A ground penetrating radar to sound the shallow lunar subsurface and search for water ice

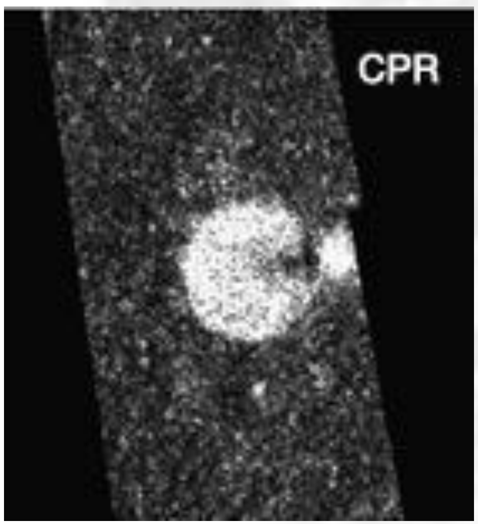
Scientific Objectives for a GPR on a Lunar Rover

- Understand the evolution of the moon through an investigation of the stratigraphic lunar subsurface features
- Access the three dimensional Composition of The Lunar Crust
- Investigate the potential presence of Water Ice (poles) in the shallow sub-surface
- Complement the data acquired from orbit and from the Chang'E-3 GPR

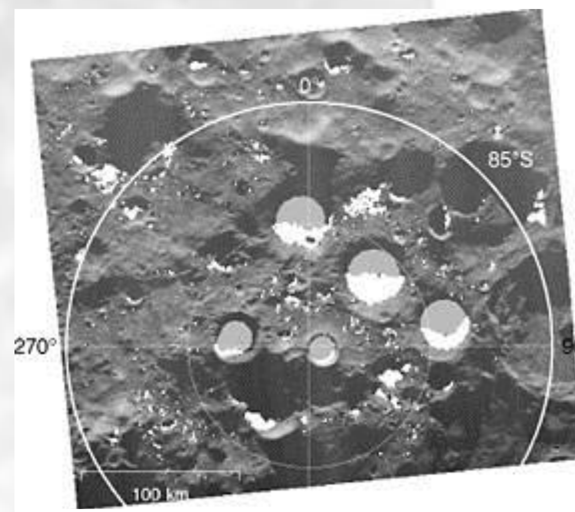
Investigation of the potential presence of Water Ice (pole)

Permanently shadowed areas exist at the bottom of deep craters near the pole

- A high Circular Polarization Ratio (CPR) value is generally due to multiple reflections or volume scattering.
- It is considered to be an indication of ice's presence



