OBSERVATION SCENARIO FOR VOLATILES OF LUNAR POLAR EXPLORATION MISSION. Y. Karouji[1], M. Ohtake[1], H. Shiraishi[1], T. Hoshino[1], and D. Asoh[1], [1]Japan Aerospace Exploration Agency (JAXA), 3-1-1 Yoshinodai, Chuo-ku, Sagamihara-shi, Kanagawa, 252-5210, Japan (karouji.yuzuru@jaxa.jp).

Introduction: The Moon is the closest celestial body to the Earth and is considered the next area of human activity. In the Global Exploration Roadmap 3rd Edition (GER 3) [1], published by the International Space Exploration Coordination Group (ISECG) in January 2018, a construction plan for a manned space station as the next International Space Station in the cislunar area is shown. In addition, a manned lunar exploration plan is also described. At present, based on this roadmap, the construction plan of the manned space station, the Gateway, led by the National Aeronautics and Space Administration (NASA) is underway.

Recently, the polar region of the Moon has attracted attention as major target for lunar exploration in the 2020's. In fact, the United States has recently announced the ARTEMS program, which will conduct a manned lunar landing around the lunar south pole in 2024 and provide sustained lunar exploration [2]. There are two main reasons why lunar polar exploration is focused. The first reason is the possibility of the existence of water-ice as a resource. From the observation results to date, it is thought that water-ice exists in the area of the specific condition around the lunar polar regions [e.g., 3, 4]. The availability of water-ice as a propellant is believed to have a major impact on future exploration scenarios and activities using the Moon. The second reason is from the viewpoint of energy resources that can be easily obtained compared to other areas of the lunar surface. From the point of view of energy, it has been known that some hills and crater rims in the polar regions of the Moon can obtain more than a half-year of continuous sunshine and more than 80 % sunshine ratio [5].

In this situation, the Japan Aerospace Exploration Agency (JAXA) is planning a lunar polar exploration mission that aims mainly to confirm the abundance of water-ice resources and to establish the technology of planetary surface exploration in collaboration with the Indian Space Research Organisation (ISRO) [e.g., 6, 7]. This paper describes the current status of consideration on water-ice observation procedure in this mission in detail.

Operational plan of observation: Figure 1 shows the overview of the observation operations flow.

a. The exploration area, including waypoints for environmental and geological features, will be selected in advance using previous lunar exploration data.
b. A landing point that satisfies solar illumination, topography, communication, and other conditions close to the exploration area will be selected [8].
c. The lander will land at the target point, then the rover will be deployed.
d. For up to one week, observations are performed to provide reference data at the landing site vicinity. The observation procedures are described as next section.
e. After these observations at the landing site vicinity, the rover head to the predefined exploration area.
f. A series of observations (see next section) will be performed at the predefined exploration area waypoints.
g. During about a half-year life, the same observations will be performed several times under significantly different solar illumination and temperature conditions.

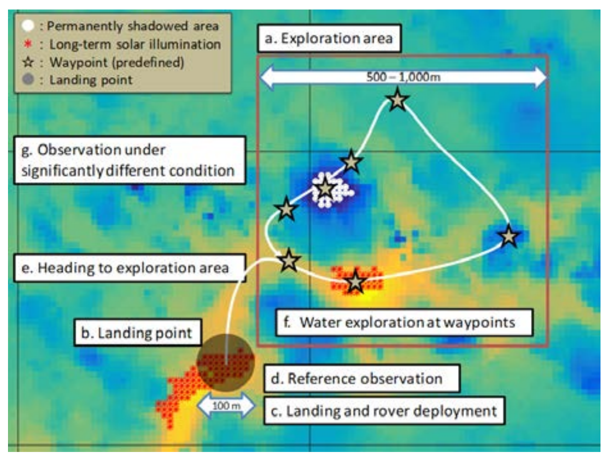

Fig. 1. Example of an exploration area and operational process of observation.

Observation Procedure: Though various methods can be considered for observation of water-ice, the following observation instruments and their operation are considered as an example.

A) Coarse observation (Fig. 2, Table 1)
- The rover runs around the waypoint in the predefined exploration area.
- At this time, the rover observes lunar surface and subsurface water and/or hydrogen distribution with an underground radar (a), a neutron spectrometer (b) and an imaging spectroscopic camera (c).

