

# 月惑星探査に向けた貫入型観測装置 ペネトレータの開発と現状

## An Introduction to the Penetrators: Development and current status

Yasuhiro NISHIKAWA<sup>1</sup> (JARE64)

Satoshi TANAKA<sup>2</sup> (JARE65)

Kodai YAMAMOTO<sup>1</sup> (JARE64)

Takamasa HIRATSUKA<sup>1</sup> (JARE65)



1: Kochi University of Technology, 高知工科大学

2: Institute of Space and Astronautical Science (ISAS), JAXA, 宇宙科学研究所

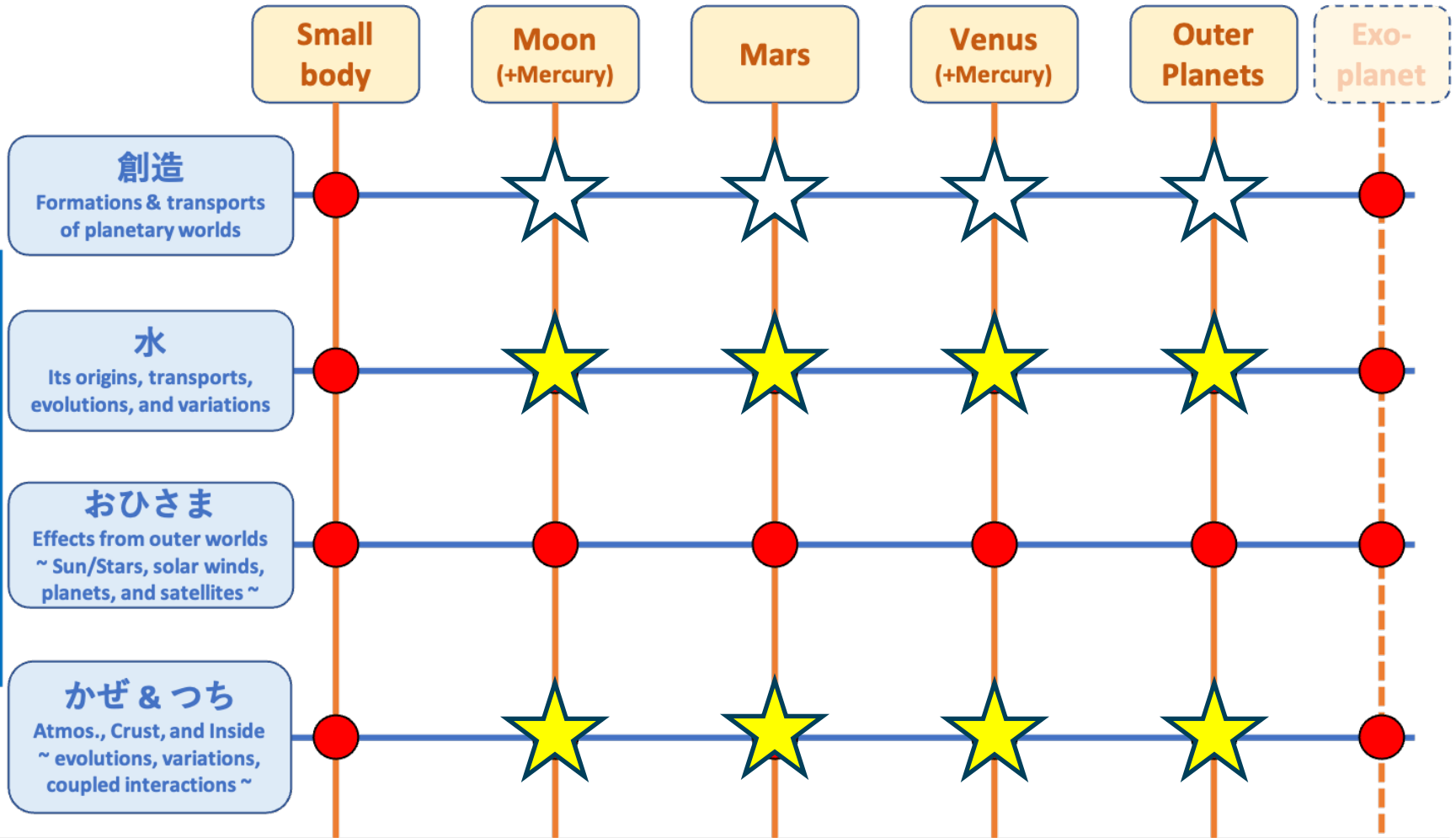
JARE : Japanese Antarctic Research Expedition, 南極地域観測隊



