

Lunar lava tube and its skylight hole

Junichi HARUYAMA

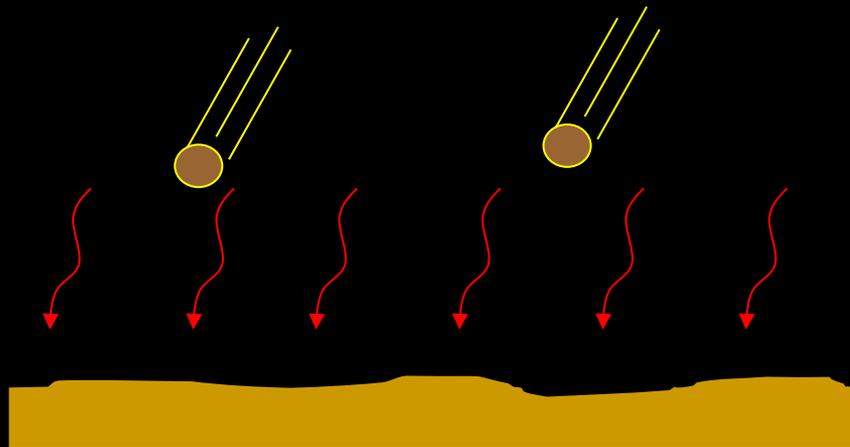
Japan Aerospace Exploration Agency (JAXA)/
Institute of Space and Astronautical Science (ISAS)



The Moon is the nearest celestial body to the Earth.

It is needless to say that the Moon is the first step for humans to go to the space.

The environment of the surface of the Moon is harsh.



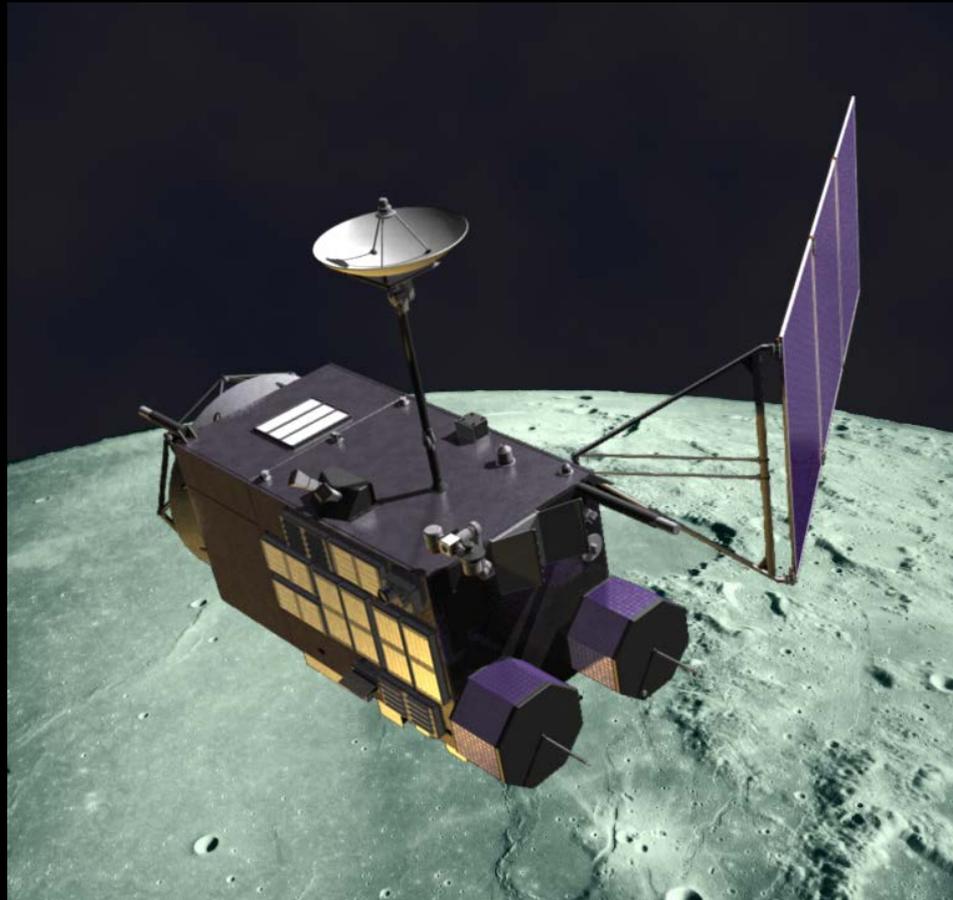
	Micro meteorites	Temperature	Radiation
Surface	× Problem requiring a several centimeter	× Terrible Wide range oscillation : -150°C to 120°C	× Fatal 4. 2 Sv (max. obs.) requiring a several meter soil coverage

**The environment of the surface
of the Moon is harsh.**

However,

**the time is coming for
humans to return to the
Moon.**

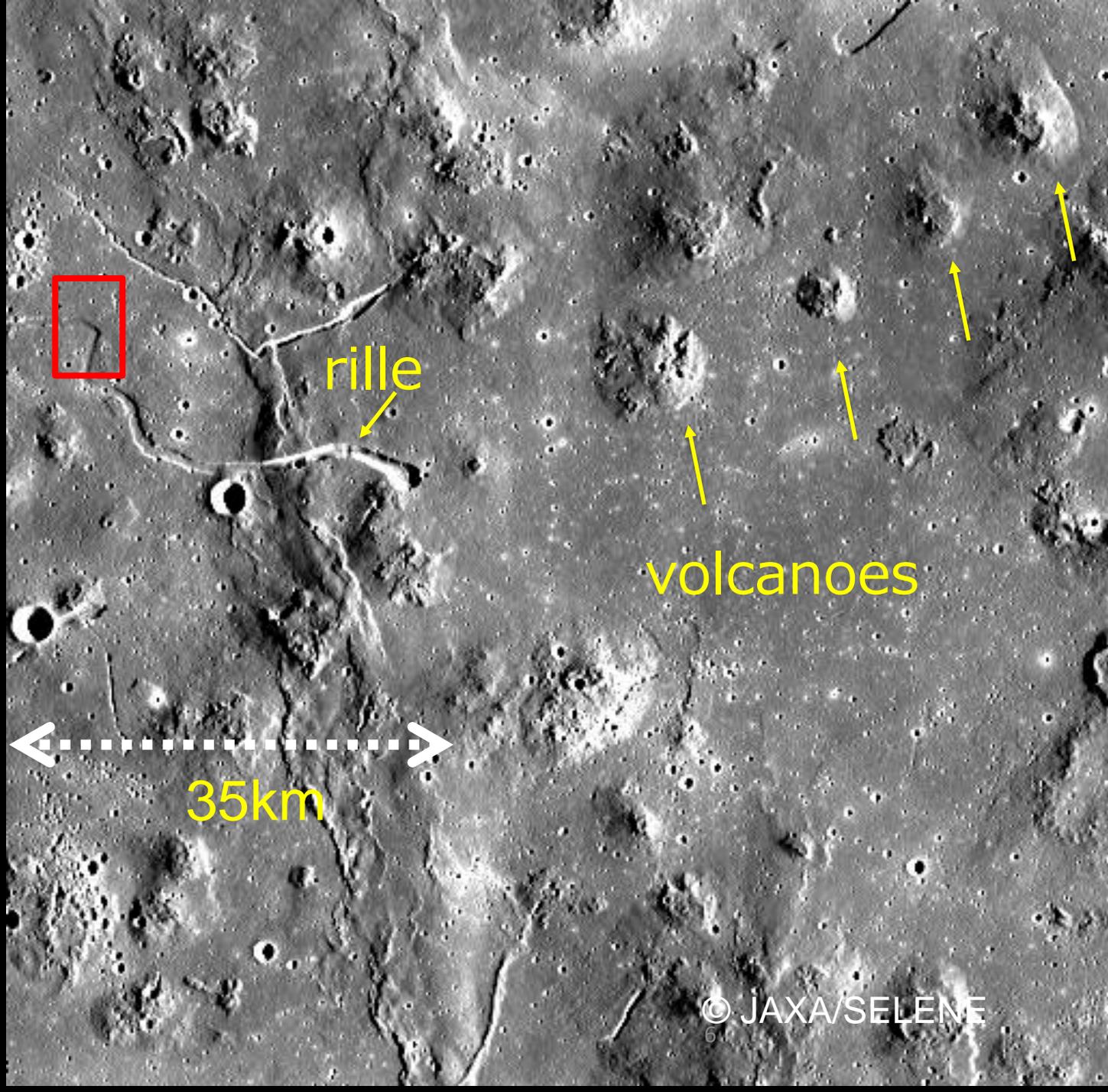
In 2009, SELENE discovered a strange feature on the Moon