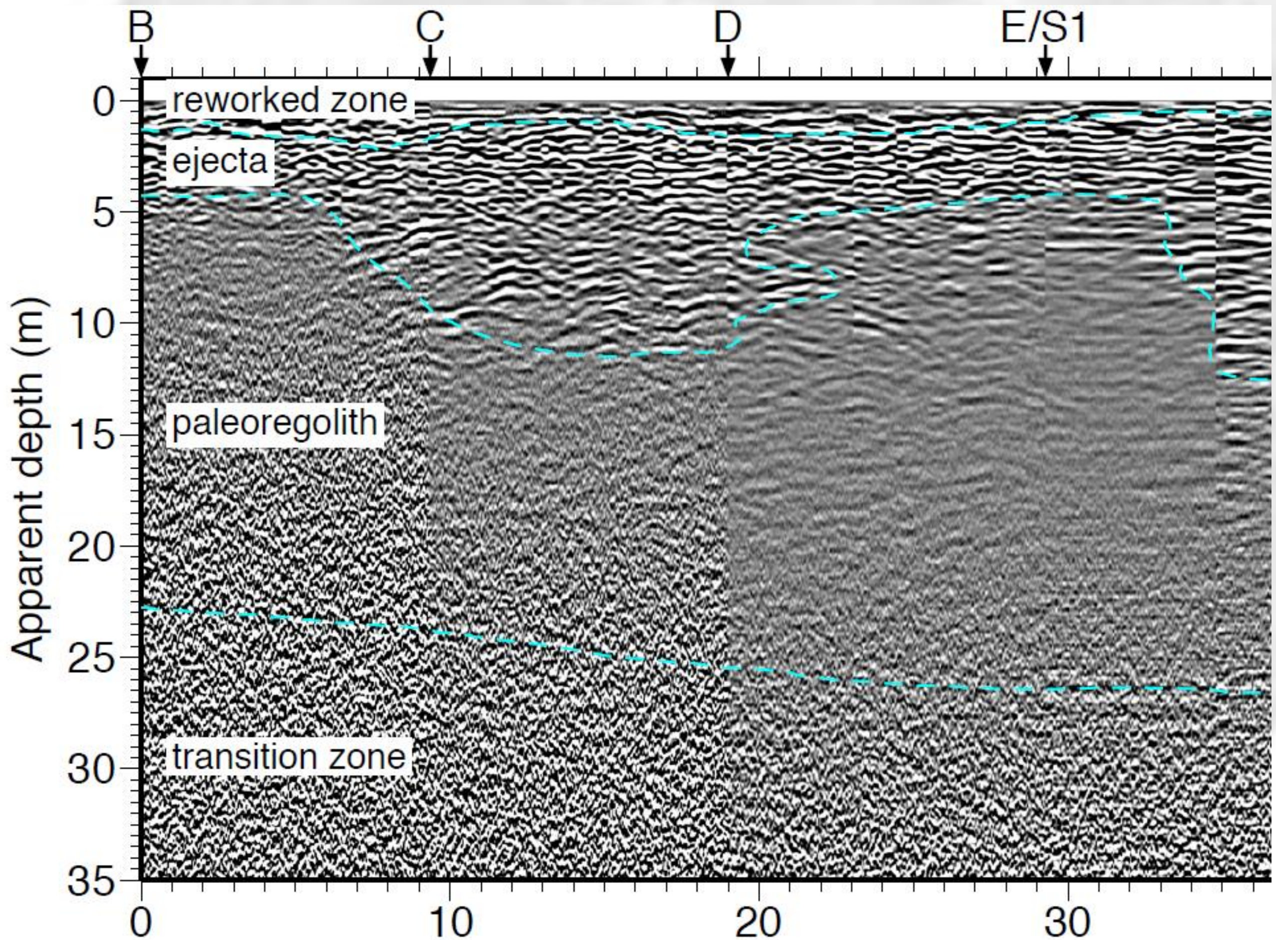
Mini-SAR Chandrayaan
12 cm
Spudis et al.,2010



Goldstone Solar System Radar
3-5 cm
J.L. Margot et al.,1999

Complement the observations made from orbit and from surface (LPR/chang'e-3)