高知工科大学  
KOCHI UNIVERSITY OF TECHNOLOGY



Cross-Boarder sciences



# What is the penetrator?

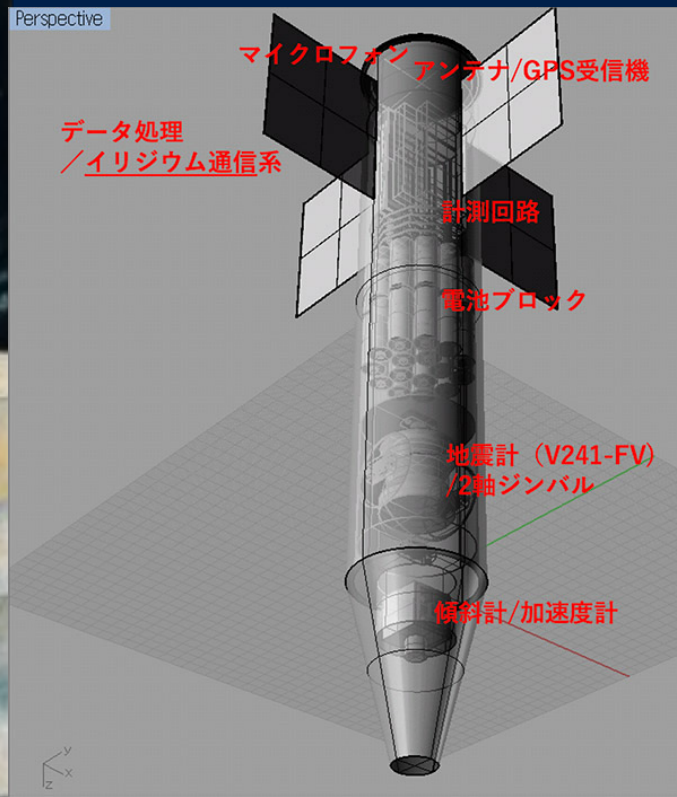
Originally developed for planetary explorations.

Pencil shaped self-contained vehicle.

Drop from high altitudes using UAV.

Install observation equipments in *dangerous and unmmaned* locations.

*Tanaka et al., 2011, Lorentz, 2011*



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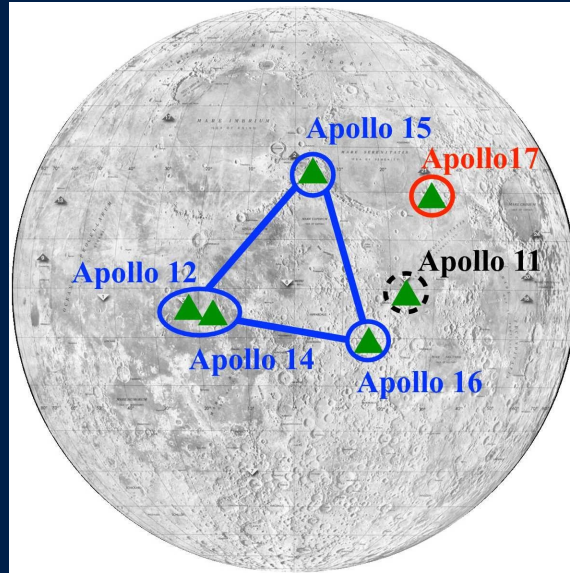
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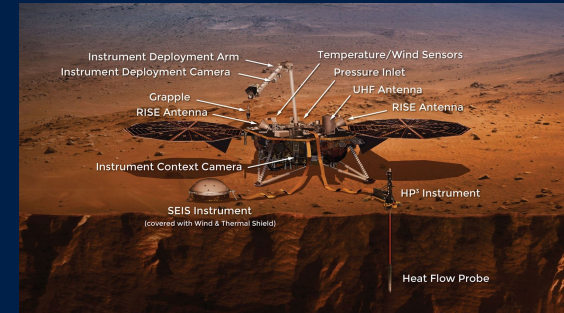
Install observation equipments in *dangerous and unmmanned* locations.