©JAXA/ISAS



Marius Hills:
The largest
volcanic
region on the
Moon



Discovery of A Huge Hole

SELENE/TC data



Diameter 50m

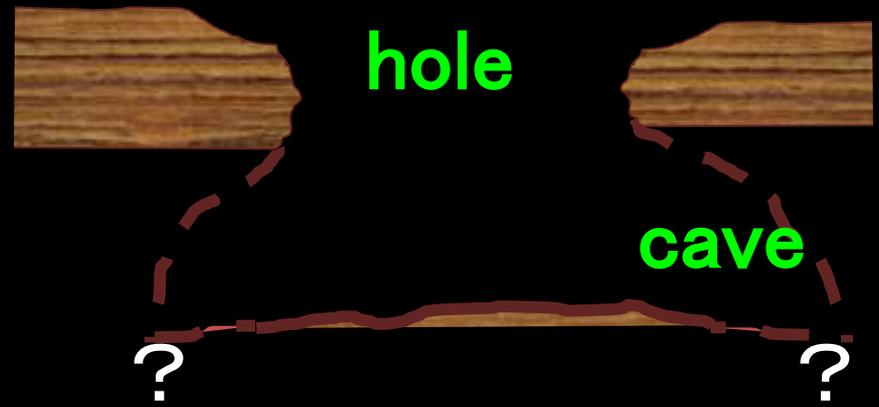
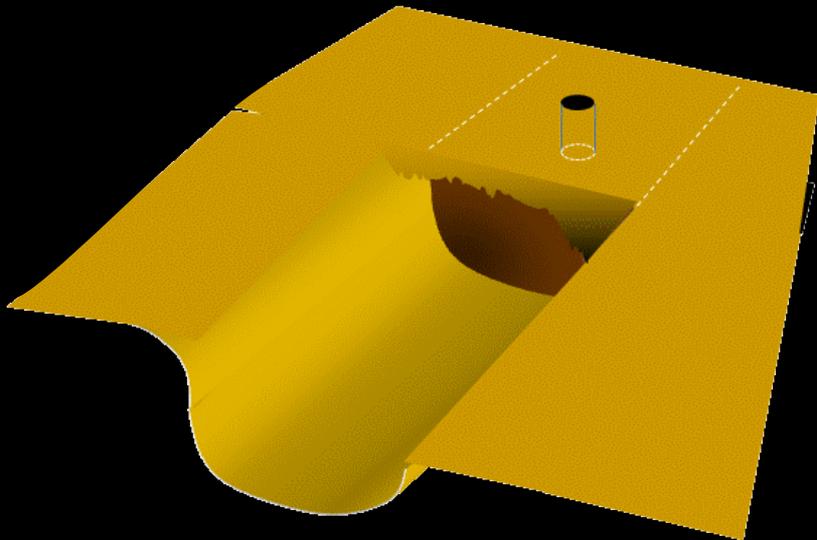
~1.5km



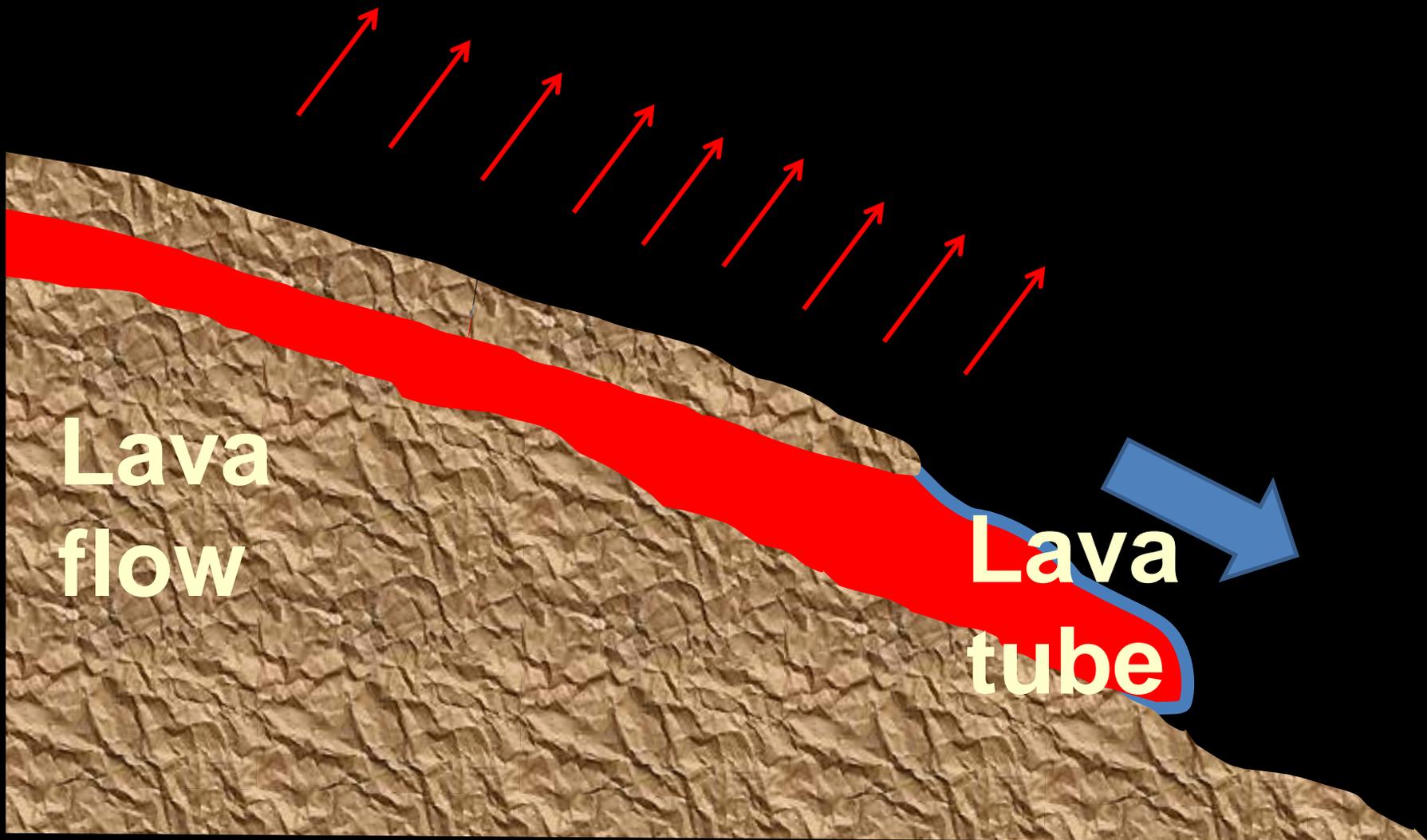
after Haruyama *et al.* (2010) © JAXA/SELENE

