

# **Lunar lava tube and its skylight hole**

**Junichi HARUYAMA**

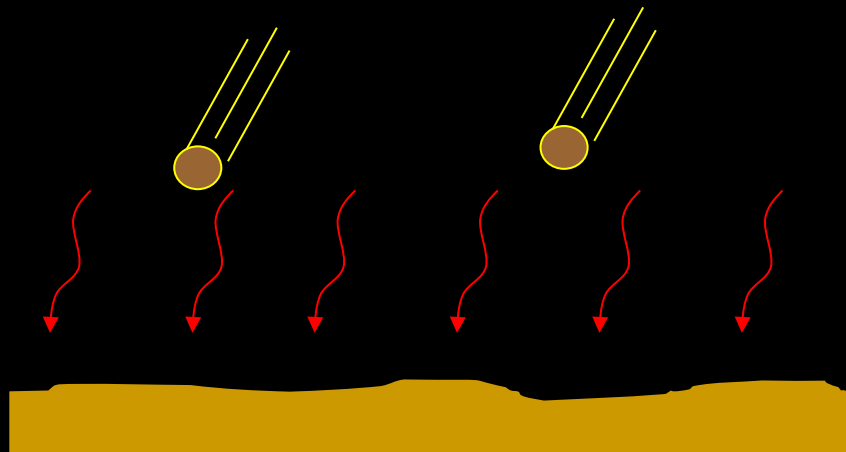
Japan Aerospace Exploration Agency (JAXA)/  
Institute of Space and Astronautical Science (ISAS)



**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.



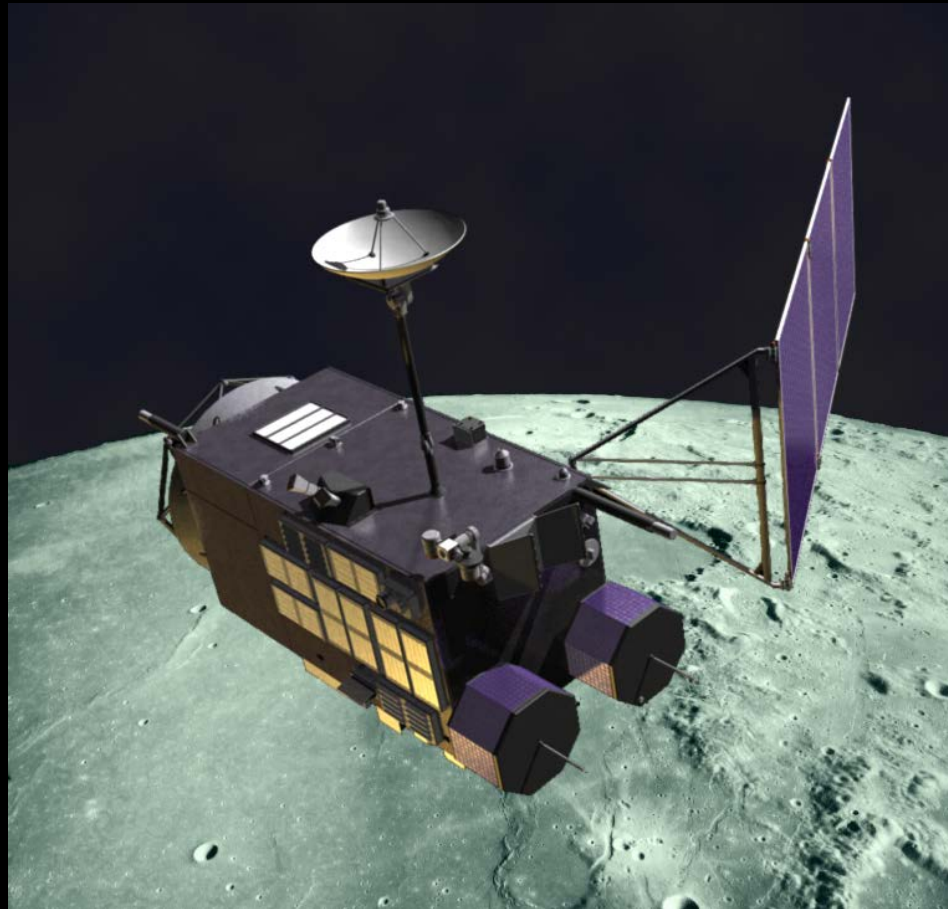
	<b>Micro meteorites</b>	<b>Temperature</b>	<b>Radiation</b>
<b>Surface</b>	× Problem requiring a several centimeter	× Terrible Wide range oscillation : -150°C to 120°C	× Fatal 4. 2 Sv (max. obs.) requiring a several meter soil coverage