*Tanaka et al., 2011, Lorentz, 2011*



*Locations of the Appollo stations on the Moon. Seismic experiments were based at 11,12,14,15 and 16*

*Nunn et al., 2020*



*Summary, Instruments – InSight Mars Lander. InSight installed a single seismic station.*

# See What Matters, Where It Matters: Observation at Your Desired Place

Install instruments **safely and inexpensively** at unmanned places (remote and/or dangerous places).



Unmanned places.  
Active Volcanos and Polar  
Regions and **Space**.

# Ongoing Research

## JARE 64-66th Challenging Research

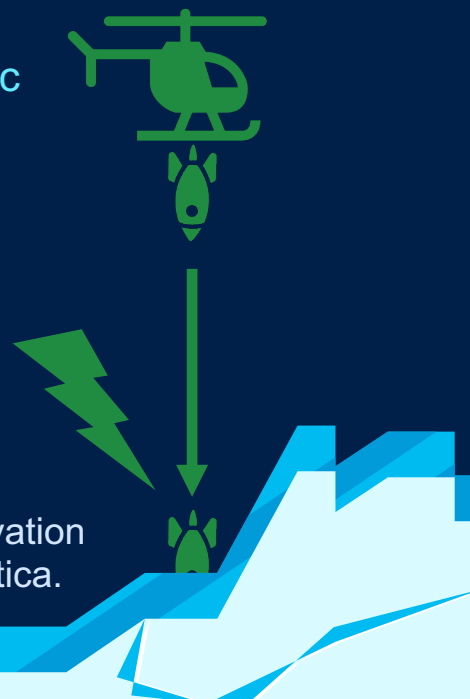


Target area of observations in JARE 64,65,66th penetrator team.

南極観測用ペネトレータの開発と白瀬氷河および周辺域での集中観測  
“Development of Antarctic Observation Penetrators and Intensive Observation in the Shirase Glacier and Surrounding Area”



We receive observation data from Antarctica.



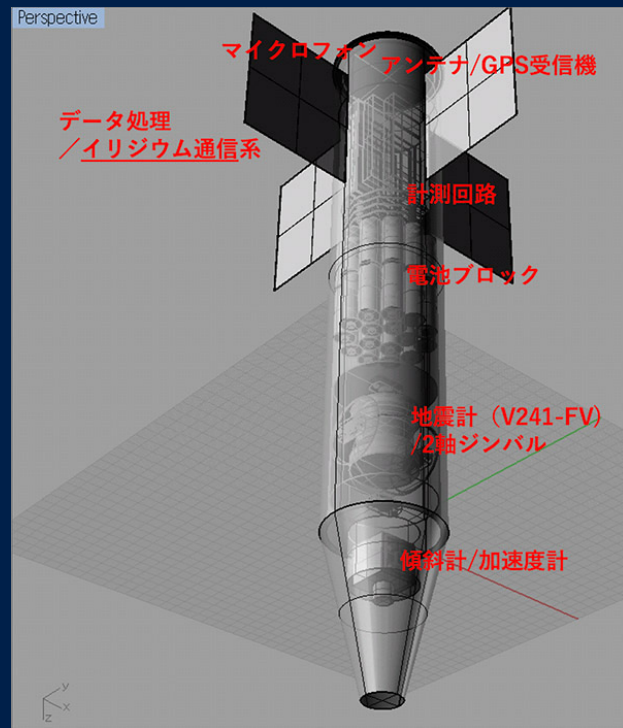
# Difficulties in Developing Penetrators