Are the Huge Holes the Skylights of Lava Tubes ?

The lunar hole is possibly a skylight of a cave like **lava tubes**.

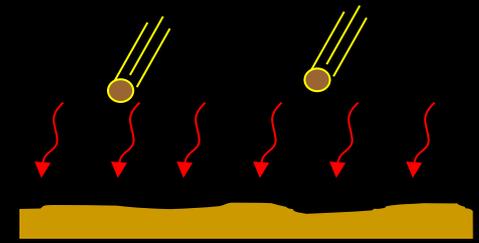


What is lava tube?



**Lava tube is a good
shelter on the Moon.**

Safe and Comfortable Lunar Lava Tube



	Micro meteorites	Temperature	Radiation
Surface	× Problem requiring a several centimeter	× Terrible Wide range oscillation : -150°C to 120°C	× Fatal 4. 2 Sv (max. obs.) requiring a several meter soil coverage

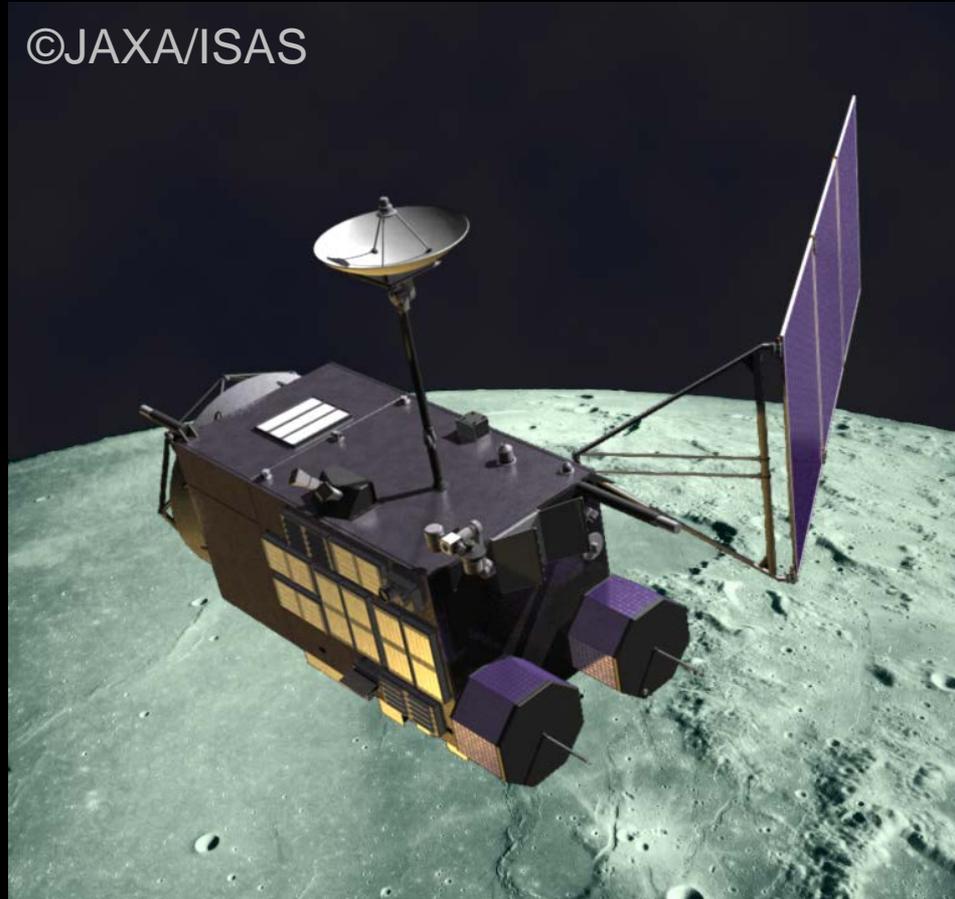
Courtesy of Shinoda

We discovered the entrance of a
subsurface **safe** area !

