

# Electromagnetic Reflection Characterization of Simulated Lunar Ice Using Ground Penetrating Radar

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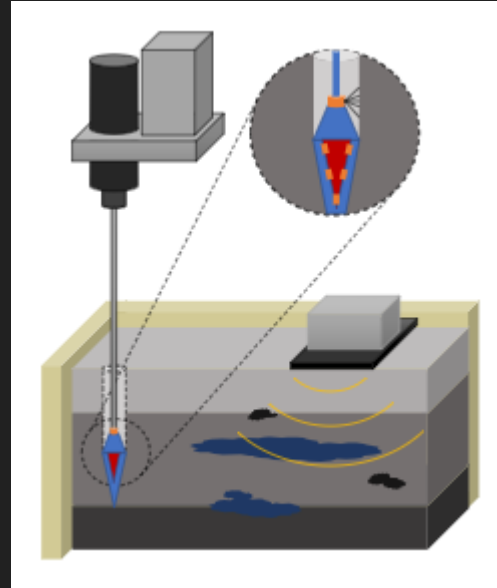


Michigan  
Technological  
University



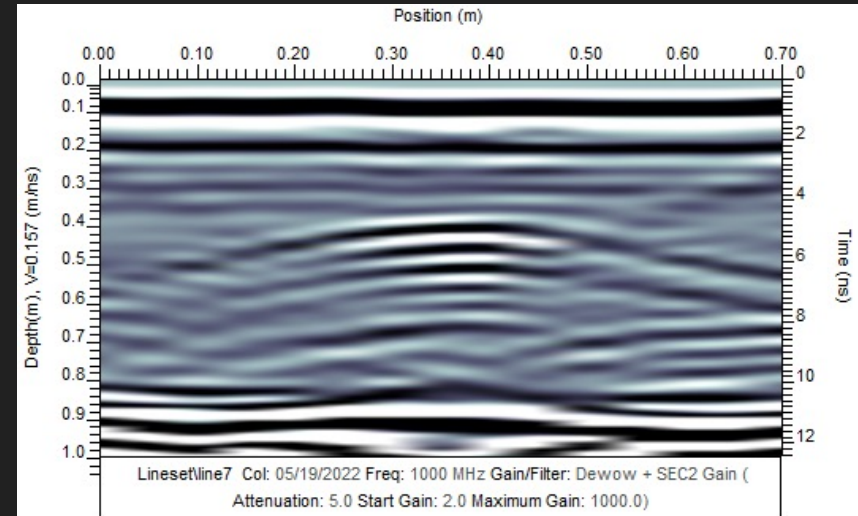
# Detection of Lunar Ice Using Ground Penetrating Radar (GPR)

- Versatile detection tool for rovers
- Used in conjunction with a Percussive Heated Cone Penetrometer
- GPR can describe homogeneities and layering within lunar subsurface
- Dataset compilation
- Extensive testing is required



# GPR Refresher

- An electromagnetic geophysical method
- Dielectric Constant (K) is the operator variable
- Subsurface velocity is approximated through additional testing and analysis
- Radio waves within 12.5-1200 MHz frequency range
- Lower frequencies can describe deeper objects depths at the cost of resolution and vice versa
- Non-destructive method
- Depicts data as a time series of points along a transect in the form of a radargram
- Raw data is typically processed using GPR software to dewow, subtract background noise, etc.



