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MSM – Magnetic susceptibility meter for planetary regolith composition studies

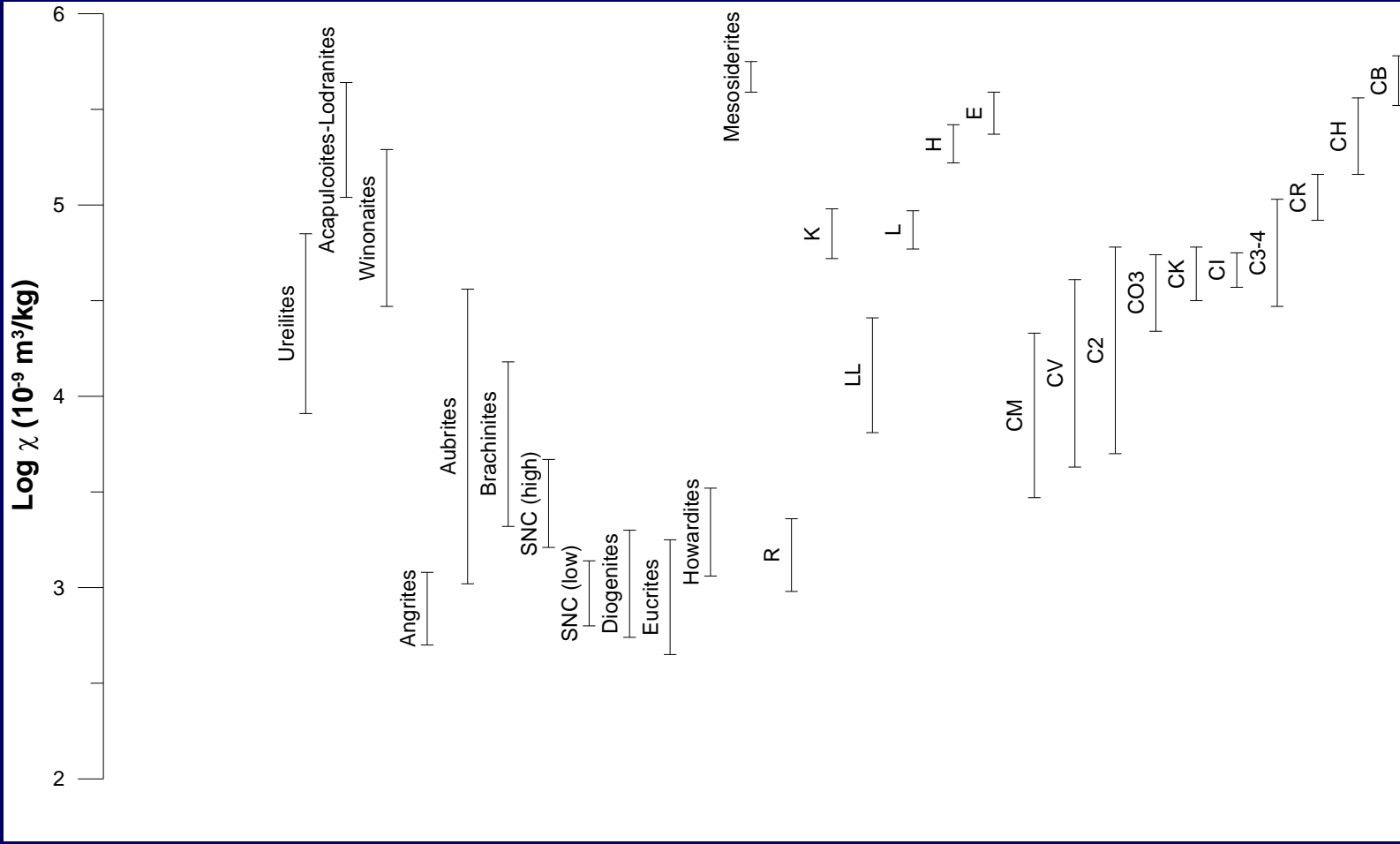
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Magnetic susceptibility

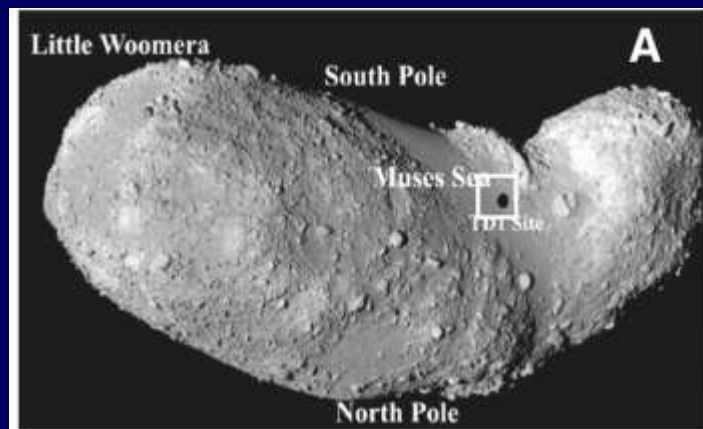
- Magnetic susceptibility is defined as a ratio of the induced magnetization to the external (inducing) magnetic field $\chi = M_i/H$
- It is a material property
- In rocks, it depends on the amount of ferromagnetic minerals (mainly metallic iron in meteorites)
- Database of meteorite magnetic susceptibility contains thousands of meteorites

