JAPAN'S EXPLORATION OF HOLES AND CAVES ON THE MOON AND MARS - UZUME PROJECT -.

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The surface of the Moon seemed to be a harsh place for humans to live on.

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

The surface of the Moon seemed to be a harsh place for humans to live on.

However,

Time is coming;

Humans return to the Moon.

Lunar holes discovered by SELENE

SELENE (Kaguya) discovered 3 large holes of several 10 m diameter and depth on the Moon.

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

Two at Near side

Marius Hills Hole

One at Far side

Mare Ingenii Hole

Mare Tranquillitatis Hole

SELENE TC data Haruyama et al., GRL 2009

Are these huge holes are skylights of subsurface caves?

These holes are probably skylights of underlying gigantic caves like lava tubes.

Koumori (bat) cave in Japan

Lava Tube is a good candidate for lunar base

- **Ceilings**

protect people and instruments from cosmic rays, UV, meteorite bombardments, hyper velocity ejecta of impacts.

- **Stable temperature**

-20℃（Hörz 1994)

- **Large space:**

several 10 m high, and a few 100 m wide from terrestrial analogues

Lunar holes discovered by SELENE

The hypothesis of existence of gigantic caverns associating to the holes was later confirmed by LRO camera data.

Mare Tranquillitatis Hole

Summarized in a reviewed paper by Haruyama et al., 2012, in “Moon -Prospective Energy and Material Resources -”, ed. by Viorel Badescu, Springer publisher) .

Lunar holes discovered by SELENE

The hypothesis of existence of gigantic caverns associating to the holes was also confirmed by LRO camera <u>oblique observation.</u>

(Robinson et al., 2012, PSS)

Mare Tranquillitatis Hole

Courtesy of Yasuda, 2015

Mare Tranquillitatis Hole

values from Robinson et al., 2012

Meiji-Jingu baseball stadium © 明治神宮球場http://www.jingu-stadium.com/base.html

www.tomthorbecke.nl/portfolio/amsterdam/amsterdam-arena-ajax-sta

www.tomthorpe.co.uk/portfolio/amsterdam/amsterdam-arena-ajax-sta

The surface of the Moon seemed to be a harsh place for humans to live on.

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

Lunar holes and subsurface caverns provide habitable space.

The insides of holes/caverns of he Moon are comfortable.

	Micro meteorites	Temperature	Radiation
Surface	× Problem requiring a several centimeter	× Terrible Wide range oscillation : -150℃ to 120℃	× Fatal 4. 2 Sv (max. obs.) requiring a several meter soil coverage
Holes, Caverns	○ No problem	○ Good Stable around 0℃	○ Safe Almost 0

Lunar holes and subsurface caverns are <u>scientifically very significant places.</u>

Lunar holes and subsurface caverns are scientifically very significant places.

- We can sample fresh (no brecciated, no fragmented, no space weathered) materials at walls, floors of holes, and insides of caverns, which will tell us
  - Lunar volcanic history / lava flow mechanism
  - Past dynamo magnetic field
  - Volatiles (including water) origin and behavior
  - Past solar activity
- We can acquire good data by settling science instruments in the thermally-quiet, dust/radiation–free condition.
  - Thermometer, Seismometer, Magnetometer, Muon detector, E-M antenna,,,. to investigate the inside of the Moon etc.

Time is coming;

Humans return to the Moon.

We are now planning a project.

Project Name

UZUME

Unprecedented Zipangu Underworld of the Moon Exploration

Uzume is a goddess appearing in the two oldest Japanese historical records, *Kojiki* and *Nihon Shoki*.

"Once upon a time, "Amaterasu-Omikami" the Sun Goddess hid into "Amano-Iwato" cave in a reason. The light was lost from the world. Other gods were troubled. Then, "Uzume", a goddess, danced in front of the cave. Other gods enjoyed seeing her dance and laughed loudly. The Sun Goddess became interested in what was going on outside and slightly opened the door of the cave. At the moment, a powerful god completely opened the door of the cave. Then the light was returned to the world."