Komakado Kazaana
In Japan



SELENE discovery of huge holes



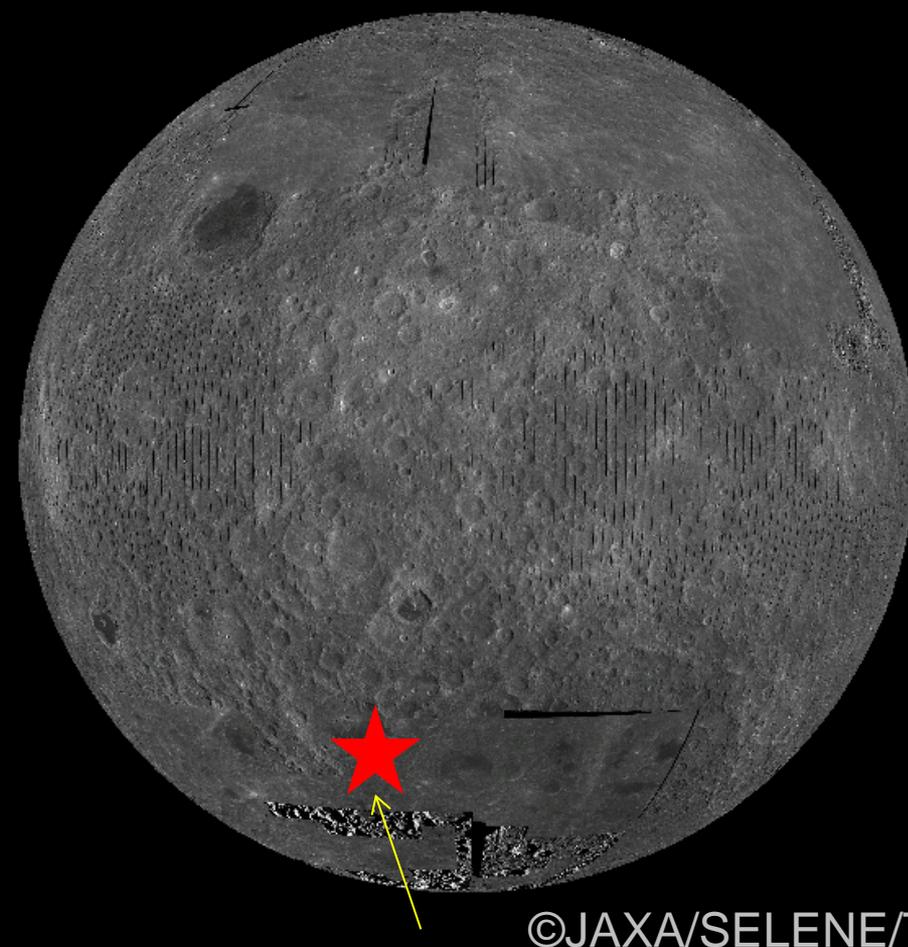
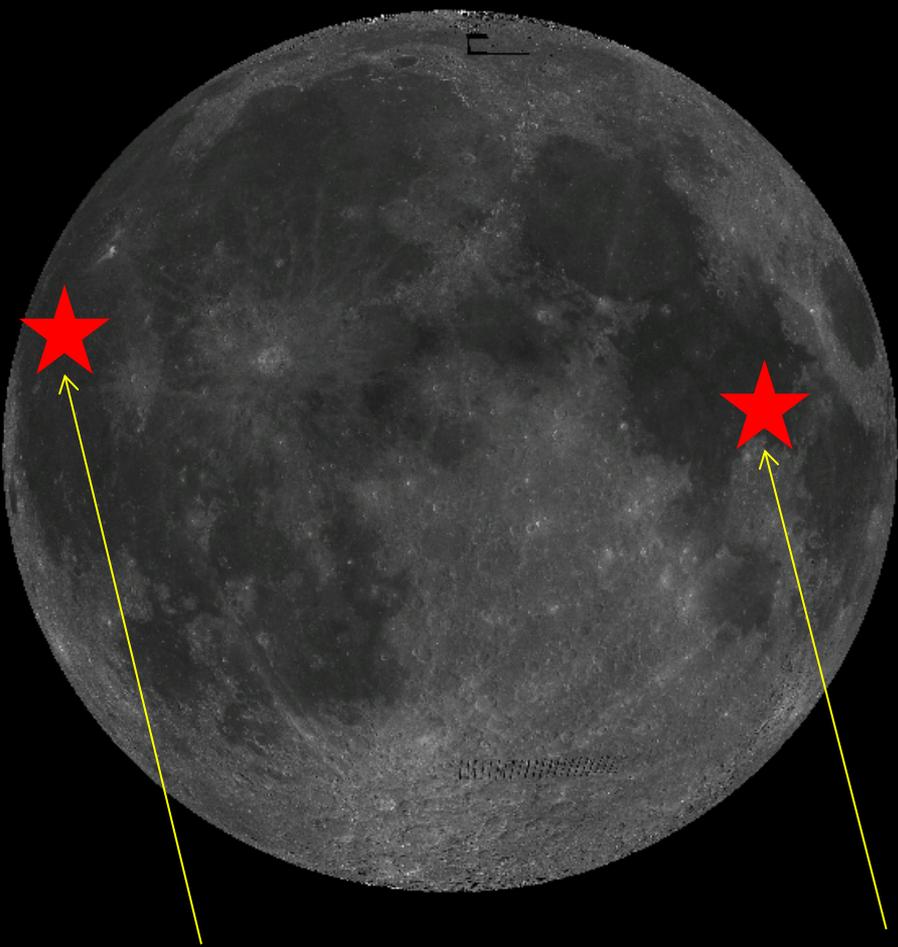
SELENE (Kaguya) discovered **three huge holes** of several 10s of meters in diameter and depth on the Moon.

(Haruyama et al., 2009 GRL, 2010 LPSC)

SELENE discovery of three huge holes

Near side

Far side



Marius Hills Hole

Mare Tranquillitatis Hole

Mare Ingenii Hole

Lunar hole must be skylight of a lava tube

MTH
(107m depth)

100m

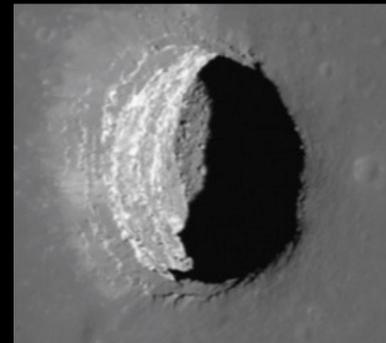
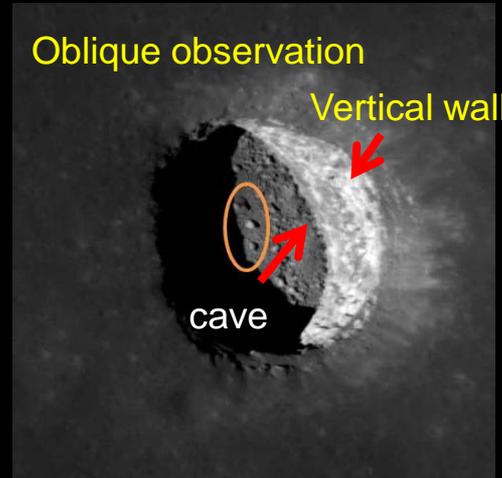
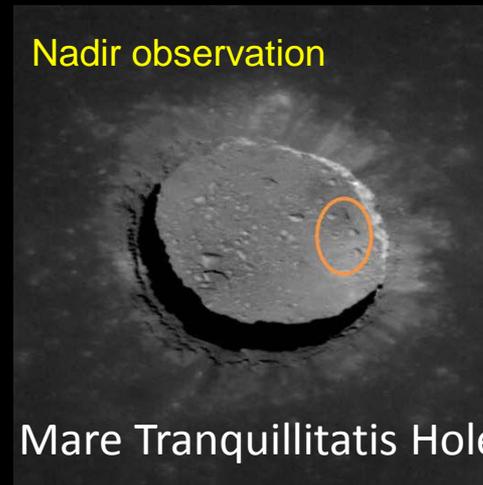
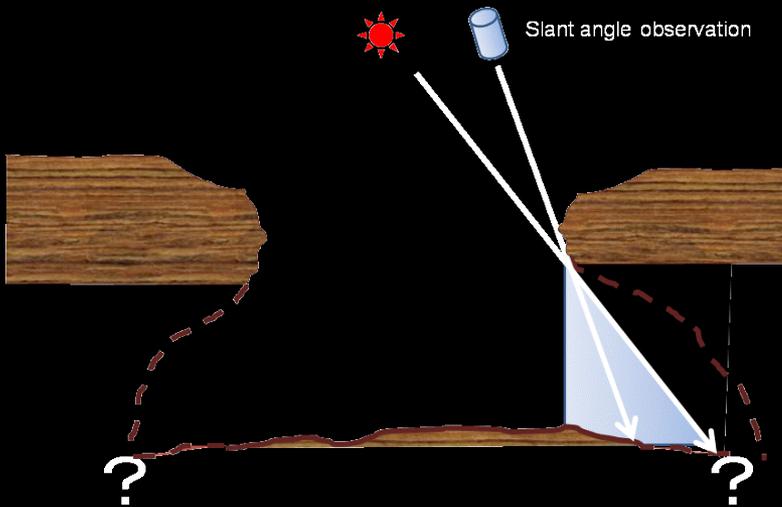
US LRO Camera image data



