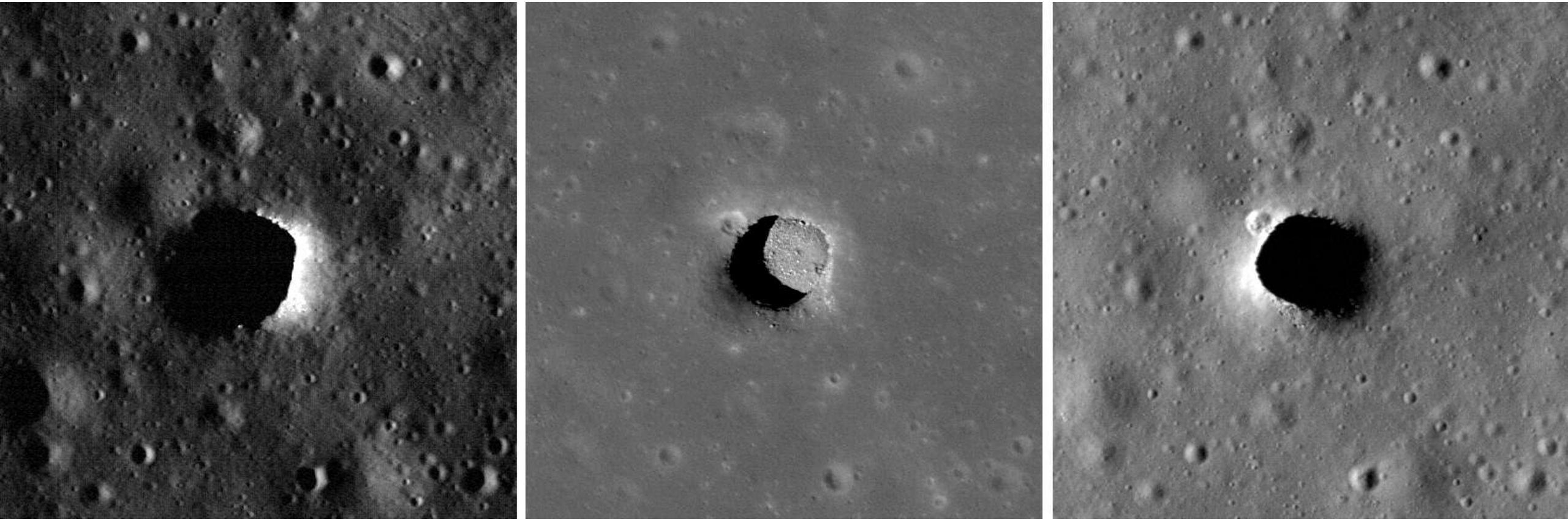
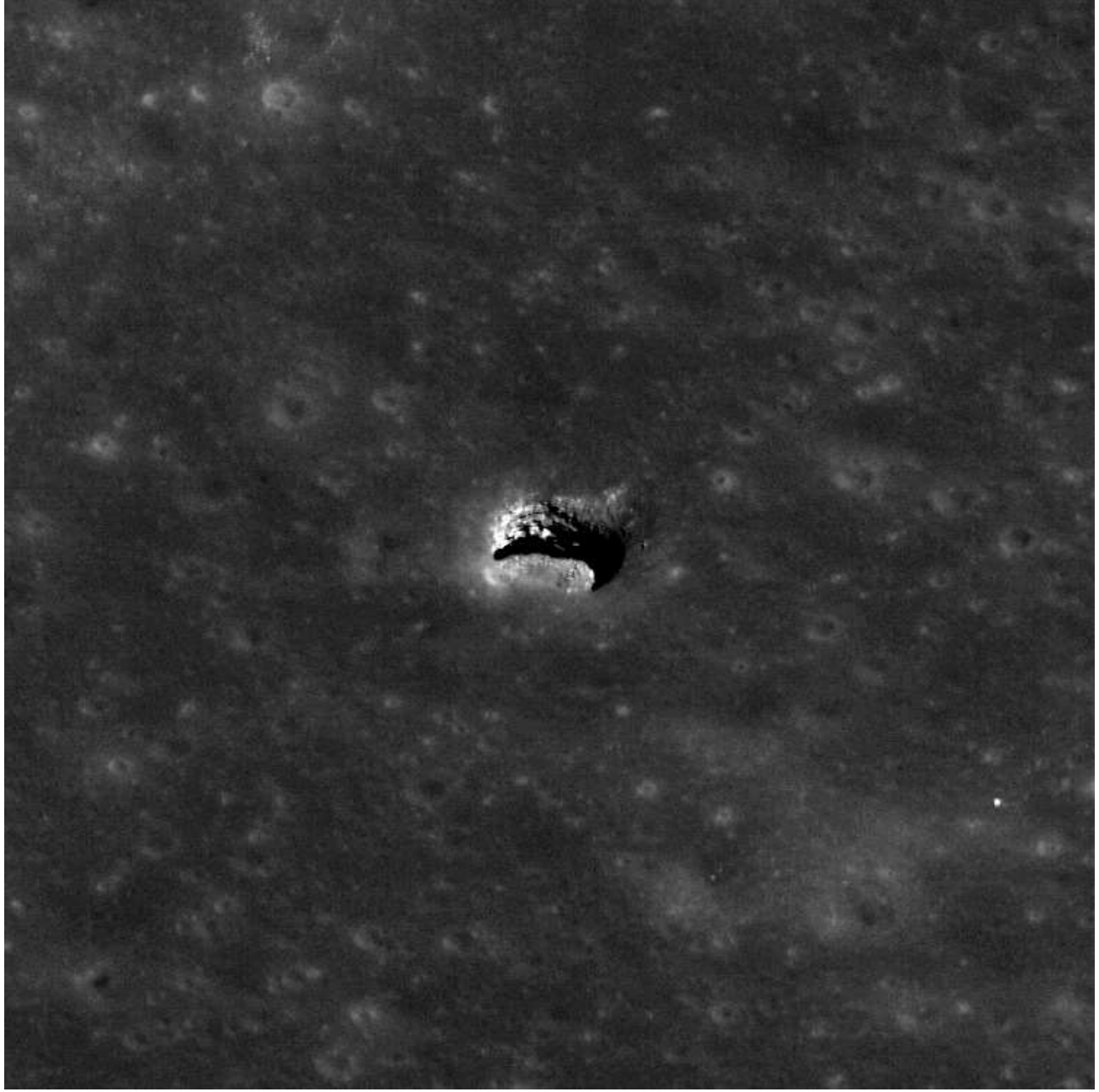


Image credit: NASA/GSFC/Arizona State University

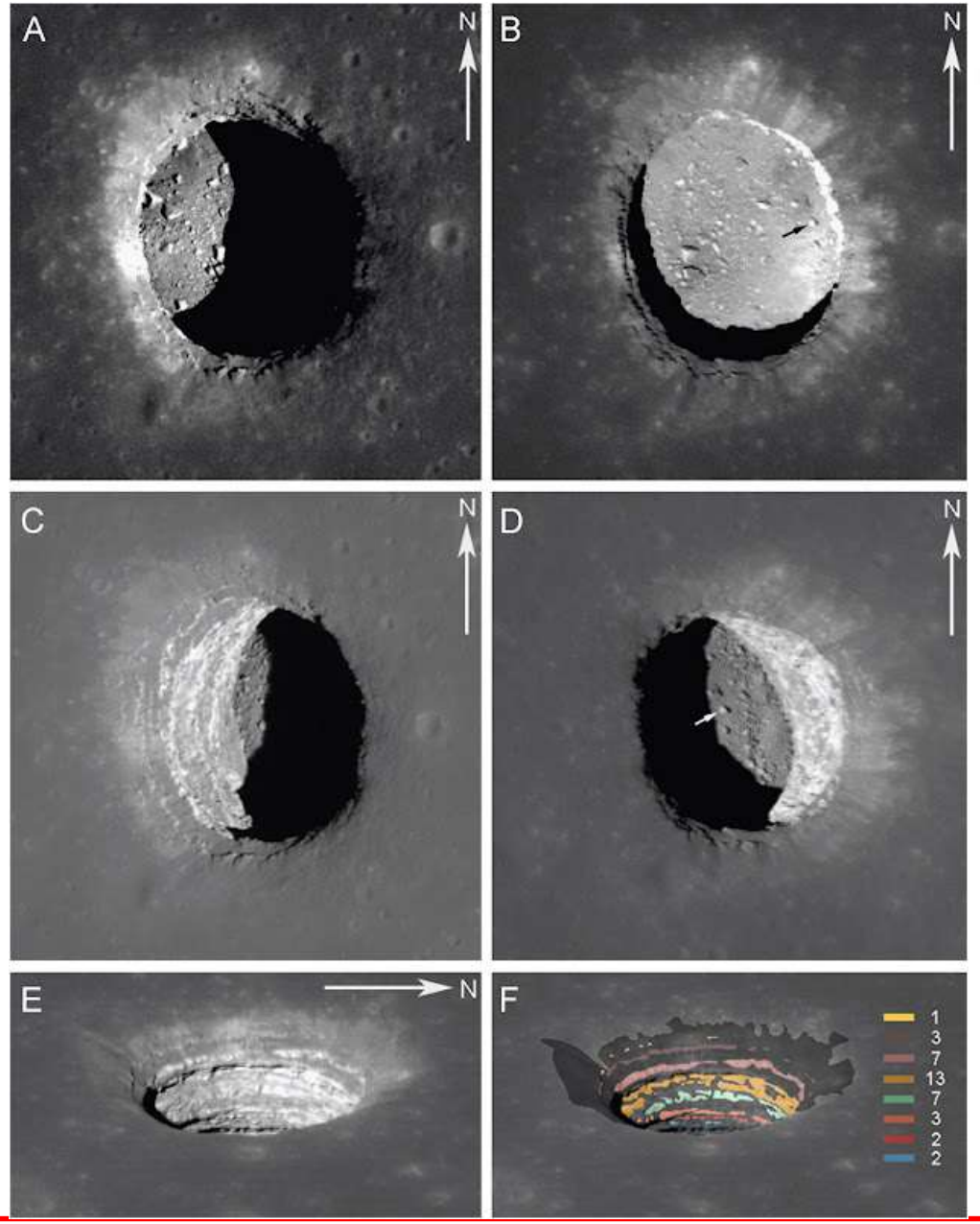
Different views of the Marius Hills Pit.



4TH PLANET LOGISTICS

Oblique view of the Marius Hills Pit.

Image credit: NASA/GSFC/Arizona State University



Mare Tranquillitatis Pit. The maximum and minimum pit diameters are 100m and 86m respectively, and the maximum depth of the pit floor below the surface is 105m.

Location: 8.34N 33.22E
A: M126710873R; B: M155016845R; C: M175057326R; D: M152662021R; E: M155023632R; F: M144395745L;

Credit: NASA/GSFC/Arizona State University; M.S. Robinson, et al., 2012

By contributor Koh Xuan Yang on http://beyondearthlyskies.blogspot.is/2012_08_01_archive.html