# Field Testing Sites

Google Earth

Image Landsat / Copernicus

Image NOAA

KRC site & Airport

Stamp Sands

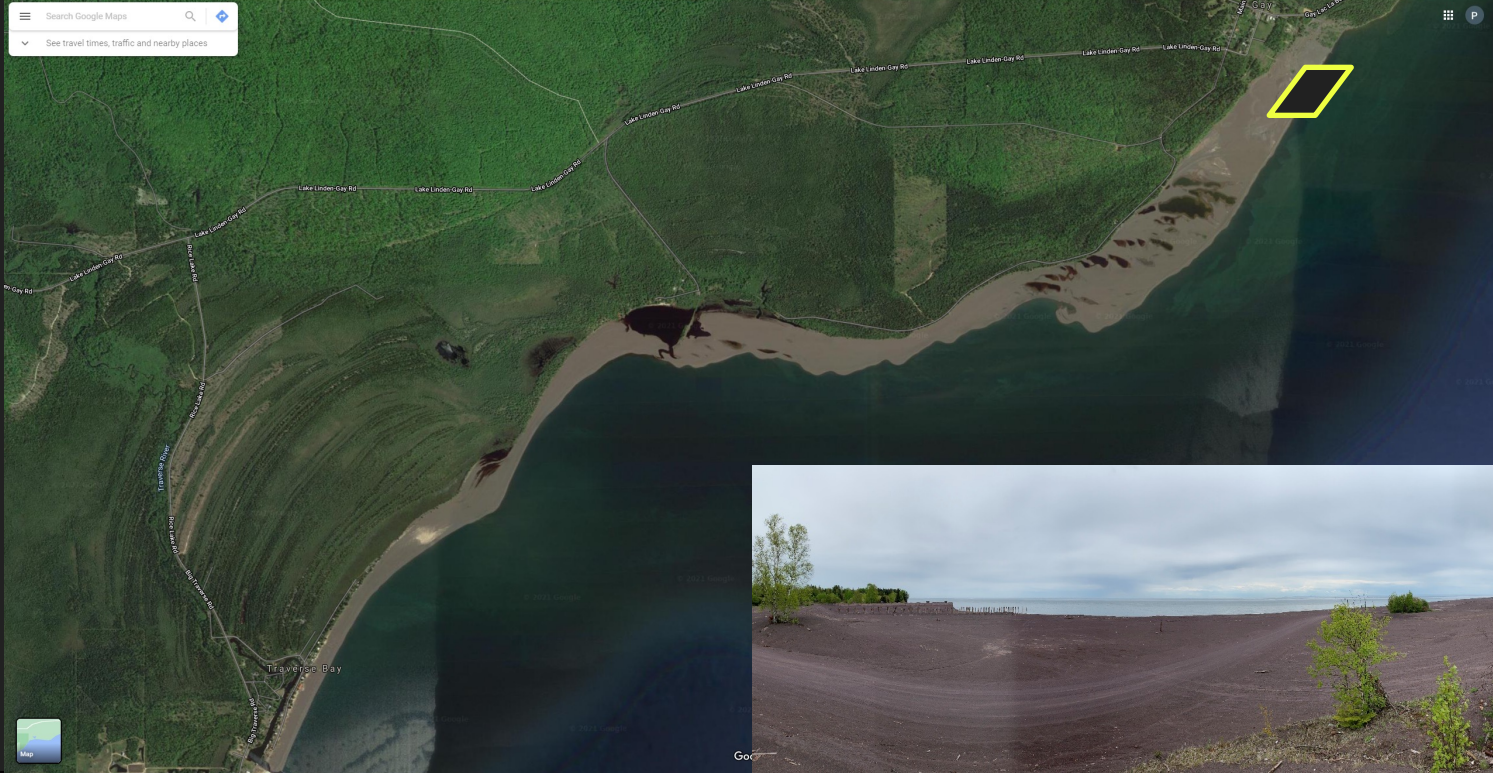
MTU in Houghton, MI

60 km



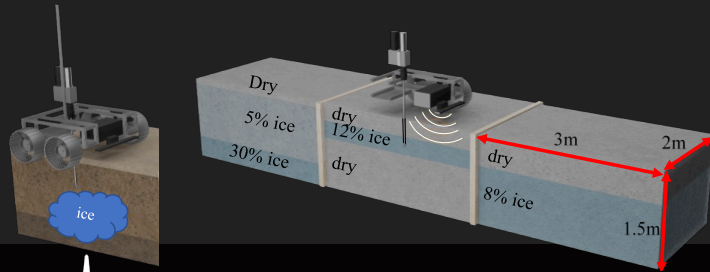


# Stamp Sands Field Site



# Keweenaw Research Center & Airport

- 900 Acres of test terrain
- Any kind of terrain created
- Summer and winter testing
- Heavy equipment, experience & operators available