**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

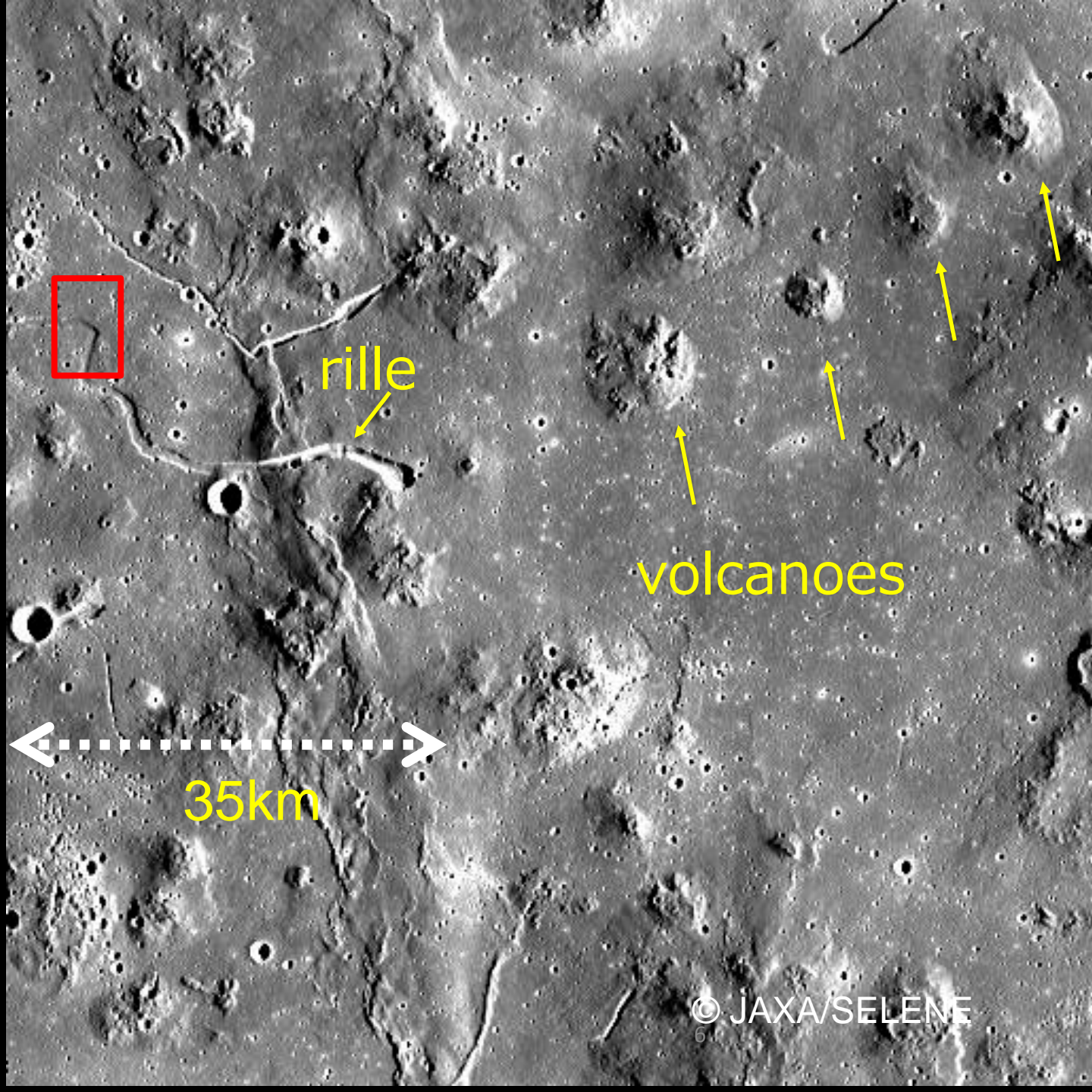


©JAXA/ISAS





Marius Hills:  
The largest  
volcanic  
region on the  
Moon



rille

volcanoes



35km

# Discovery of A Huge Hole

SELENE/TC data



Diameter 50m

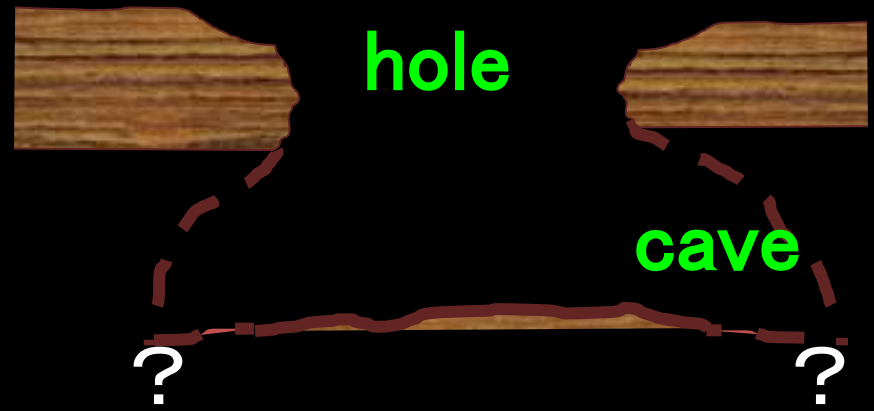
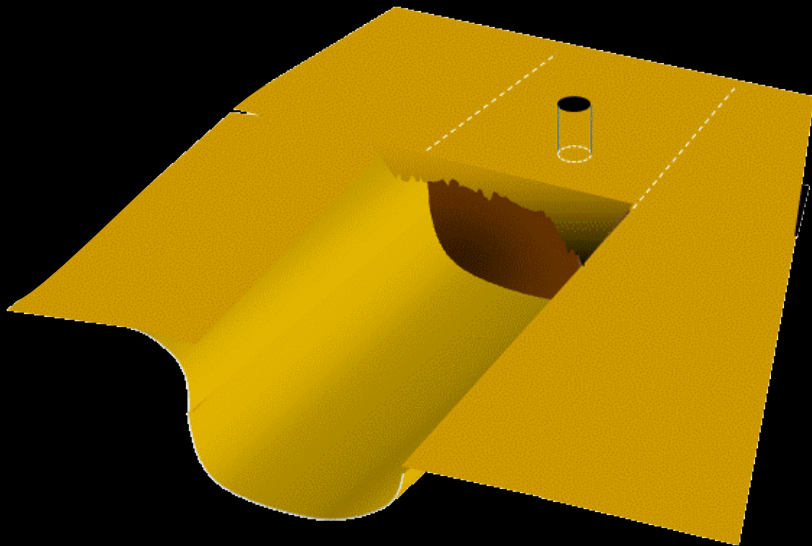
~1.5km