Example : Chang'e-3 LPR data at 500 MHz

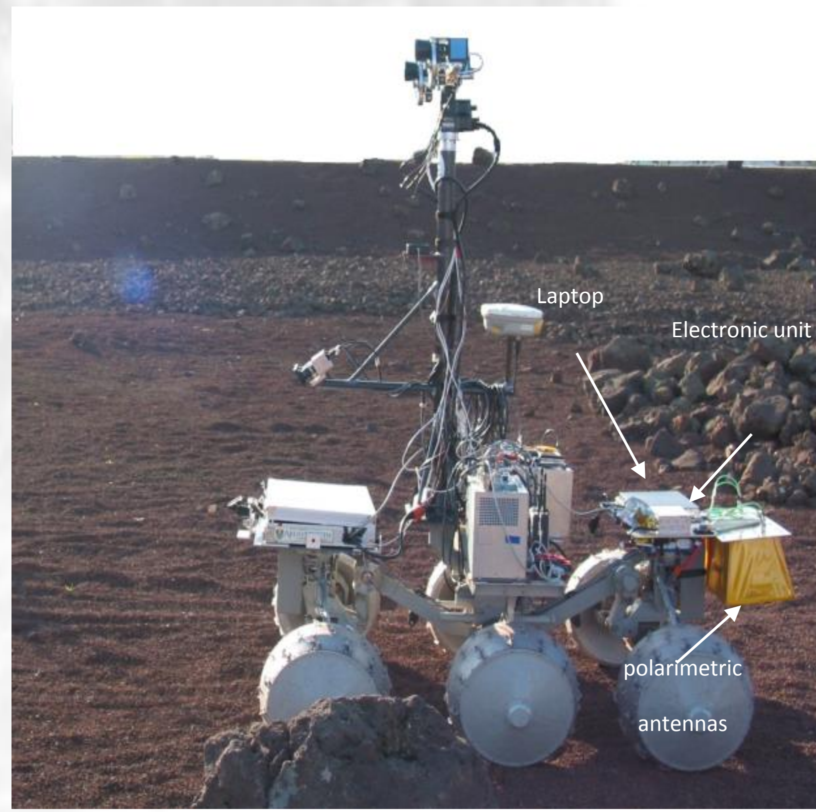


Ref : W. Fa et al. Shallow subsurface structure of the Moon at the Chang'e-3 landing site as revealed by the Lunar Penetrating Radar LPSC 2015

WISDOM
A GPR designed for shallow sounding from a rover

EXOMARS

Phase B1 Design



WISDOM Scientific objectives in the ExoMars context

Investigate and remotely characterize the subsurface

- Understand the 3-dimensional geologic context and history of the landing site
- understand the local subsurface distribution and state of H_2O (such as segregated ground ice, ice-wedges associated with polygonal ground).

Identify the most promising locations for drilling that combine targets of high scientific interest with minimum risk to the drill

The Instrument main characteristics

A Ground Penetrating Radar (GPR)

- Broad band UHF GPR : from 0.3 to 3 GHz
- Step frequency
- Polarimetric measurements (XX - XY - YX - YY)

Anticipated performances

- Vertical resolution of a few centimeters
- Penetration depth (< 10 m)

Operating modes

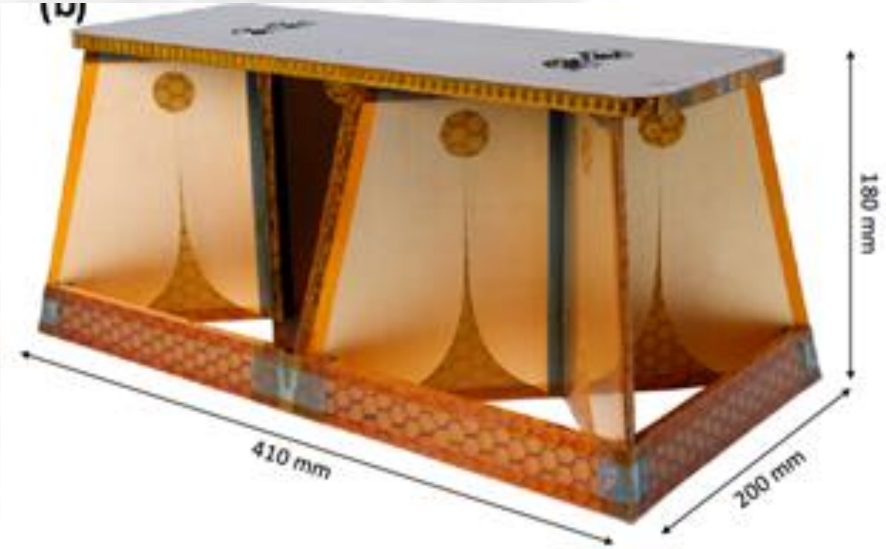
- Rover in motion : Measurements along the Rover path to get 2D profiles or 3D mapping