# Freezer Container at MTU



# GPR Equipment



50 and 100 MHz



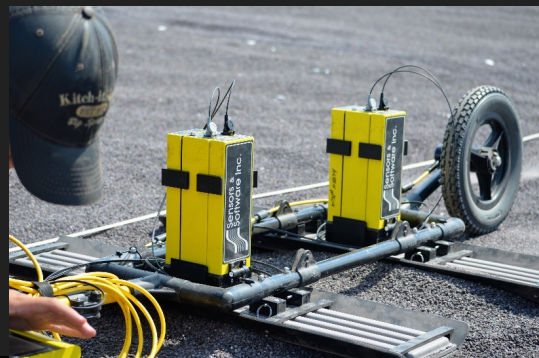
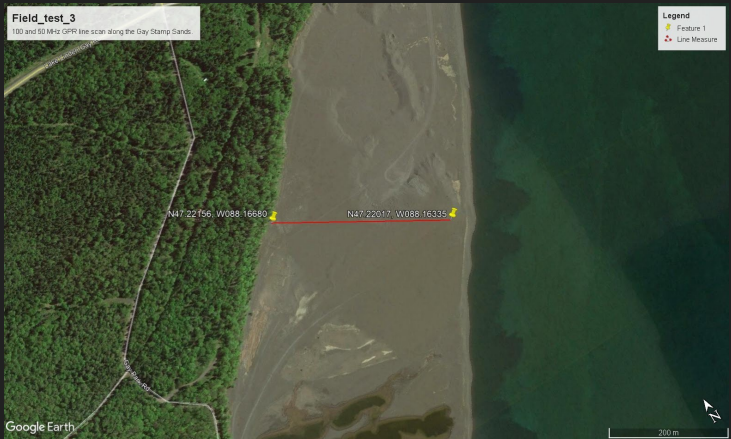
500 MHz



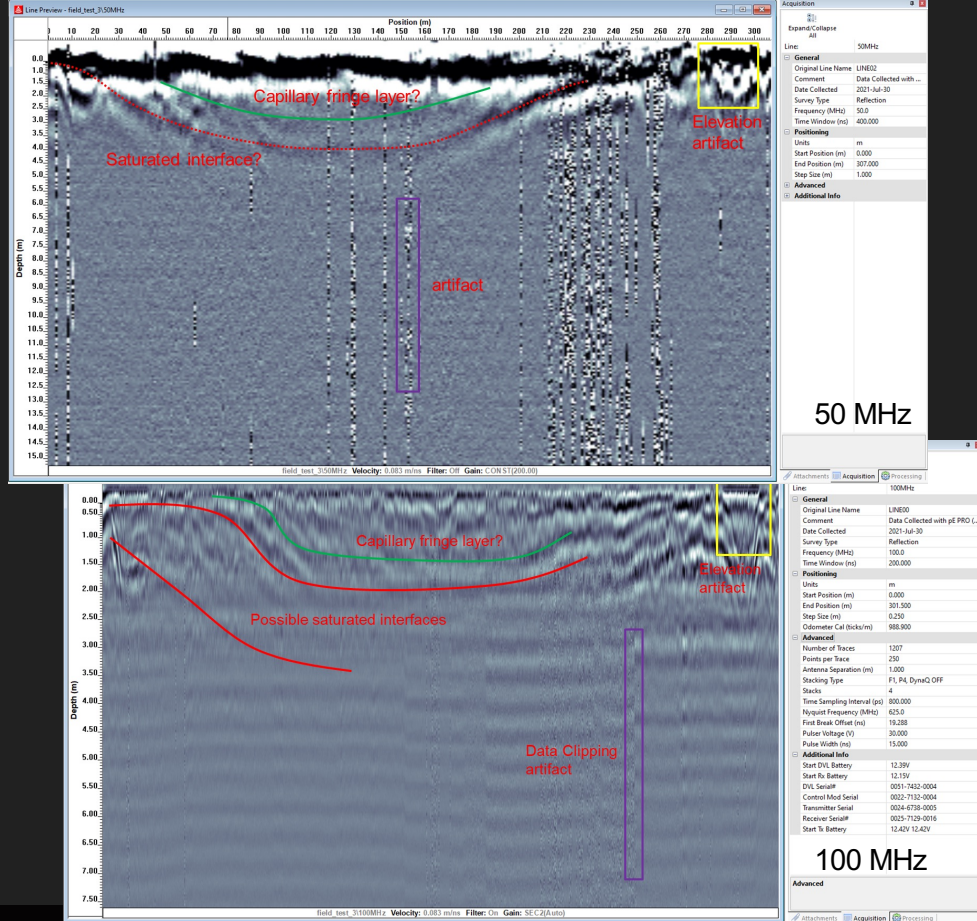
500 and 1000 MHz  
connected with SPIDAR