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

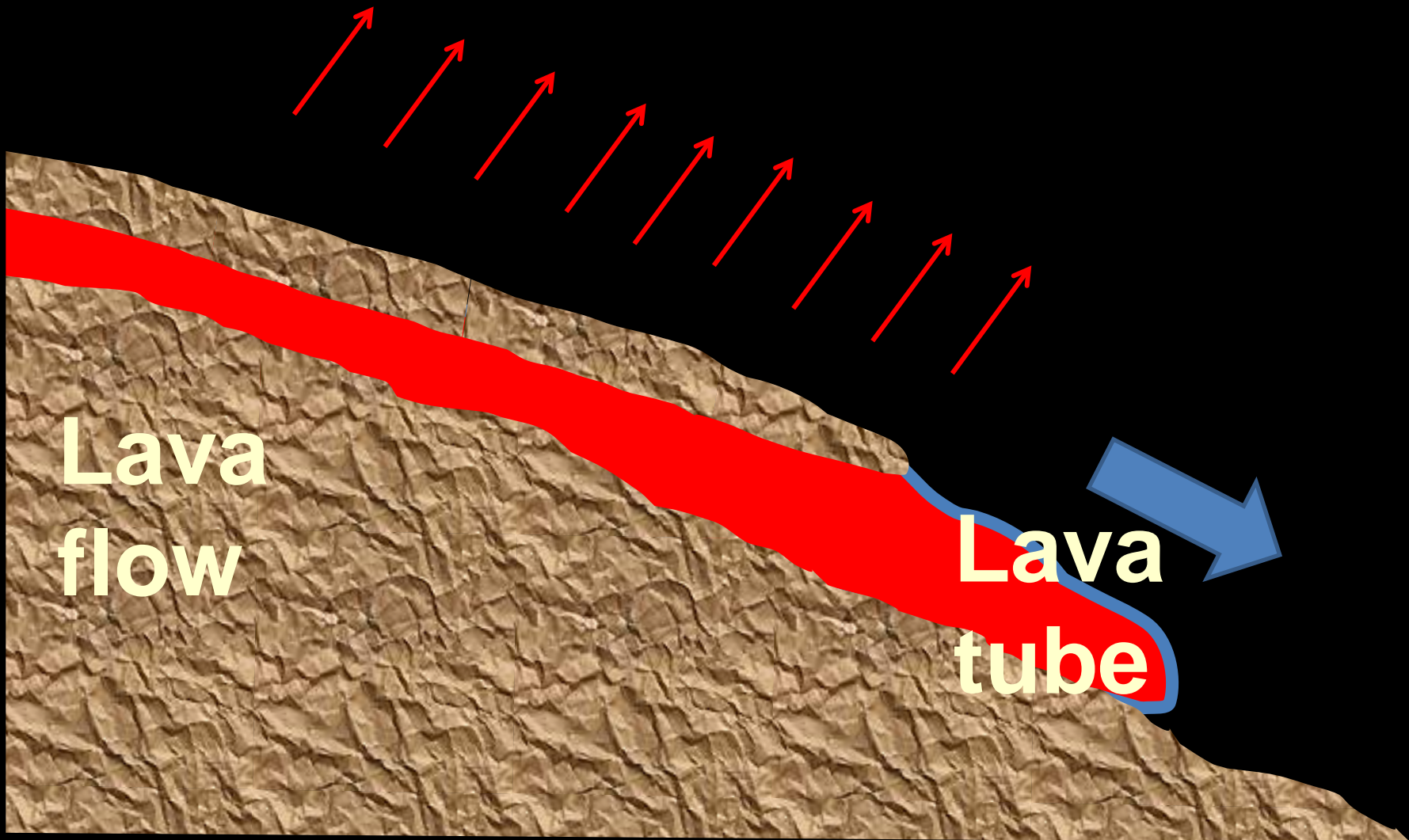
# Are the Huge Holes the Skylights of Lava Tubes ?

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



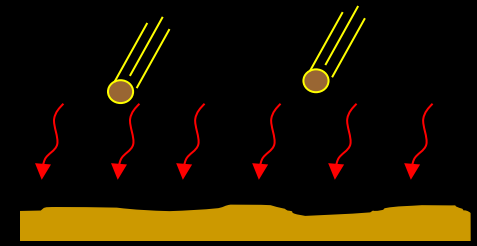


# What is lava tube?



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

# Safe and Comfortable Lunar Lava Tube



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

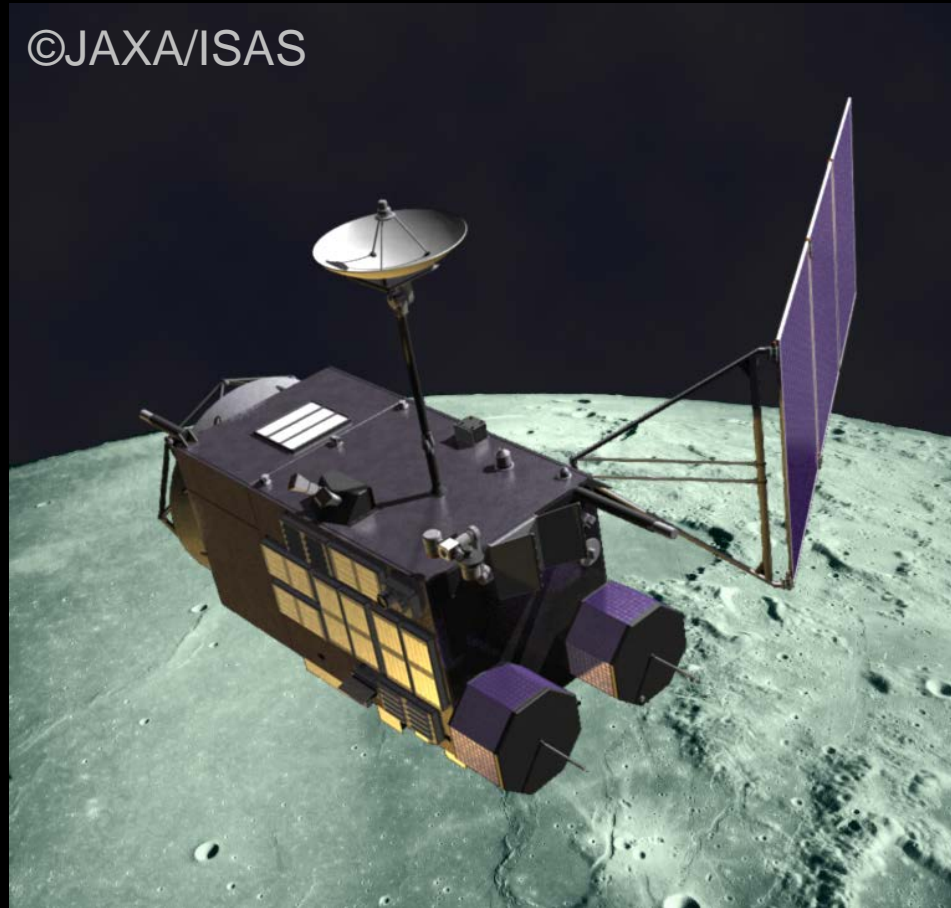
Courtesy of Shinoda

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.

