‘PASS’ : an Instrument for *in situ* Permittivity And Susceptibility Sounding of a Regolith

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The point of measuring electromagnetic properties of the surface

Matching its chemical and mineralogical composition with a known meteorite class.

- the chemical and mineralogical probes are sensitive to the first few microns of the asteroid's surface only, prone to a severe alteration by space weathering.

– The NEAR mission to 433Eros demonstrates the ambiguity of such instruments (APXS, IR spectra, etc.) to decide for a meteorite class assignment (McCoy et al., 2001).

The point of measuring electromagnetic properties of the surface

Quantifying the effect of space weathering and the thickness of the weathered regolith, able to determine the age and history of the investigated surface.

Therefore a non-invasive geophysical probe, is the only way to respond unambiguously to these two objectives (Rochette et al., 2004).

The magnetic susceptibility and electric conductivity/permittivity profiles down to about one meter depth will allow to define the **vertical gradient in metallic iron** produced by space weathering (Sasaki et al., 2001; Korotev et al. 1997).

Definition of an unaltered amount of magnetic minerals (metal or magnetite) using magnetic susceptibility will allow narrowing the possibilities for assigned chondrite classes (Fig.1 after Rochette et al. 2003 and in press).

The point of measuring electromagnetic properties of the surface

- **Other applications**
  - 1) **Constraining radar impedance** for the orbiter or Earth-based studies,
  - 2) Estimate of **the porosity**, i.e. decide the regolithic or coherent rock nature of the lander subsurface,
  - 3) Detect the **presence of ice and hydrated phases** (showing a distinct electrical signature). For this quite critical objective it is necessary to couple electric and magnetic properties, to delineate the contributions of water and metal or magnetite to the electric properties. For that objective the profiles are also important as water could be more abundant at depth.

Scientific outlines

- Regoliths result from a number of past and present processes : volcanism, differentiation, impacting, gardening, wheathering… that can be identified by measuring its physical properties.

- EM measurements will contribute to reach that goal.

- As regolith properties are expected to vary with depth, it is mandatory to dispose of, at least, two different depths of investigation

Dielectric Permittivity

$$\varepsilon_r = \varepsilon' + \frac{\sigma}{i\omega\varepsilon_0}$$

•The complex relative **dielectric permittivity**

•(where σ is the electric conductivity and ω the angular frequency) is a volume property depending on the content in the different components, the permittivity of most of the solid fraction being around 3. This property will be sensitive to the **porosity** and eventually to the presence of small **mineralised water drops**.

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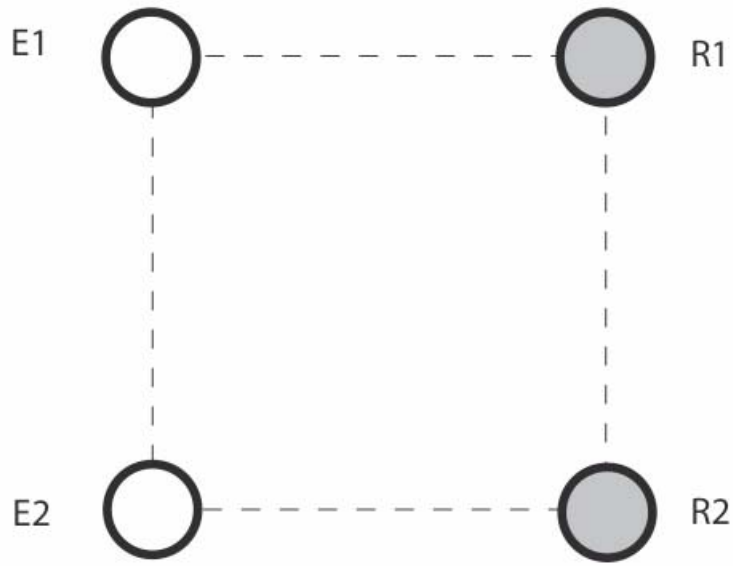
•**Technical elements**

• For permittivity measurements (one quadrupole: 2 emitters and 2 receivers), one must locate the poles at the tip of small light non-conductive feet 2 or 3 centimeters thick.