WISDOM Resources **10% maturity margin**	
Power Allocation (Watt)	
Full Power	**~ 12**
Low power	**~ 6**
Energy per sol (Watt.hr)	
Depending on the operations	
Volume (cm × cm × cm)	
Antenna System (AS)	**42 × 20 × 18**
Electronics Unit (EU)	**9 × 15.5 × 5.5**
Mass Allocation (g)	
Antenna System (AS)	**450**
Electronics Unit (EU)	**850**
Cables	**300**
Total	**1600**

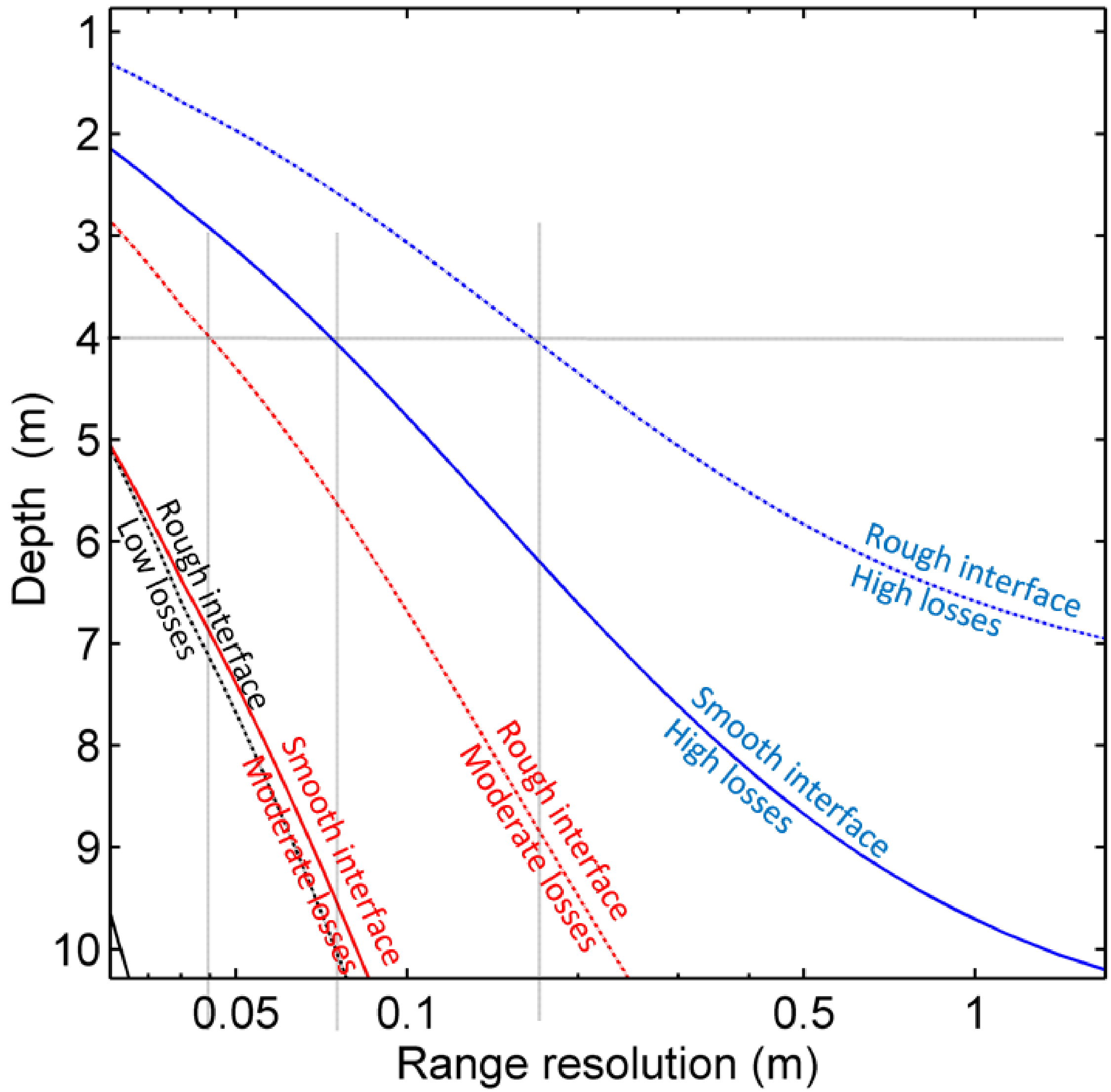
The Instrument

The WISDOM Electronics are included in a single stand-alone mechanical box. This box is made of 3 stacked modules for EMI