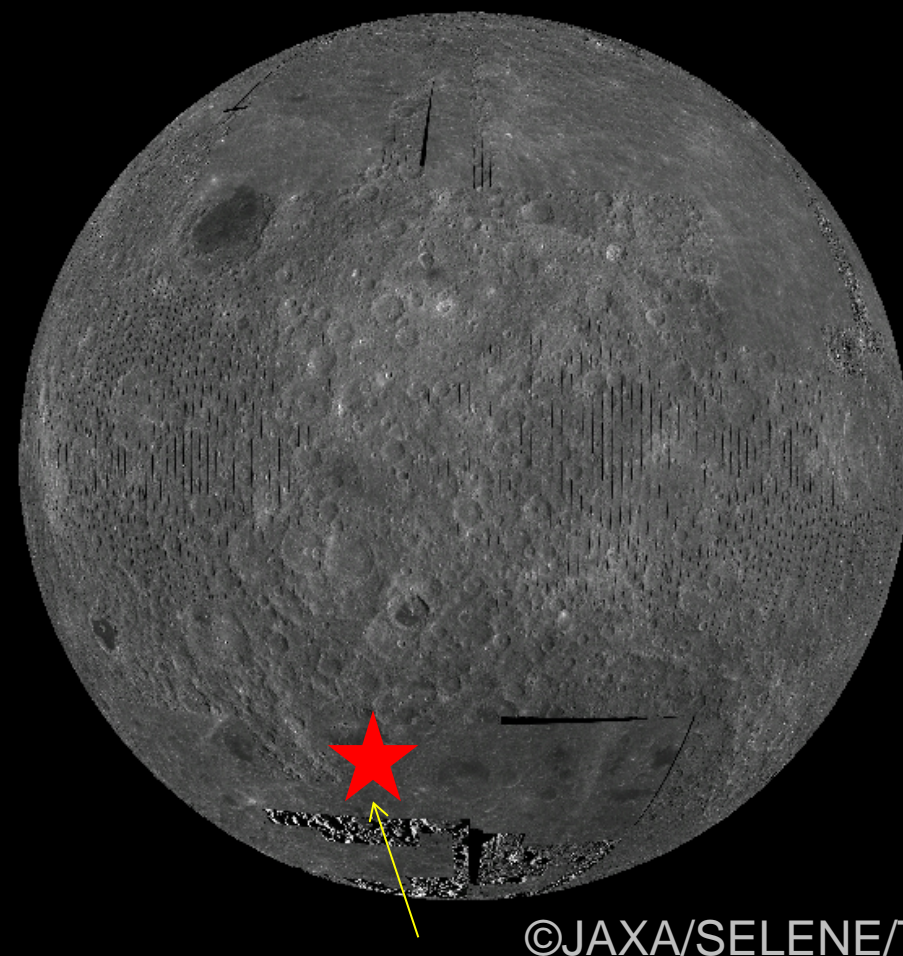
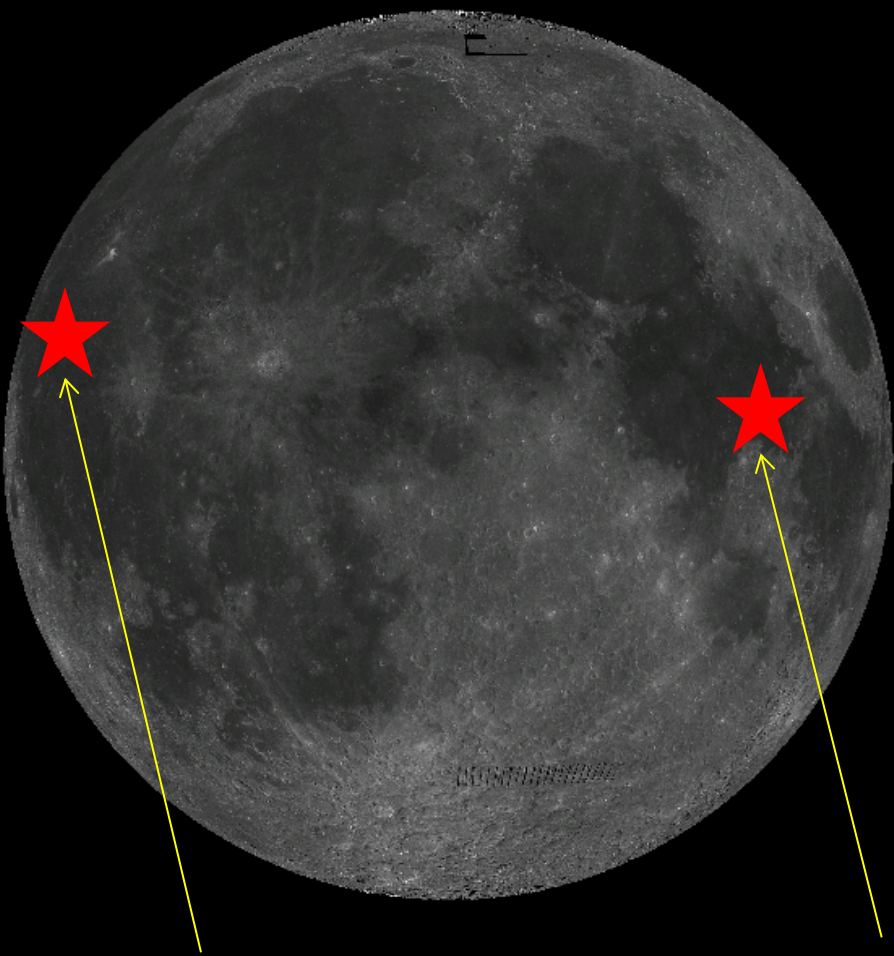
(Haruyama et al., 2009 GRL, 2010 LPSC)



# SELENE discovery of three huge holes

Near side

Far side



©JAXA/SELENE/TC

Marius Hills Hole

Mare Tranquillitatis Hole

Mare Ingenii Hole

# Lunar hole must be skylight of a lava tube

MTH  
(107m depth )