Lunar hole must be skylight of a lava tube

Oblique observation

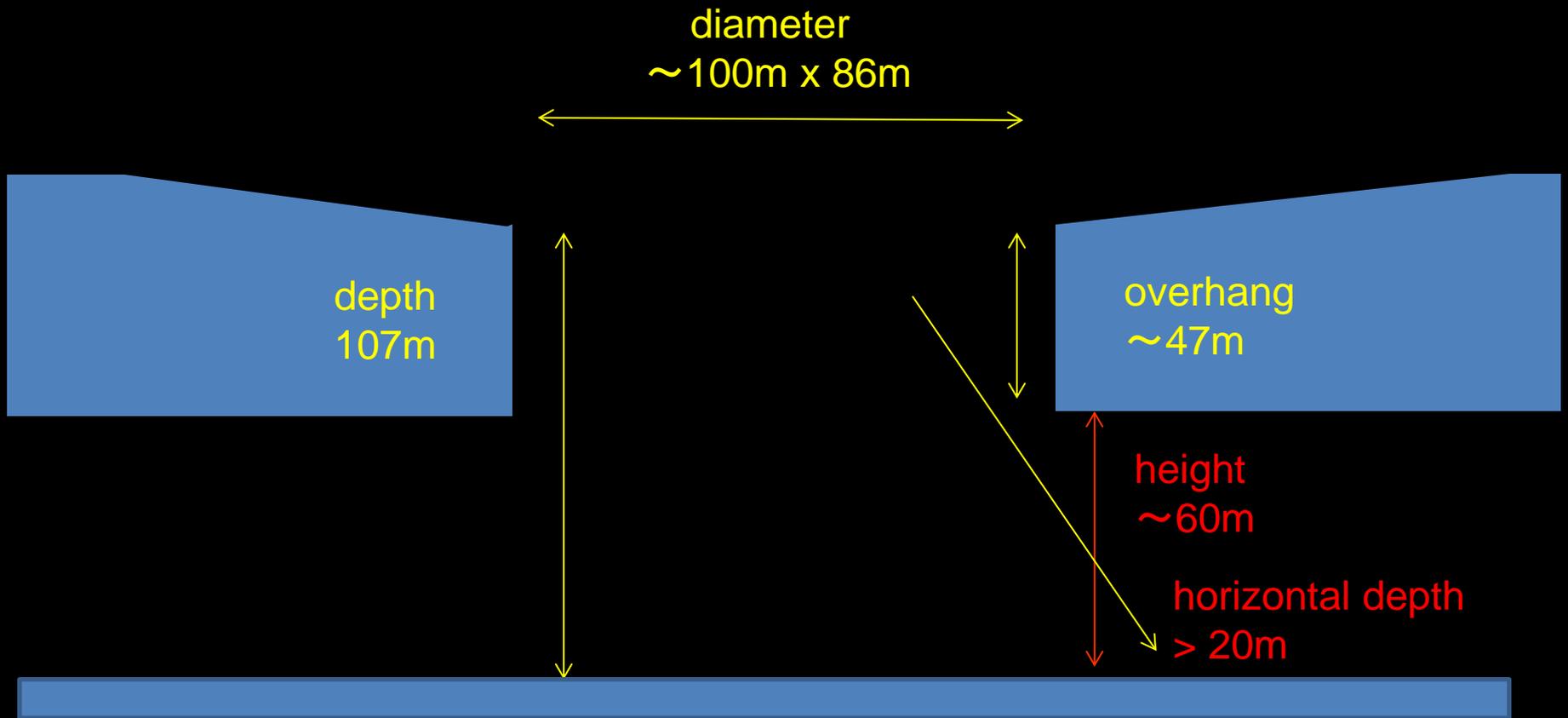
(Robinson et al., 2012, PSS)