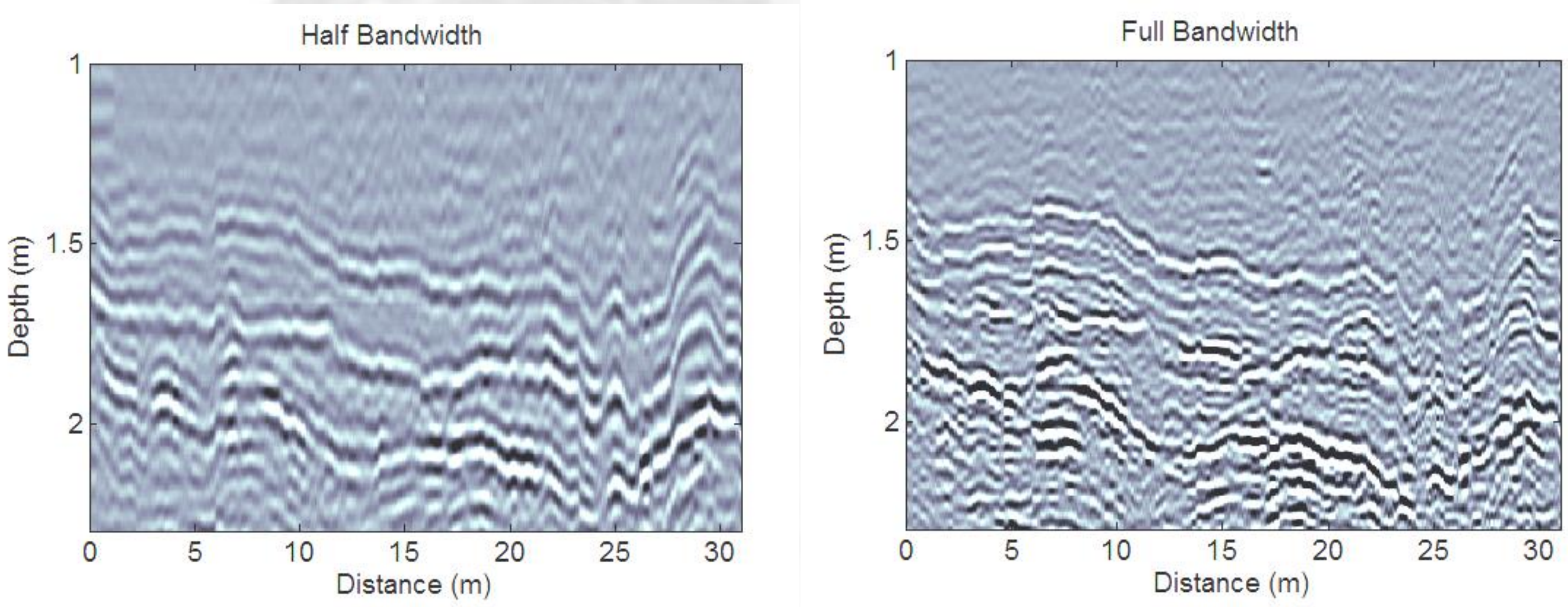
Two identical dual-feed, fully polarized Vivaldi horns for transmission and reception