100m

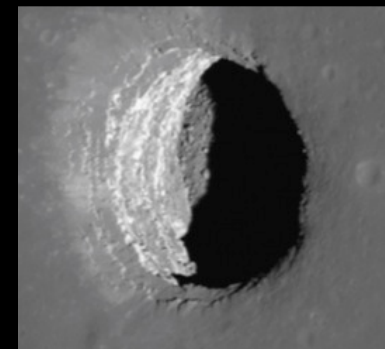
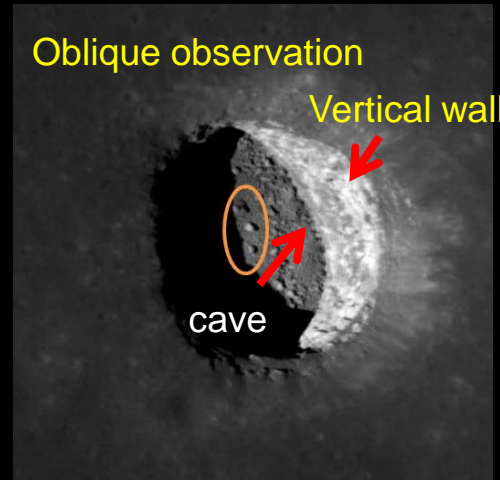
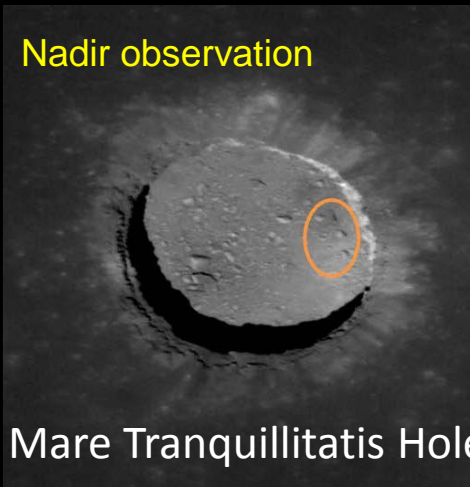
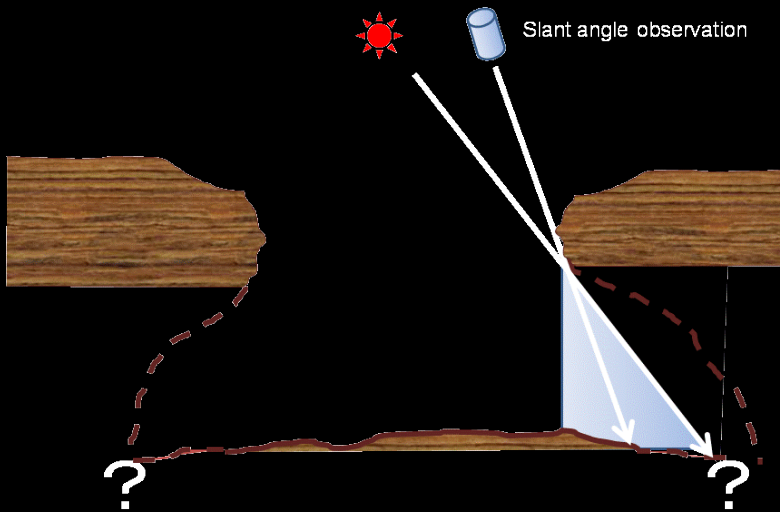
US LRO Camera image data



# Lunar hole must be skylight of a lava tube

## Oblique observation

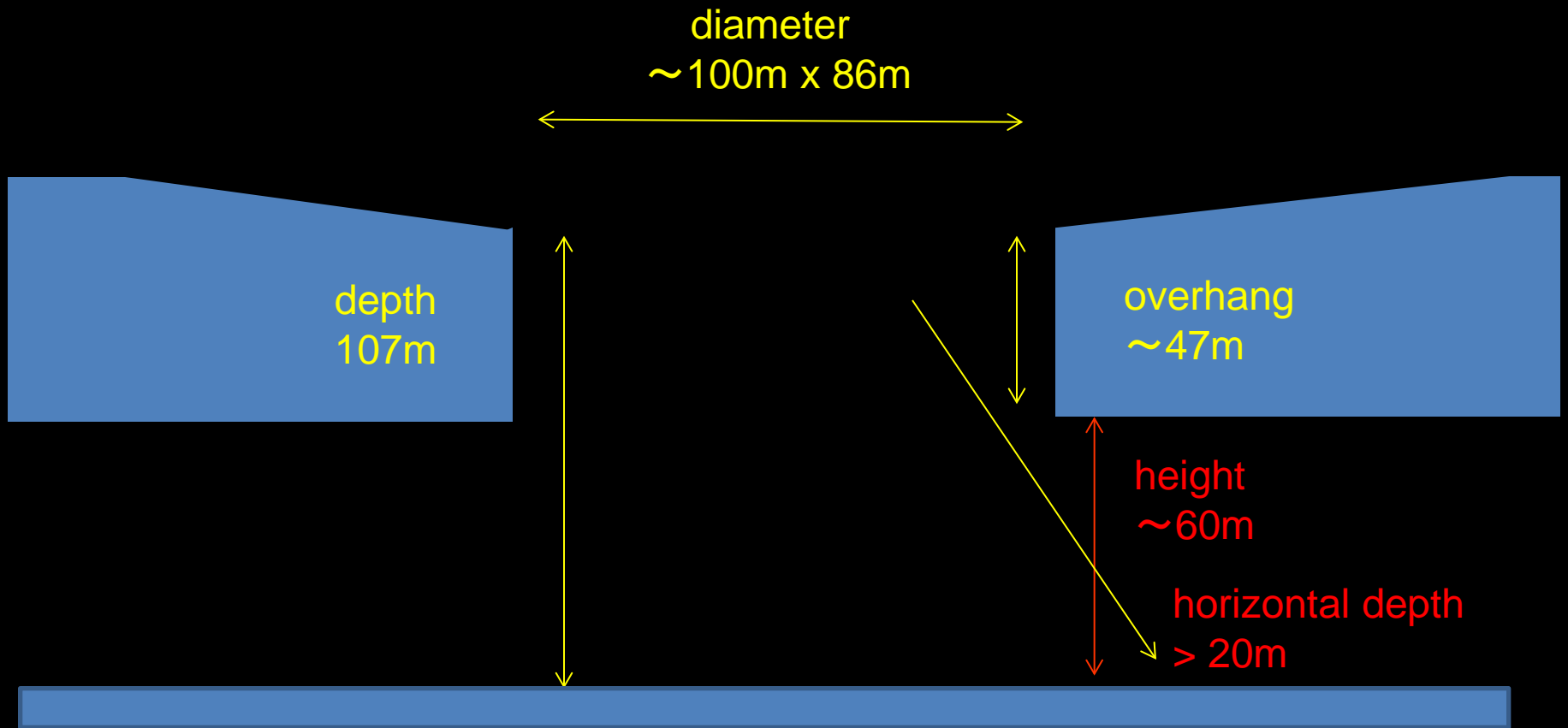
(Robinson et al., 2012, PSS)



Courtesy of Yasuda, 2015

LROC images  
(NASA/ASU)