## 3-TION concepts of penetrator

- PENETRATION
- OBSERVATION
- COMMUNICATION

## Our penetrator

- 60 cm length
- 13 cm diameter
- 3 kg weight (10 kg)



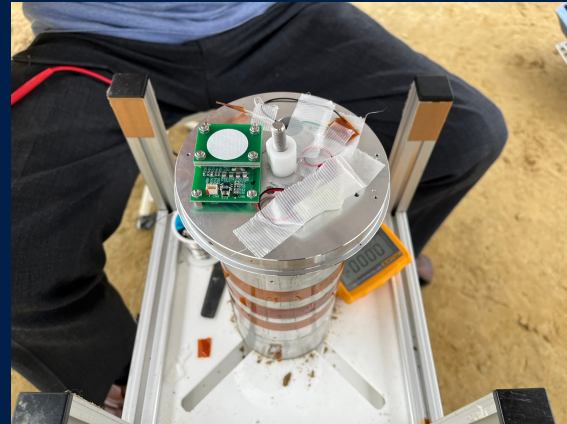
# Difficulties in Developing Penetrators

Seismometer : V241



V241 will be installed on Titan.

Infrasound sensor : INF03



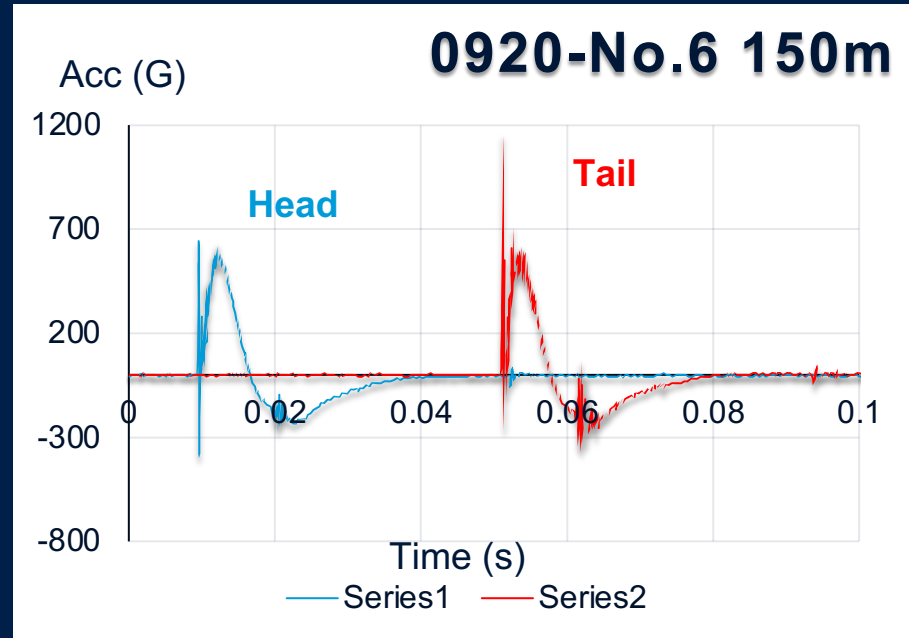
INF03 was developed to detect dust devils on Mars.