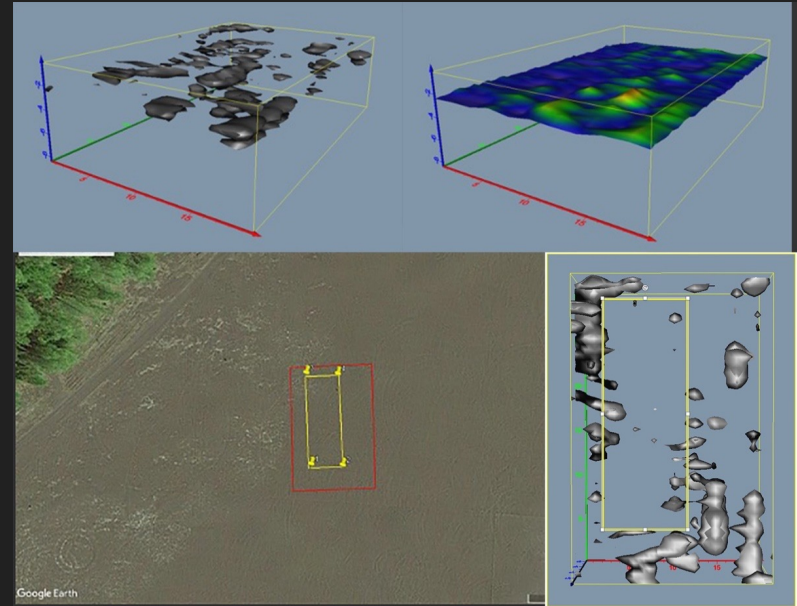
# GPR 50 MHz and 100MHz subsurface survey