Magnetic susceptibility of meteorites



Meteorites, asteroids and regolith the scale difference

Itokawa asteroid

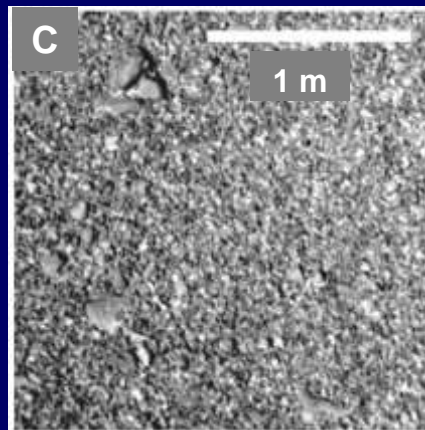


550 m

Hayabusa space probe



Detail of the surface

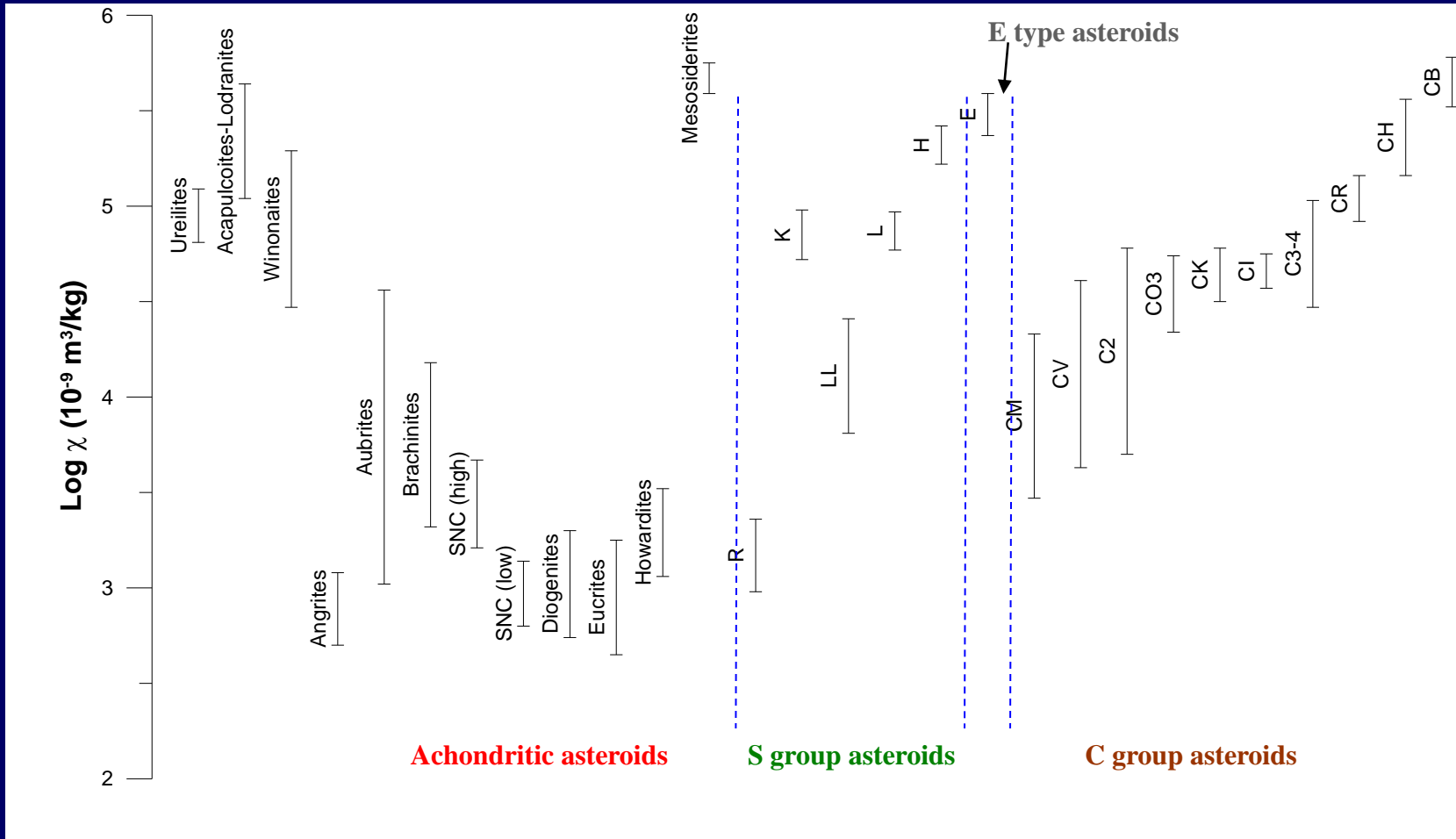


Bjurböle meteorite



5 cm

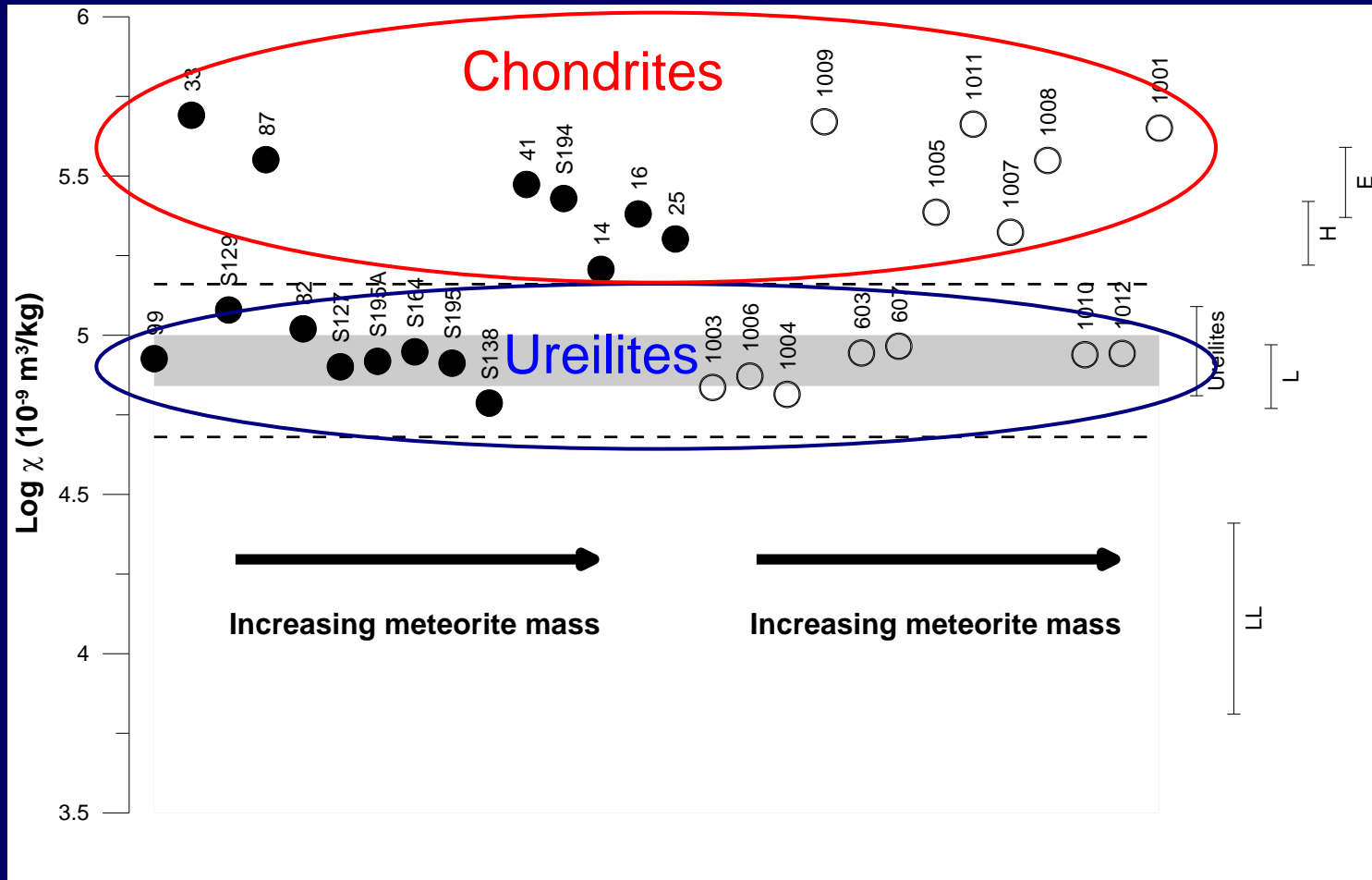
Magnetic susceptibility of meteorites and asteroids



Comparison of susceptibility measurement and reflectance spectroscopy

- Both are sensitive to asteroid composition.
- Silicates and organics can be detected in reflectance spectra.
- Presence of metallic iron, sulfides and oxides can be determined from magnetic susceptibility (quantitatively).
- Thus reflectance spectroscopy and susceptibility measurements complement each other.