- At the same time, the rover observes lunar surface ambient pressure (d).
- Based on these data, an area where water-ice may exist is identified.

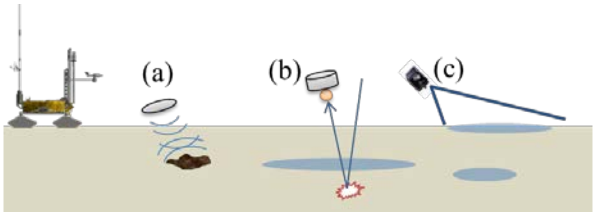

Fig. 2. Coase observation.

B) Data analysis
- The rover moves to the nearest area with the best sunshine and communication.
- The rover transmits the acquired data to the ground station and charges its battery.
- The operation center analyzes the received data and selects some points for detailed observation.

C) Fine observation (Fig. 5, Table 1)
- The following observations will be made using samples acquired while excavating up to 1.5 m underground by an earth auger.
  (e) Soil temperature measurement.
  (f) Thermogravimetric analysis (TGA) of the sample (measuring the content of volatile substances from the mass loss with heating).
  (g) Analyzing volatile molecular species by a mass spectrometer.
  (h) D/H ratio measurement by a cavity ringdown spectroscopy.

D) Moving and preparation
- When a series of observations are completed, rover moves to the next waypoint.
- The rover performs battery charge an observation preparation.

The steps from A) to D) are repeated at each predefined waypoint in the exploration area.

Table 1. Model payload instruments

	Instruments	
(a)	Underground radar	
(b)	Neutron spectrometer	
(c)	Imaging spectrometric camera	
(d)	Pressure gauge	
(e)	Thermometer	
(f)	Water analyzing package	Thermogravimetric analyzer
(g)		Mass spectrometer
(h)		Cavity Ringdown Spectrometer

Conclusion: JAXA is planning a lunar polar exploration mission in collaboration with ISRO that aims mainly to confirm the abundance of water-ice. In this paper, we have reported on the current study status of water-ice observation procedure in this mission. We also reported the model payload instruments for water-ice observation.

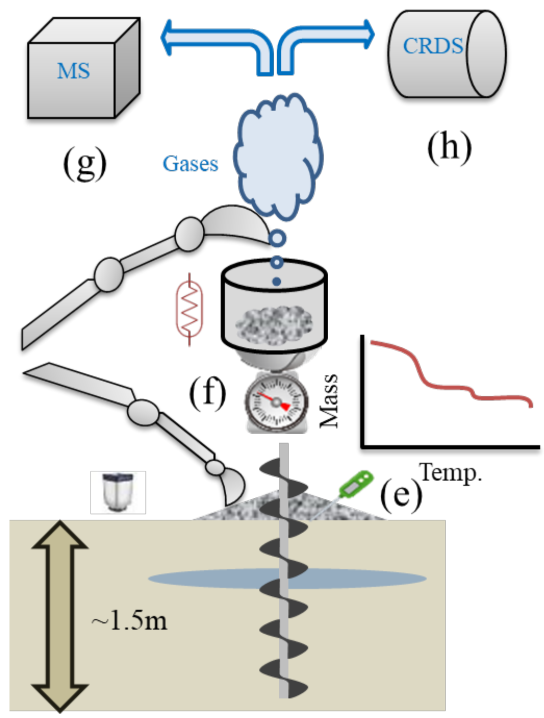

Fig. 3. Fine observation.

References: [1] The International Space Exploration Coordination Group (ISECG), Global Exploration Roadmap (3rd Edition), January 2018, https://www.globalspaceexploration.org/wordpress/wp-content/isecg/GER_2018_small_mobile.pdf (Posted on 2 February, 2018), [2] Humanity's return to the Moon, https://www.nasa.gov/specials/artemis/ (accessed January 7, 2020), [3] Li S. et al., (2018) *PNAS September 4, 115 (36)*, 8907-8912. [4] Sanin A. B. et al. (2017) *Icarus 283*, 20-30. [5] Rosa D.D. et al. (2012) *Planetary and Space Science 74, 1*, 224-246. [6] Hoshino T. et al. (2019) *70th International Astronautical Congress*, IAC-19.A32A16. [7] Ohtake M. et al. (2020) *LPSC 51st*, this volume. [8] Inoue H. et al. (2020) *LPSC 51st*, this volume.