# Difficulties in Developing Penetrators

## Penetration impact on **solid ground**

Drop height	Velocity	Impact
80 m	40 m/s	~400 G
150 m	55 m/s	~600 G

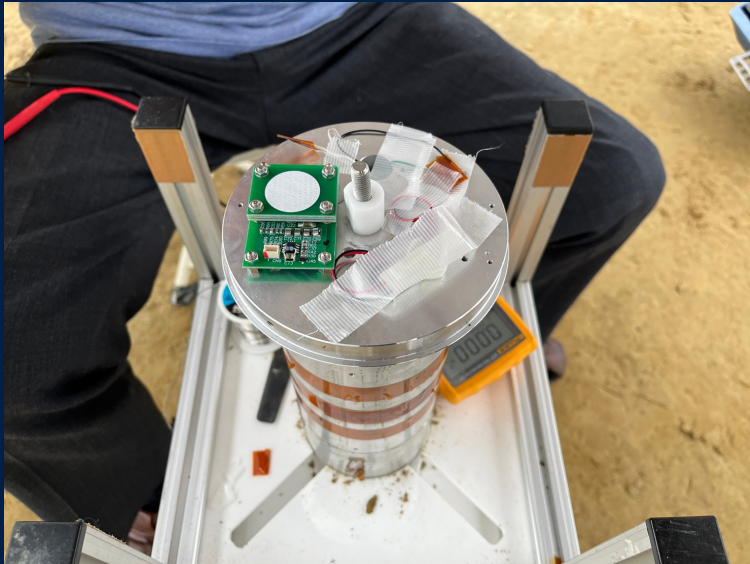


Altitude 150m (54m/s)

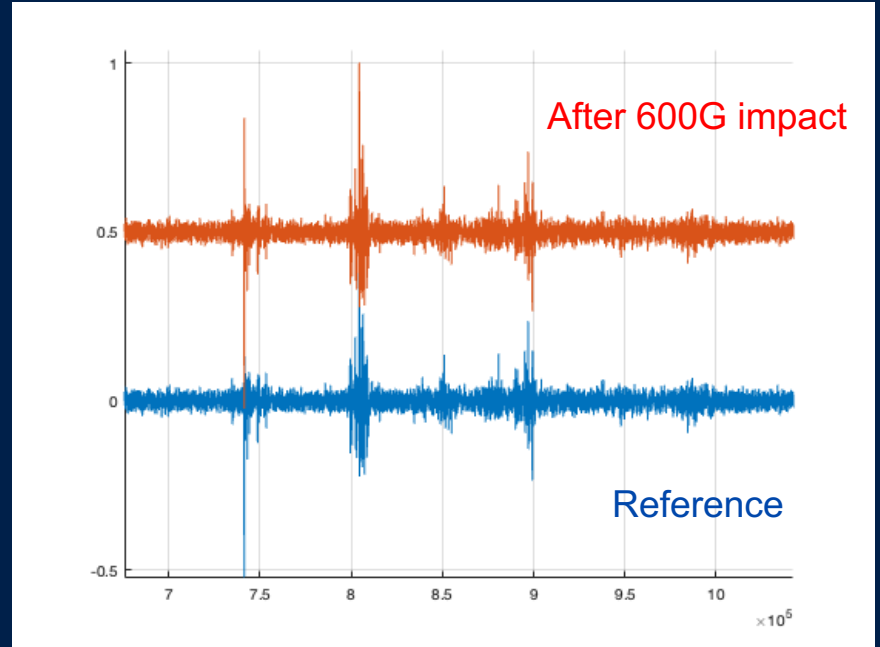
We need to develop instruments that can withstand even the most intense shocks **without breaking**

# Difficulties in Developing Penetrators

## Performance evaluation of sensors



Infrasound sensor on a penetrator.



Comparison data between reference and after drop test sensors.

# Difficulties in Developing Penetrators

## Penetration impact on **ice sheet**

Drop height Angle	Penetration depth	Impact
75 m 31 degree	20 cm	~400 G
90 m 58 degree	76 cm	~120 G
120 m 86 degree	84 cm	~140 G



Penetrator drop test from 75 m height on Antarctica. The penetrator did not penetrate vertically because it fell while rotating.