A pair of pits North of Ascraeus Mons

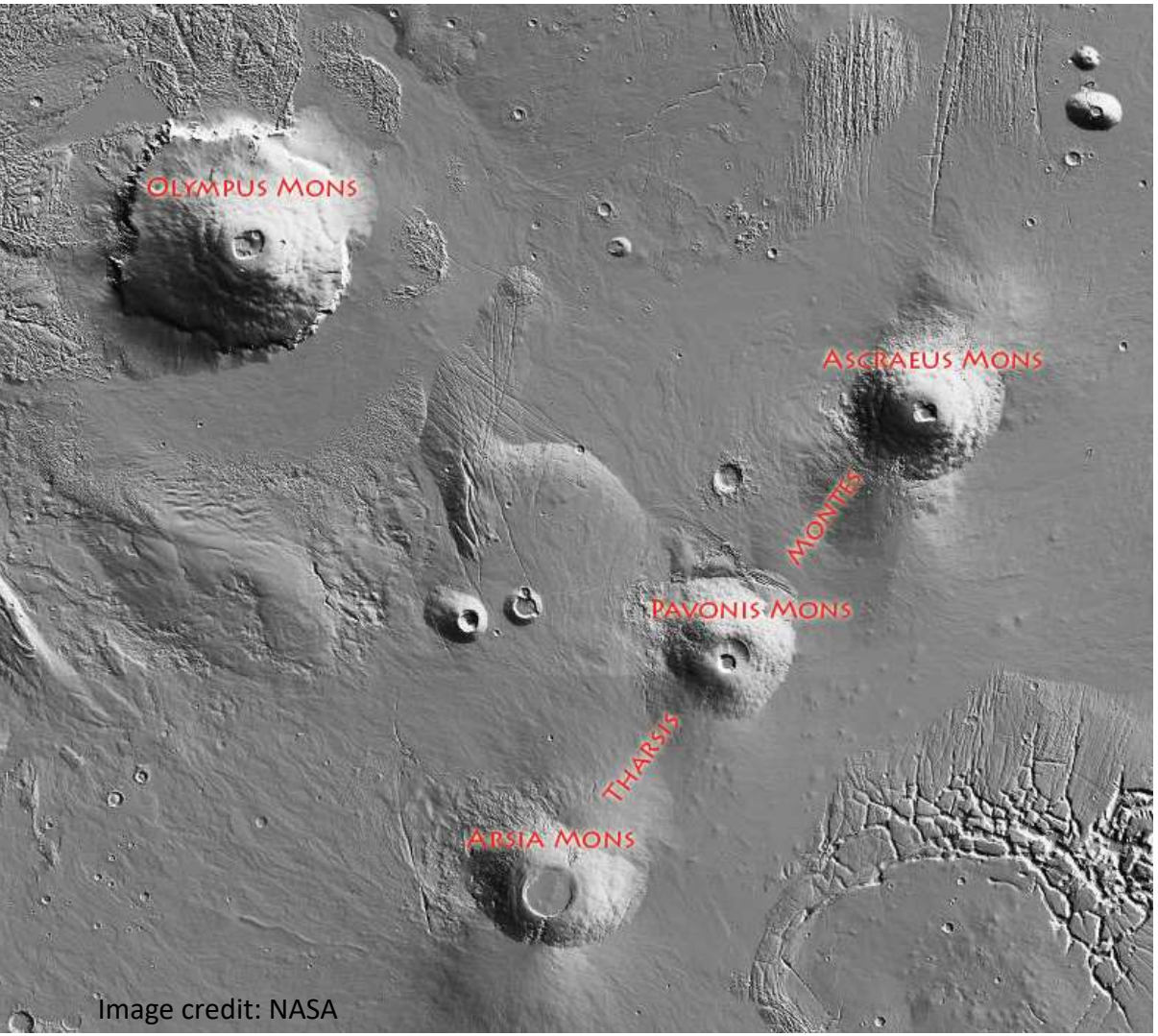


Image credit: NASA

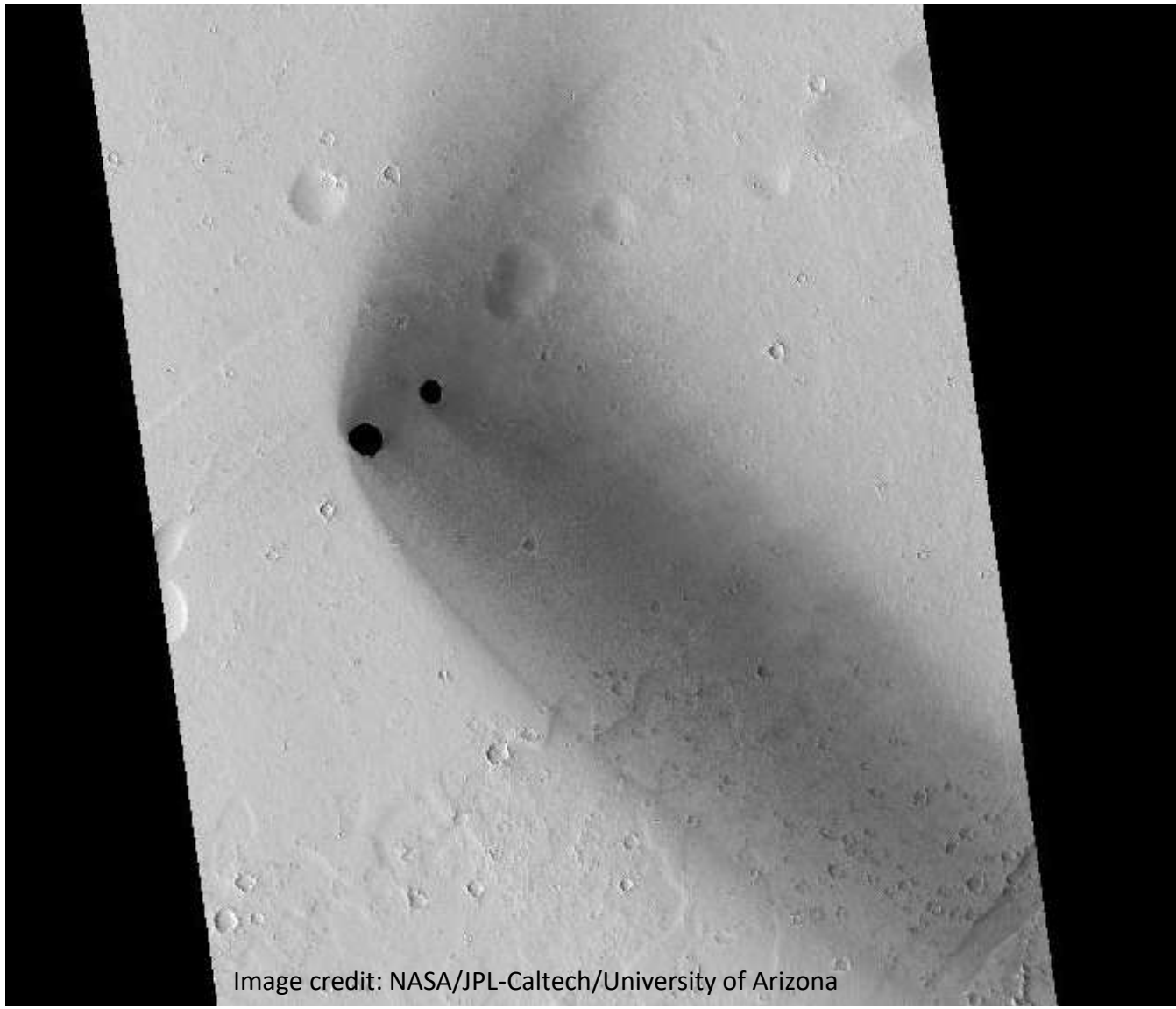


Image credit: NASA/JPL-Caltech/University of Arizona

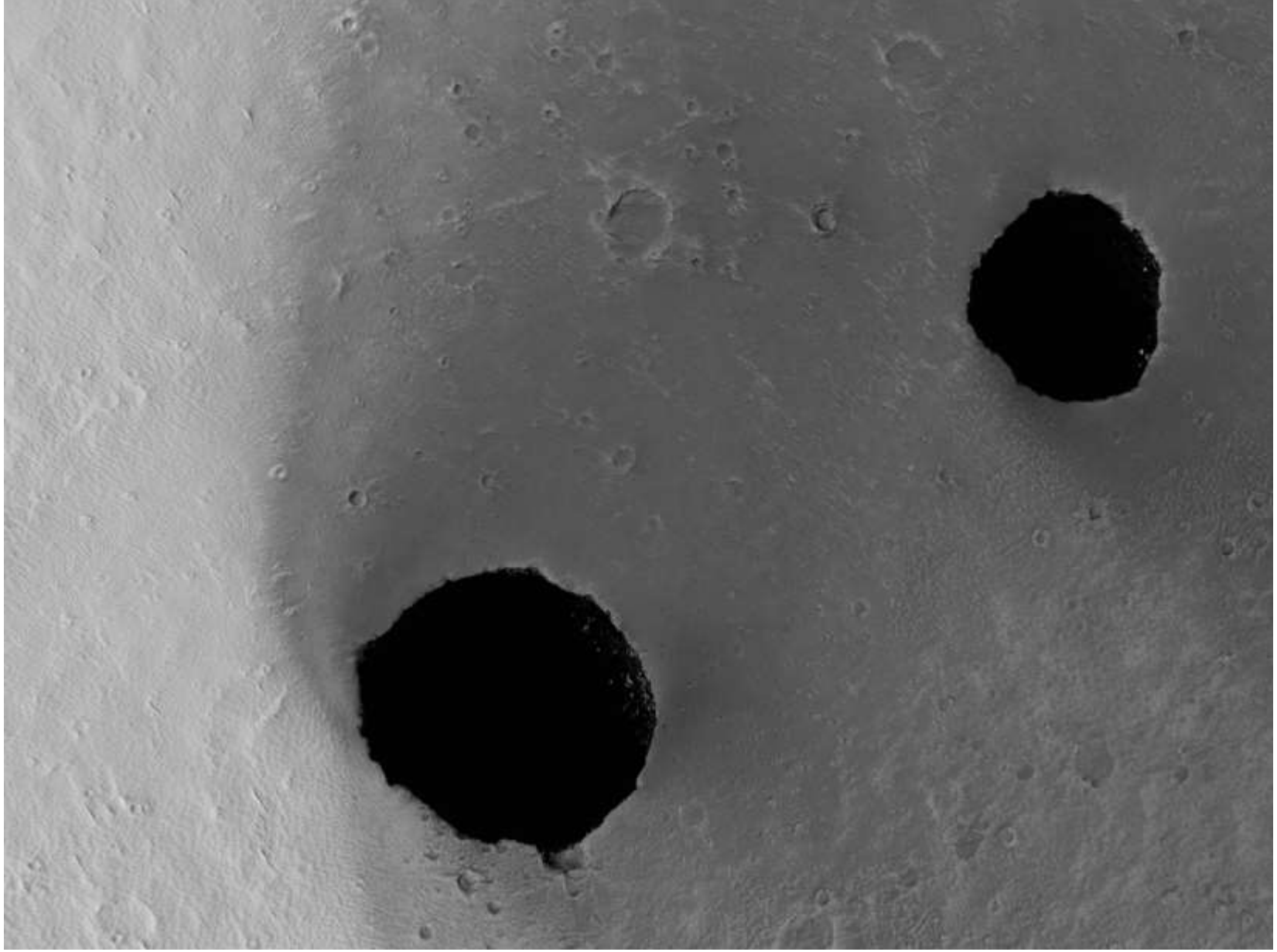


Image credit: NASA/JPL-Caltech/University of Arizona

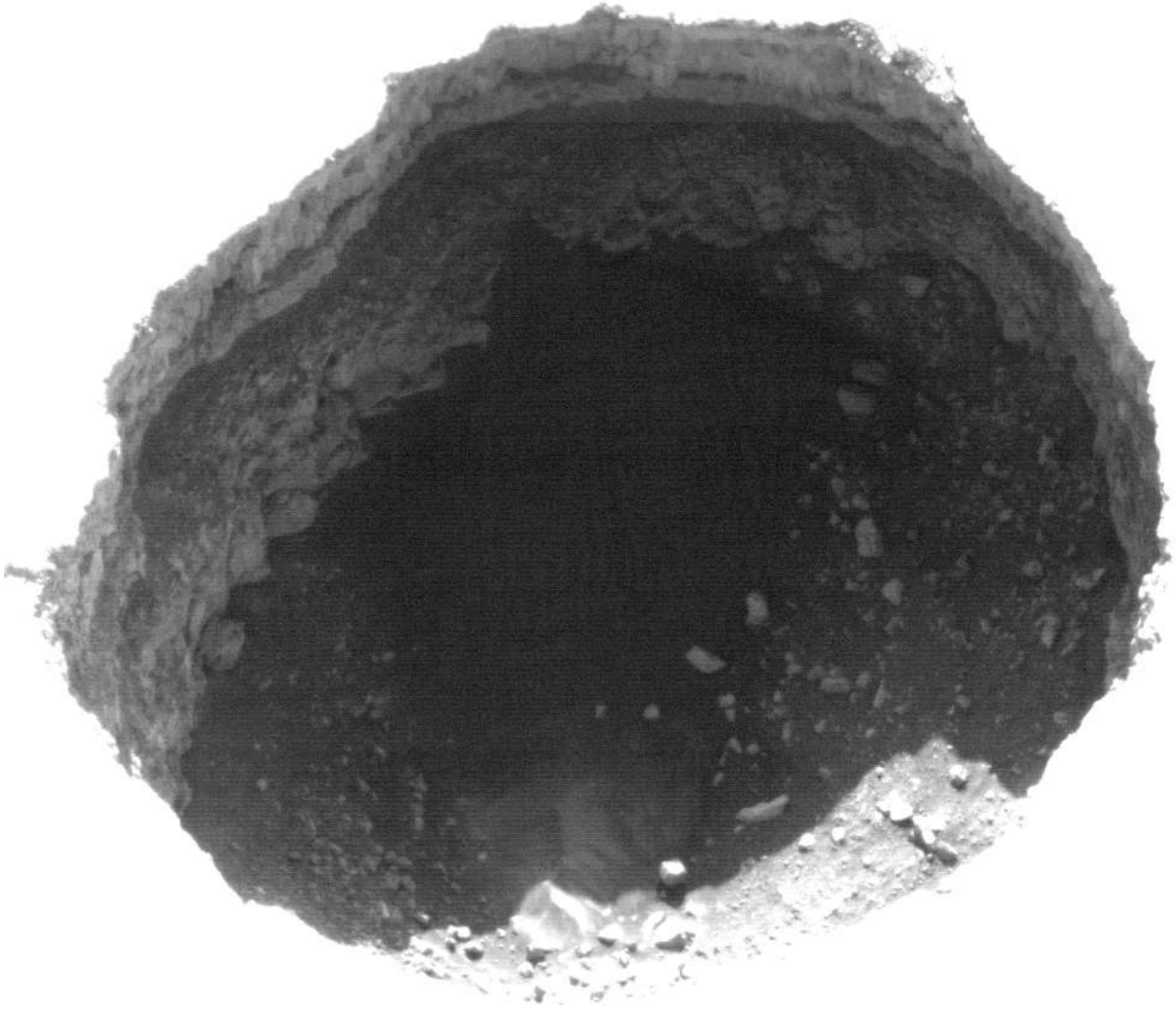
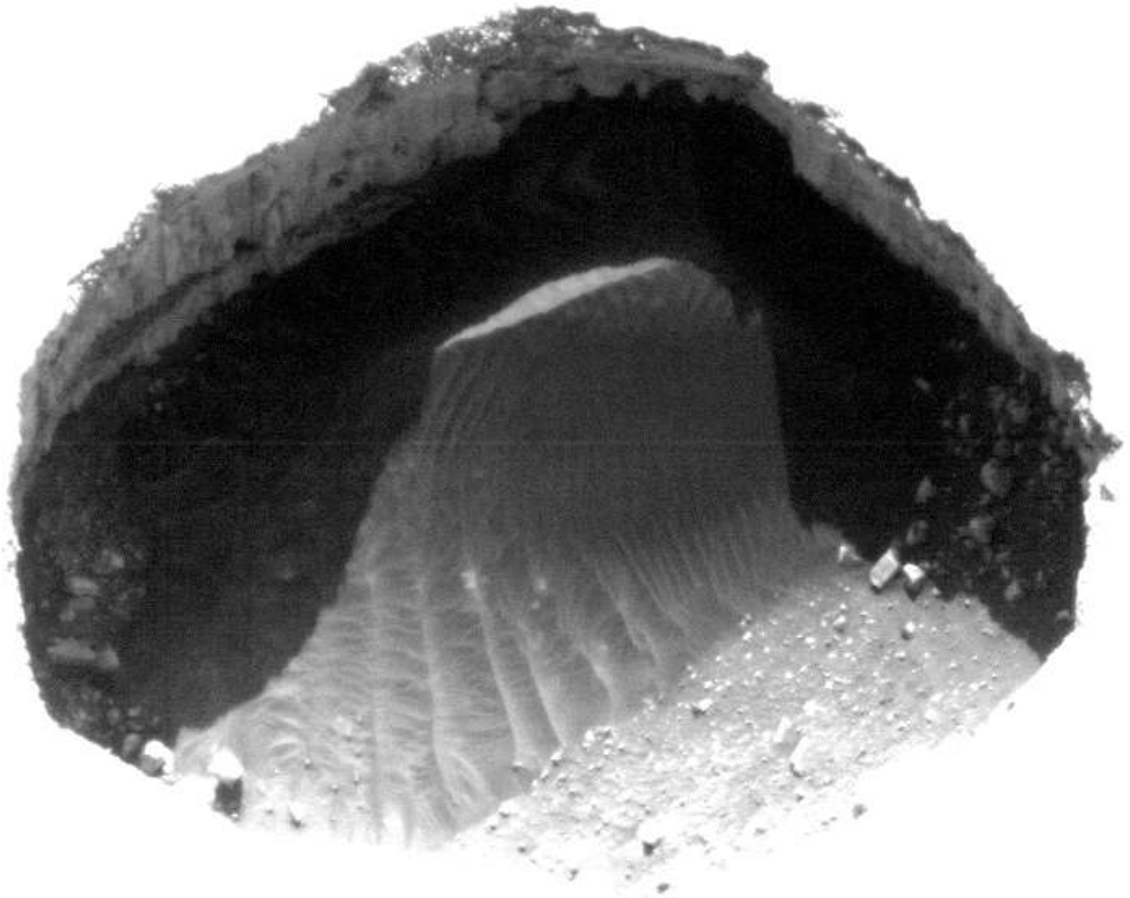


Image credit: NASA/JPL-Caltech/University of Arizona



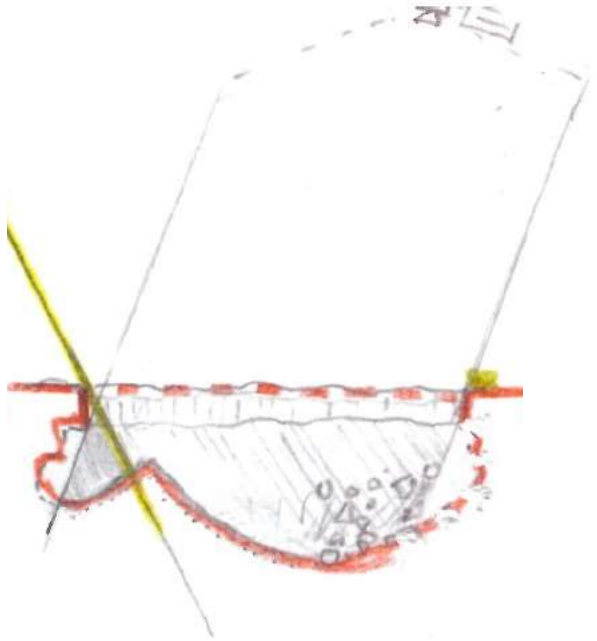
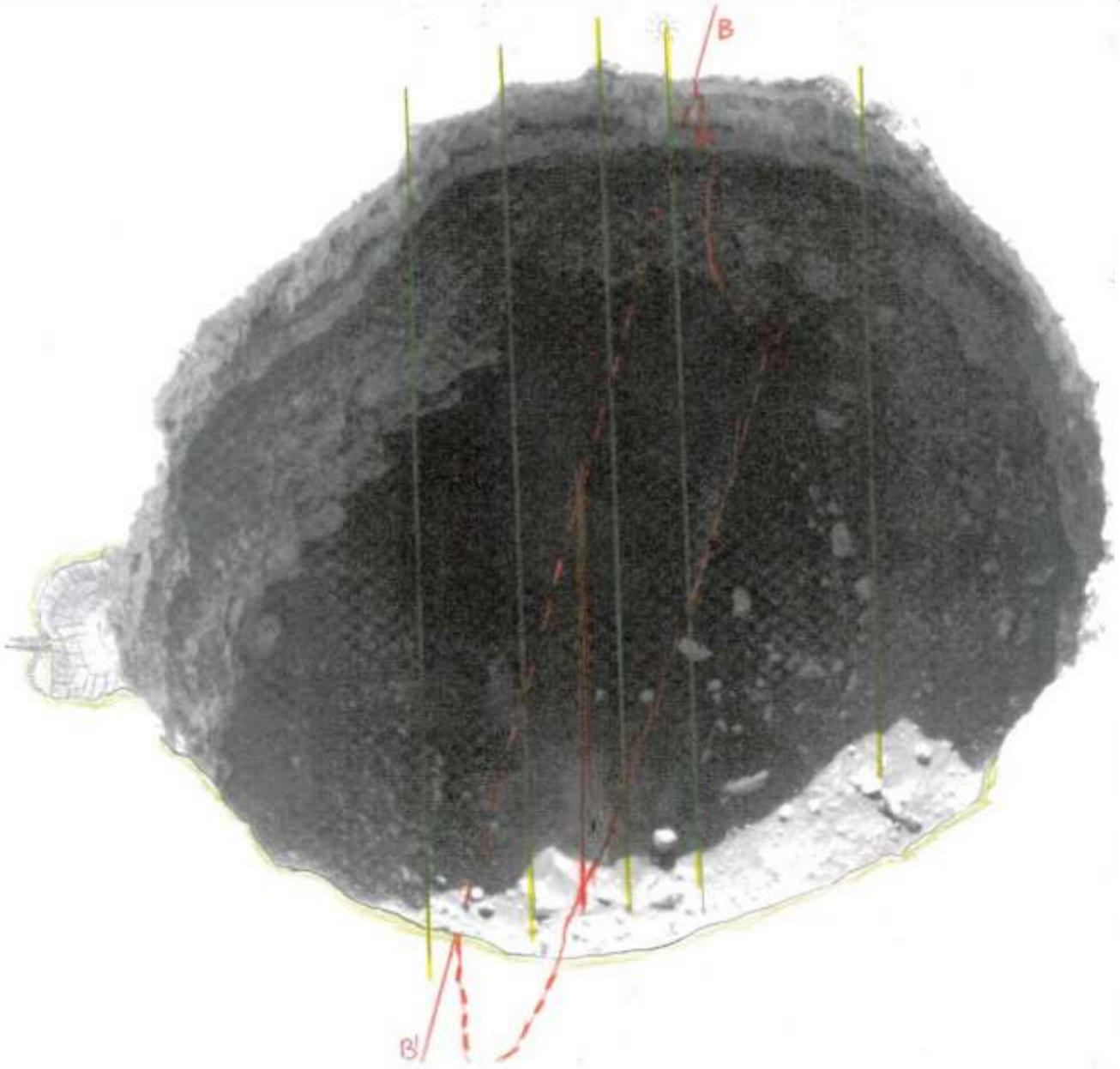


Image credit: NASA/JPL-Caltech/University of Arizona



The bigger one of the two Pits N of Ascraeus Mons. Cross section inferred from shadow geometry. The pit is roughly as deep as it is wide, about 300 meters.

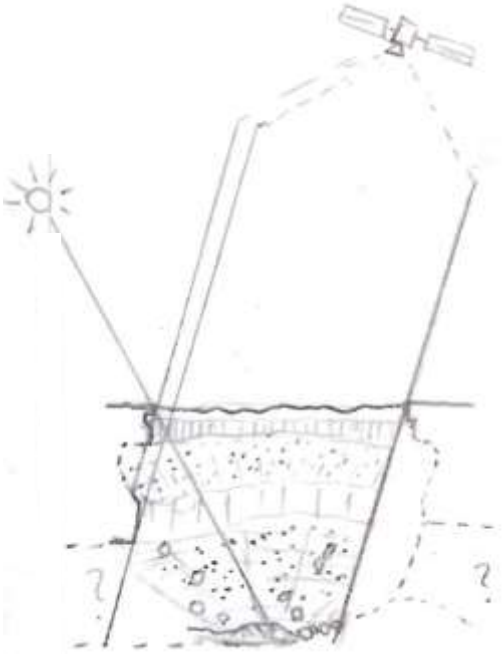
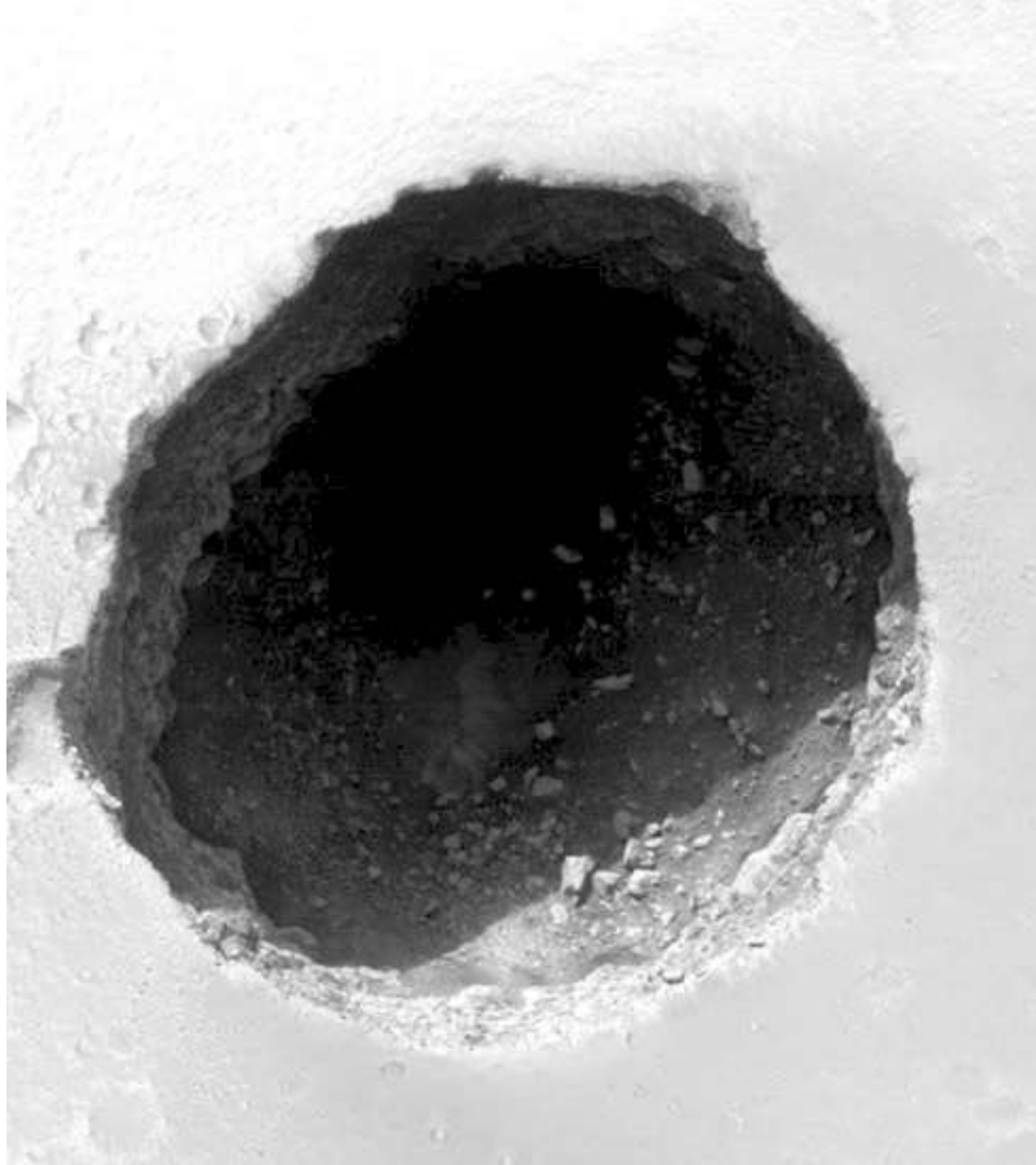
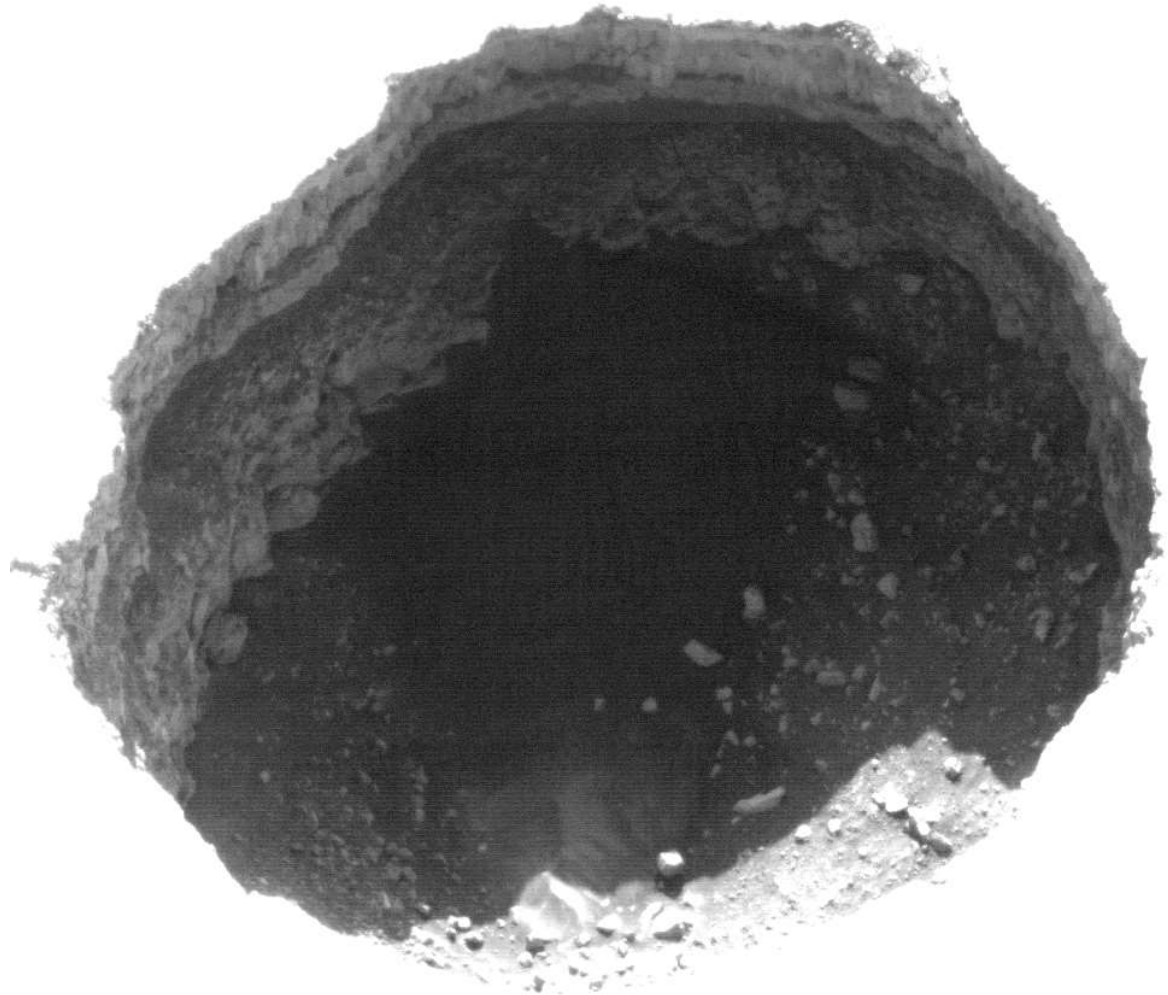