•Frequency from 1 Hz to 1 MHz . Liquid water will exhibit a transition near 10 kHz (iron sulfide near 1Hz, other oxides near 1MHz)

PASS : Electrical Permittivity



Electrical permittivity

Magnetic susceptibility

- **Magnetic susceptibility** is a volume property due to the presence of ferrimagnetic grains (metal, iron oxides or sulphides. The sources of iron can be both local magmatic rocks and dusts associated with meteorites, the chemical status of iron depending on the past and present conditions at the surface of the planet.

- The **vertical variation** of the magnetic susceptibility will document the existence of a chemical gradient in the regolith

Magnetic susceptibility

- **Technical elements**
- - Magnetic susceptibility measurements necessitate a rigid mechanical configuration that can be achieved by the fixity of the lander and assuming sufficient time for successive measurements is available.

- - For the susceptibility measurements one must use low frequencies (1 to 10 Hz)

PASS :Magnetic Susceptibility Sounding

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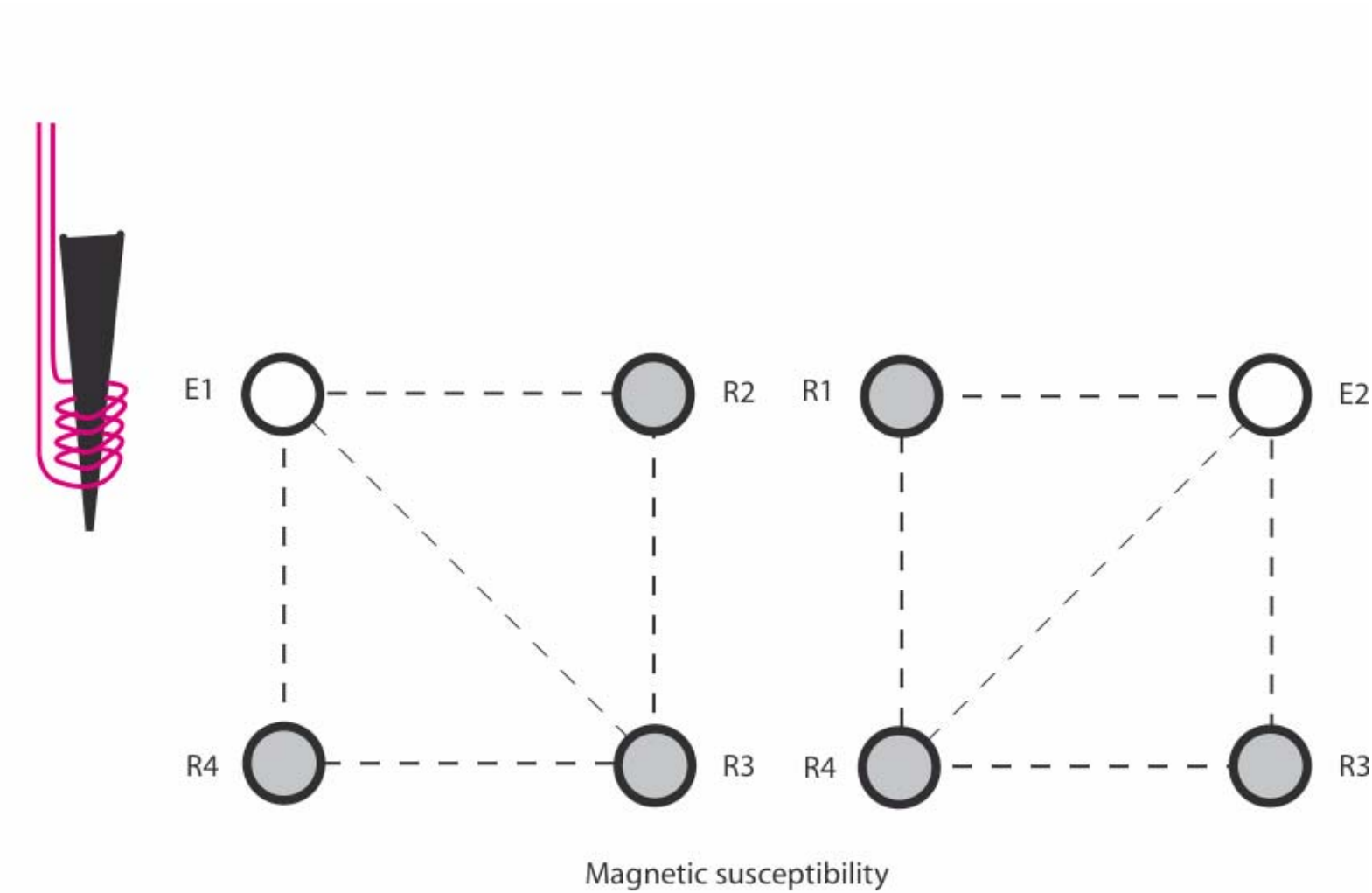