# Difficulties in Developing Penetrators

## Penetration impact on **ice sheet**

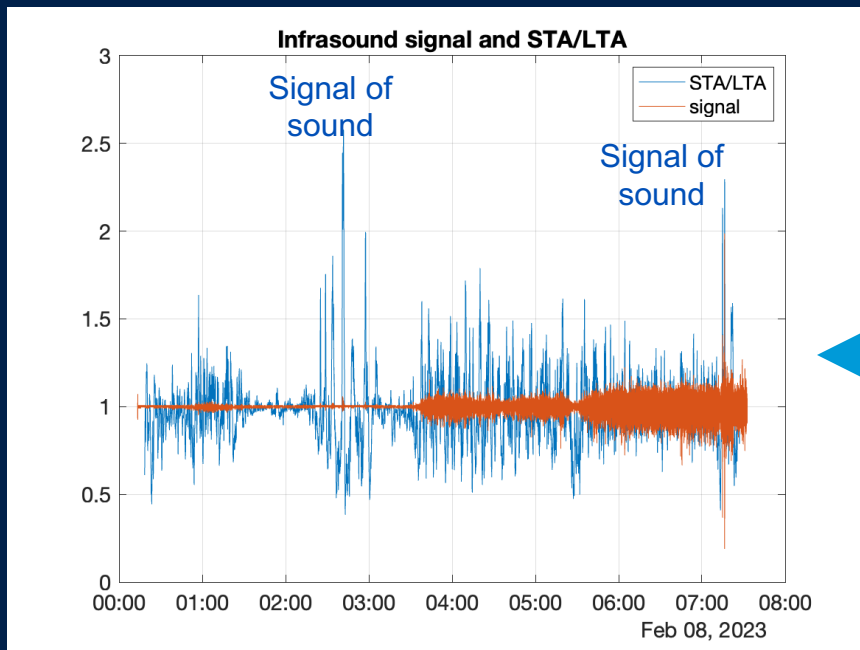
Drop height Angle	Penetration depth	Impact
75 m 31 degree	20 cm	~400 G
90 m 58 degree	76 cm	~120 G
120 m 86 degree	84 cm	~140 G



Penetrator drop test from 120 m height on Antarctica. The penetrator penetrated vertically.

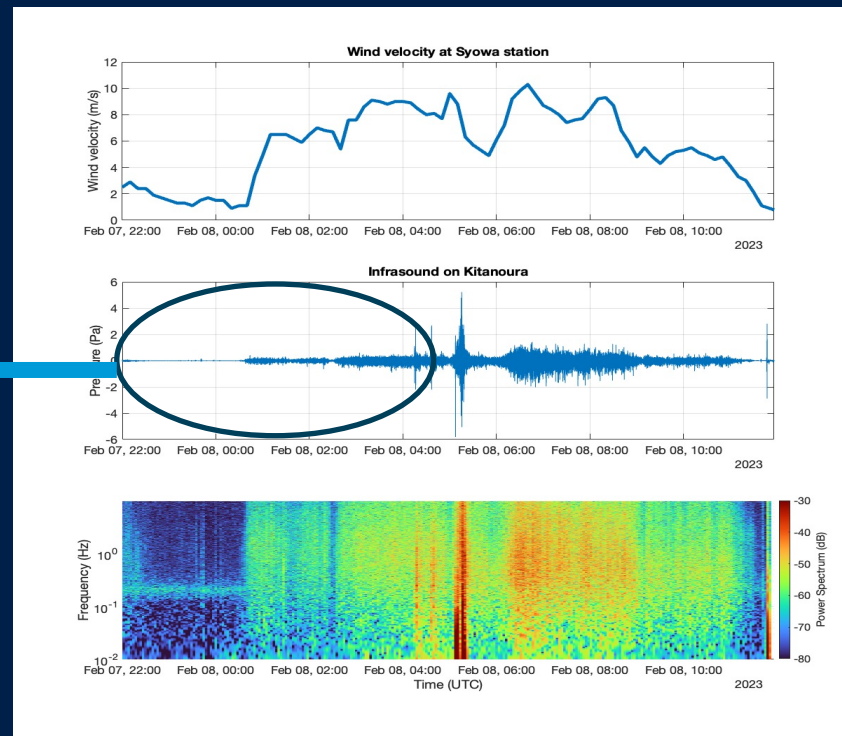
# Difficulties in Developing Penetrators

## Observation in polar regions (pseudo icy planet)



Detection of signals from noisy data.