Image credit: NASA/JPL-Caltech/University of Arizona





Etna, Sicily

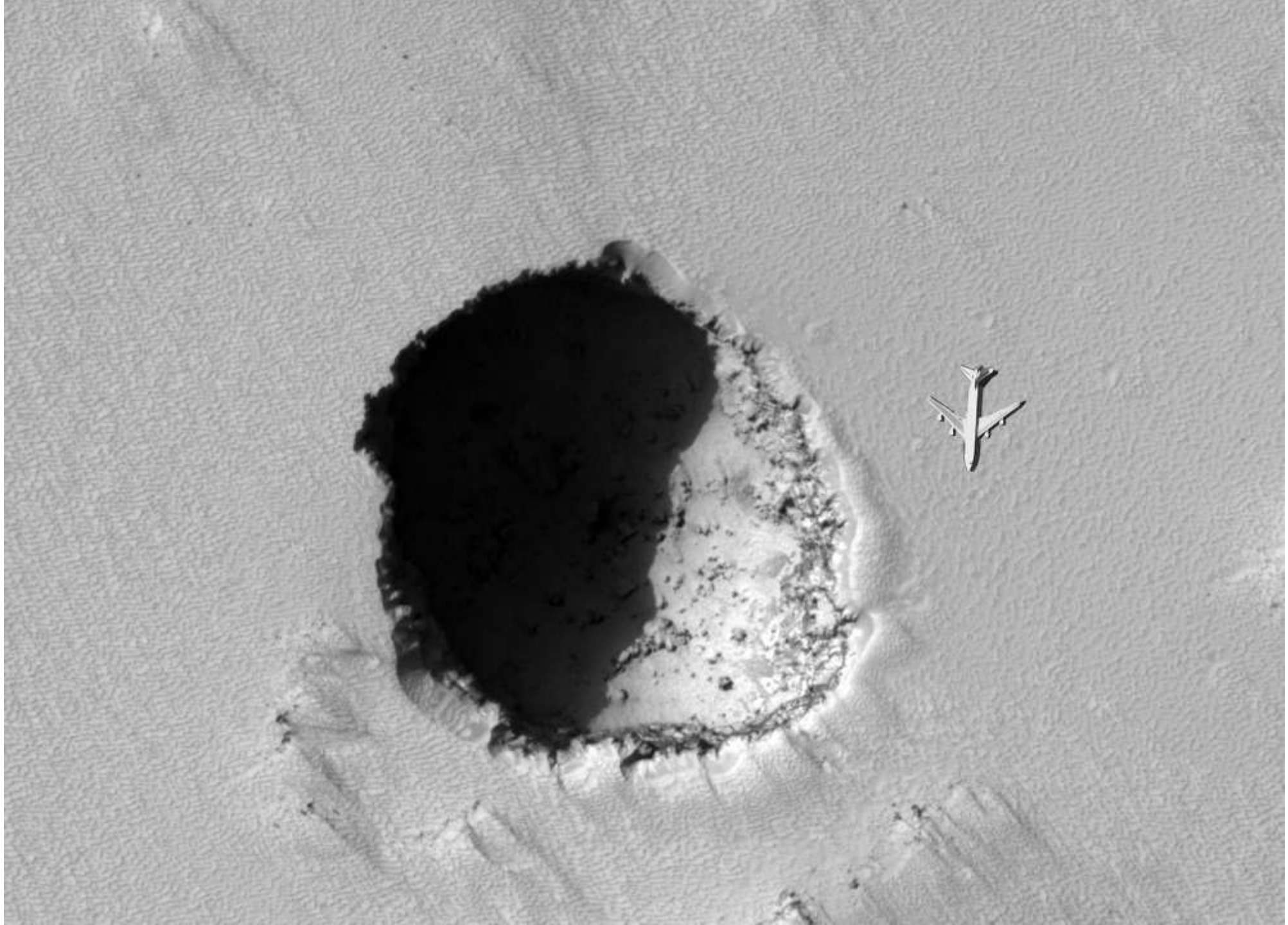
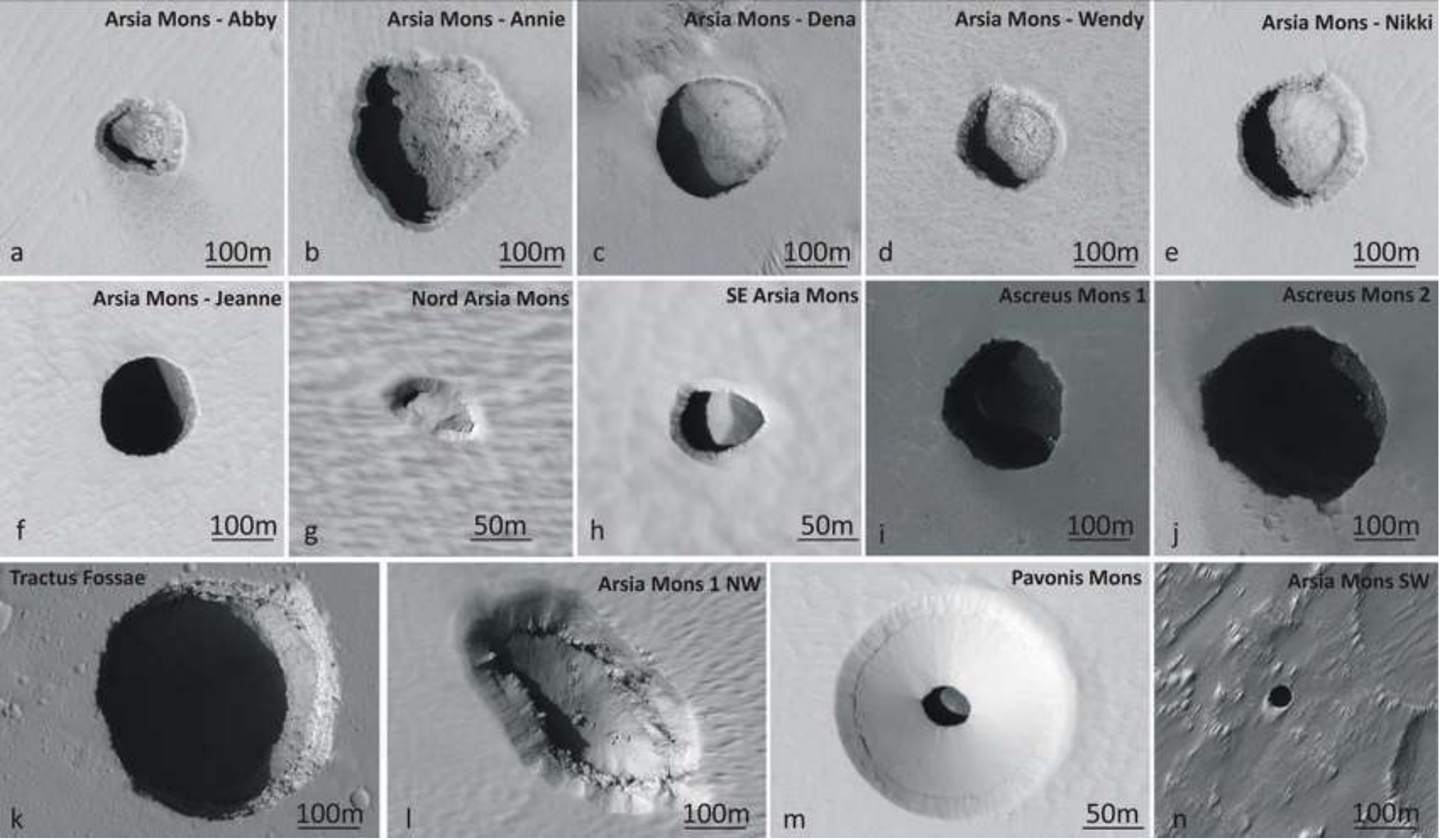


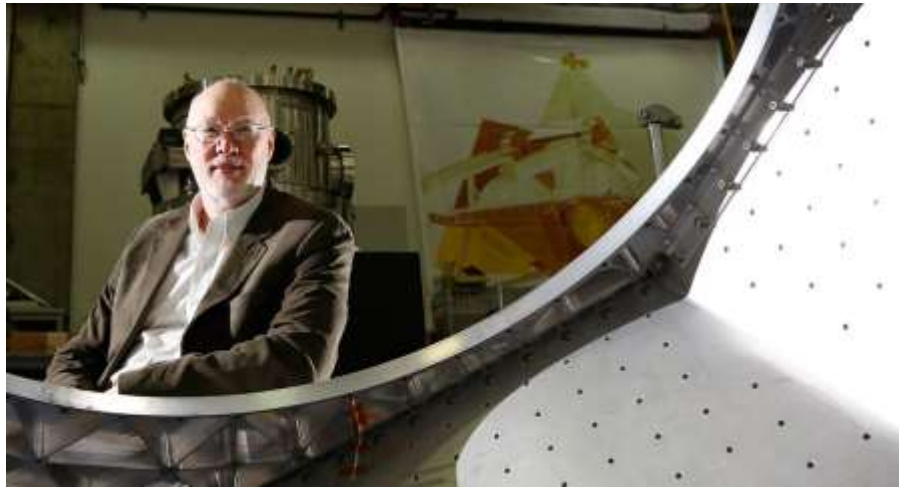
image credit: [Simotron](#)
Science and Fiction

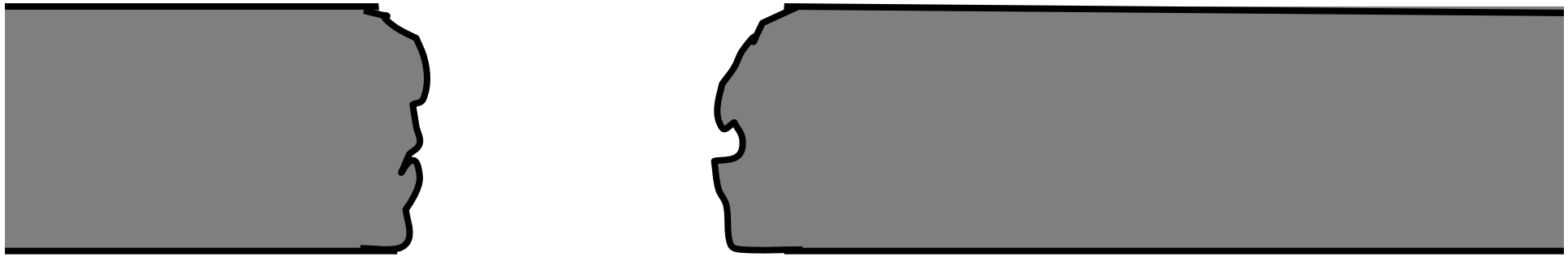


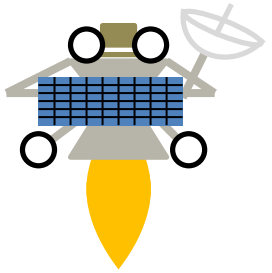
Images: HIRISE

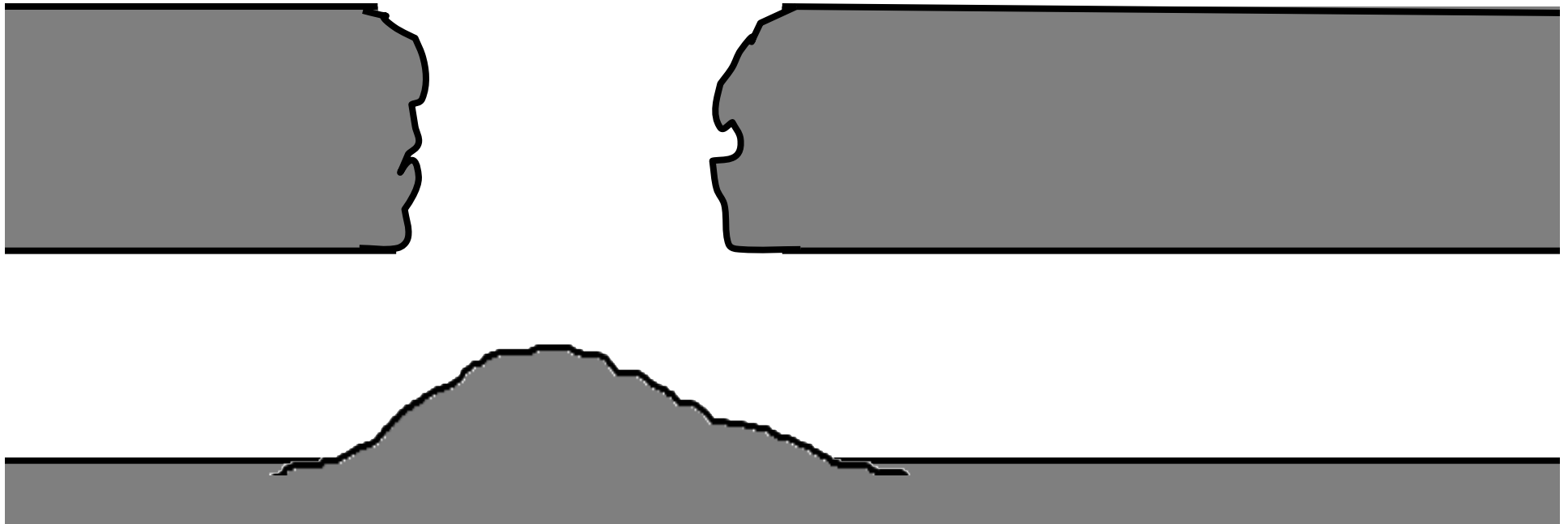
Techniques to get in there

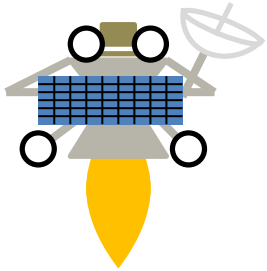
Dr. Red Whittaker
Carnegie Mellon University,
Astrobotics Technology