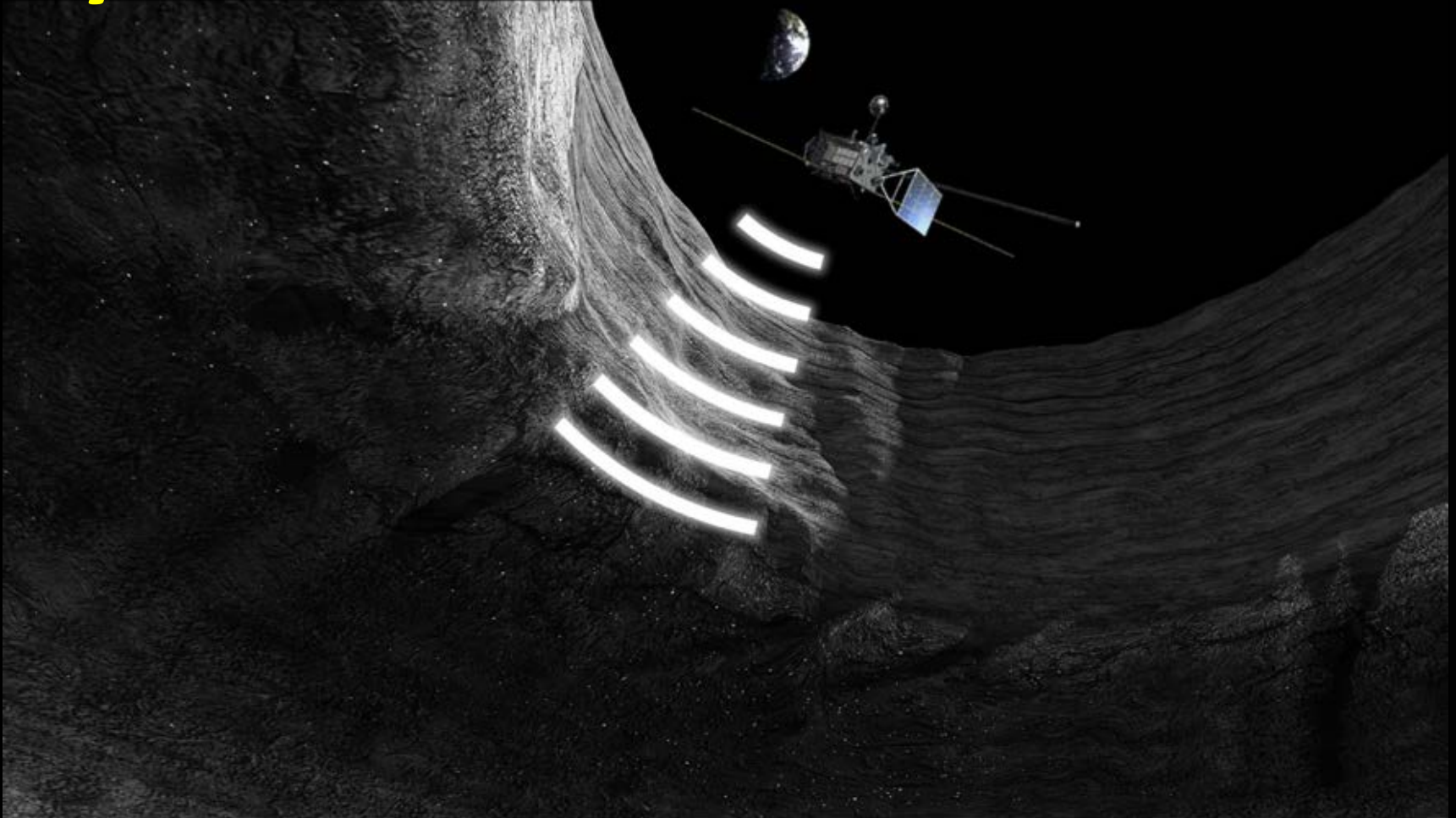
# Mare Tranquillitatis Hole



values from Robinson et al., 2012

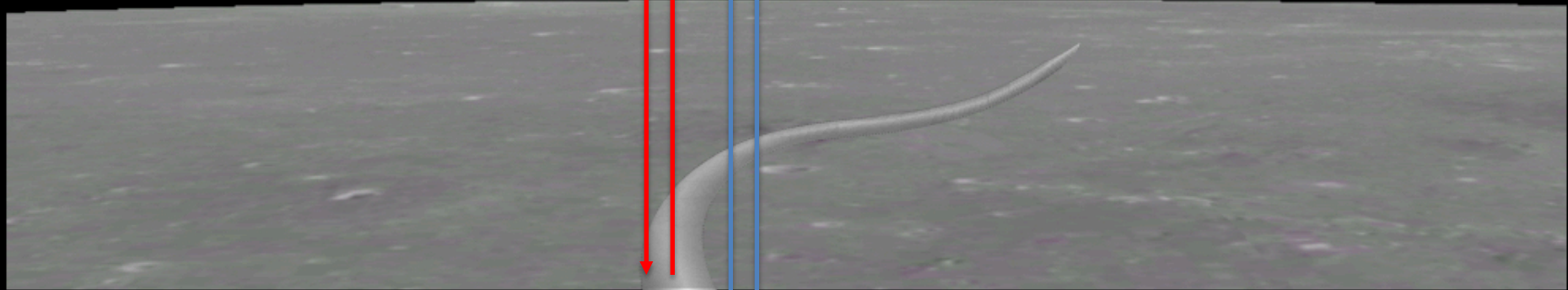
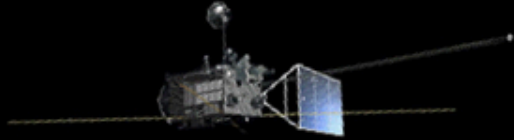