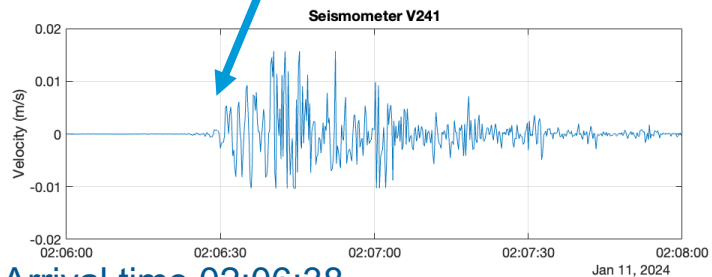
南極資料 11/6 受理



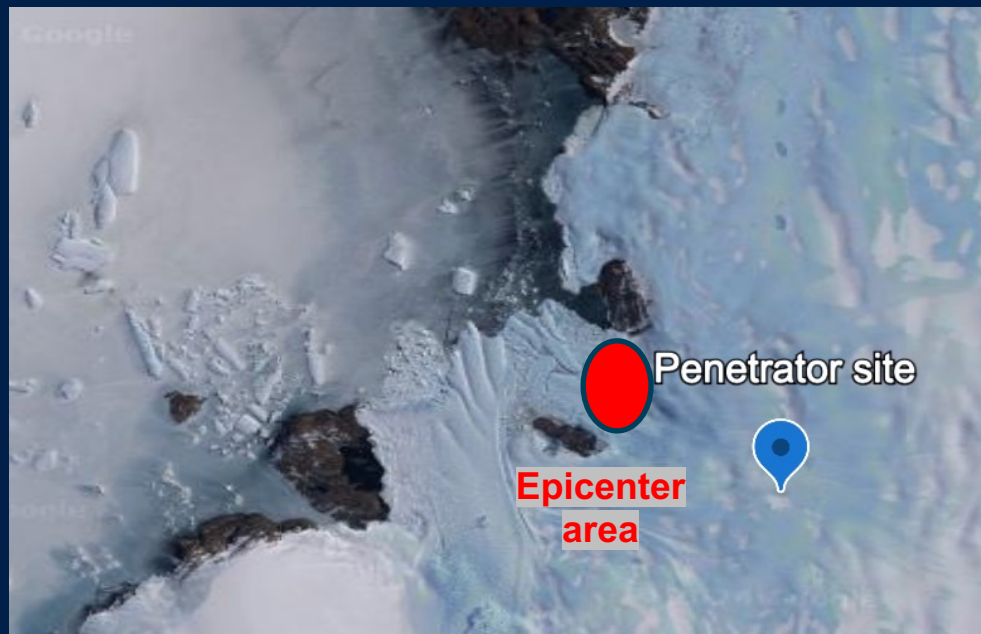
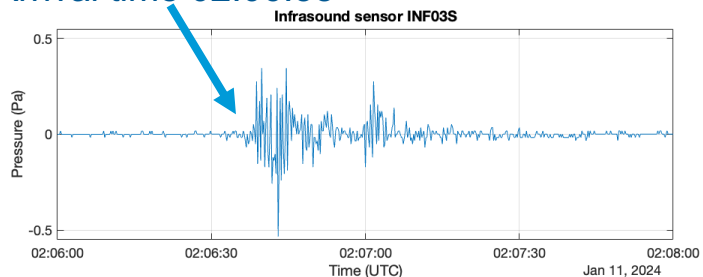
Infrasound data observed by the penetrator.