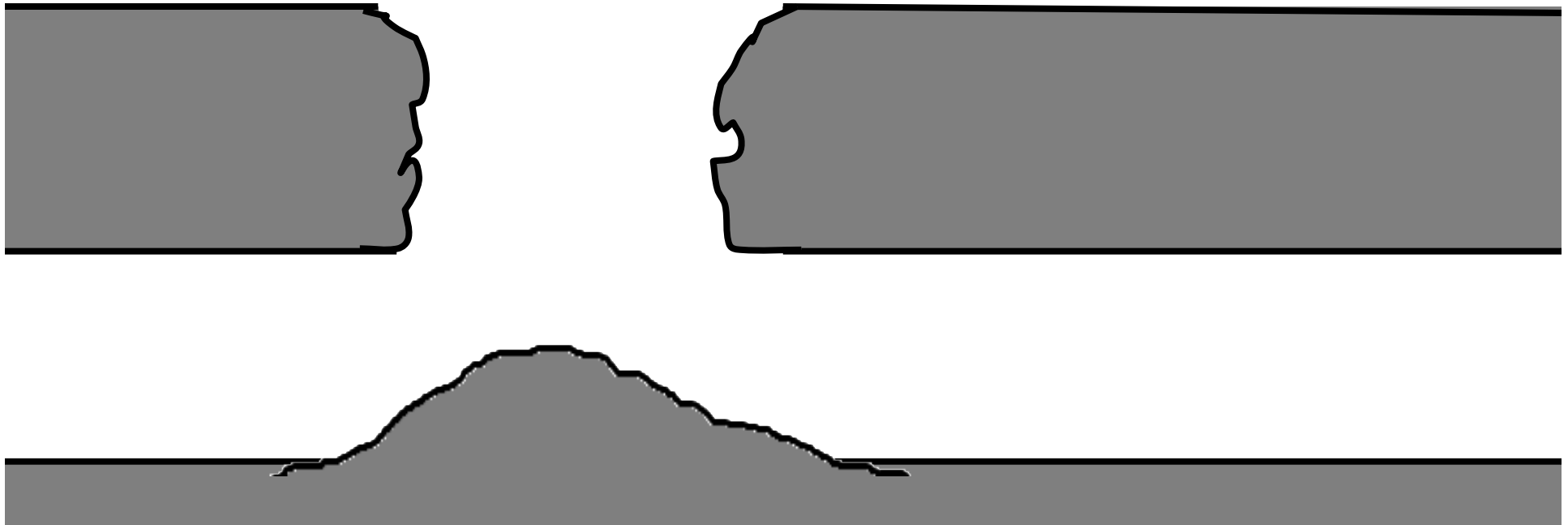


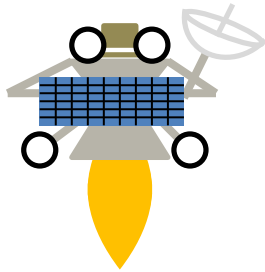


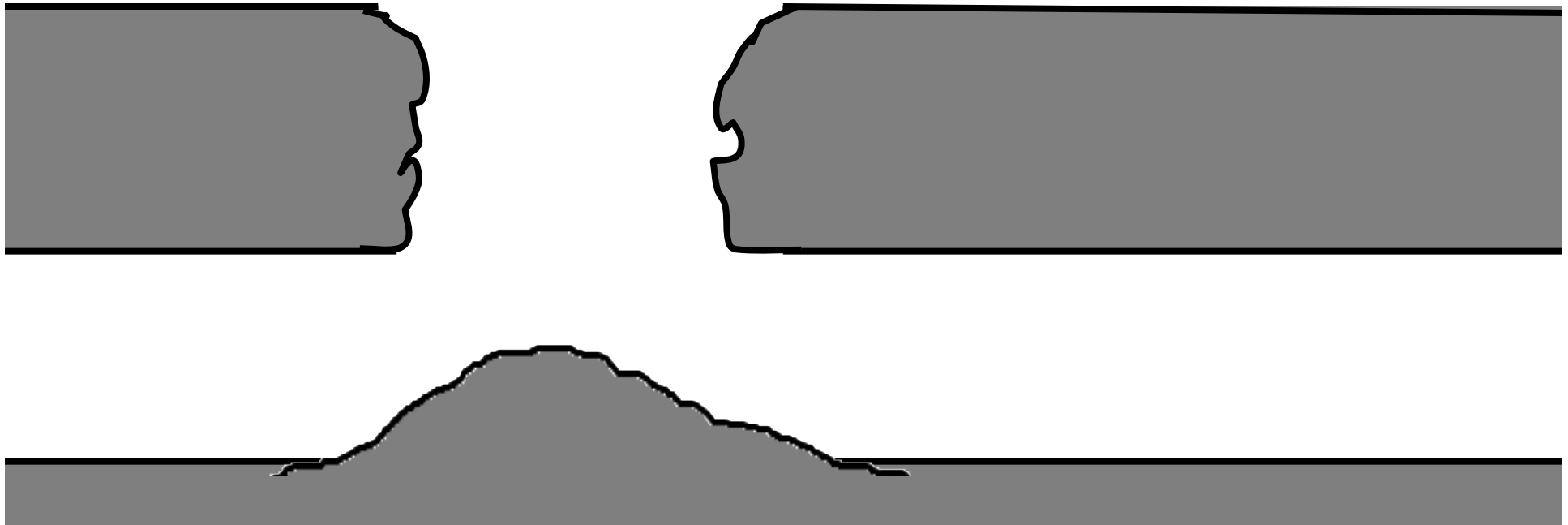


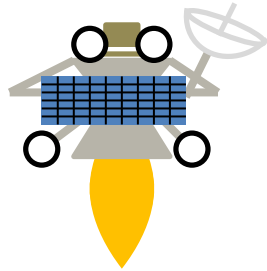


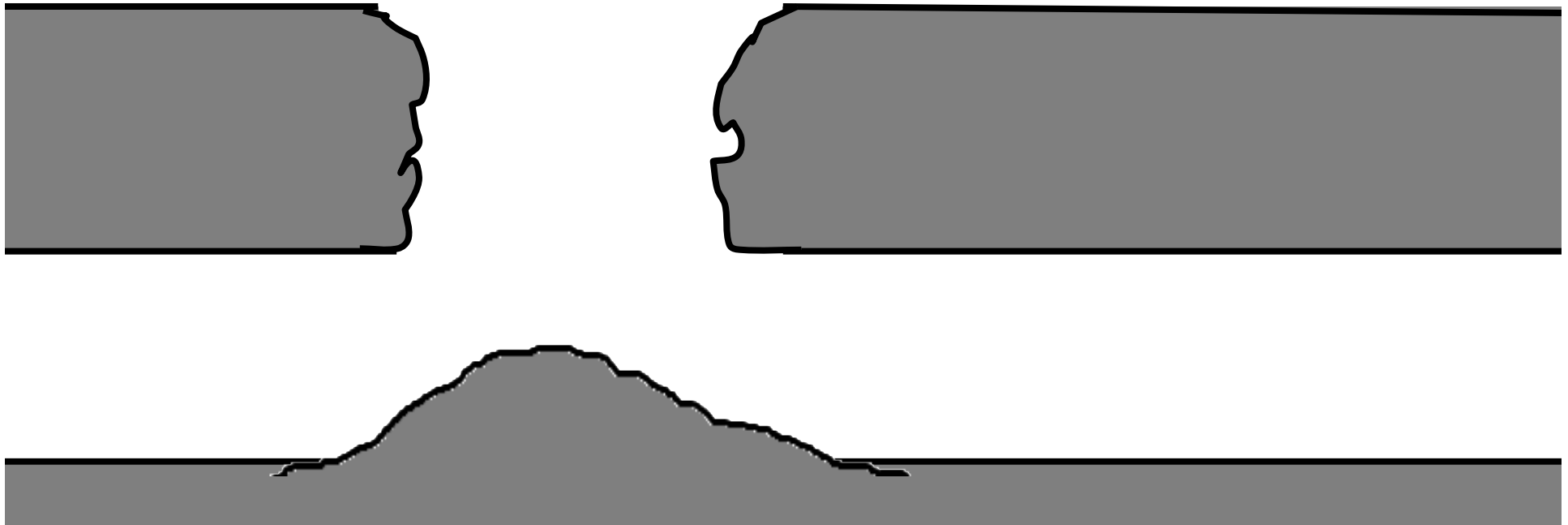


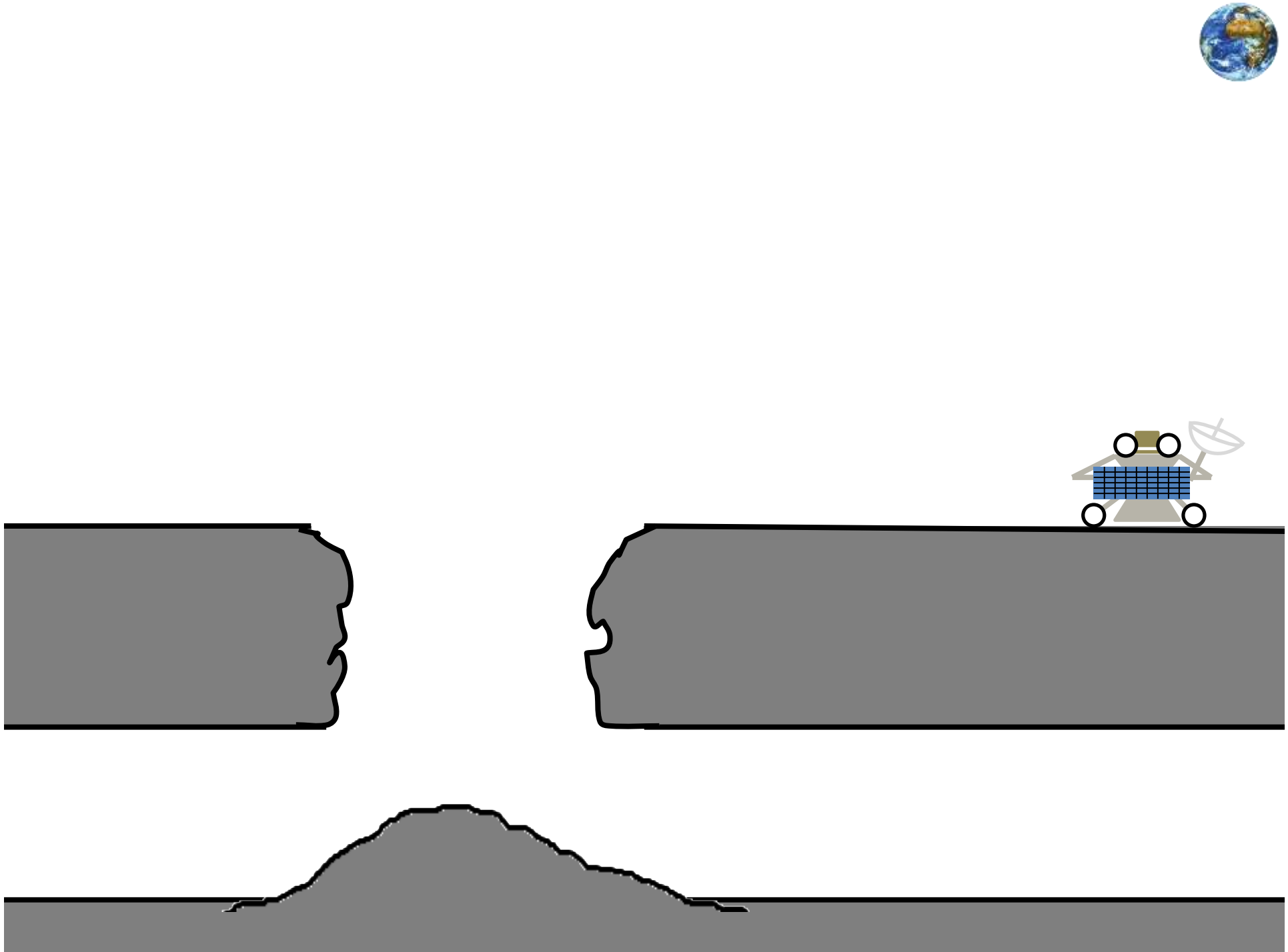


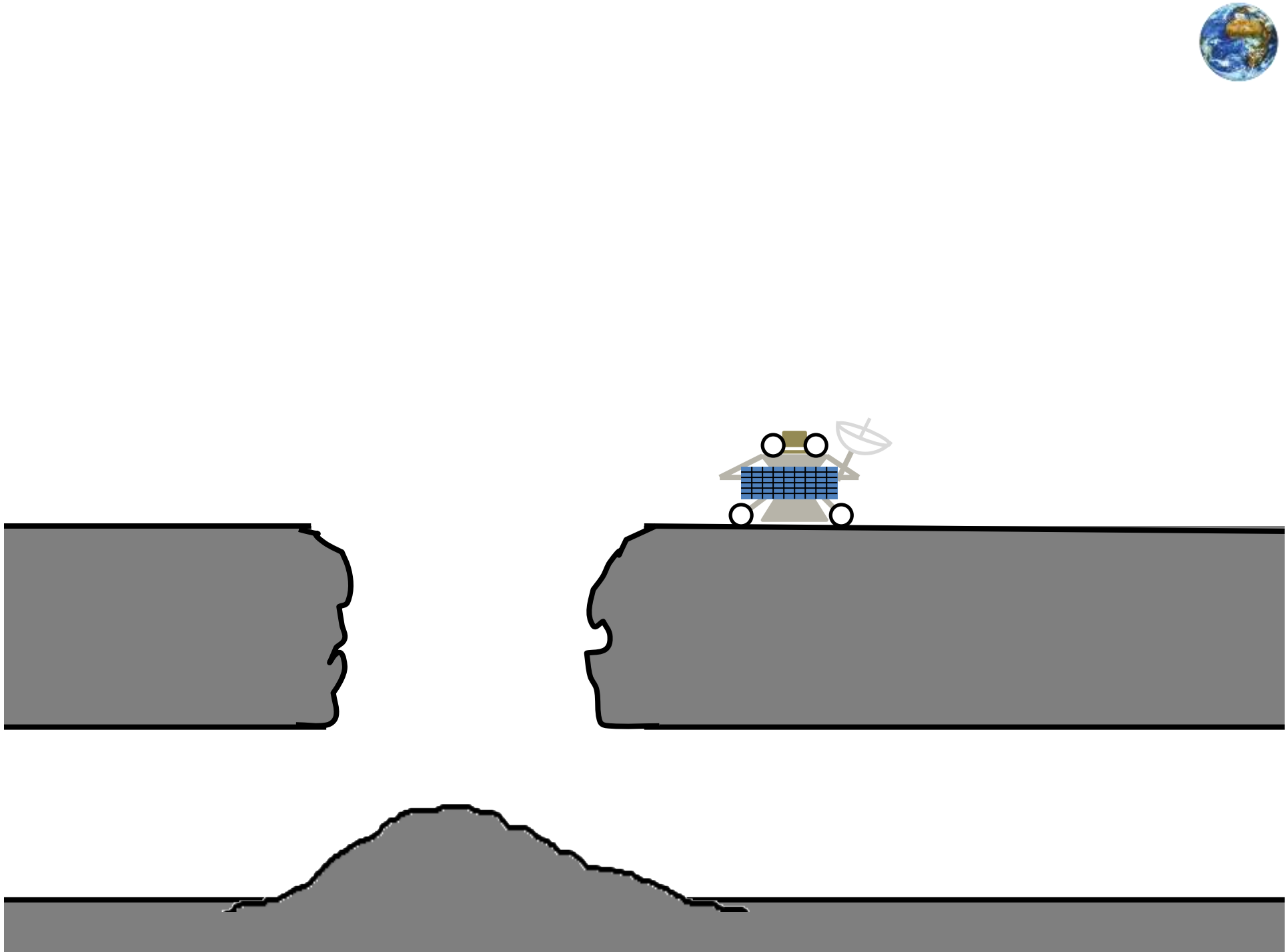


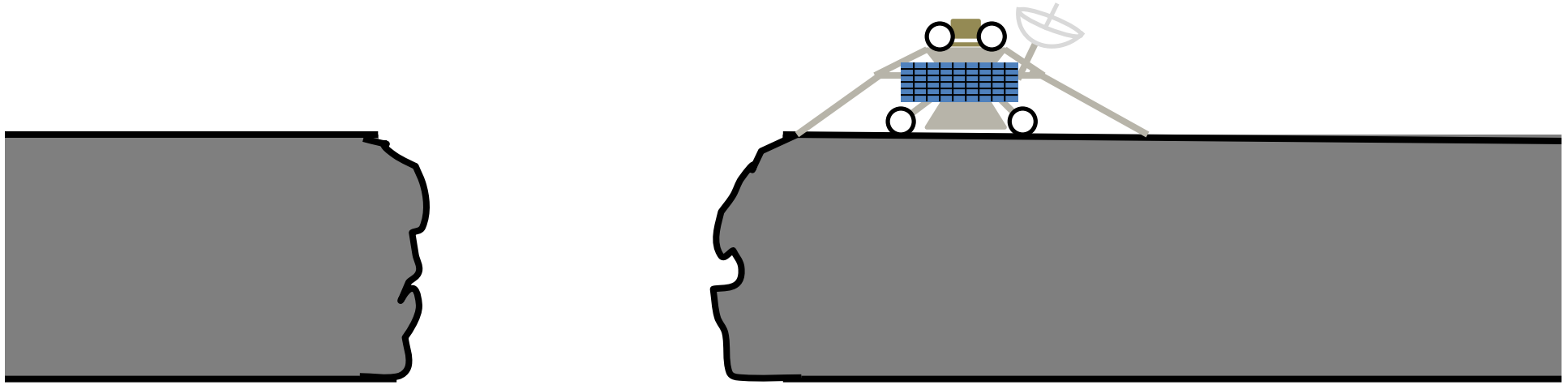


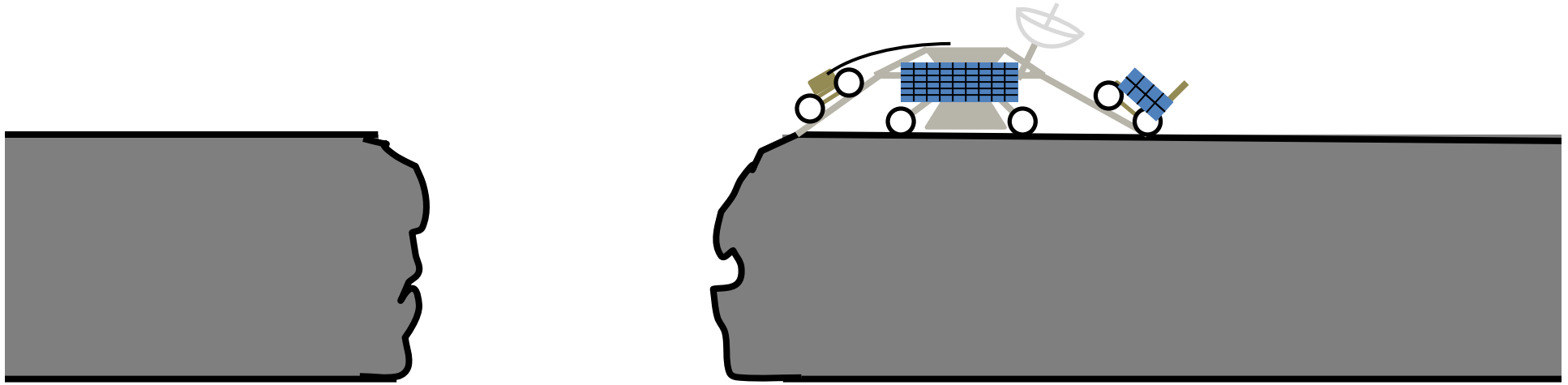


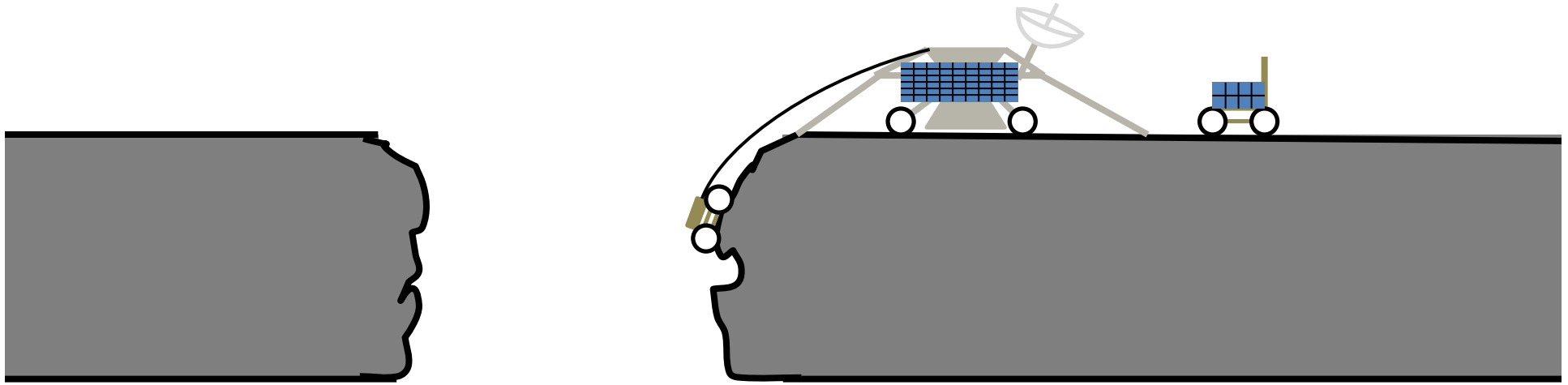


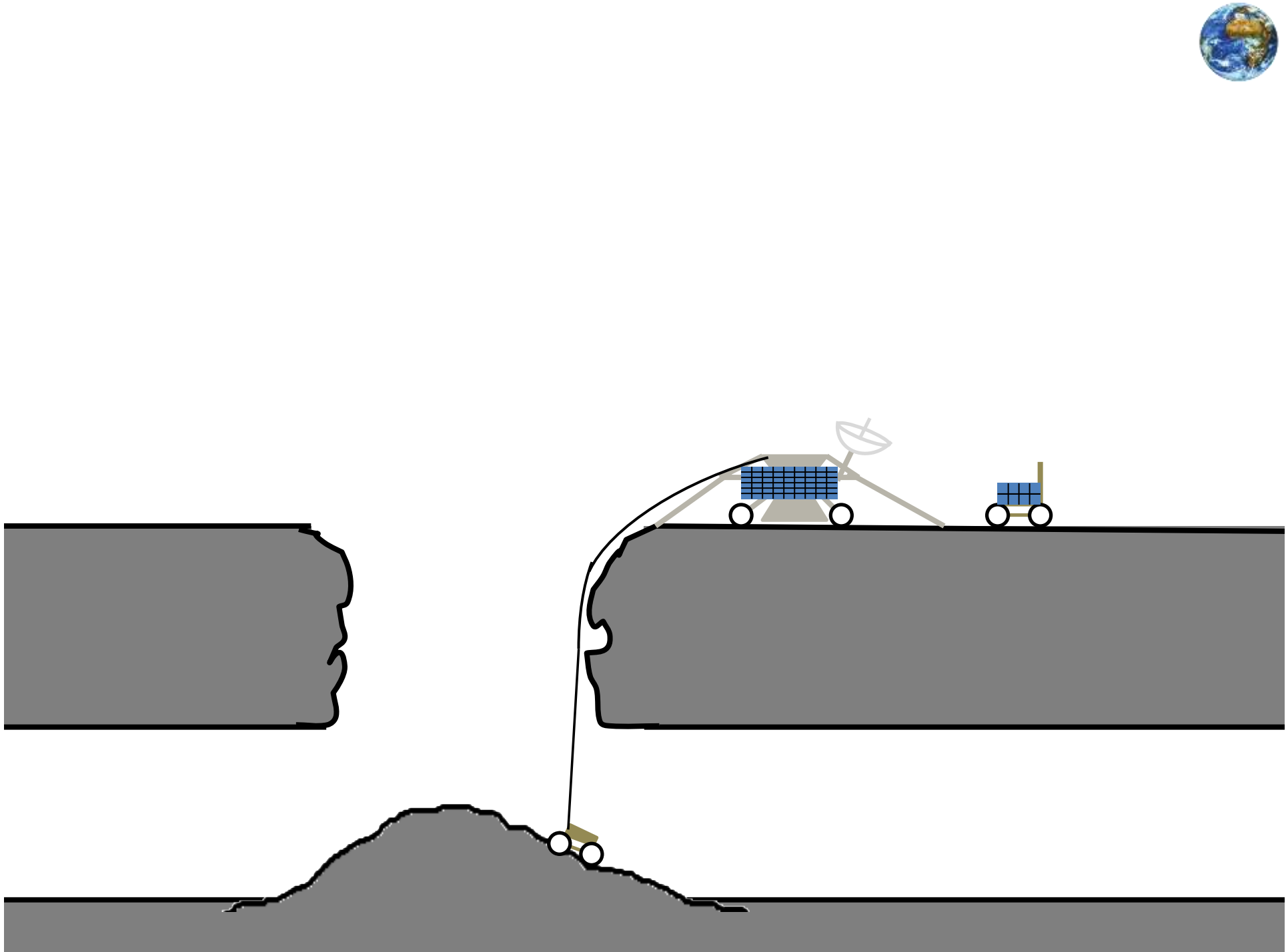


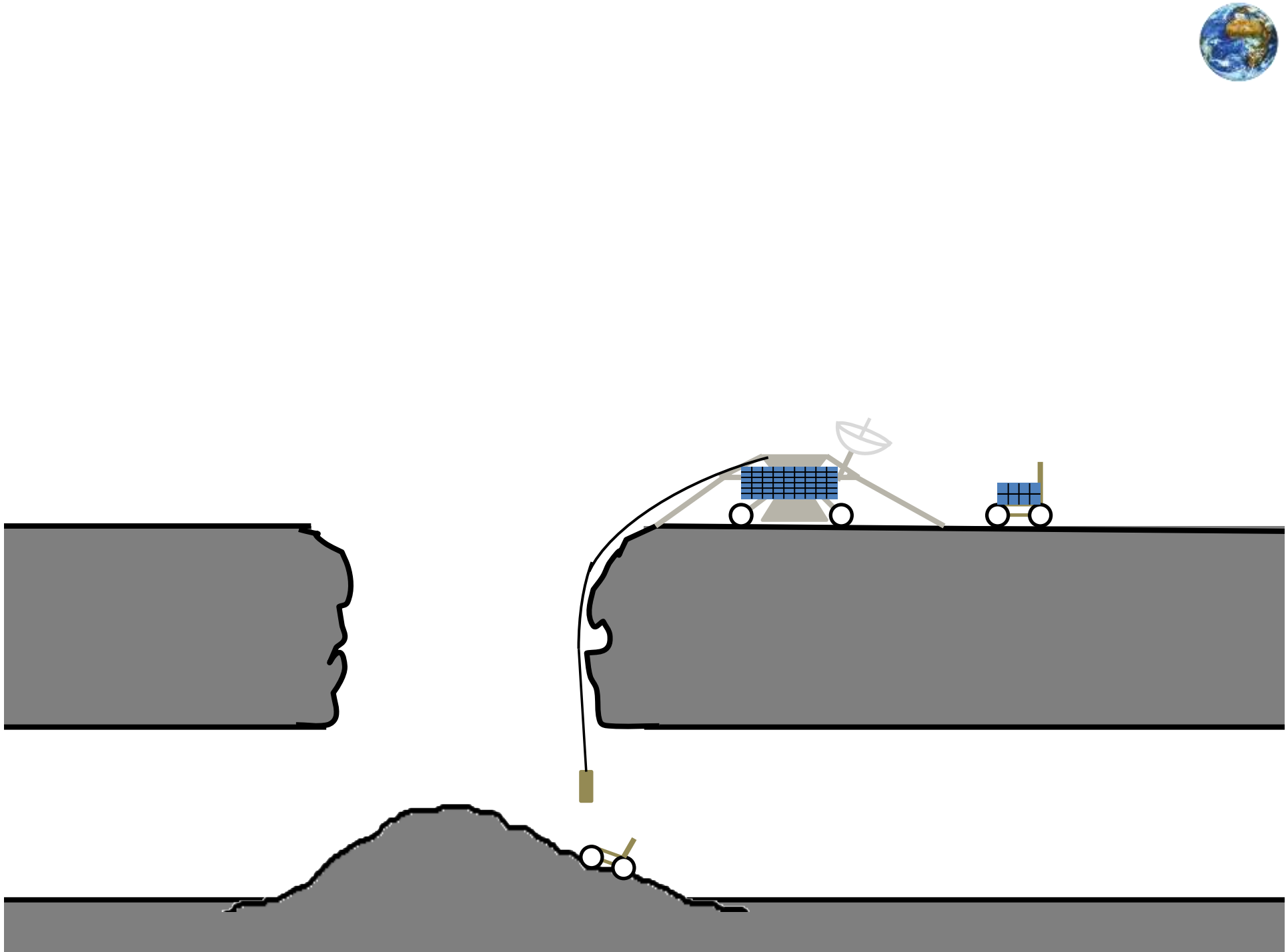


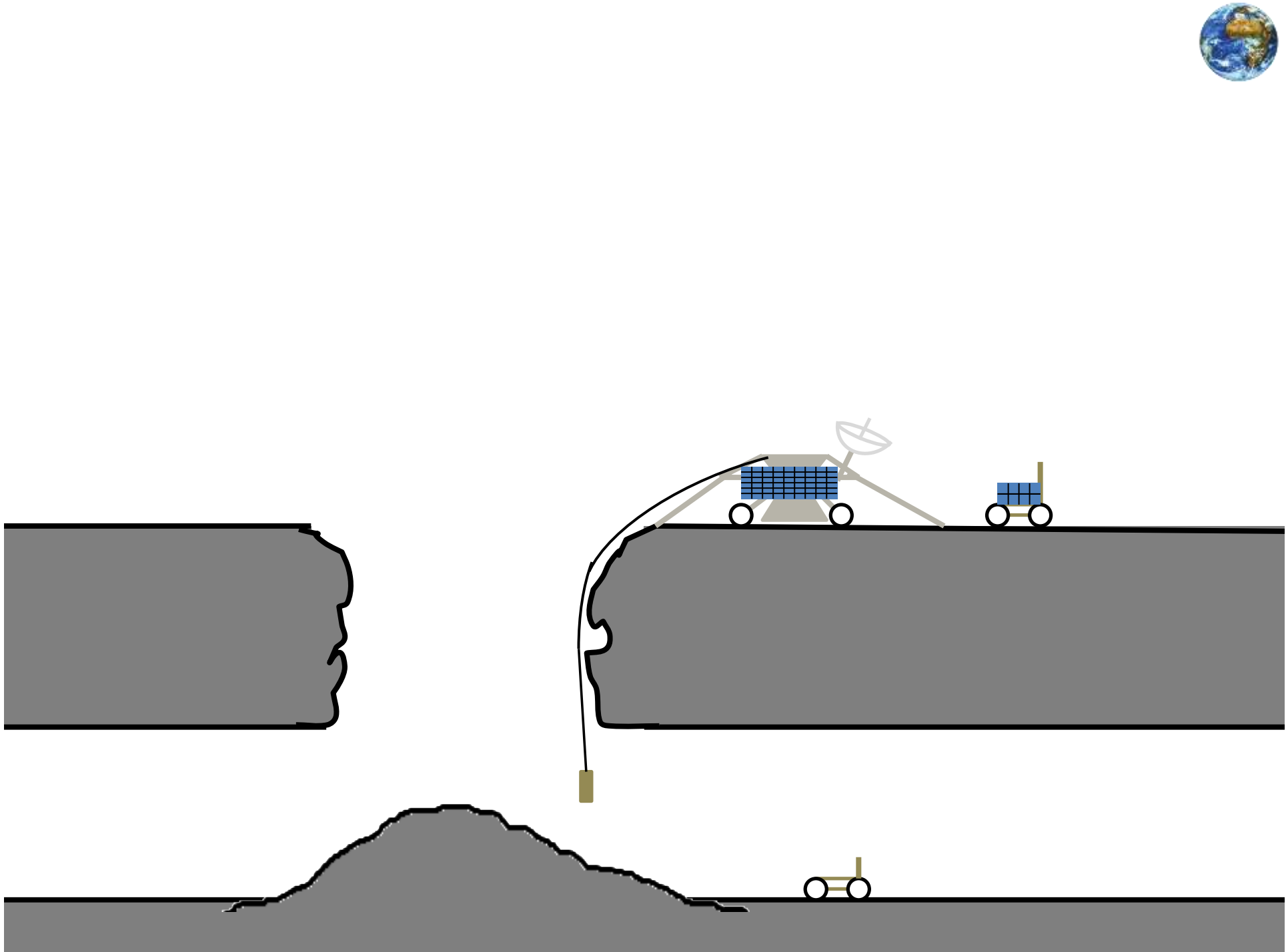


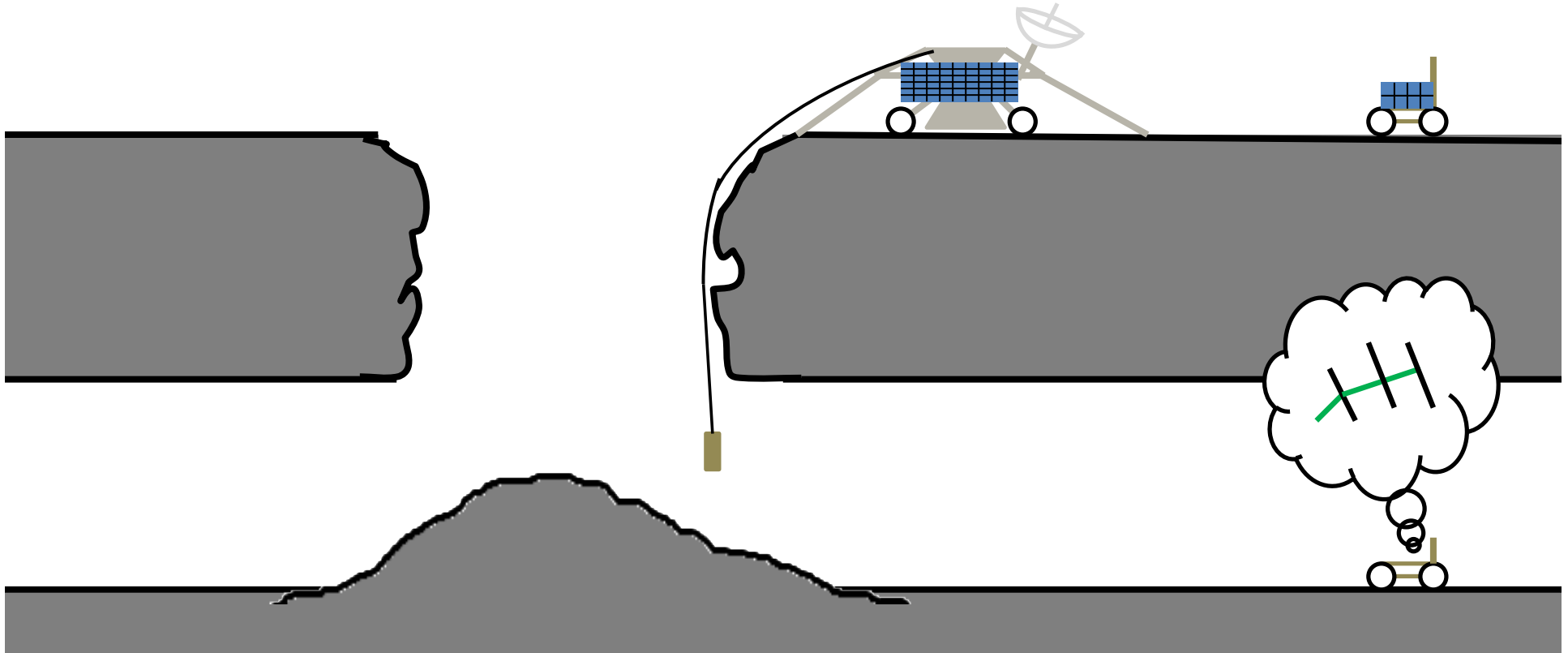


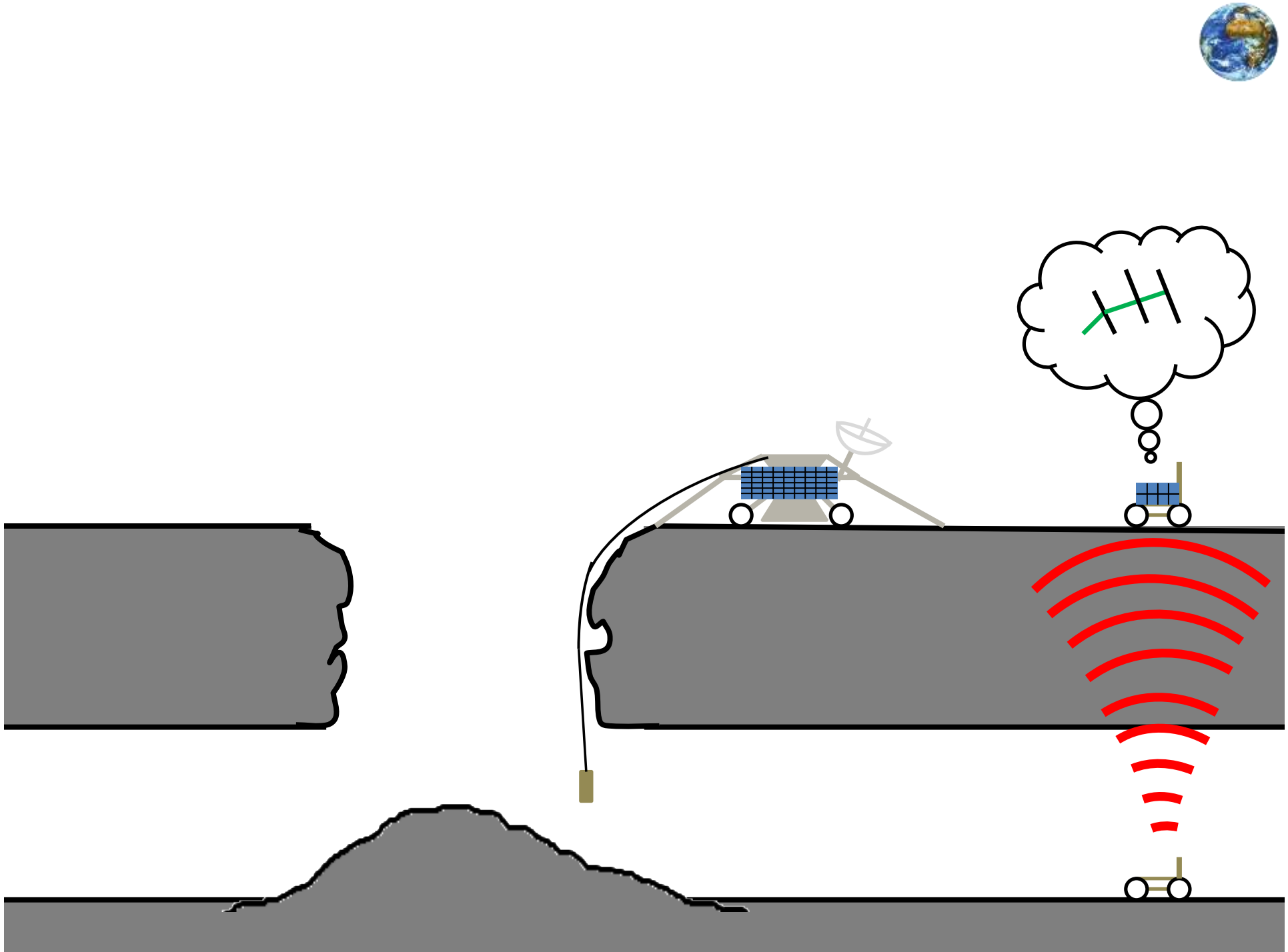


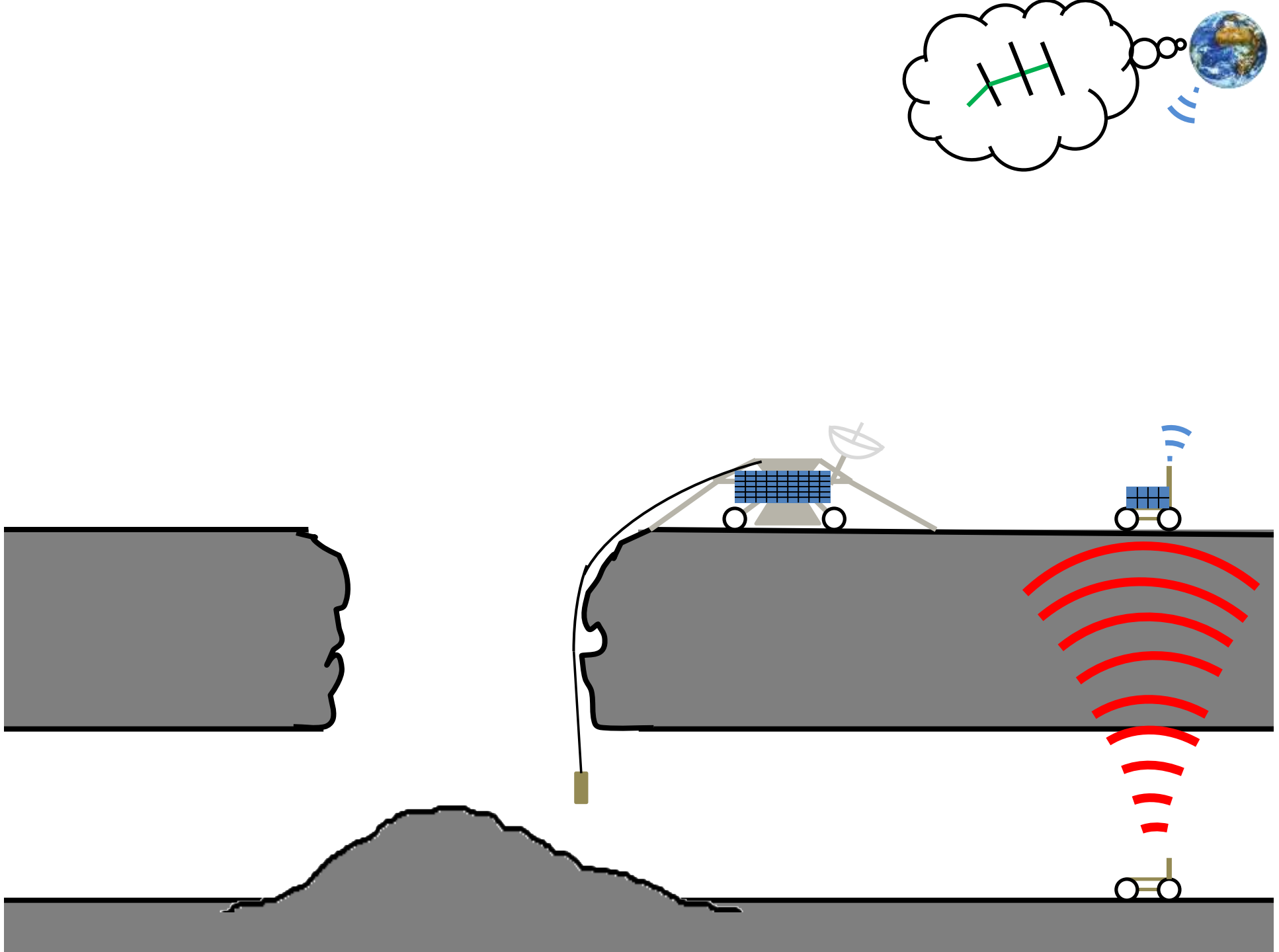


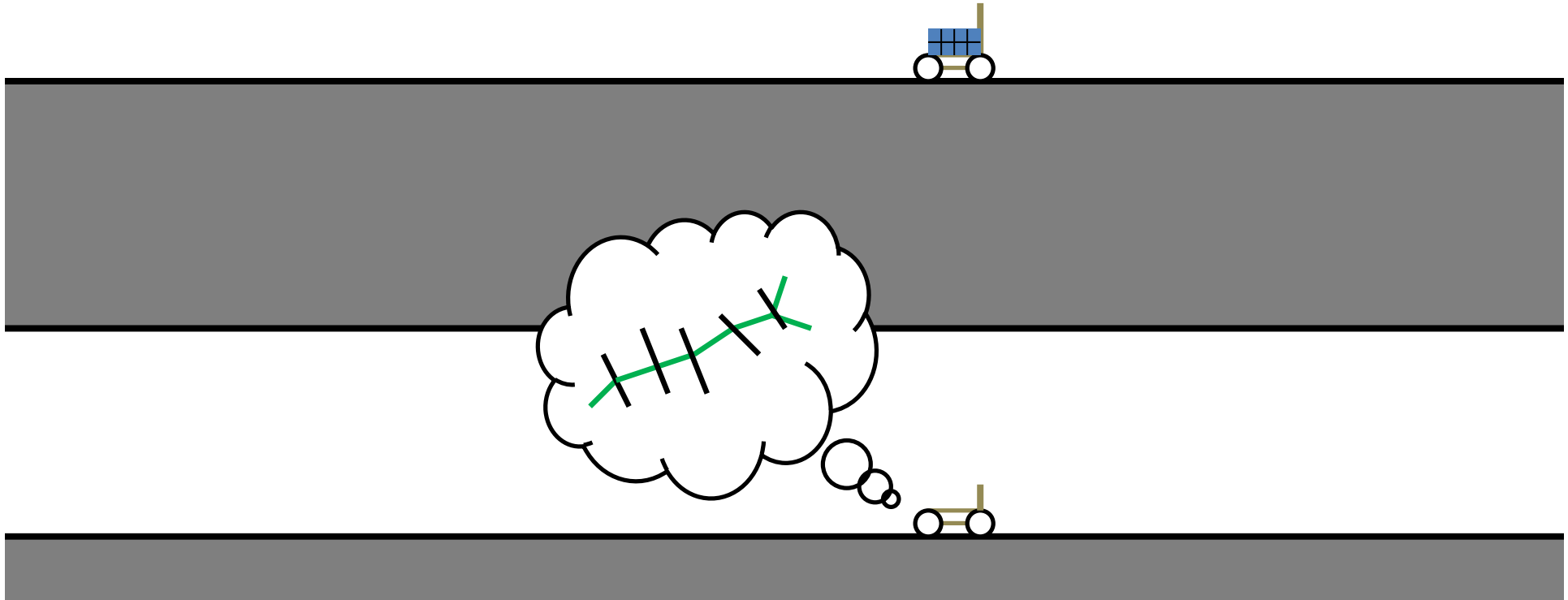


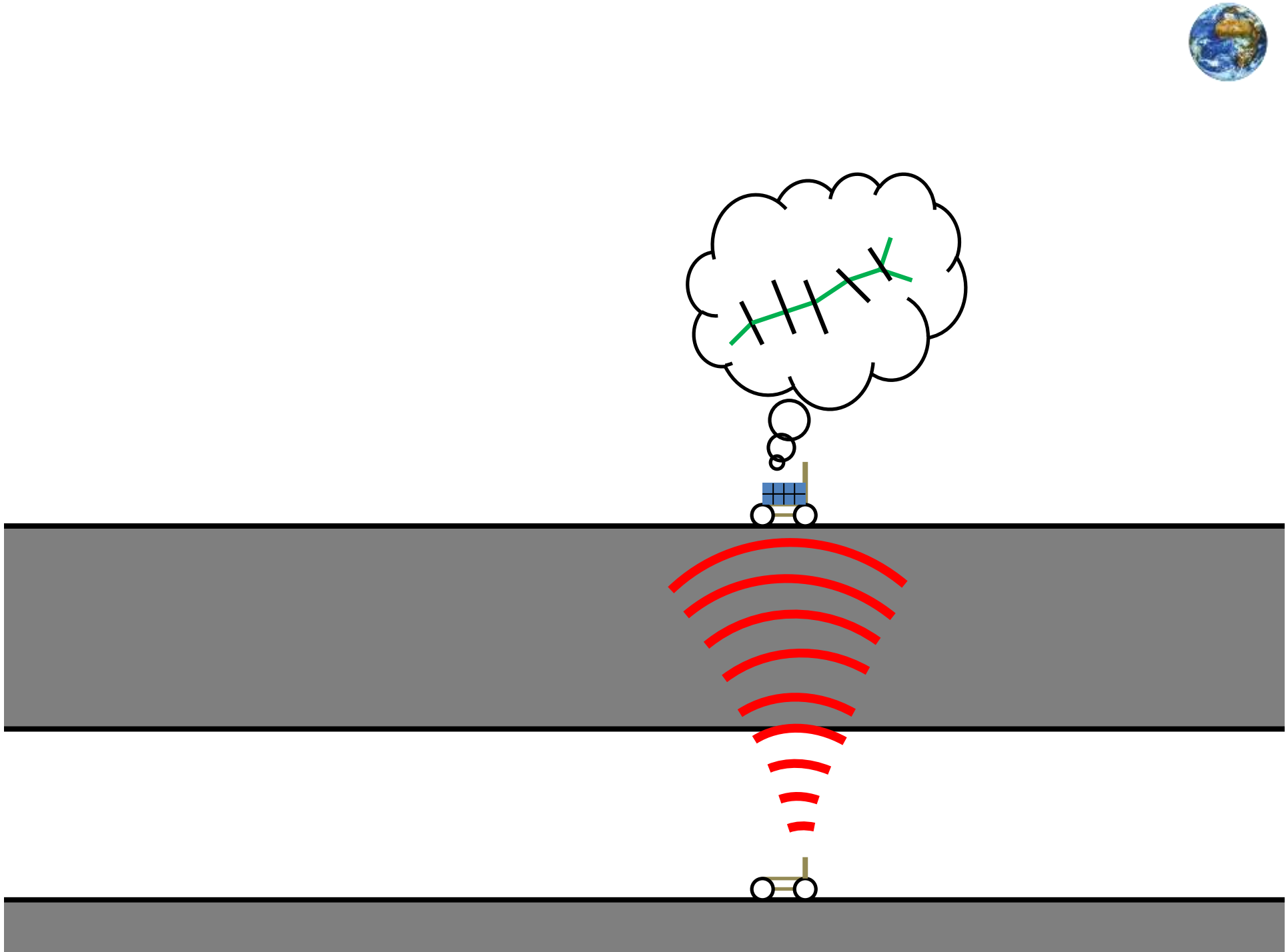


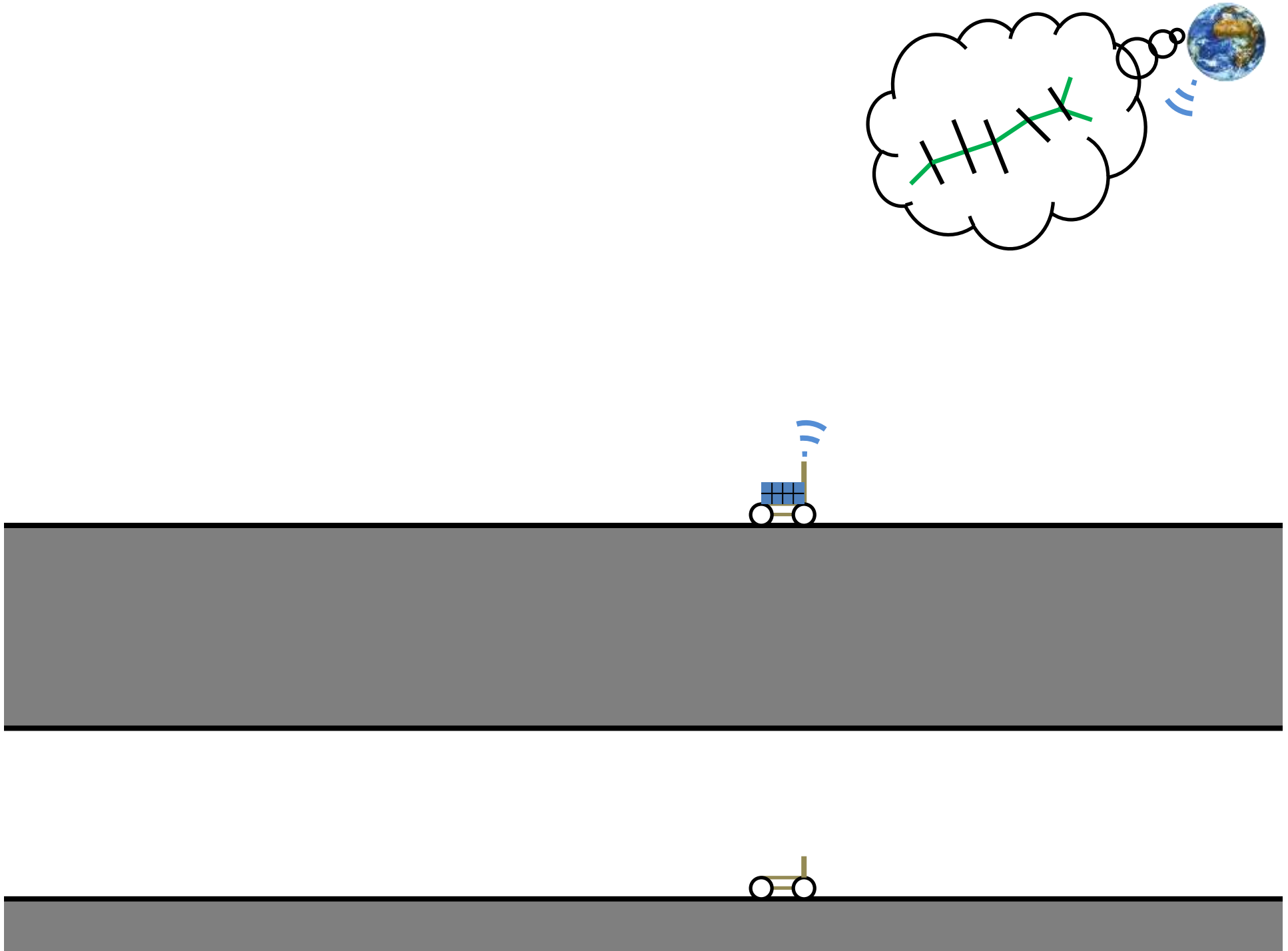


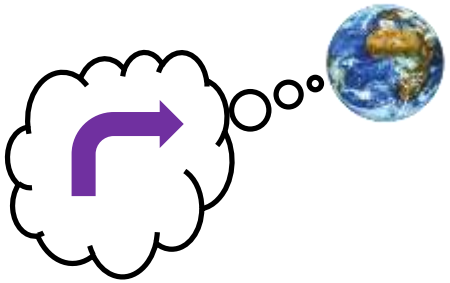


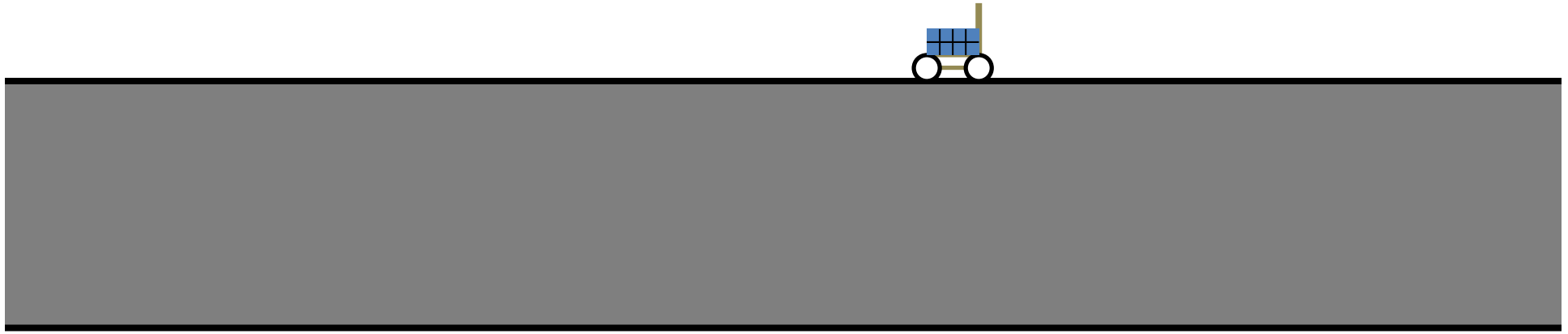