# Possible Detection of Lava Tube by SELENE Lunar Radar Sounder





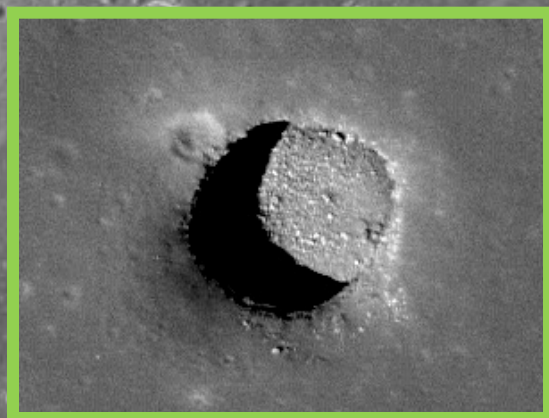
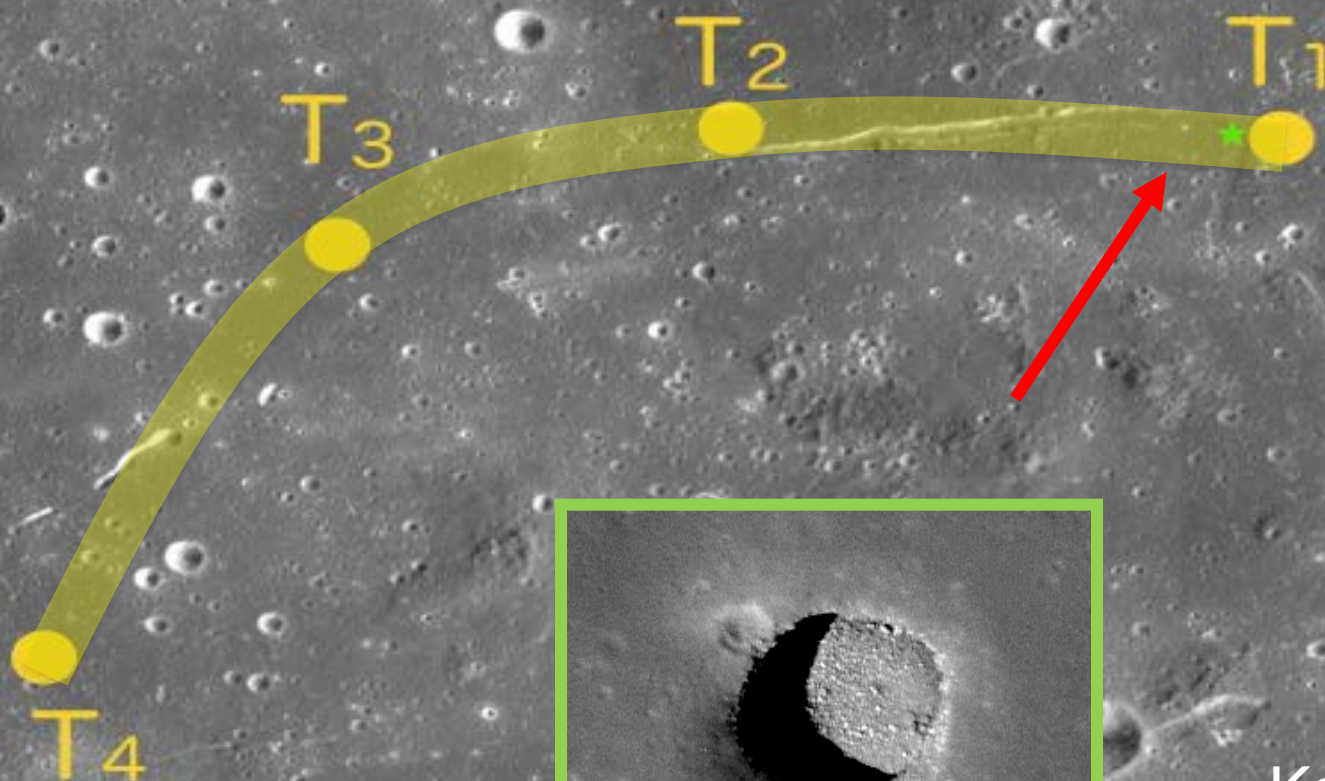
# Possible Detection of Lava Tube by SELENE Lunar Radar Sounder