Case study – Almahatta sitta meteorites and asteroid 2008 TC₃

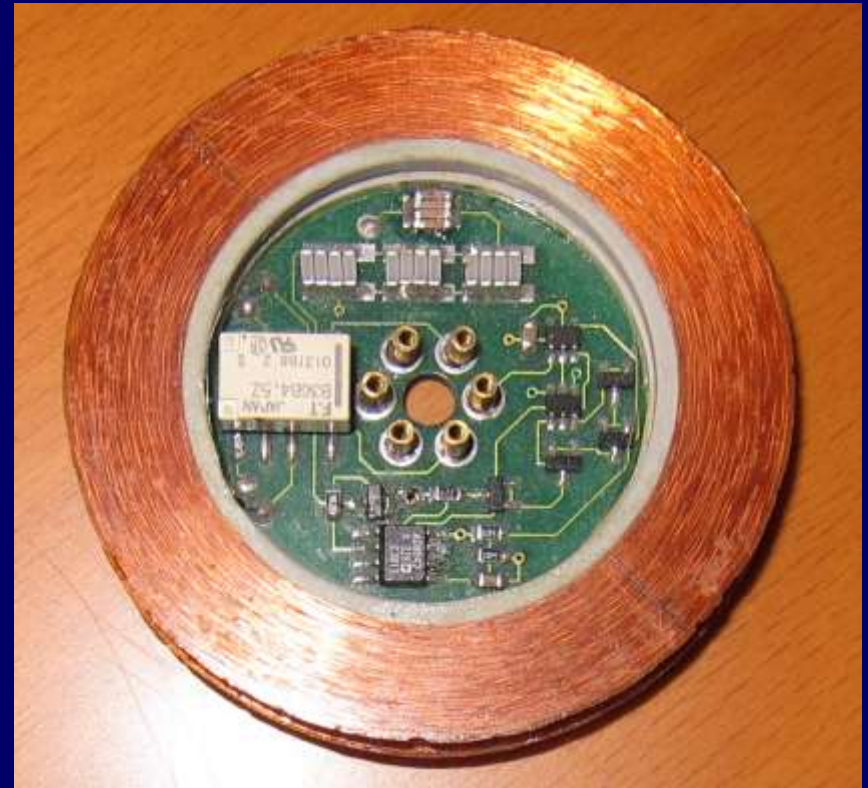


MSM – Magnetic susceptibility meter for asteroid regolith composition studies

- MSM is a simple instrument to measure magnetic susceptibility of a the regolith.
- The design is based on the proven commercial product (SM-30) from ZH instruments.
- Dual frequency measurement option provides a possibility to detect iron nanoparticles as products of space weathering.
 - Susceptibility decay with increasing frequency is diagnostic to presence of superparamagnetic nanoparticles.

MSM specifications

- Single coil design
- Low mass (~ 100 g)
- Compact and robust design (~ 5 cm, encapsulated coil)
- Low power consumption (< 50 mW)
- Fast measurement (~2-3 s)
- Elimination of moving mechanical parts
- Dual frequency measurement option for iron nanoparticle detection
- Regolith temperature measurement option



MSM team

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Instrument location

On the main spacecraft

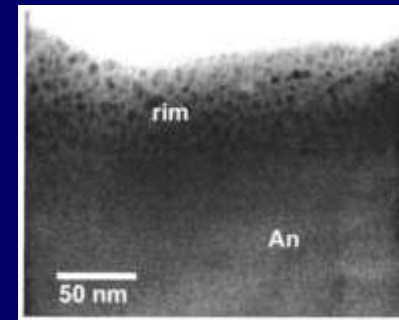
- Attached to the landing gear or sampling mechanism.
- Spot measurement during sampling.

On the lander

- Attached to the bottom of the lander in order to obtain direct contact with asteroid surface.
- In the case of roving / hopping lander, several spots across asteroid can be measured.
- Regolith temperature variations can be measured.
- Susceptibility thermal variations are diagnostic of various magnetic minerals.

MSM contribution of the instrument to planetary missions

- Primary goal of the instrument is the characterization of planetary regolith composition and its (in)homogeneity.
- Through susceptibility measurements, similar meteorite types can be determined.
- Secondary goal of the instrument is a search for iron nanoparticles (space weathering products).
- In the case the instrument is part of a lander package and is deployed on the surface for a longer period, it can be used for measurements of regolith temperature and its variations.



MSM applications

- MSM is currently ongoing one year CISI assessment study for ESA Marco Polo-R asteroid sample return mission.
- MSM will be submitted as optional payload to Marco Polo-R AO call.
- MSM was also submitted to ESA Lunar Lander CDI.