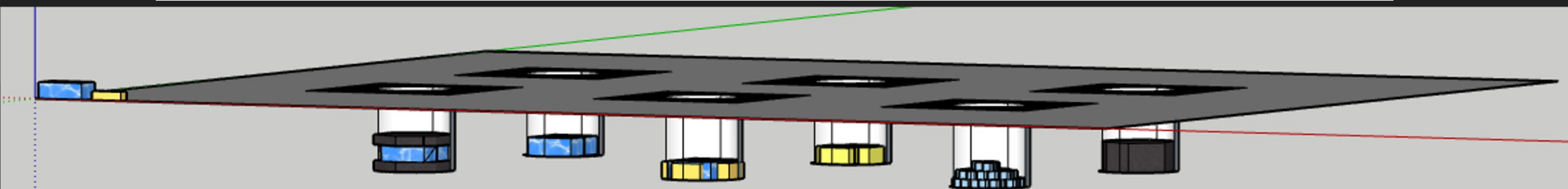
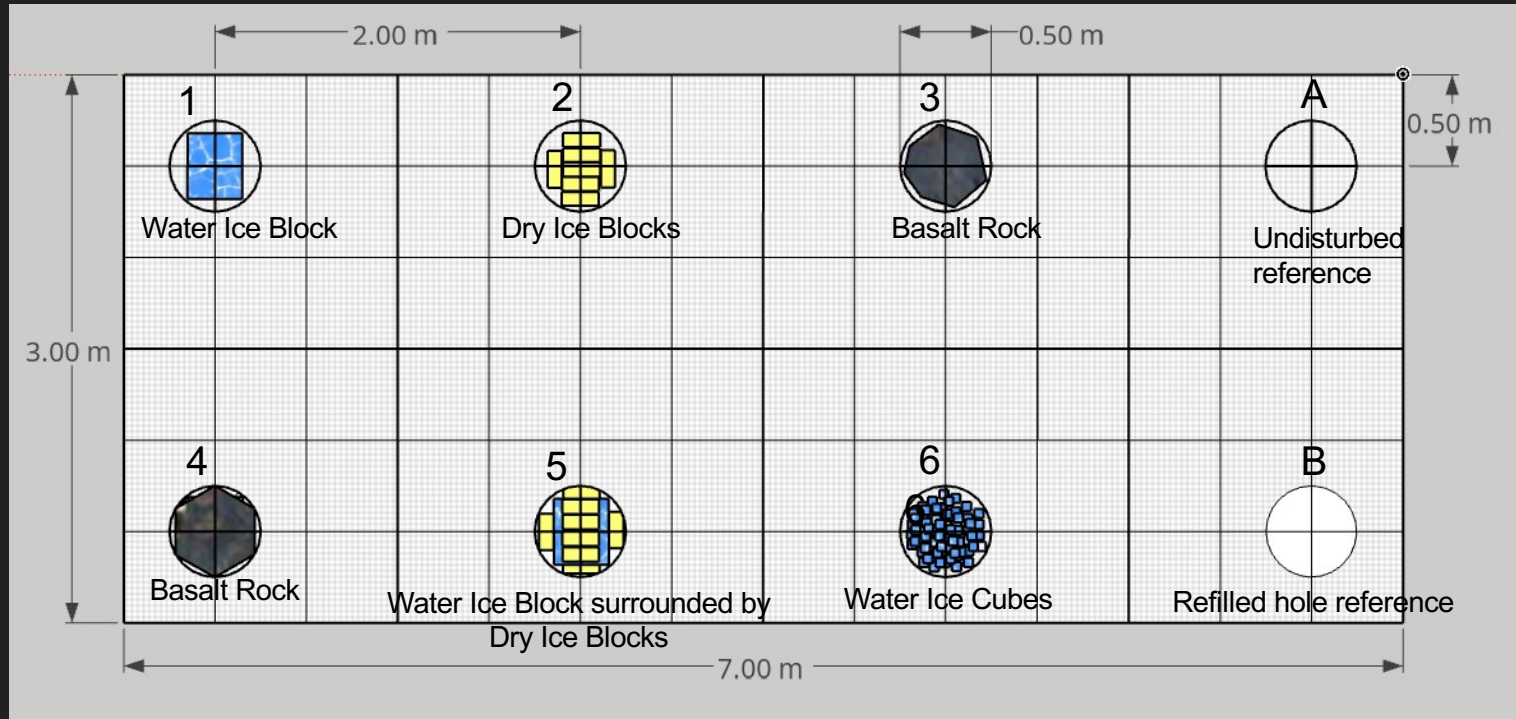




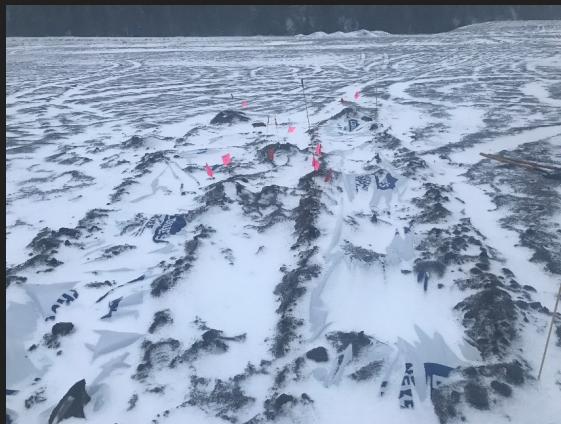
# Water table & clear area determination



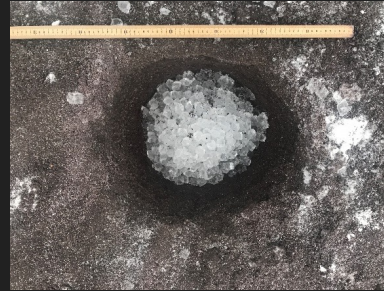
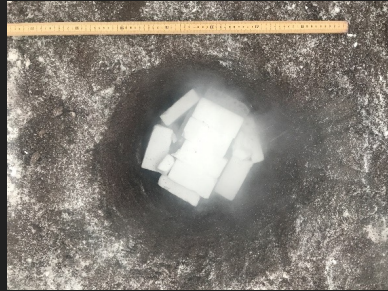
# Trench Template for field test #9