Several 10m~200m

Several 10m~150m

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

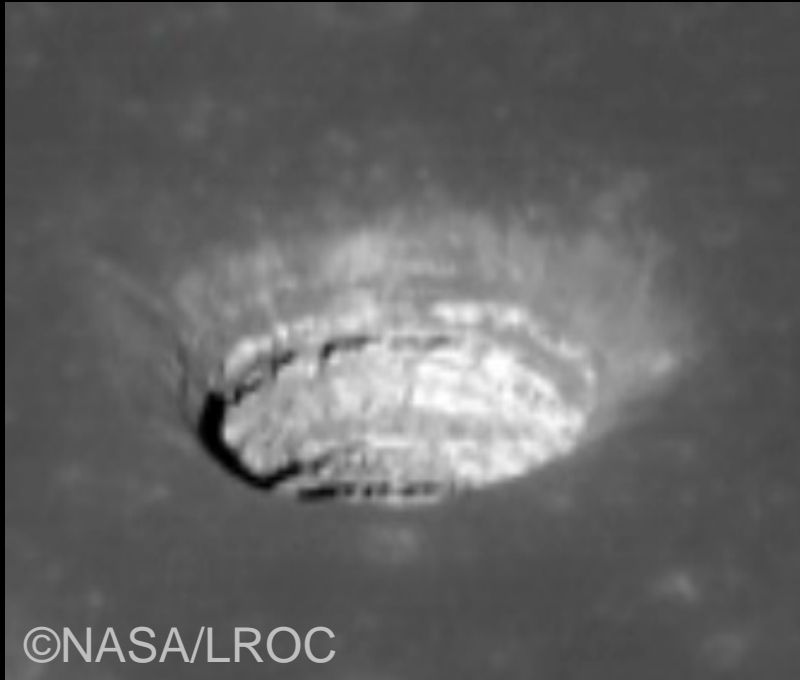


Kaku et al. 2017

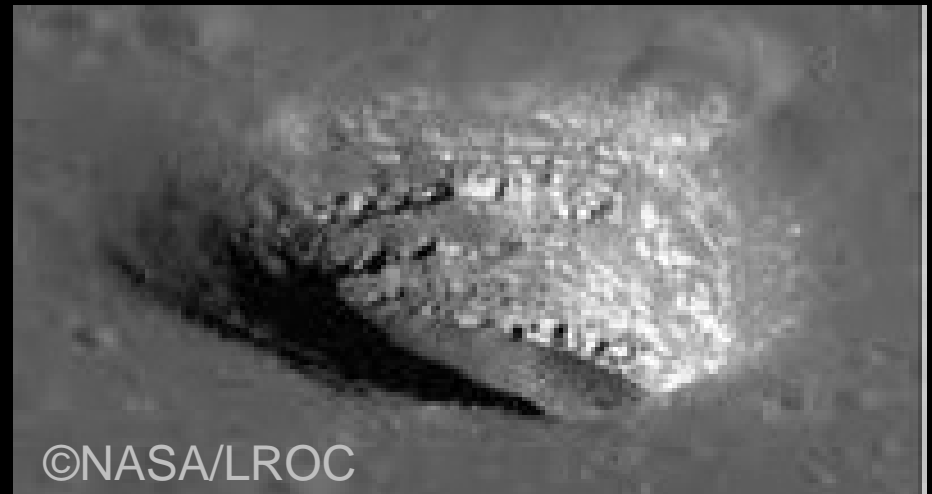
# Treasure Cave for Science

# 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?

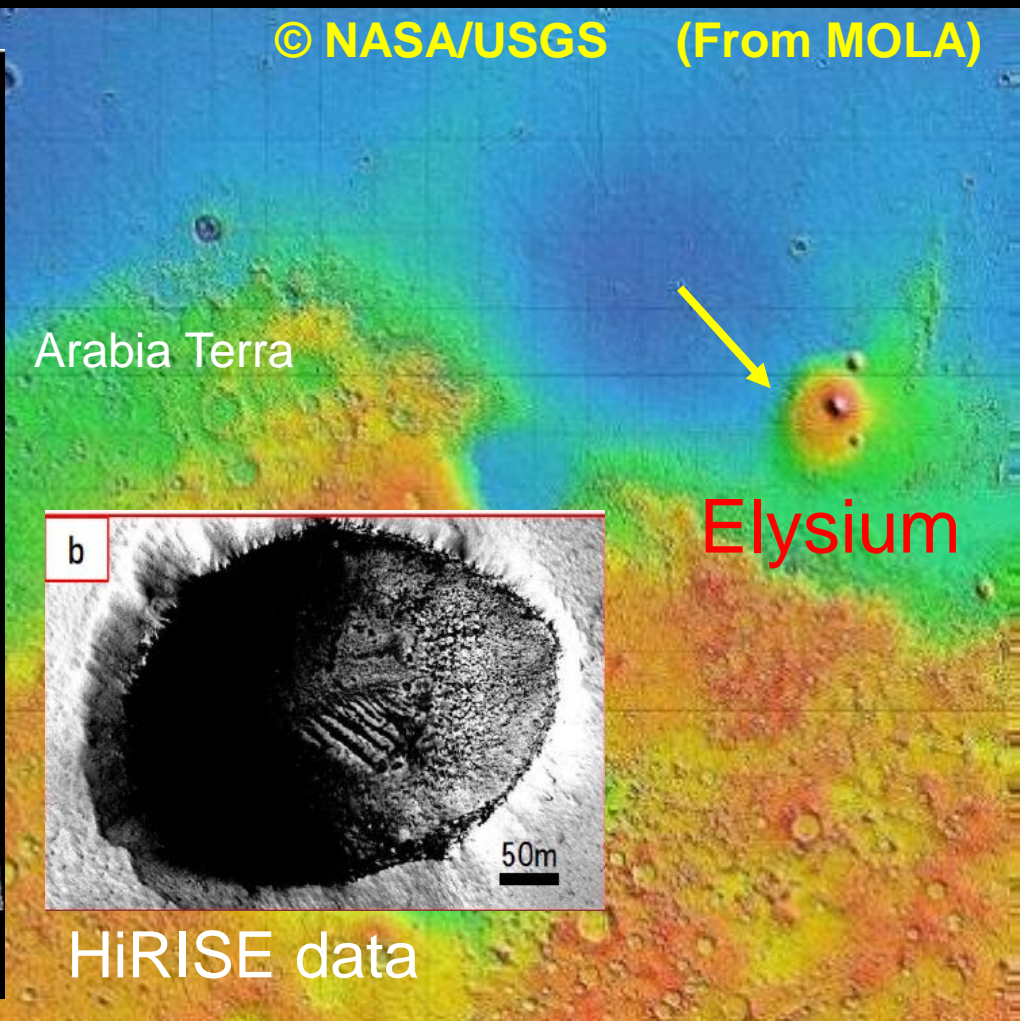
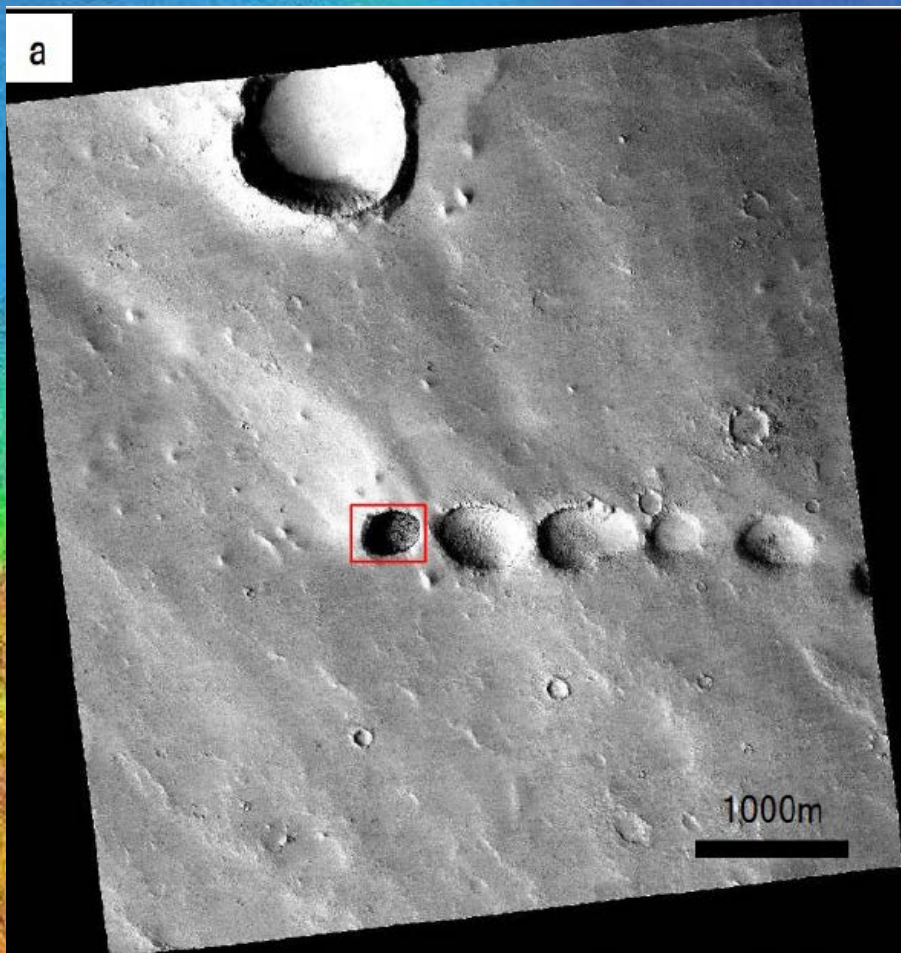


**Mars • Syrtis Major • March 10, 1997**      **HST • WFPC2**

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**