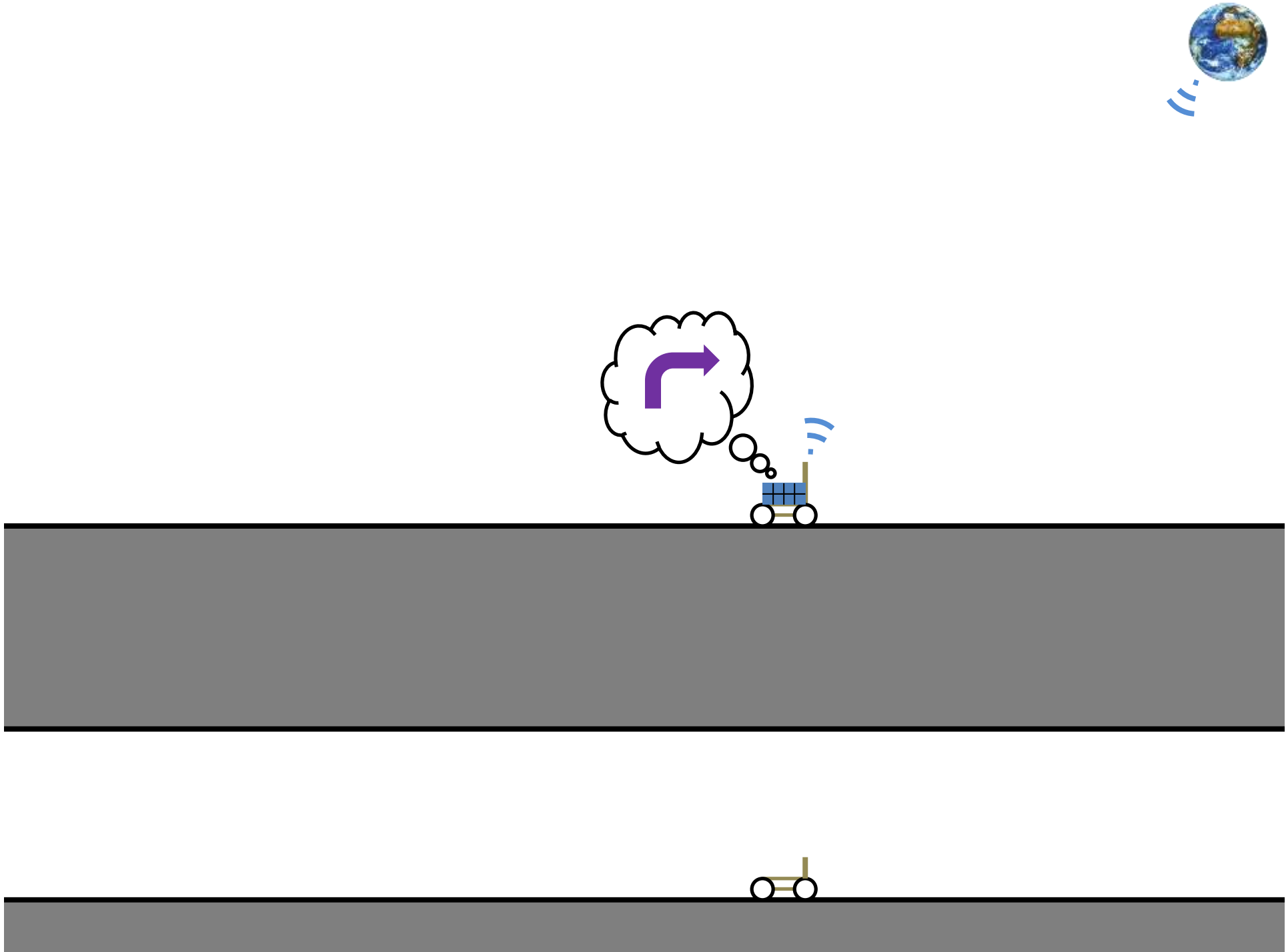


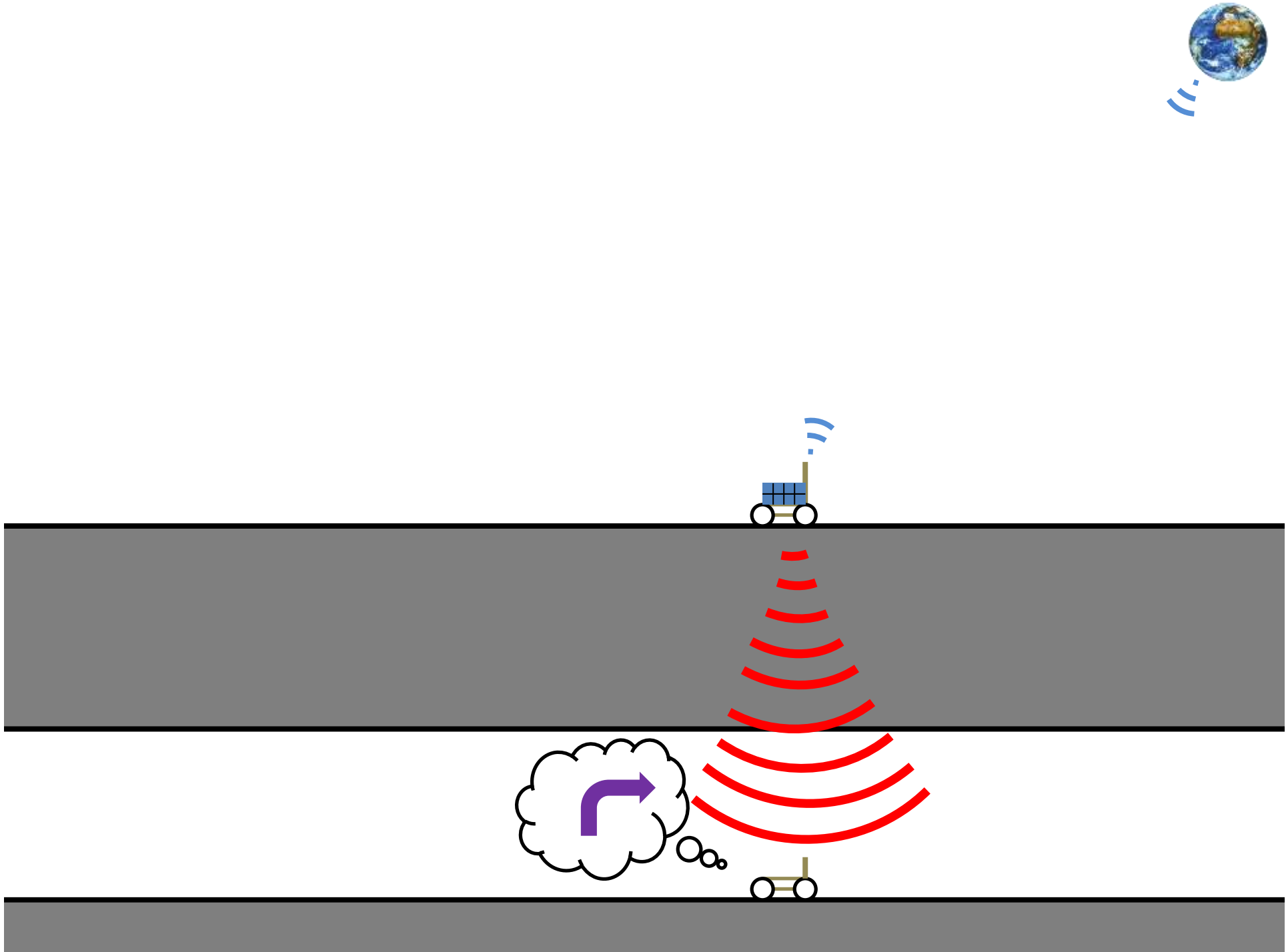


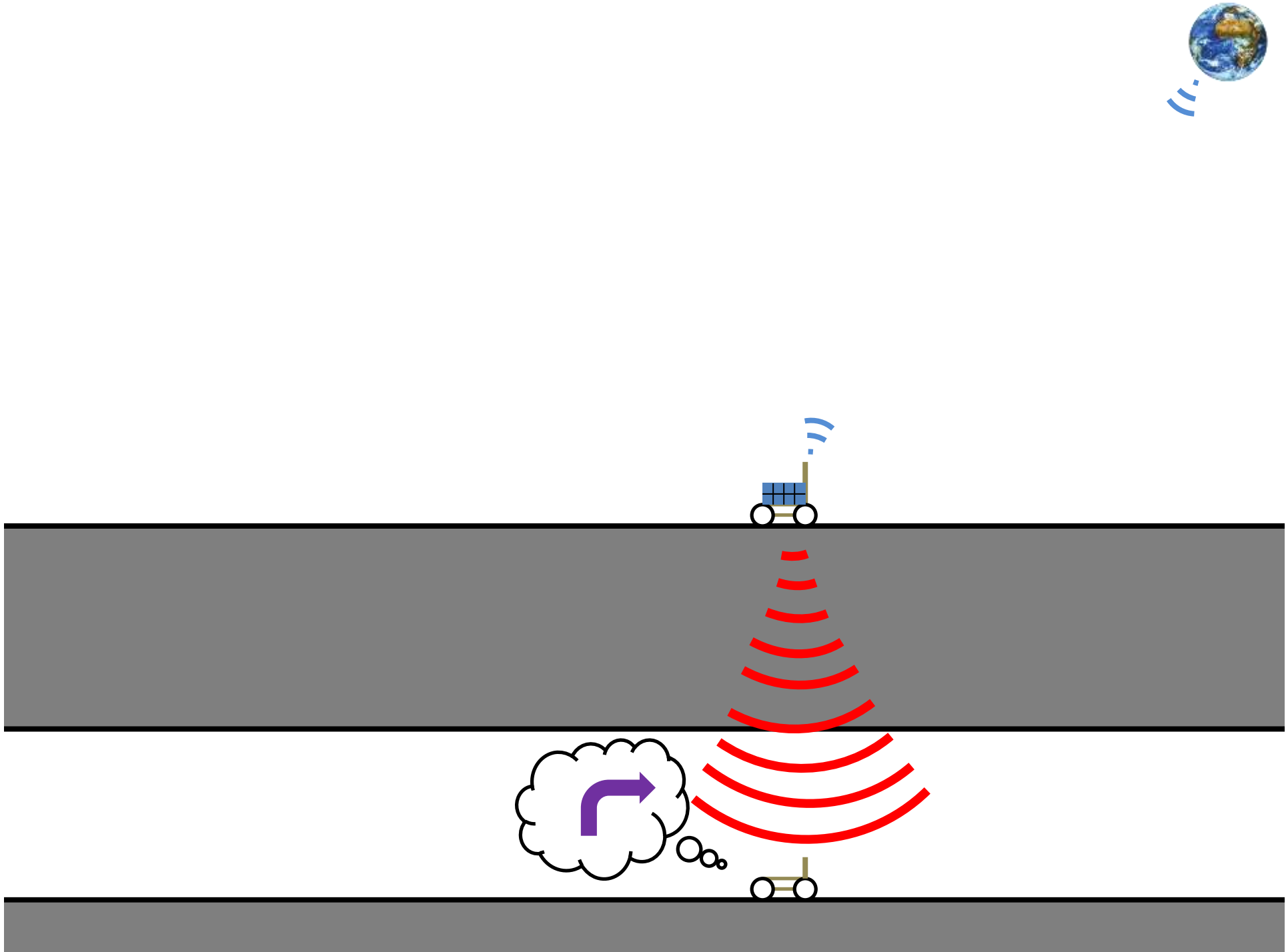


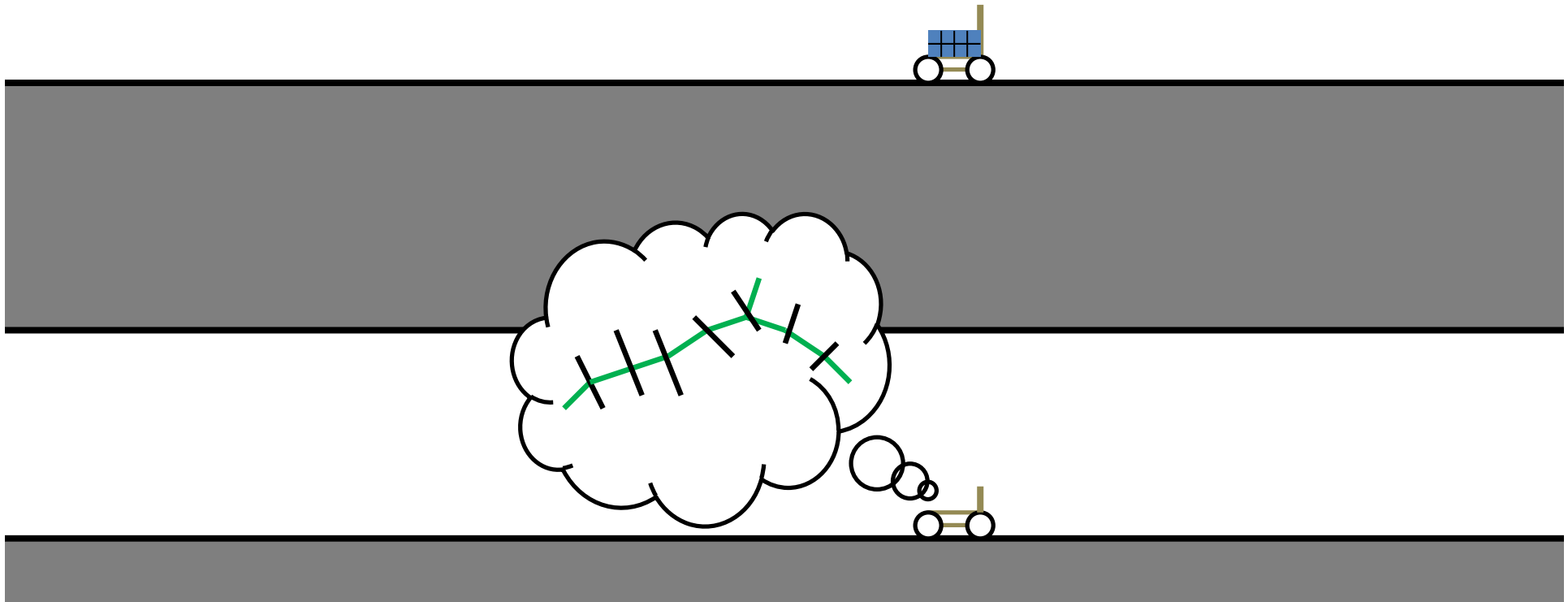


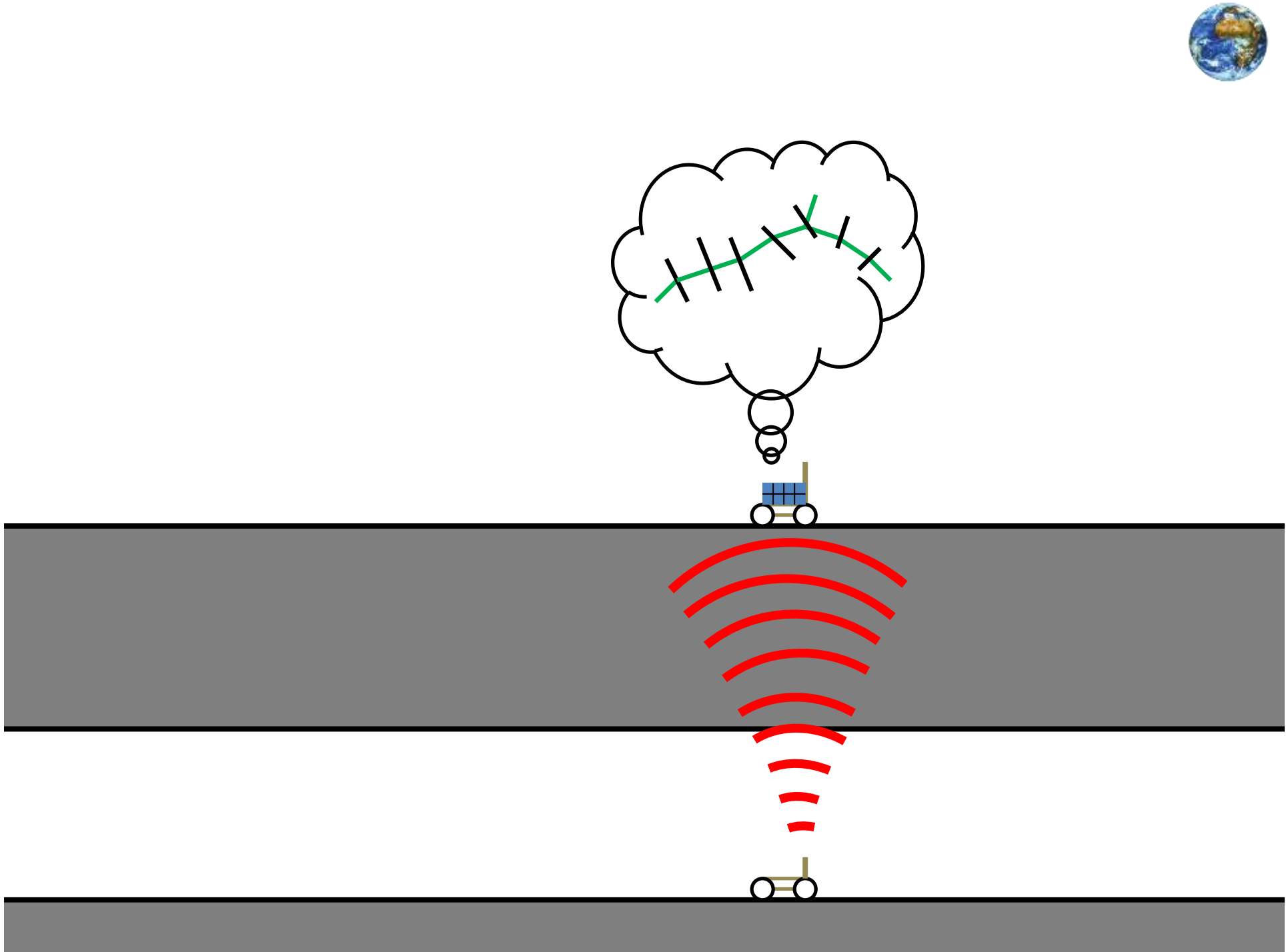


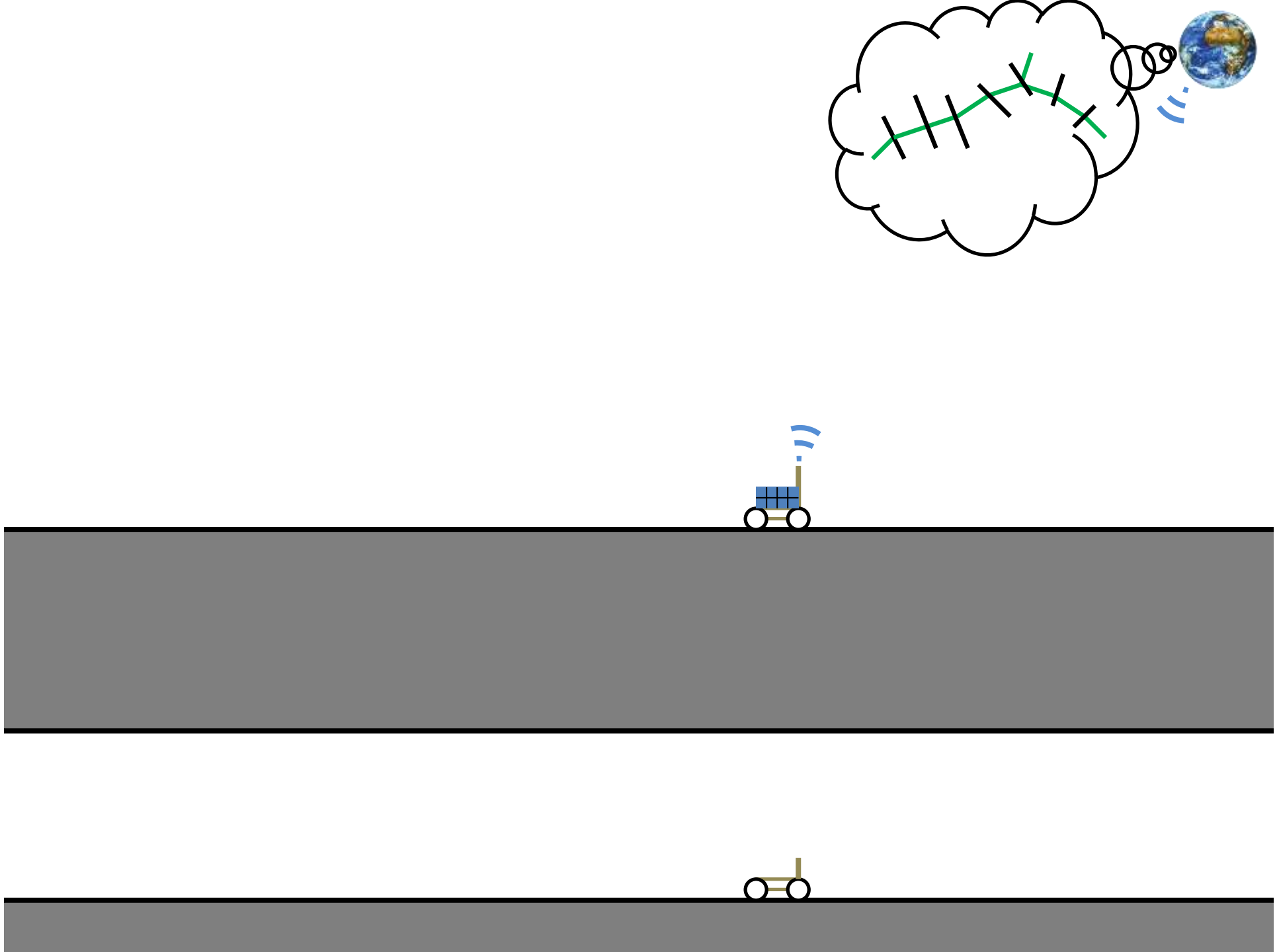


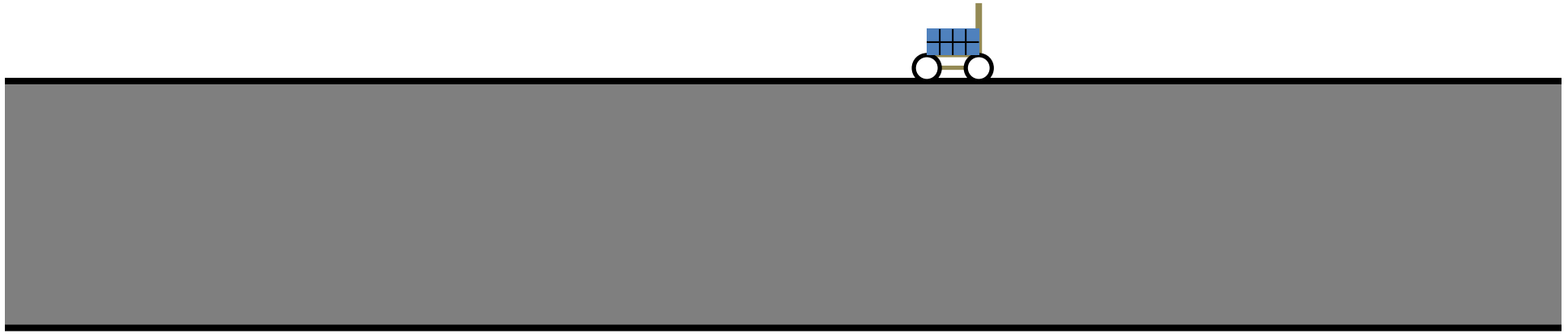


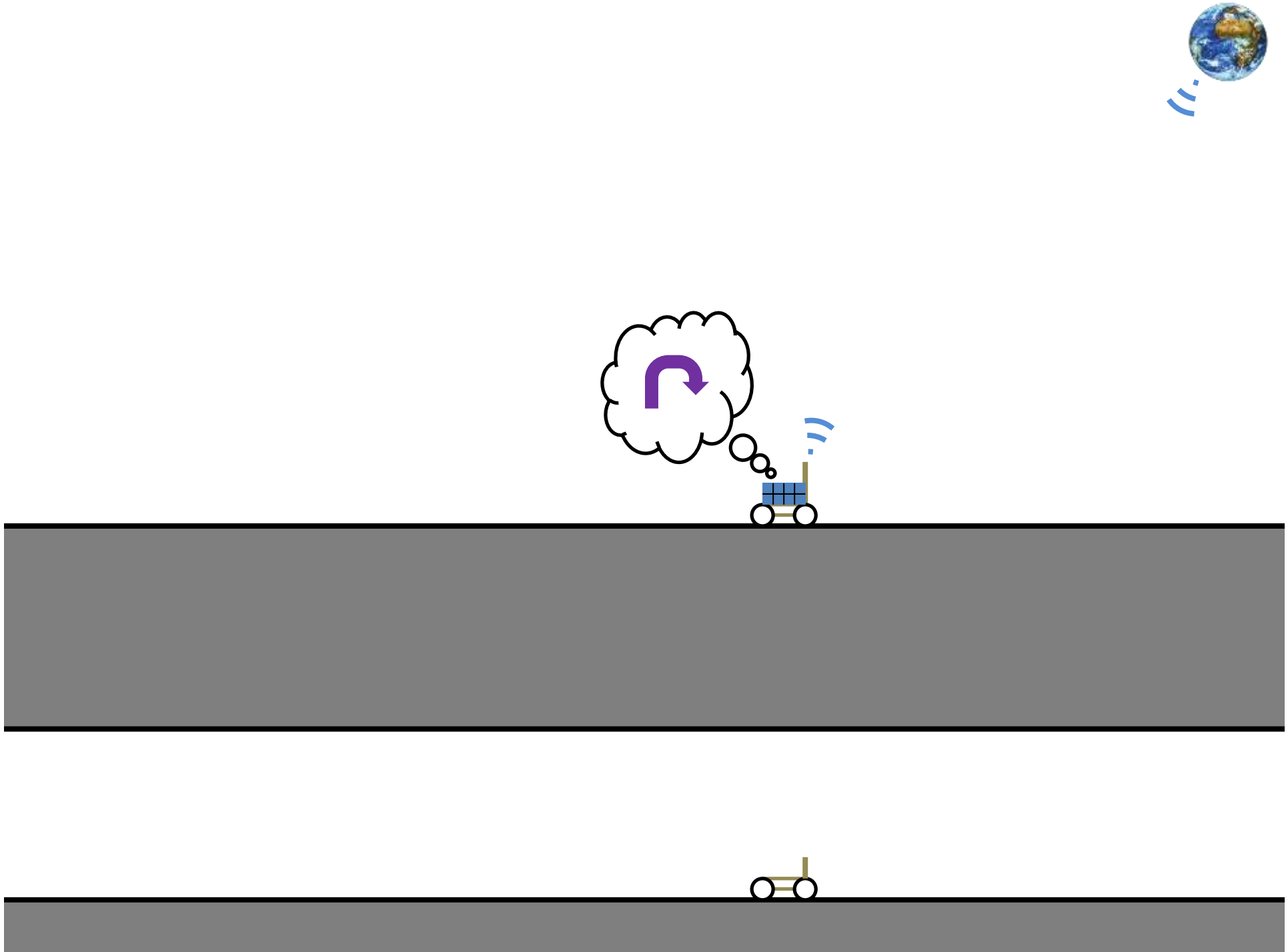


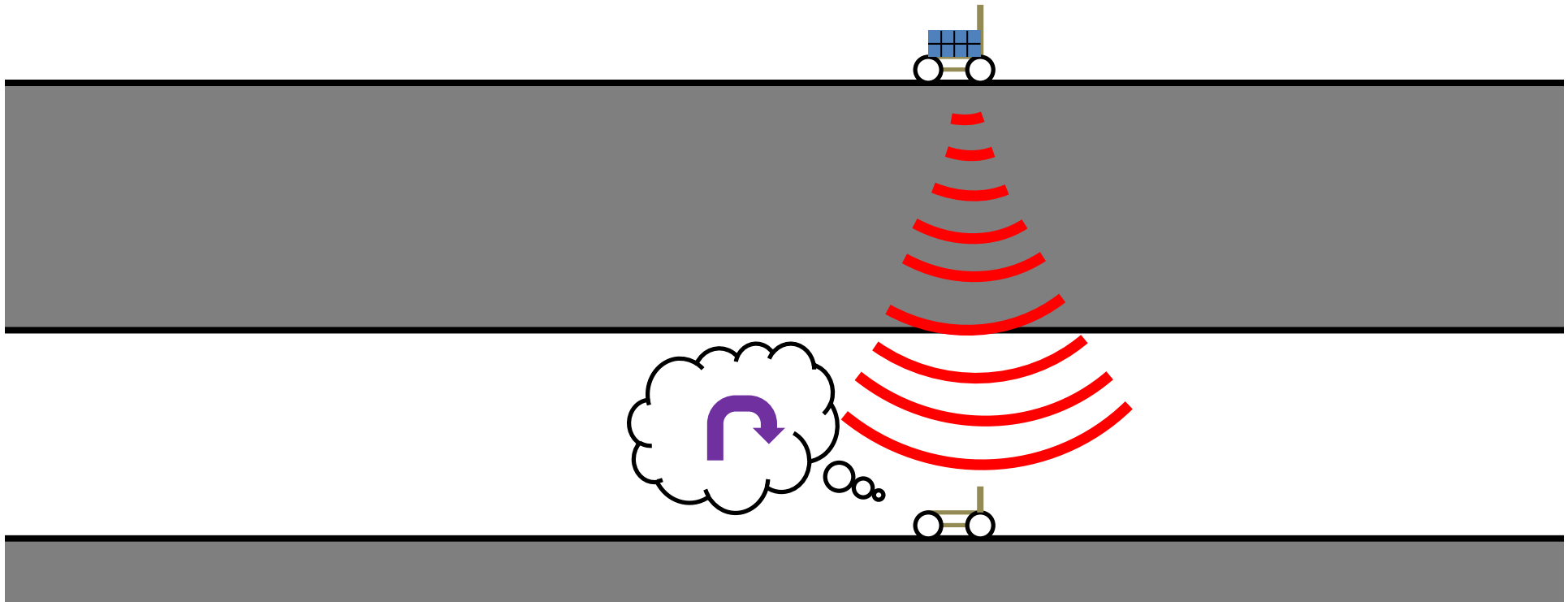


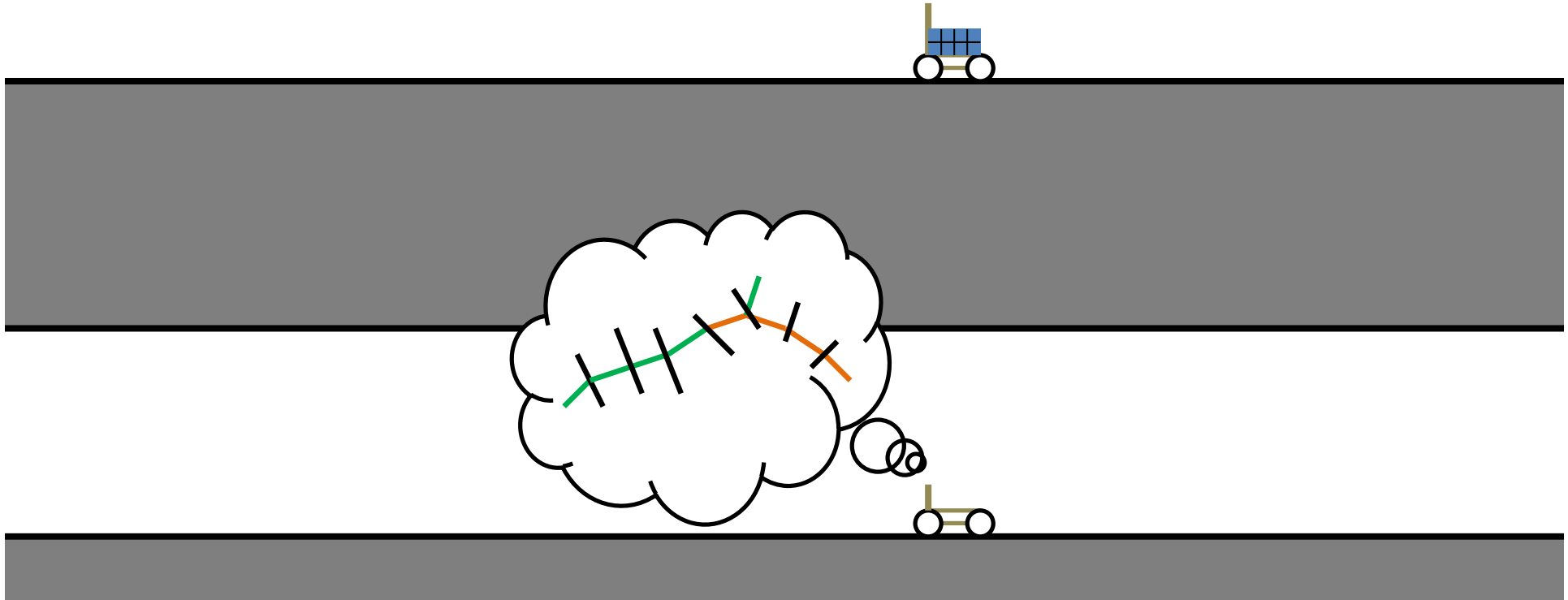


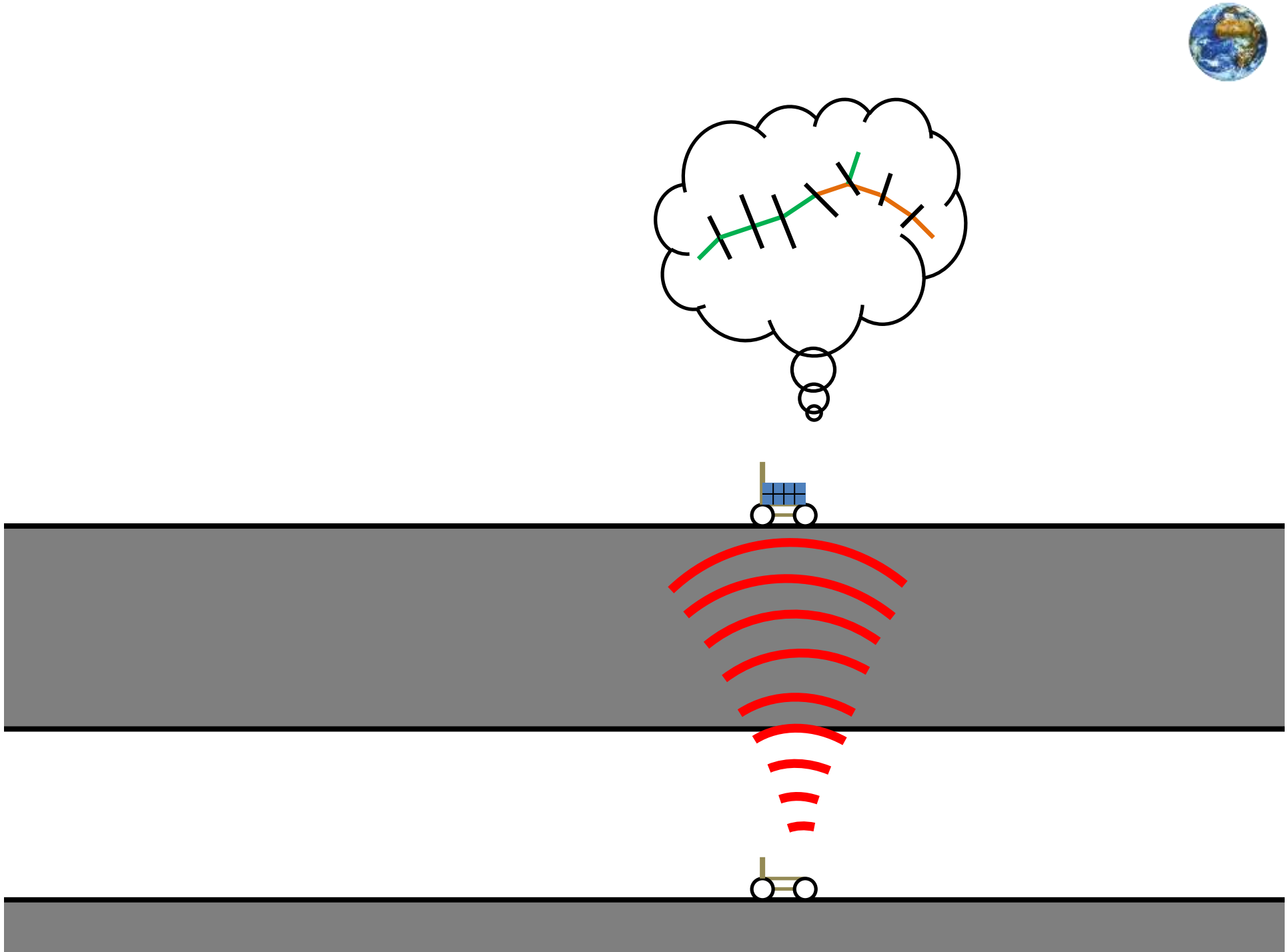


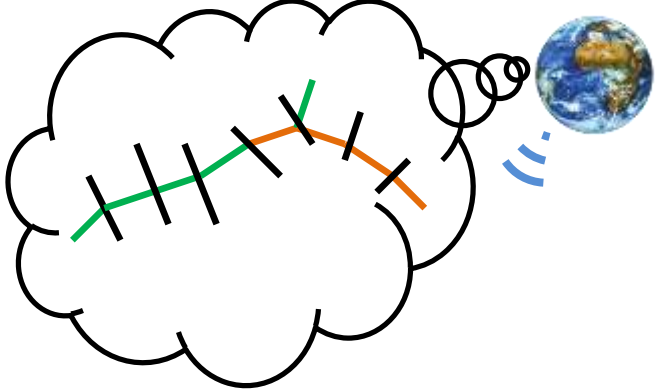


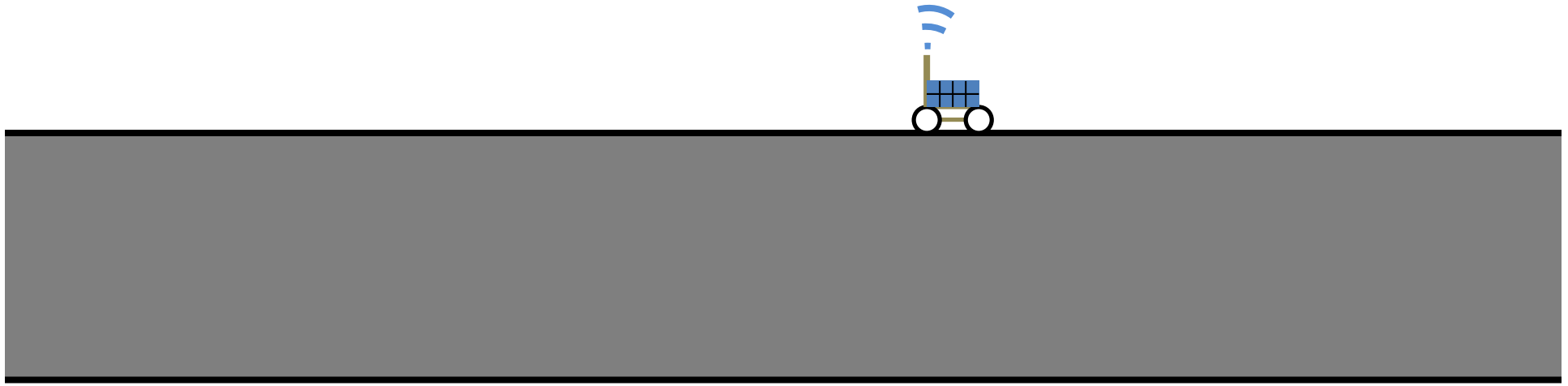


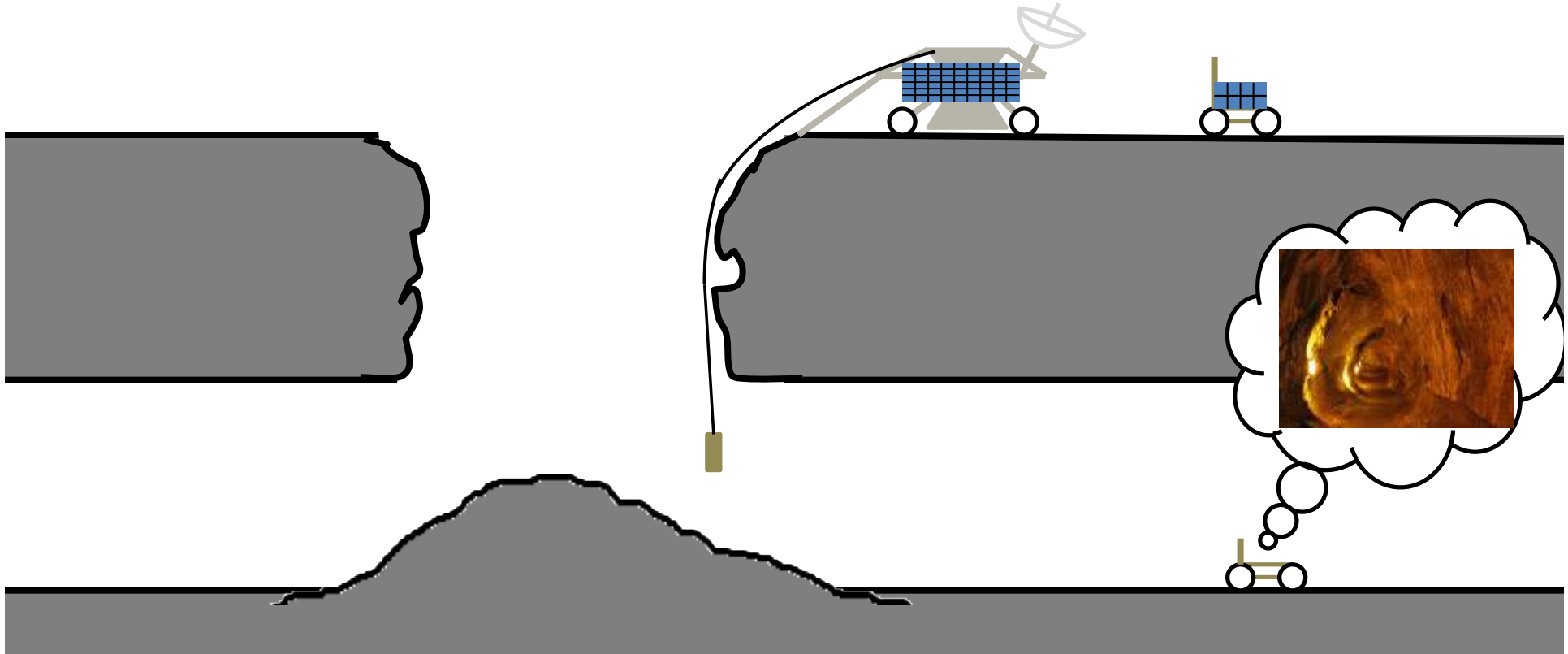


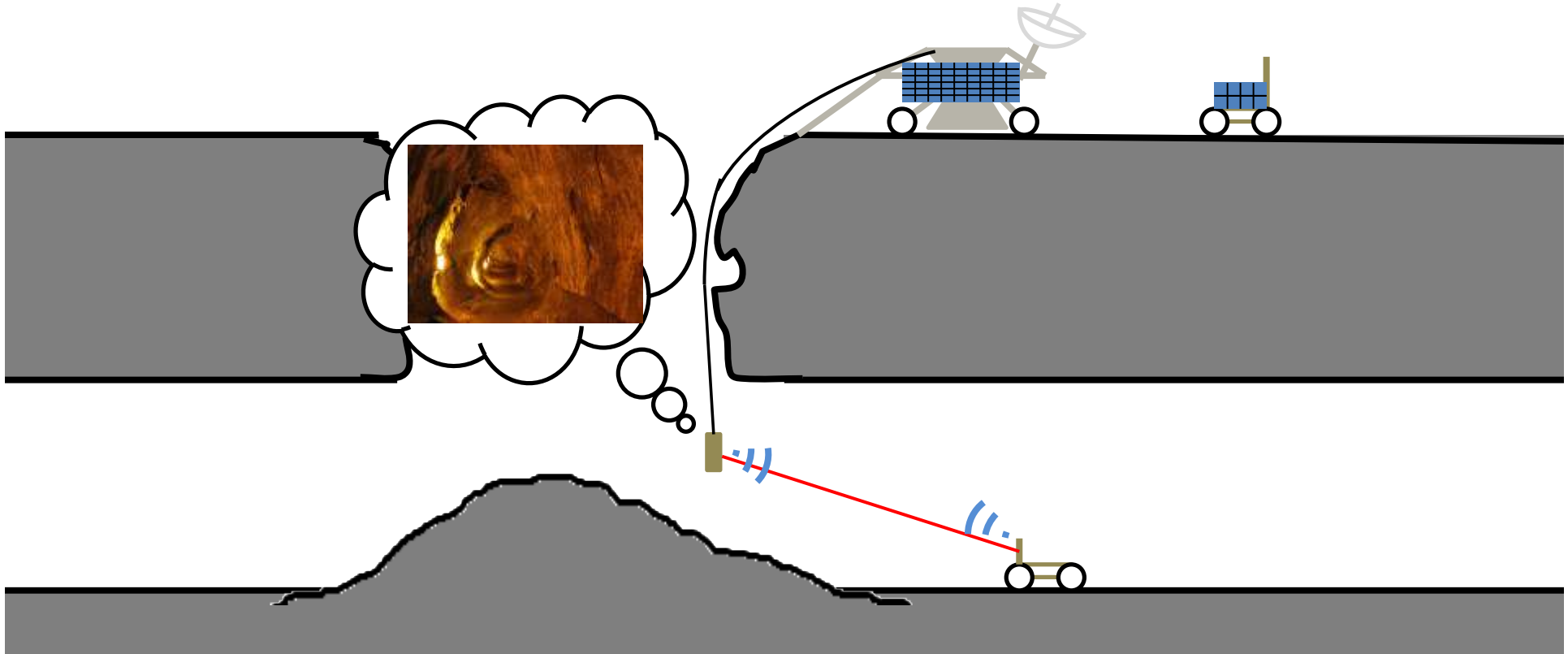


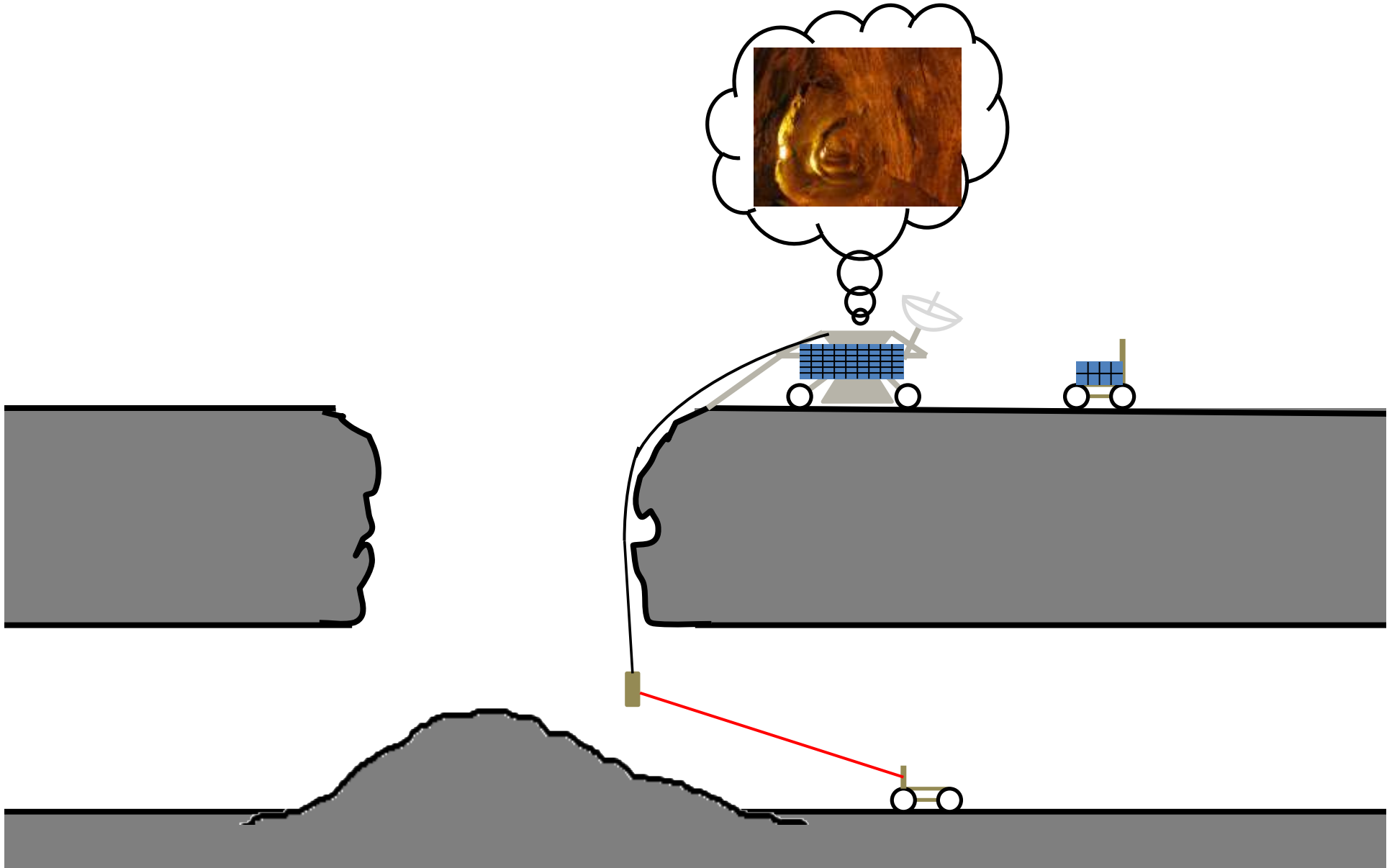


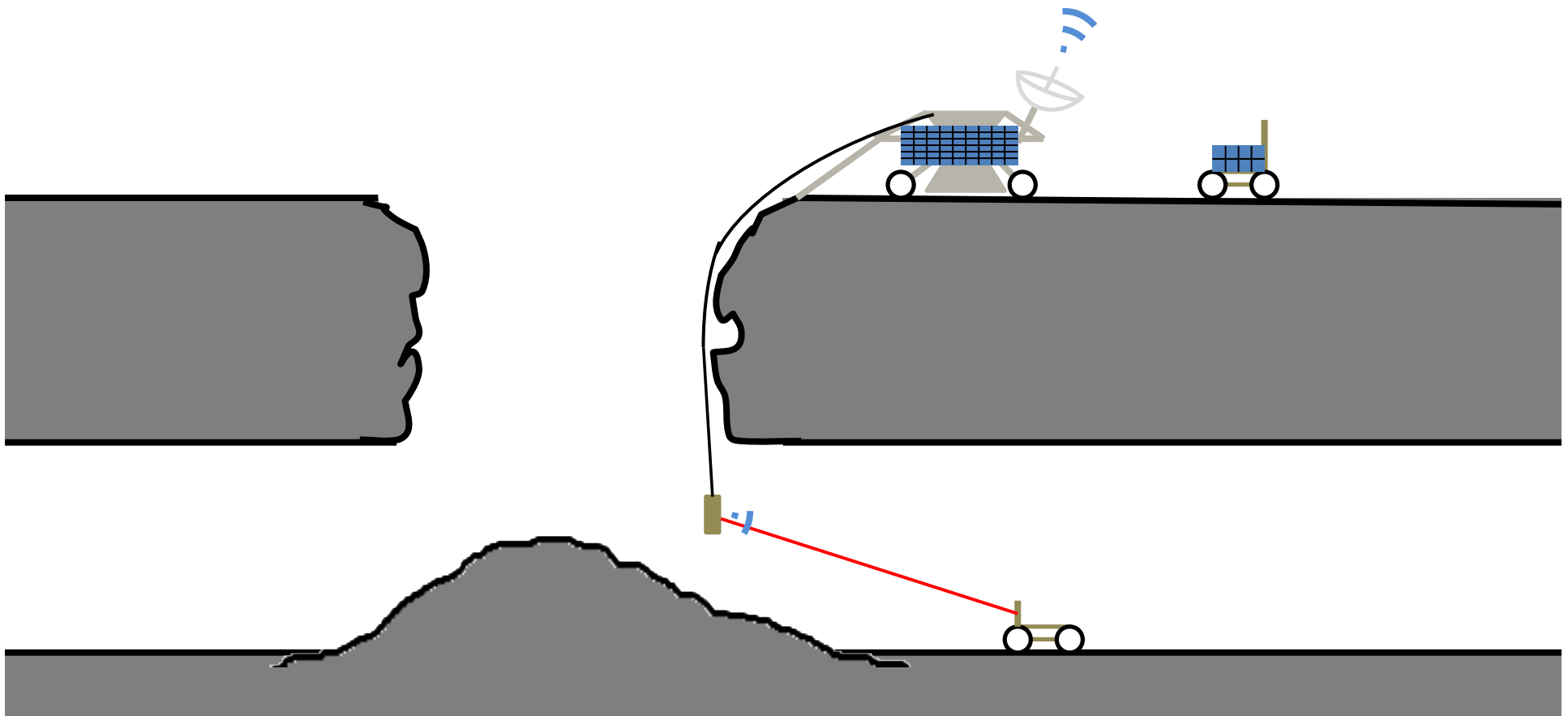












Challenges:

- NASA is scared of slopes > 30°. And of blocky terrain.
- Caves are very blocky terrain with commonly vertical entrances.
- SpaceX, Mars Society, Ansari, Branson, Bezos, Bigelow, Allen…