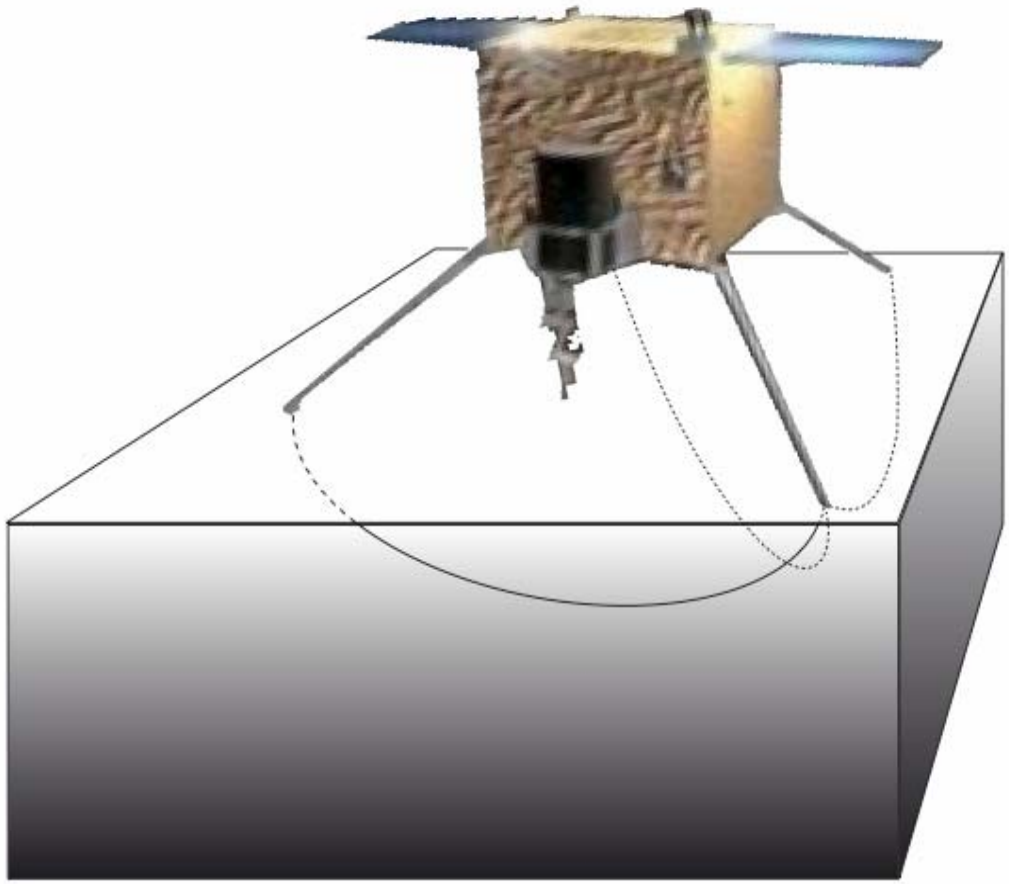

Technical data

- ***Weight** : 80 g*
- 40 g for the poles (10 g each) and 40 g for the electronics.
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- ***Power requirements** : Average W, Peak W*

