Lunar Landing Site Candidates Discussed In the Japanese Science Community

Junichi Haruyama (JAXA/ISAS)
Contents

- Status of lunar landing missions in Japan
- SLIM project
- Science interests for lunar landing missions in Japanese communities
Status of lunar landing missions

(Lunar science for landed missions workshop)

- SELENE (Kaguya): 2007 – 2009
- SELENE lander was given up in 2000
- SELENE 2 was canceled in 2015
- SLIM (small landing demonstration mission) is ongoing to be launched in 2020
- SELENE-2: canceled in 2015

Timeline:
- 2005
- 2010
- 2015
- 2018
- 2020
- 2025
- 2030
Beyond SELENE, Japanese lunar scientists are considering next lunar missions:

In a decadal survey for Japan’s lunar and planetary exploration (~2015)
- Penetrator demonstration in the 1st half of 2020s
- In-situ age determination in the 2nd half of 2020s
- Sample return from farside highland after 2030

Recent research for cave exploration (2016~)
- Lava tube in-situ at/sample return from lava tube and/or its skylight hole

On the other hand,
Research for top down lunar exploration (2014~)
- In-situ measurement
- Sample return

All have not been approved.
<Top-down (politics leading) projects>

Keywords:
- international
- pathfinding for human exploration

(under consideration)
- in 2020’s first half, investigating water ice at polar region with India
- sample return from high-latitude with Europe and Canada, using Deep Space Gateway Station.

(both are in preparation for Mission Design Review (MDR))
SLIM project
SLIM project

SLIM (Smart Lander for Investigating the Moon)

SLIM started its plan in parallel to SELENE-2, by engineers of ISAS and universities in Japan. In 2015, SLIM project was approved to be launched.

- to be launched in 2020
- Engineering demonstration
  Pin-point (< 100m) landing guided by automatic obstacle avoidance system.
- 100kg (incl. payload of less than several kg)
- Landing site and missions are in discussion
SLIM project

SLIM will reach the surface on the Moon by a new concept. SLIM will intentionally tip over;

Lunar Landing Site Candidates Discussed In the Japanese Science Community (examples)
Beyond SELENE, Japanese lunar scientists are considering next lunar missions:

In a decadal survey for Japan’s lunar and planetary exploration (~2015)
- **Penetrator demonstration** in the 1st half of 2020s
- **In-situ age determination** in the 2nd half of 2020s
- **Sample return from farside highland** after 2030

Recent research for cave exploration (2016~)
- **Lava tube in-situ at /sample return from** lava tube and/or its skylight hole

**Key terms**
- Age
- Internal structures
Key terms Japanese lunar science community thinks important are:
- Age
- Internal structures
Key terms Japanese lunar science community thinks important are
- Age
- Internal structures
Model Age Investigation

Hiesinger et al. 2008, LPSC)
Based on SELENE TC data, model ages of
- Farside (Haruyama et al. Science, 2009)
- PKT region (Morota et al. EPSL, 2011)
- Others (Morota et al. EPS, 2013)
were investigated.
1 Ga for the youngest basalt units is based on crater chronology;

However, 3 Ga for the youngest samples based on radiometric dating.
[e.g., Taylor et al. 1983; Nyquist et al., 2001]

Confirmation of consistency between model age based on crater chronology and radiometric dating by in-situ at or sample return from geological units of young model age (2.0 -1.0 Ga) are required.

Morota et al. 2011, EPSL)
Model Age Investigation at PKT (center part of Oceanus Procellarum)

A. Mons Rümker
B. Arsitarchus Platau
C. Keplar Crater
D. Marius hills
E. Flamsteed crater

Morota et al. EPSL, 2011
Age determination at high latitude
Model Age Investigation

High latitude Area

Antoniadi Crater
(69.7° S 172.0° W)

Haruyama et al., 2008, Science
Model Age Investigation near a skylight hole

Hiesinger et al. LPSC, 2016

SELENE/ MI pseudo color data from Haruyama et al., in prep
The accuracy of Crater Chronology is important to check a hypothesis.
Hypothesis: hot plume at later stage

To confirm this hypothesis, we need younger basalt samples of < 2.0Ga old.
The accuracy of Crater Chronology is important to be checked.
Key terms Japanese lunar science community thinks important are
- Age
- Internal structures
Key terms Japanese lunar science community thinks important are:
- Age
- Internal structures
Hypothesis: massive PAN layer

SELENE global data: ubiquitous PAN
Ohtake et al. 2010

Serial magmatism?

Yamamoto et al. 2010, 2012: PAN and Olivine

Mission in-situ at / SR from PAN-Olivine coexistence area are required.
Hypothesis: Wander of magnetic axis

Investigation of Lunar dynamo is important to understand of lunar core formation and evolution.

Paleo magnetic field component data in various dates are required to understand core formation.
Hypothesis: Polar wander of magnetic axis

To investigate this hypothesis, lava tube and its entrance “skylight hole” is one of the best places.

By knowing paleo dynamo magnetic field of the Moon, metal core formation of small celestial body like the Moon will be understood.
Hypothesis: Water “rich” interior

Volatiles perhaps trapped in the wall of lava tube will tell us whether the lunar interior was rich or poor in water, and the origin of the water.
Summary

- Several Japanese lunar landing missions have been canceled.

- SLIM project is going.

- There are some riddles (hypotheses) from recent lunar exploration data.

- “Age” and “Internal structures” may be key-terms for lunar exploration in the next decade.
The Moon is fascinating.
Let’s return to the Moon, together.