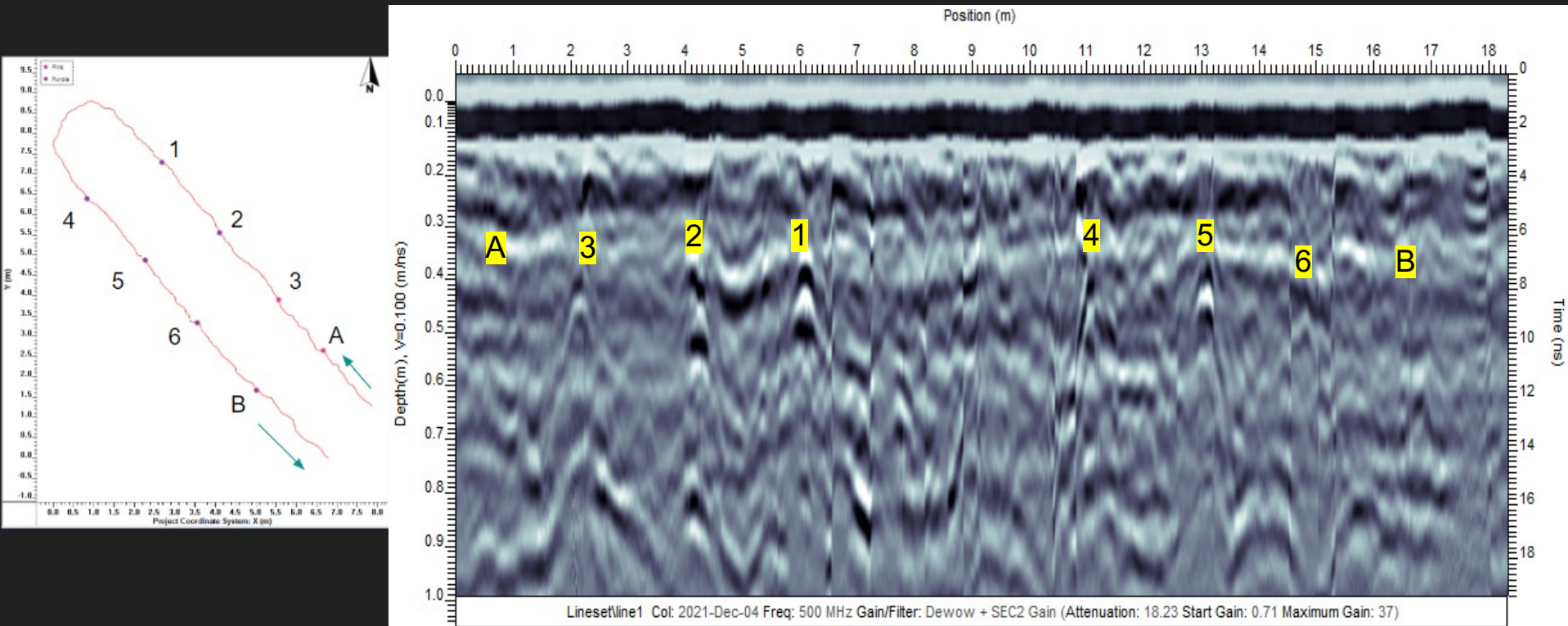


# Excavated holes for testing





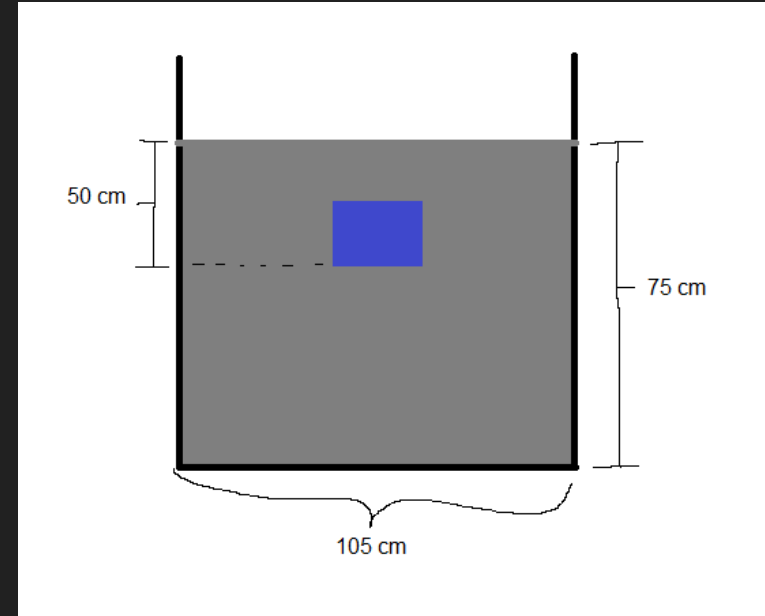
# Field Test #9 Line scan Data



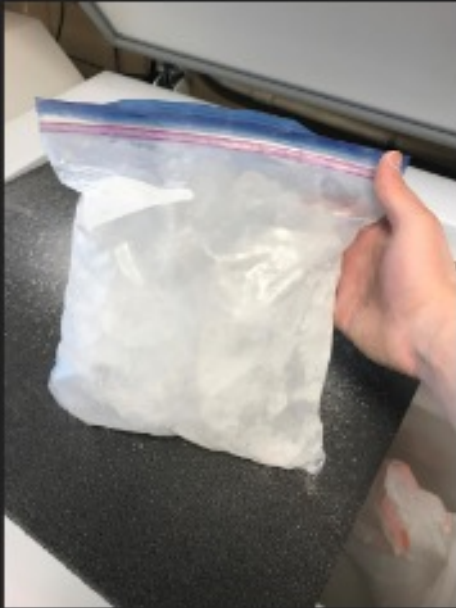