- Caves are not everywhere. More difficult, higher altitude landing sites to be expected.
- Horizontal entrances even more sparse and hard to detect from orbit.
- A lot of interested people, but little coordination. Critical mass? $?

4TH PLANET LOGISTICS

Our overarching goal is to create and test various habitats from naturally occurring terrestrial lava tubes analogous to the Moon and Mars. The advantage of this approach is that it reduces the amount of construction materials required to be placed in orbit and then relocated on a lunar and/or martian surface. Currently, 4th Planet Logistics' objective is an evaluation of the practicality of pressurizing terrestrial lava tubes directly by creating atmospheric barriers that utilize the lava tube's naturally occurring regime as a primary or secondary structural shell. This approach will involve the use of 3D printable, locally derived, geological materials and complementary robotic assembly techniques.

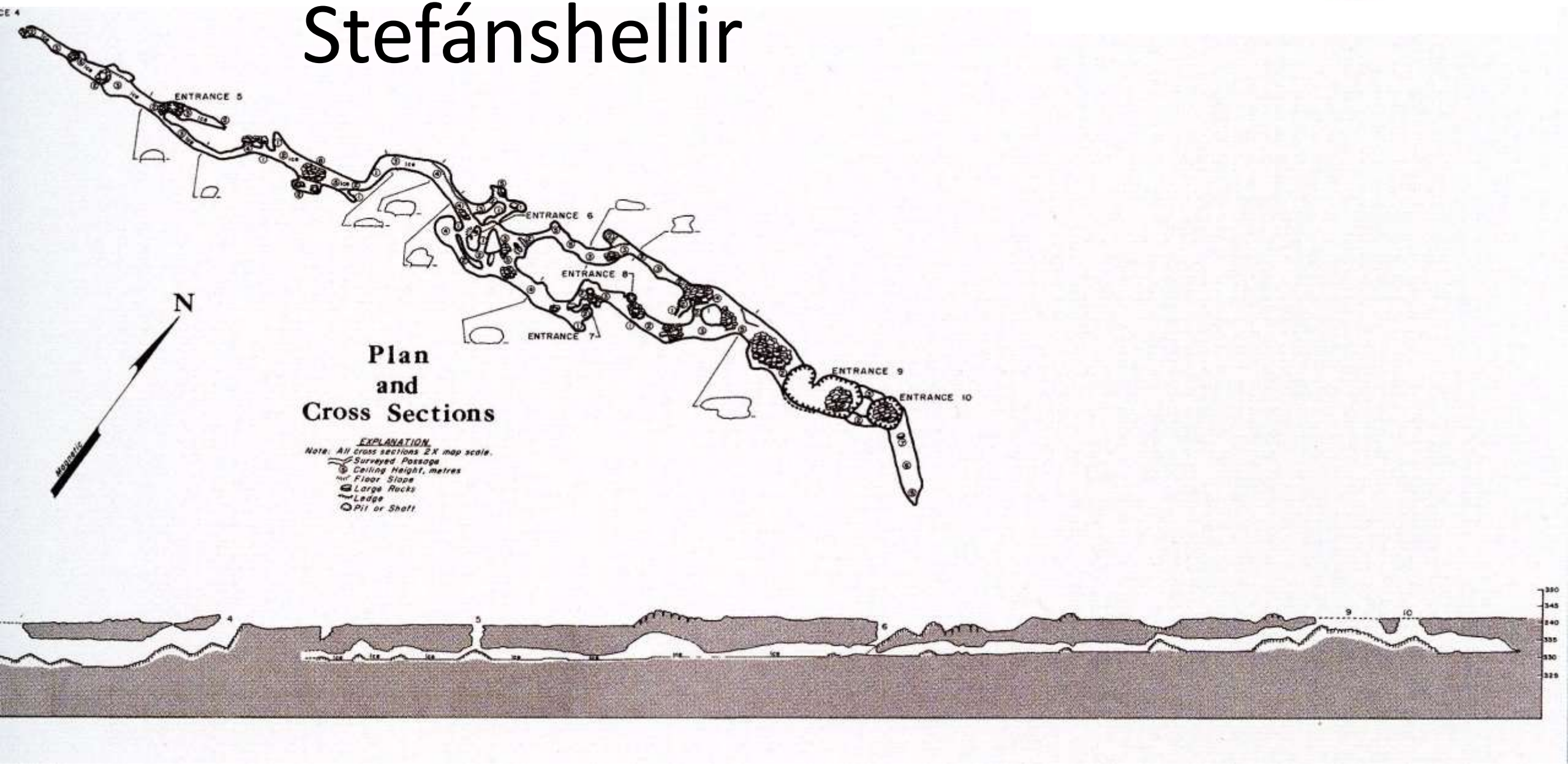
4th Planet Logistics' principal customer-base are organizations, institutions and companies involved in commercial and/or governmental efforts to return to, and establish, long-term outposts on the Moon and eventually on Mars. Our secondary market includes underwater research facilities, mine rescue operations and portable, pressurized emergency medical facilities for both military and civilian application.

4th Planet Logistics also offers consulting and field testing regimes designed to assist various organizations in evaluating prototype product development for application for off-planet or other hostile environment application. 4th Planet Logistics' competitive dominance resides within its unique ability to implement a multidisciplinary laboratory facility and field-based approach to cutting edge technical and engineering challenges that are associated with living in extreme environments on Earth, the Moon, Mars and beyond. 