Courtesy of Yasuda, 2015

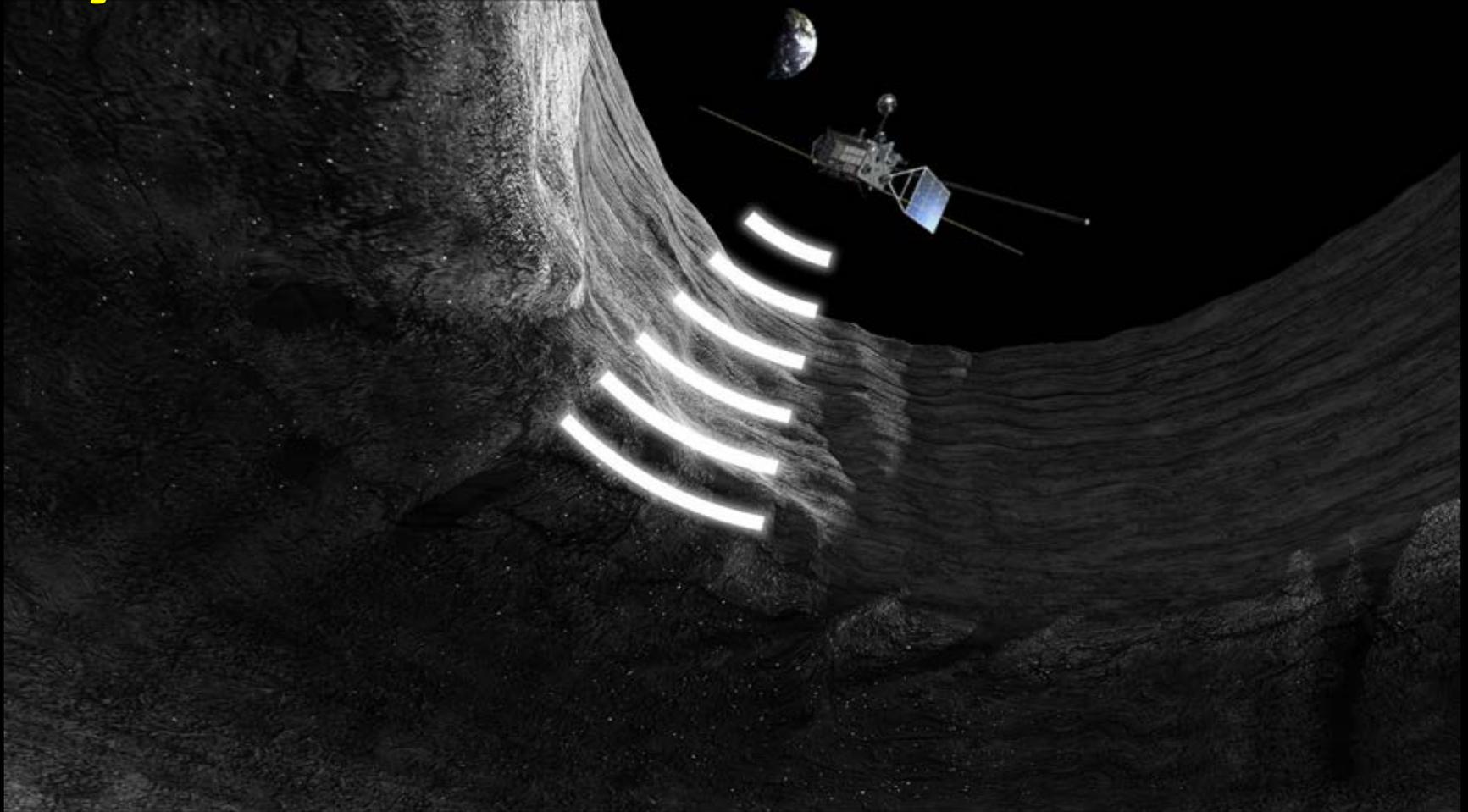
LROC images
(NASA/ASU)

Mare Tranquillitatis Hole

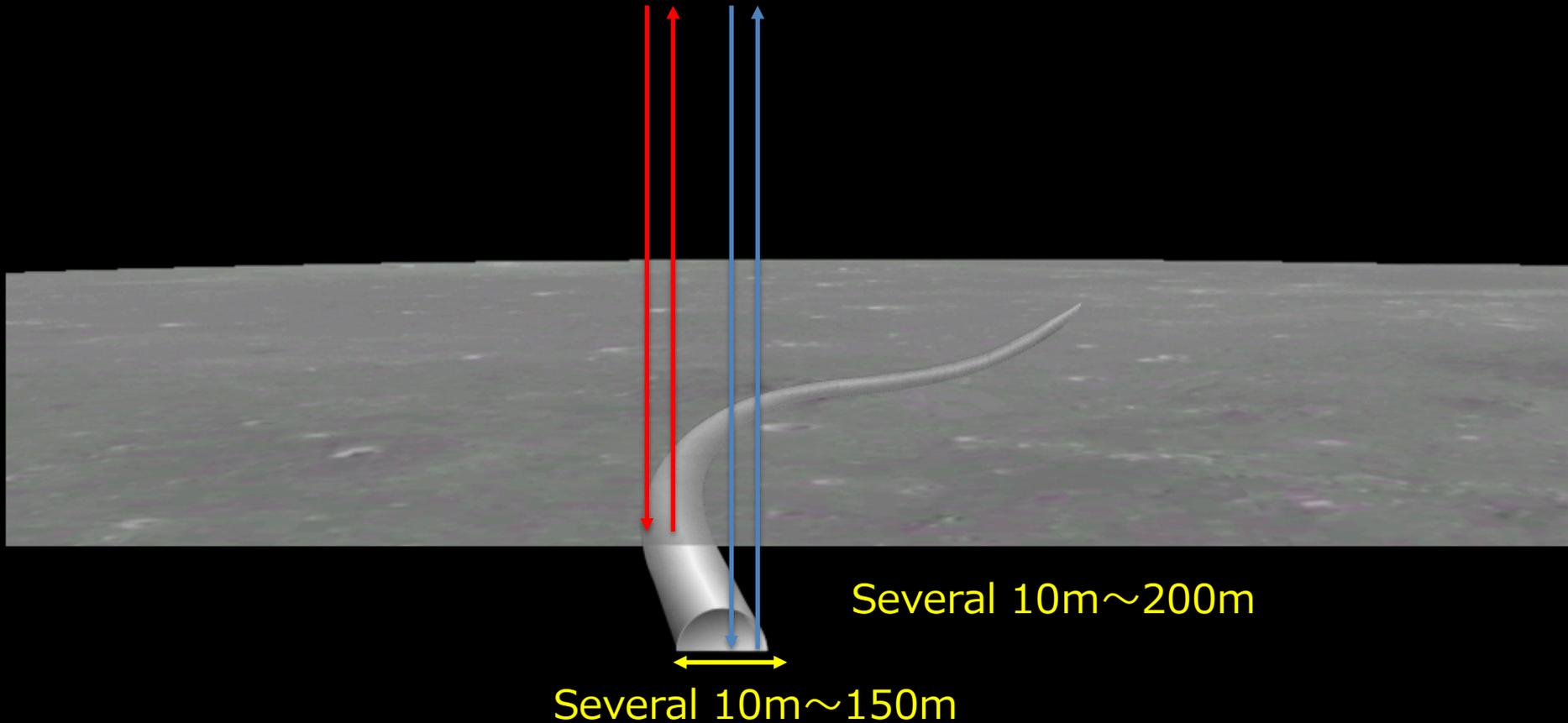
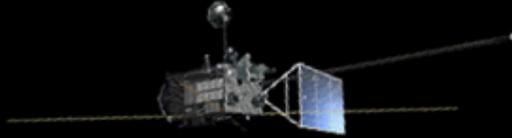