# Regolith Simulant Test #1

- 1000 MHz GPR test
- Continuous scanning
- 0.140 m/ns Regolith Velocity



# Regolith Simulant Test #1



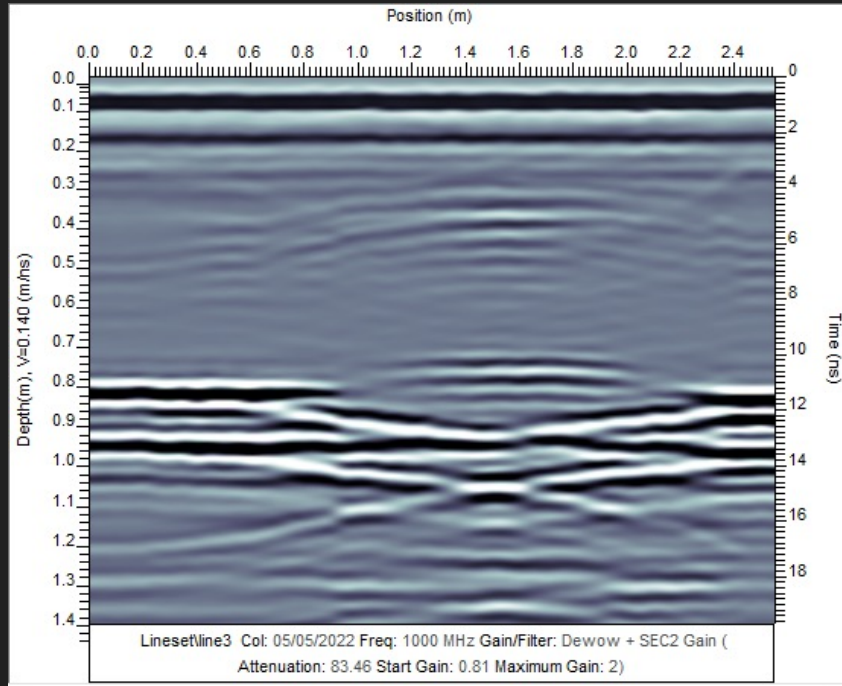
Crushed ice dimensions:  
Two layers of 23 x 21 x 10 cm