# Observation results

Arrival time 02:06:29



Arrival time 02:06:38



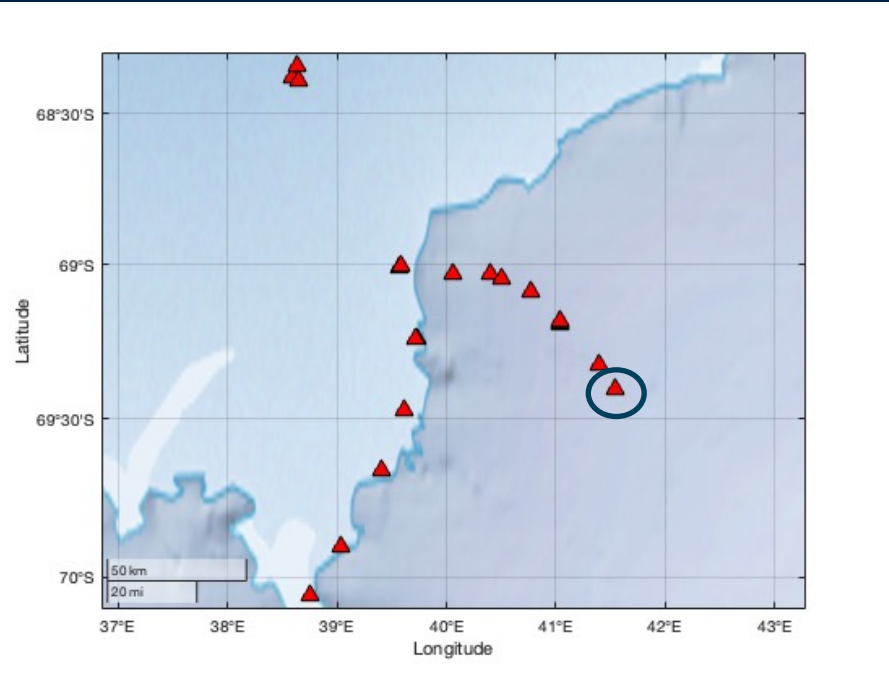
Seismic and Infrasound data  
observed by the penetrator.

# Difficulties in developing penetrators

## Communication from polar region (pseudo icy planet)



Communication penetrator on Antarctica 100 km away from Syowa station.



Location information in Antarctic regions sent to Japan by a communication penetrator.

# Difficulties in developing penetrators

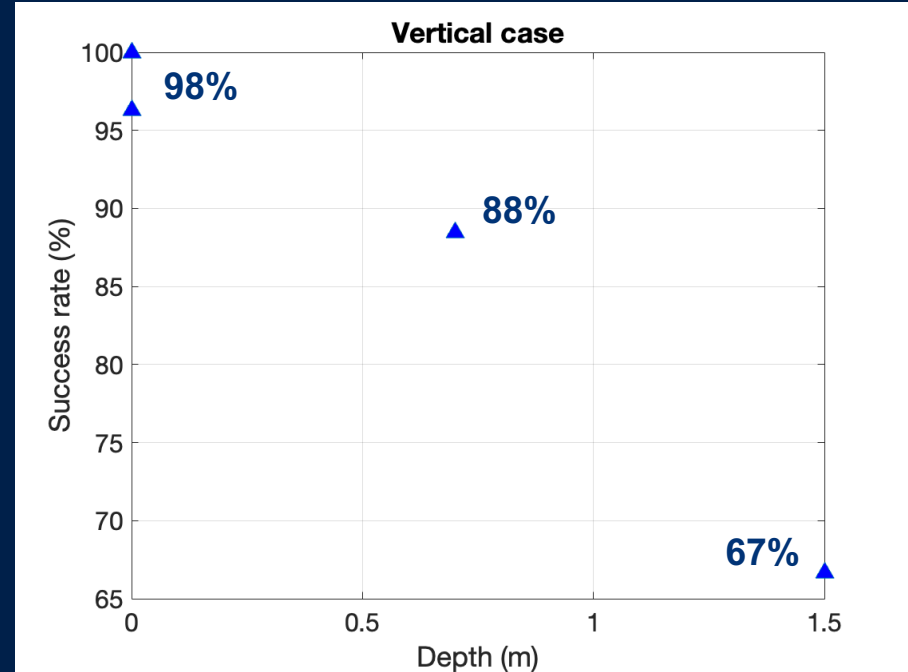
## Communication in a variety of fixed positions



Ideal position  
Installed in vertical.  
Tail above the surface.



Installation of communication  
penetrator below the snow surface.





# Future Work

Fixed-wing air plane.



3 m length, 5 m width, 47 kg weight.  
The air plane needs a runway of 250 m for  
takeoff and 150 m for landing.  
Can travel automatically for 4 hours at 80km/h.



Moon,  
Mercury

Mars, Venus,  
Titan...



# Thank you



Details of 64th JARE penetrator tests are in

南極資料 Antarctic Record (印刷中)