values from Robinson et al., 2012

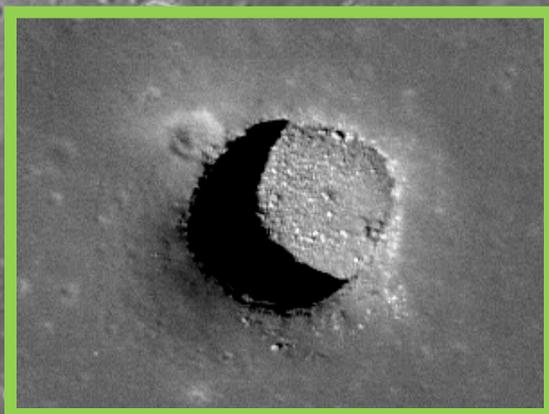
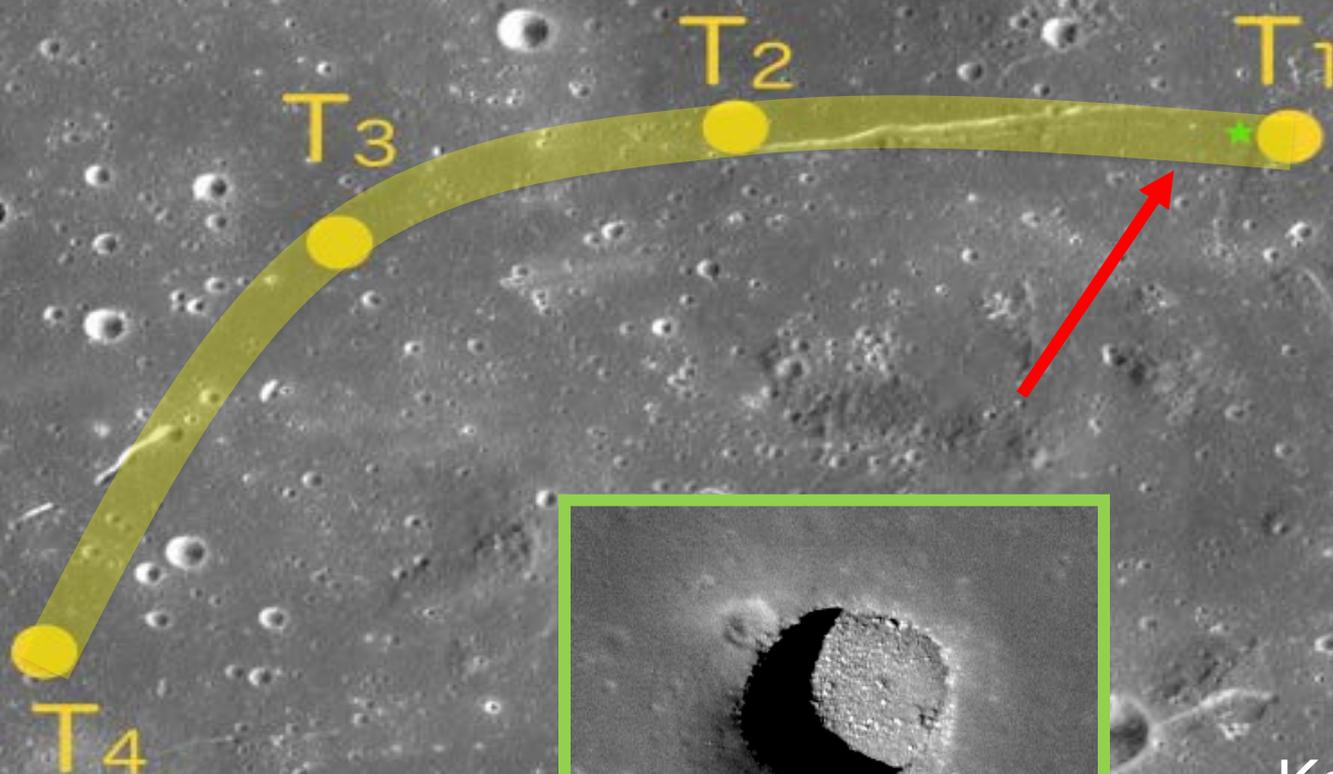
Possible Detection of Lava Tube by SELENE Lunar Radar Sounder



Possible Detection of Lava Tube by SELENE Lunar Radar Sounder



Possible Detection of Lava Tube by SELENE Lunar Radar Sounder at Marius Hills

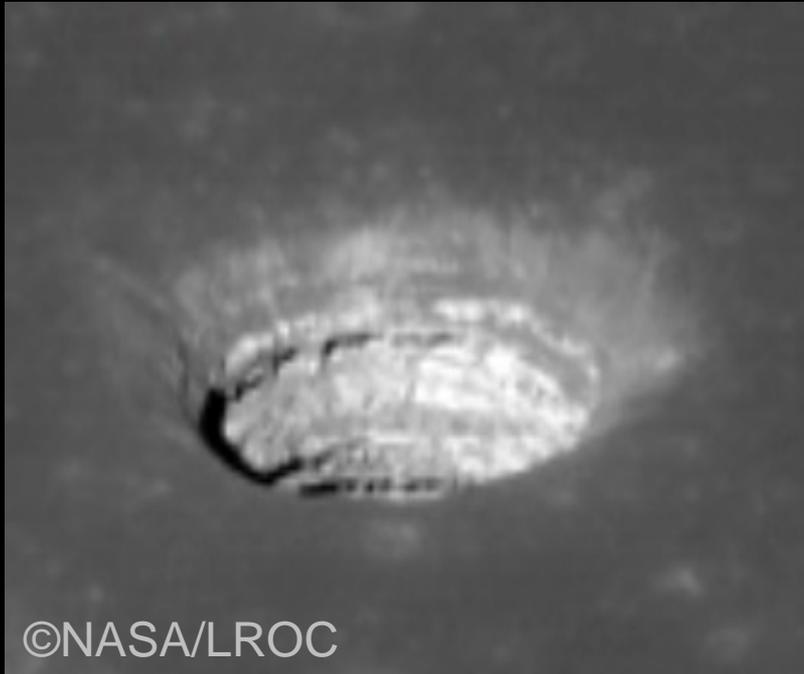


Kaku et al. 2017

Treasure Cave for Science

Treasure Cave for Science

Mare Tranquillitatis Hole by LROC



Mare Ingenii Hole by LROC



The surface was covered by lava,
3.5 billion years ago.

Strata exposed on the wall, telling volcanic history
occurred in very old time.

Treasure Cave for Science



万丈窟 (Korea)
Photo by Shirao

Information of lunar paleo magnetic field will be acquired.

Water may be trapped in rocks forming lava tube.

How about Mars?