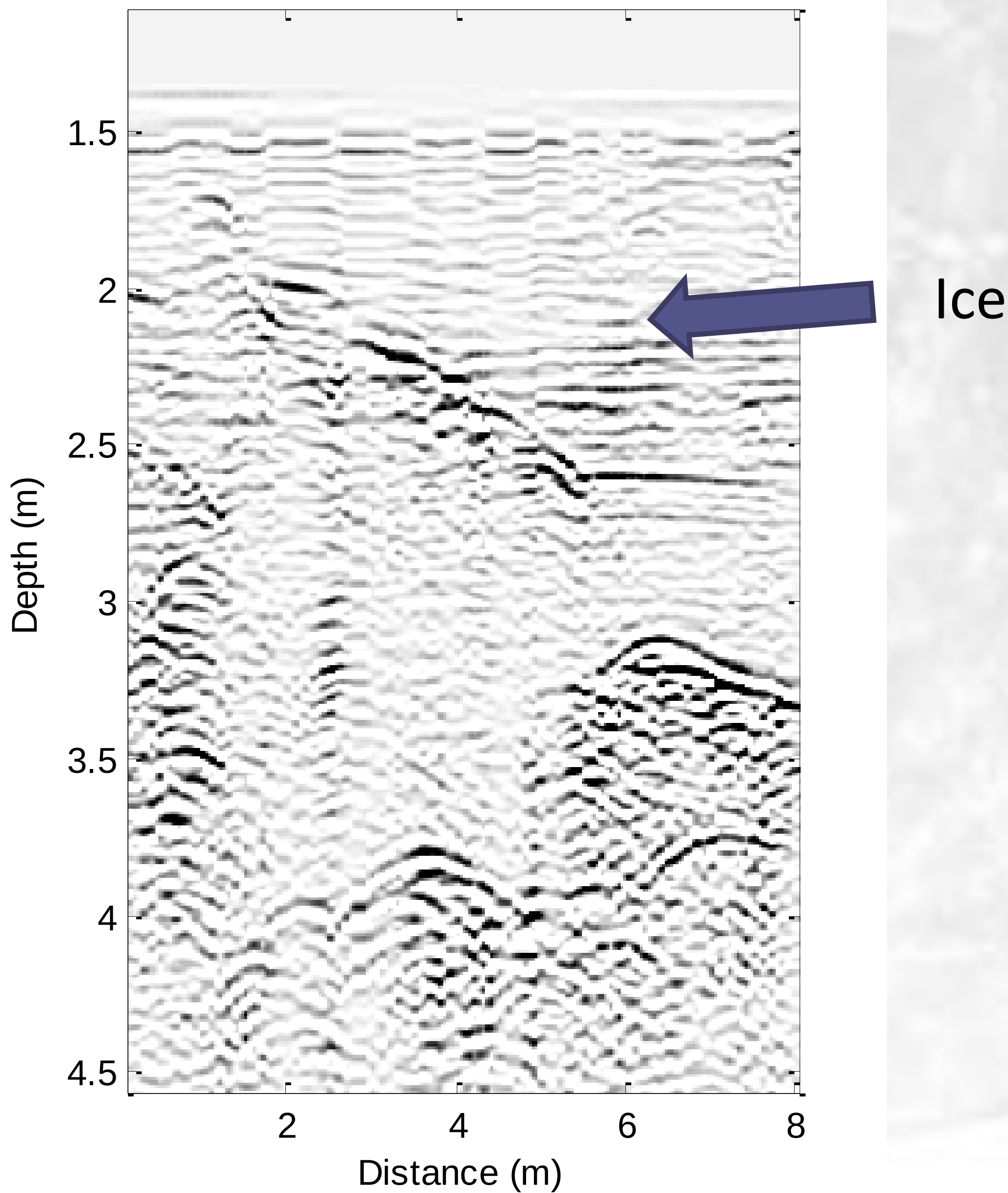
Expected performance



Example of the achieved range resolution

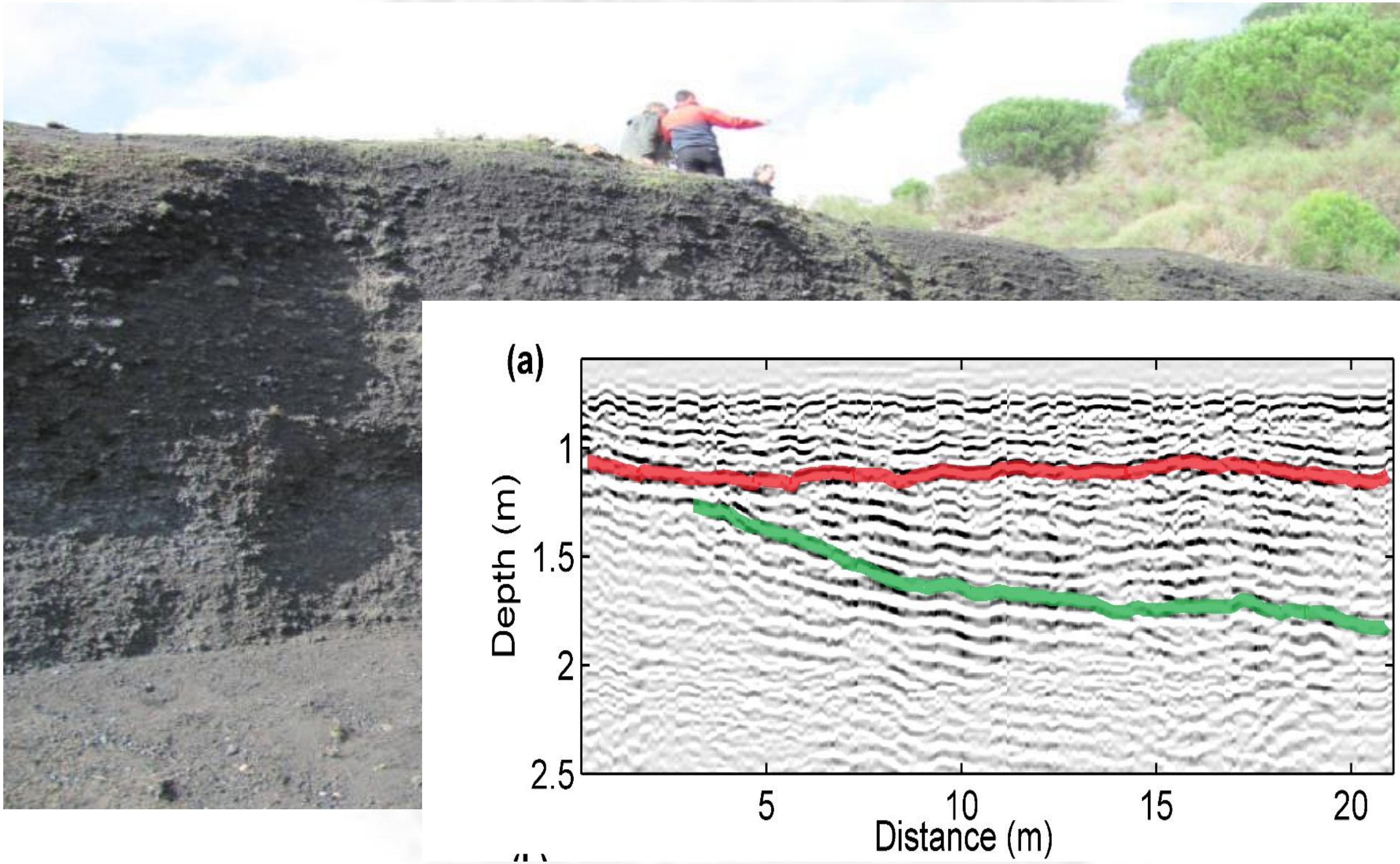


Radargram of an icy environment



Permittivity ~3.2
Extremely low losses

pyroclastic deposits



Conclusion

- A GPR like WISDOM gives access to the structures (> 10 cm) at depth (<5m in lithic environments)
- It can detect, localize and characterize homogeneous units

  -> segregated ice
- It can estimate permittivity values

  -> If the rocks electrical properties are well constrained, it might be possible to detect the presence of ice (vs vacuum) in the regolith.
- The synergy with a neutron detector improves significantly the GPR interpretation in terms of ice content.