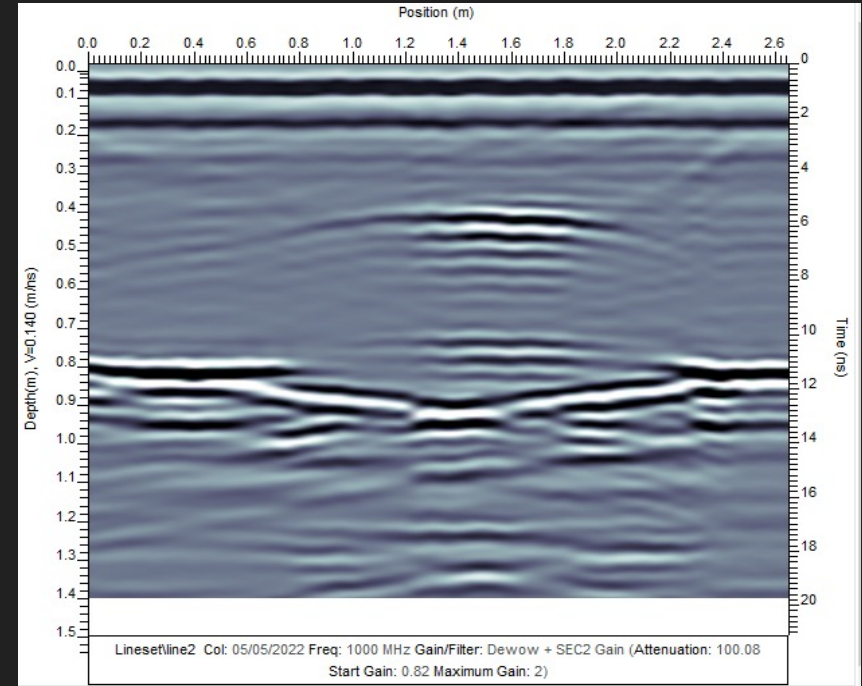
Ice block dimensions:  
21 x 21 x 14 cm

# Regolith Simulant Test #1 Processed Data

## Crushed Ice

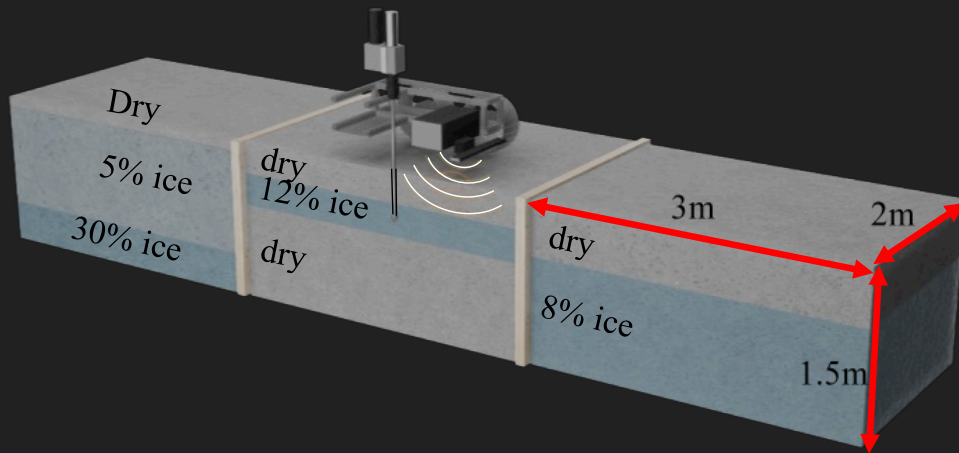
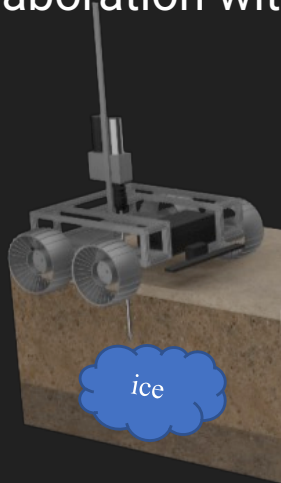


## Ice Block



# Future Work

- Specific target GPR measurements of targets in simulant
- Exploring GPR modeling in further detail
- Data value assessments
- Integration of GPR and PHCP at test sites
- Trench testing at KRC using prepared lunar simulant and ice material
- Collaboration with others (Astrobotic, Notre Dame, etc.)



# Thank you!