4th Planet Logistics encapsulates these capstones by ensuring project expenditures remain cost effective and by offering professional services that allow companies to undertake extensive field tests in extreme regimes without incurring the expense needed to duplicate our expertise. 4th Planet Logistics plans to make available, to qualified, partnered organizations, access to a low pressure test chamber that can be incorporated within the confines of an analogue lava tube.


NASA

NASA / NOAA GOES Project

Stefánshellir



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4TH PLANET LOGISTICS

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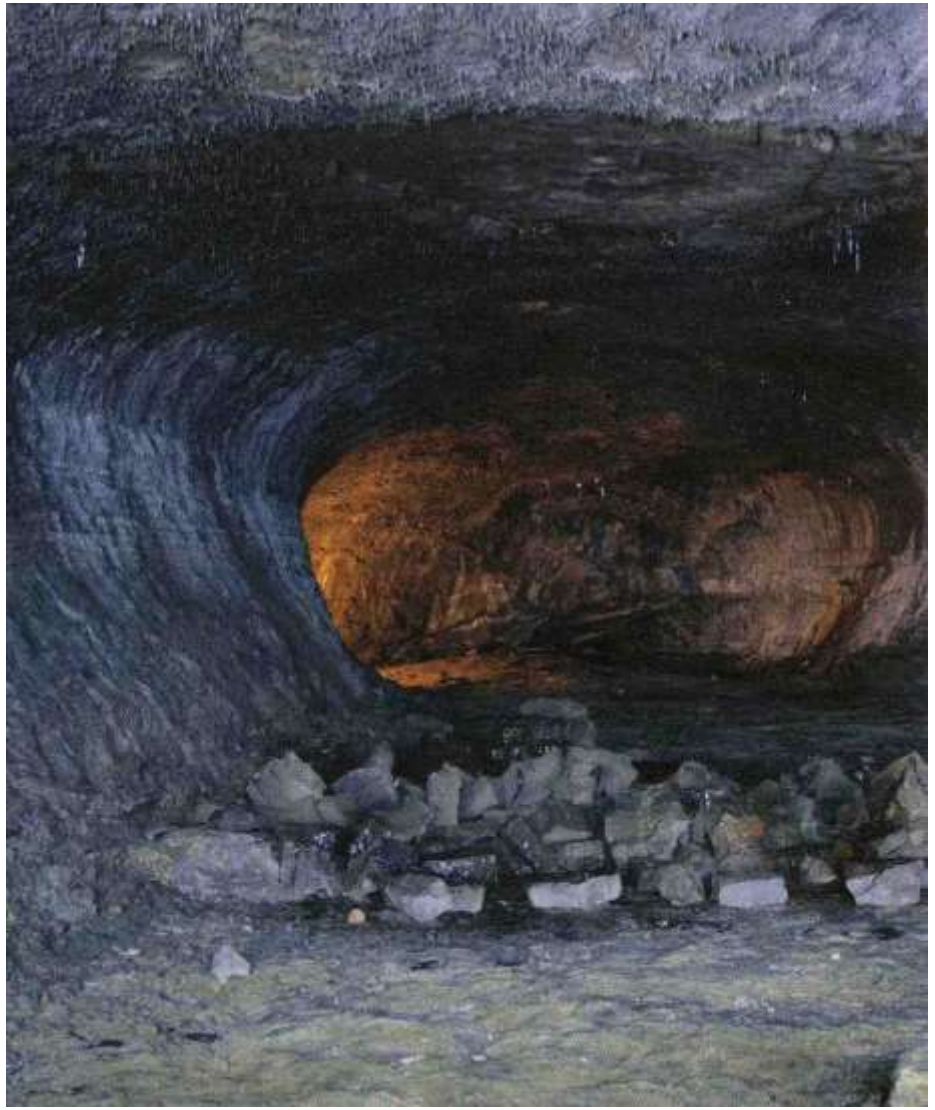

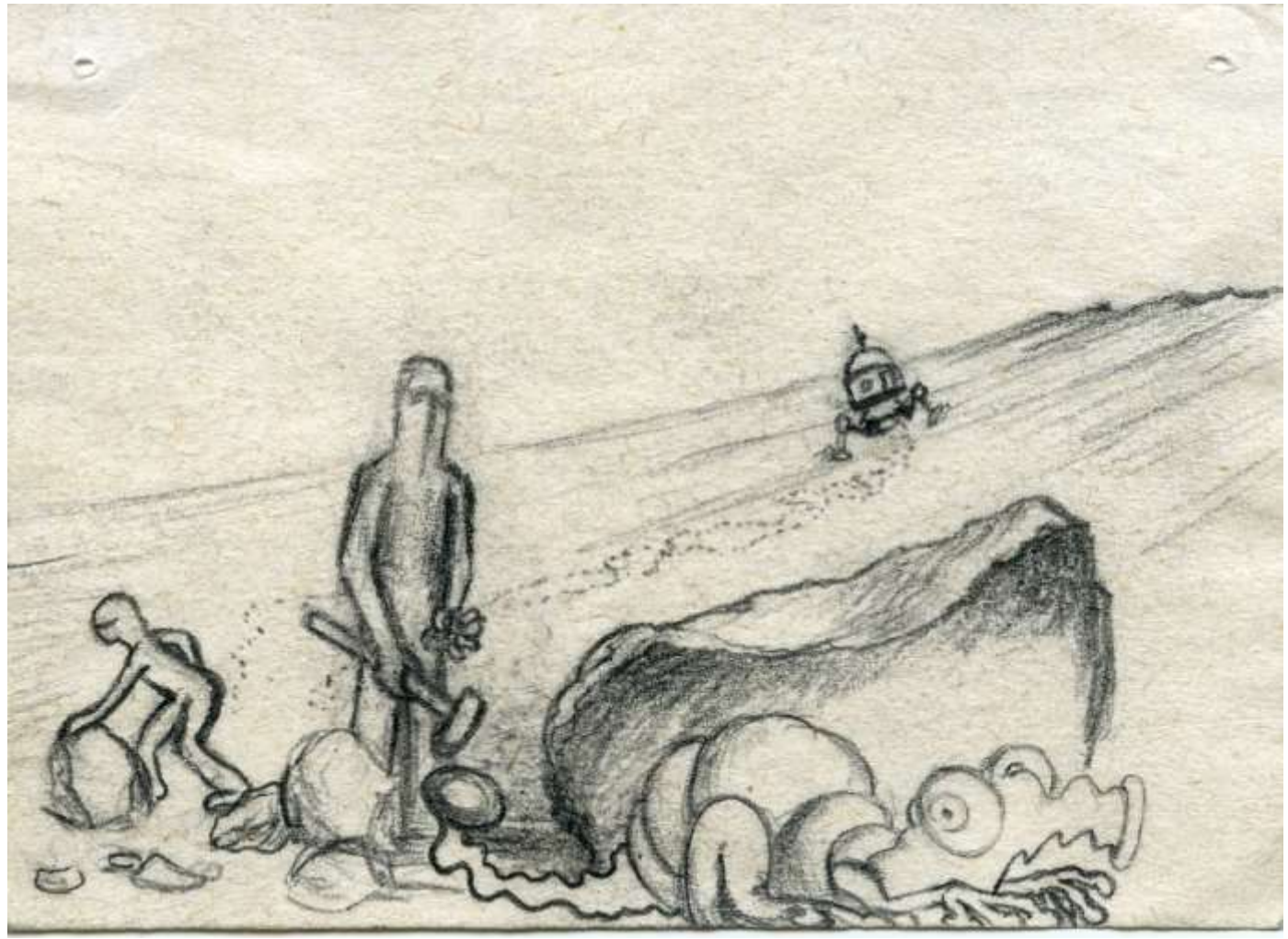

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