Project Name

UZUME

Unprecedented Zipangu Underworld of the Moon Exploration

Marco Polo (wiki)

Zipangu: Japan.

About 700 years ago, a Venetian merchant Marco Polo (1254-1324) who traveled to China wrote a book for what he had seen and heard. In the book, there is a description:

"People on the Island of "Zipangu" in a sea of the far east have tremendous quantities of gold. The King's palace is roofed with pure gold, and its floors are paved in gold two fingers thick."

This island is thought to be Japan.

"Zipangu" is the original of English word "Japan".

UZUME

by Mari NAKAJIMA

Martian pits (holes)

Similar pits (holes) have been discovered on Mars.

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diamter100-250m

道上 2010

G. E. Cushing et al., 2007

G. E. Cushing et al., 2015 (#9026)

Martian holes and subsurface caverns will be bases and are scientifically significant, too.

In the underworld of Mars, there must be something …

We are planning to explore the Martian caverns, too.

Mission Code Name

UZUME

Unprecedented Zipangu Underworld of the Moon Exploration

Mission Code Name

UZUME

Unprecedented Zipangu Underworld of the Mars Exploration

However, UZUME project
has not been approved.

There are some people who comment to me

"Exploring the subsurface of the Moon and Mars? I have never heard such an idea from NASA."

There are many NASA fans in Japan.

- NASA legend (in Japan)-

or

“There must be so many difficulties that even the NASA has not planned.”

There are many NASA fans in Japan.

- NASA legend (in Japan)-

Challenge to explore into the holes and gigantic caverns.

The exploration into the lunar holes and further gigantic caverns will be confronted with many difficulties.

However, "Because of difficulties, we should challenge. "(by Prof. Kubota (ISAS))

Some engineers are ambitious.

“Let’s enter into a hole directly!

<Hole in one> mission !
We can do it !”

Mare Tranquillitatis Hole
(~100m diameter and depth）

Please
don’t pollute the insides of the holes!

A key technology for UZUME

Robotics

Robotics: Throw machine

A machine will throw a probe from the landing point.

1. うちの可愛い娘をそんな危ないところに連れて行けるか！という親心，
2. 技術レベルの現状を踏まえて，2010年代に実現するため

A key technology for UZUME – Robotics -

Multi-leg type (incl. humanoid type) robots may be appropriate for exploring caves.

We are starting to develop robots to explore the caves.

Many robot engineers have joined in.

Image Capture（Tsukuba Univ.）

Head Mount System (Adv. Inst. Sci. & Tech)

Humanoid type robot (Tokyo Univ.)

A key technology for lunar hole and cavern exploration –Robotics-

We will develop
Remote-controlled Scientist Agents.

→New Infrastructure

Demonstrated robot-technology will be spun off to the industrial world.

© JAXA

UZUME project (has not been approved)

We are aiming to realize UZUME project.

Plan

～2020 SLIM： landing technology	2020（target year） UZUME-1	2025（target year） UZUME-2	2030（target Year） UZUME-3
	First exploration (Engineering. demonstrations.)	Sample return（Science mission）	Exploration to Martian caves
Science	-Detailed features (including largeness of sub-surface caverns) -Environments (temp. radiation, volatiles)	Samples from outcrops of walls, floor, insides of caverns Water molecules, Information of lunar volcanic activity	Lives and/or life-system, minerals Water, volatiles Volcanic activity
Engineering（Robotics）	-Multi-leg type tech. -Descending tech., -Remote tele-operation（in situ)	-Return/Recovery, observation infra. -Unmanned construction ifra	Sampling and in-situ analysis Macro-scope obs.

There are many difficulties.

UZUME We are challenging.

Mari Nakajima

UZUME

Let’s return to the Moon together!.

Mari Nakajima