- ***Data flow***
- This flow can be very slow, because the instrument is stationary, each elementary measurement will correspond to 100 octets, taking into account a redundancy short messages of 1Ko will be sufficient (they can be repeated once per hour to follow a possible daily change).
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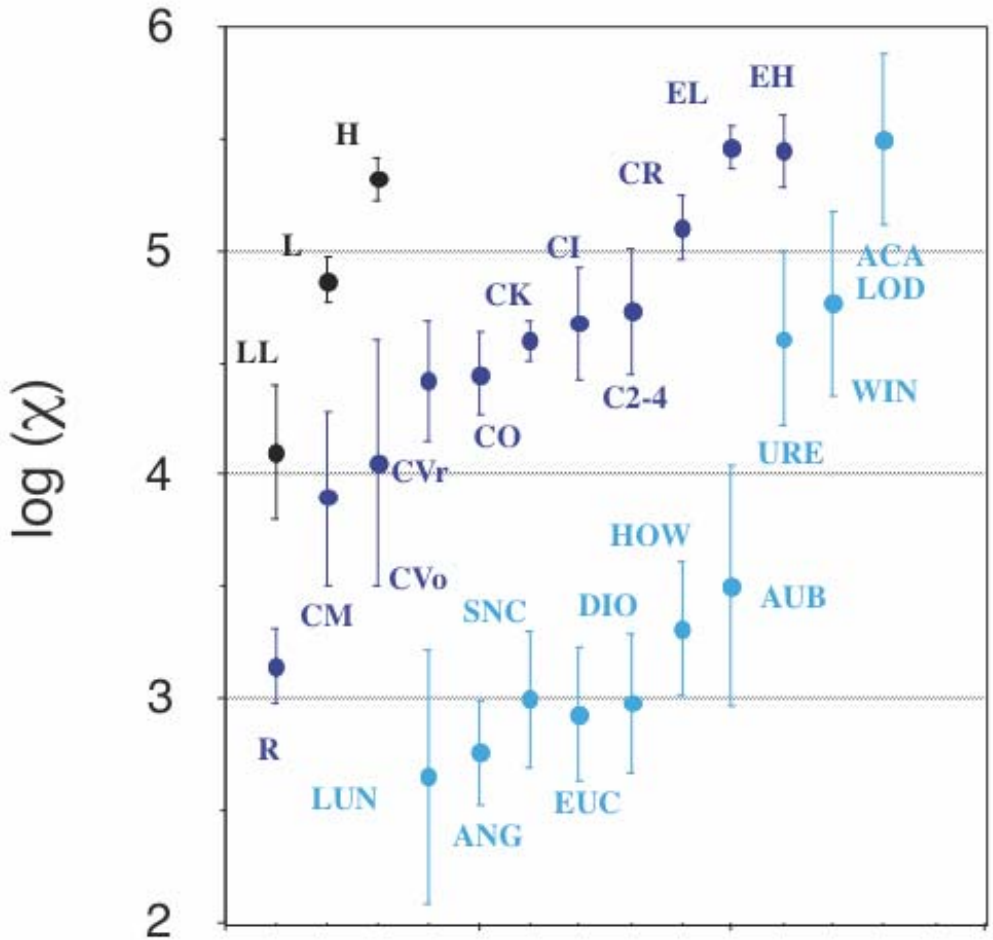
- **Present status of the project: TRL=4**
- Our laboratory has a sound experience in the designing and building of geophysical prospecting apparatus and logging sensors in both electrical and EM domains.

Magnetic susceptibility of meteorites



Conclusion

- Simple experiment (low weight, low power, low cost), no mechanical parts.
- Physical data not provided by other equipments.
- Can be adapted to study the surface of any solid body (comets, planets or asteroids).