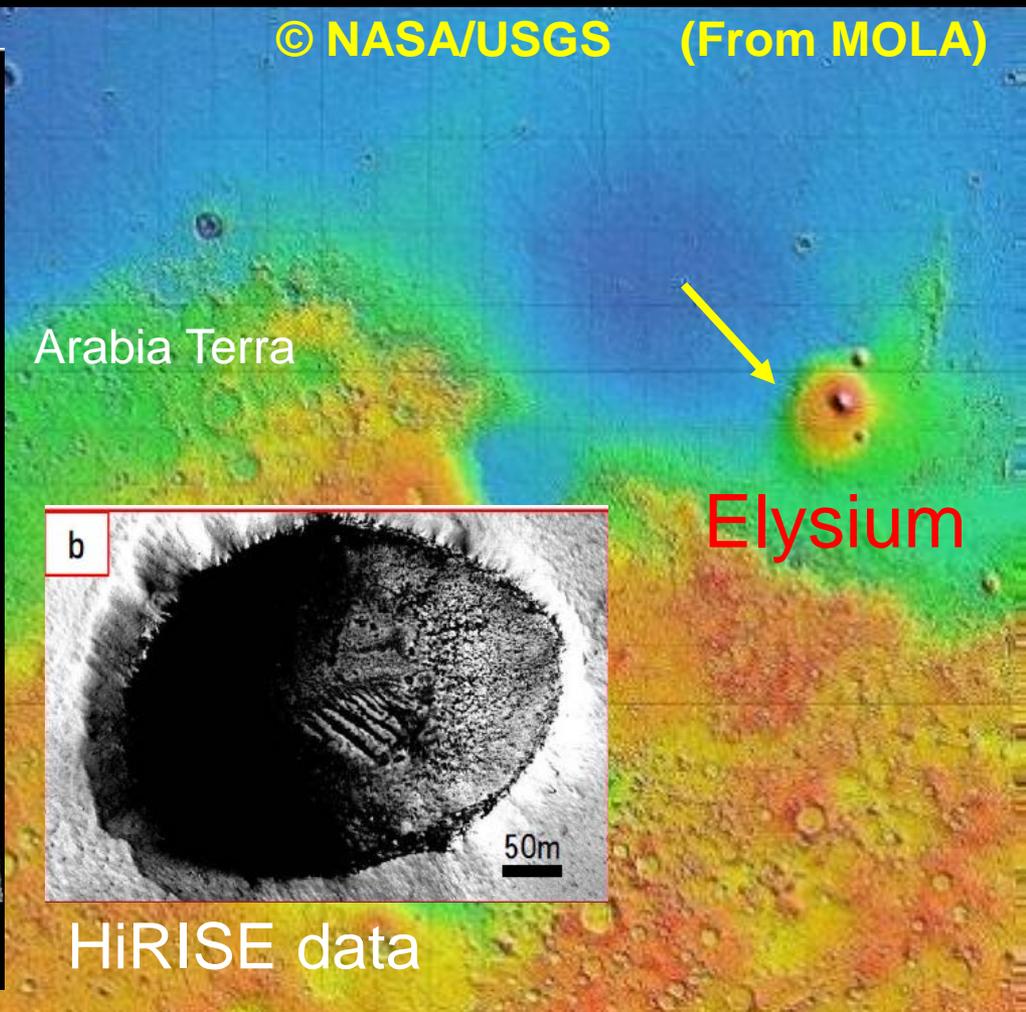
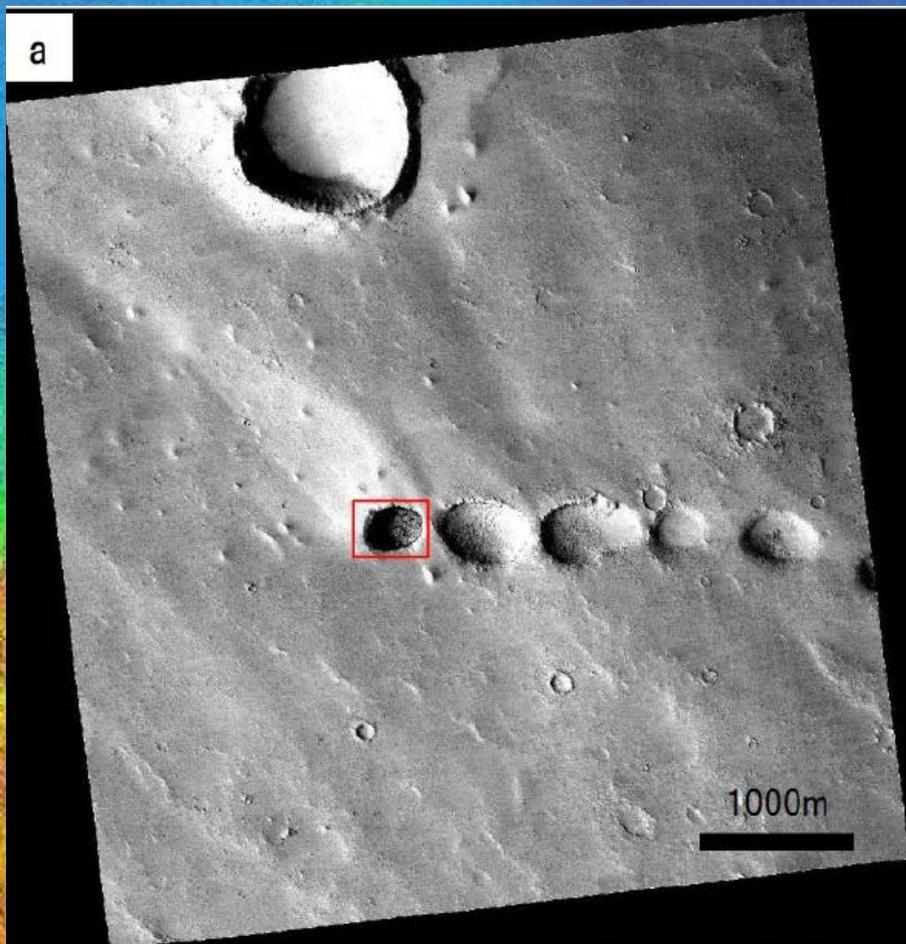


Mars • Syrtis Major • March 10, 1997 **HST • WFPC2**

PRC67.00a • ST (ed. GPO) • March 24, 1997 • D. Crisp (JPL), the WFPC2 Science Team and NASA

Tarsis Montes and Elysium Mons

© NASA/USGS (From MOLA)



In the underworld of Mars, there must be something...

The time is coming;
Humans return to the Moon,

But why will humans return to the Moon?

Is it necessary for humans to
go to the Moon and beyond?

From my experience as a researcher in
space exploration, I believe so.

2011. 3. 11



© Iwate quake disaster archive, Miyako-city



© Iwate quake disaster archive, Miyako-city

Science tells us such a cataclysmic disaster occurs one time per 1000 years.

But who was living there had imagined it would occur on the day after a peaceful day?
We should prepare against any natural disasters.

Nature is not always kind to humans.



**Humans will go to the Moon
and beyond**

**to prepare against natural disasters, and
to know this world from various aspects.**

**Going to the Moon and beyond
will face many difficulties.**



One country can not achieve it alone.

**Many nations, many people will need
to cooperate.**

**Then, we will recognize that
we can realize the world without
border.**

End