



χ - Susceptibility measurements

Magnetic characterization is essential to know the past and present of planetary objects. To make magnetic prospections in-situ, we have developed a magnetic susceptometer (it's real: and imaginary: parts) to determine the magnetic structure recorded during the formation of the studied rocks. Complementary measures with vector magnetometers to know the total magnetic field (B) and its components (Bx, By, Bz), complete a total study of the planetary exploration.

The measurement of the complex magnetic susceptibility (χ' and χ'') and the availability of handheld devices to perform such measurement is scarce and very limited. We have developed an instrument and adapted a procedure for the determination of this characteristic in natural environments.

The instrument is a susceptometer based on inductive methods with the capability to determine the complex magnetic susceptibility in a fast, non-invasive and non-destructive way, without the need of sample preparation. It performs the measurement of the volume magnetic susceptibility by exciting the sample using the stray magnetic field of low intensity produced by the sensor core, which penetrates the sample up to 1 cm depth.

The procedure for the measurement of the complex magnetic susceptibility included the development of our own reference samples for the calibration of the instruments. On the one hand, the instrument is not adapted for the measurement of the susceptibility of conductive materials, and the primary patterns of magnetic susceptibility are made of bulk nickel – conductive- samples. On the other hand, the samples are excited with alternative field at frequencies from tenths to hundreds of KHz, and the reference equipment (VSM and other magnetometers) measures in DC or different frequencies. The developed reference samples are made of ferrite powder within a matrix of epoxy resin to ensure non-conductive samples and a real component of the susceptibility that varies as least as possible with the frequency in the measurement range.



The instrument, developed within the frame of the H2020 project “NEWTON”, includes magnetometer, portable susceptometer, power supply system immune to radiation and a frequency generation system. Current state of the prototype is a fully operative sensor, tested in relevant environments (TRL6), suitable for boarding in a planetary exploration rover in the short term.

The susceptometer measures the complex magnetic susceptibility in a demonstrated range from $\chi' = 10^{-4}$ [S.I.] to $\chi' = 101$ [I.S.], and theoretically it can measure susceptibilities up to $\chi' = 103$ [I.S.].

Range	Min (I.S.)	Max
Real Vol. Susceptibility	10^{-4}	10^1
Imaginary Vol. Susceptibility	10^{-5}	N.A.*

** Imaginary component of susceptibility is expected to be lower than the real component, which establishes a theoretical maximum value in the range of $\chi'' = 100$ [S.I.], achievable by the instrument.*

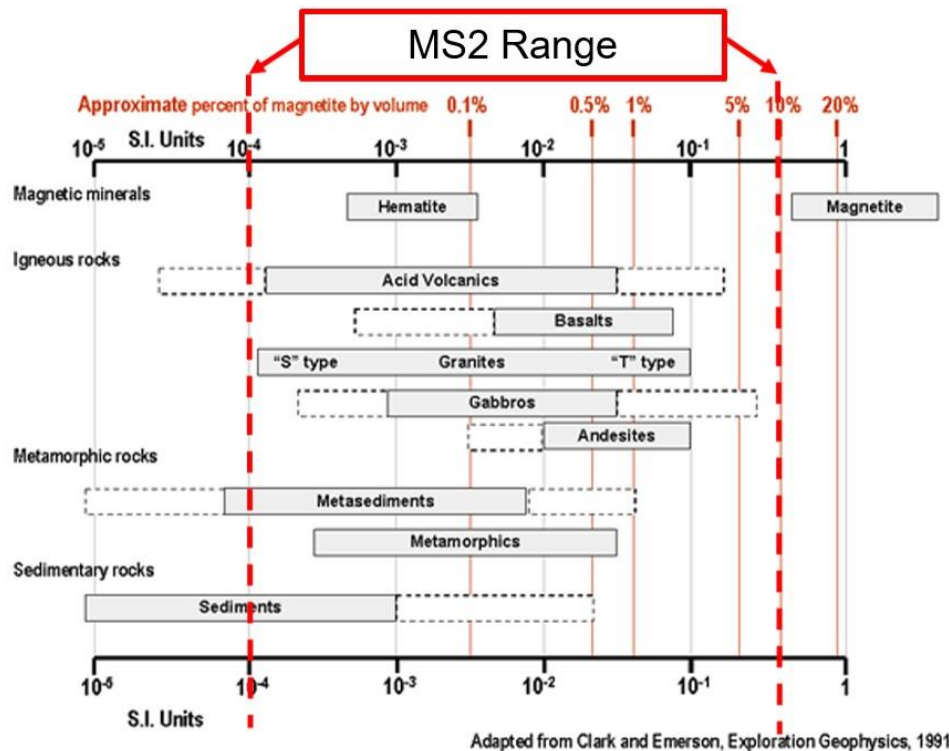


Figure 1. Bulk magnetic susceptibilities of magnetic minerals as well as igneous, metamorphic and sedimentary rocks.

The sample does not need any special preparation.

However, there are some requirements for the samples to be measured.

The sample surface to be measured should be at least the same size of the sensor core contact surface, and with a roughness which must not exceed 0.5 cm. It is required a thickness at least double of the penetration length to ensure maximum reliability for the measurement. The more flat the surface is, the more reliable is the susceptibility determination.

Instead of preparation, the sample must be selected following the criteria:

- Minimum surface equal to sensor contact surface (4 cm x 3 cm).
- Minimum thickness equal to sensor penetration depth (2 cm).
- Minimum roughness or surface roughness.



The current design of the instrument provides a flexible physical interface for the susceptometer with the capability to shortcut tilted samples or soils, ensuring maximum contact between the sample under measurement and the sensor core.

Sample properties	Minimum	Maximum
Surface	4 x 3 cm	N.A.
Thickness	2 cm	N.A.
Roughness	N.A.	20% (<10% error)

The instrument is currently divided into two boxes:

- 1) The electronics box, including dc-dc converter, control electronics, resonant circuit, power interface, sensor interface, cpu interface and all the auxiliary electronics of the instrument (Table 1).
- 2) The sensor box, including the susceptometer ferrite core, an AMR triaxial magnetometer a two platinum thermos-resistors to monitor the temperature (Table 1).



		Maximum
Electronics Box	Dimensions	
	Length (mm)	90
	Width (mm)	90
	High (mm)	80
	Weight (g)*	350
Sensor Box	Power Consumption **	2.75 W (Stand-by) 3 W (Operation)***
	Dimensions	
	Length (mm)	70
	Width (mm)	24
	High (mm)	53
	Weight (g)*	212 (AL 70705)
	Power Consumption	5 mW _{AC} (Stand-by) 10 mW _{AC} (Operation)

Table 1. Physical and power characteristics.

The shape, volume, weight and power consumption can be adapted to the mission constrains.

Web: <http://www.h2020-newton.eu/>