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NEWTON - NEW portable multi-sensor scienTific instrument for non-invasive ON-site characterization of rock from planetary surface and sub-surfaces

M. Díaz-Michelena, J. de Frutos, A.A. Ordóñez, M.A. Rivero and J.L. Mesa (1), L. González and C. Lavín (2), C. Aroca, M. Sanz, M. Maicas, J.L. Prieto, P. Cobos and M. Pérez (3), R. Kilian and O. Baeza (4), B. Langlais and E. Thébault (5), J. Grösser and M. Pappusch (6)

(1) Instituto Nacional de Técnica Aerospacial (INTA), Madrid, Spain, (2) TTI, Santander, Spain, (3) Universidad Politécnica de Madrid (UPM), Madrid, Spain, (4) Universitat Trier (UT), Trier, Germany, (5) Laboratoire de Planétologie et Géodynamique (LPG), CNRS and University of Nantes, Nantes, France, (6) IGU Institut fur Industriellen Undgeotechnischen Umweltschutz GMBH (IGU GmbH), Wetzlar, Germany. (clavin@ttinorte.es / Fax: +34-942-270139)

Abstract

In space instrumentation, there is currently no instrument dedicated to susceptibly or complete magnetization measurements of rocks. Magnetic field instrument suites are generally vector (or scalar) magnetometers, which locally measure the magnetic field. When mounted on board rovers, the electromagnetic perturbations associated with motors and other elements make it difficult to reap the benefits from the inclusion of such instruments. However, magnetic characterization is essential to understand key aspects of the present and past history of planetary objects. The work presented here overcomes the limitations currently existing in space instrumentation by developing a new portable and compact multi-sensor instrument for ground breaking high-resolution magnetic characterization of planetary surfaces and sub-surfaces. This new technology introduces for the first time magnetic susceptometry (real and imaginary parts) as a complement to existing compact vector magnetometers for planetary exploration. The objective is to obtain unique information on the magnetic structure recorded during the formation of the studied rocks, and thus to derive information regarding the ancient global magnetising field. This novel instrument is being developed under a H2020 RIA project entitled NEWTON. This project started in November 2016 and has a duration of 36 months.

1. Introduction

Apart from the Earth, the Moon, Mars, Ganymede and possibly Mercury possess an intrinsic magnetic field. On the Moon and Mars, this magnetic field is purely the remanent signature of a past global magnetic field whose spatial and temporal characteristics remain largely inaccessible. This is because remote measurements (on board spacecraft) do not allow to unambiguously determine the magnetization [1]. To fully characterize these magnetic bodies and sources, planetary surface prospection with rovers carrying compact and light multi-sensor instruments are necessary. These can obtain detailed information on the magnetic signatures and rock susceptibilities, allowing for instance the required identification of key landing sites for a more complex sample-return mission. The combination of magnetic and susceptibility measurements can be used to investigate the disputed origin of Martian moons Phobos and Deimos: whether they were captured asteroids, remnants from Mars formation, impact ejecta from the planet reaccreted in its orbit or a combination of all [2], [3]. Landed instruments which combine vector magnetometers and susceptometers can shed new light on key questions like the intense magnetic anomalies of Mars, or the disputed origin of the small scale lunar magnetic anomalies

This work provides a first and unique technology capable of performing a complete characterization of the rocks based on a magnetic instrument. This instrument will include a recurrent vector magnetometer, a highly innovative susceptometer with a power supply system and a very sophisticated frequency generation and shift detection. The goal is to achieve a TRL6 at the end of the current project, to make the multi-sensor instrument suitable for boarding on a planetary exploration rover in the short term.

2. Instrument Requirements

The proposed instrument will measure the magnetic susceptibility, environment magnetic field and other paleomagnetic parameters on the Earth, Mars, Moon and other bodies. In order to define the instrument requirements needed to perform such measurements, an exhaustive analysis of available literature has been done to compile the magnetic parameters of the rocks most representative of the Earth, Mars and the Moon. Other parameters such as mass susceptibility and saturation remanence of their principal rocks have also been considered. All this data analysis is reported in [4]. As an example, the mass susceptibility of rocks from the Moon is shown in Figure 1.

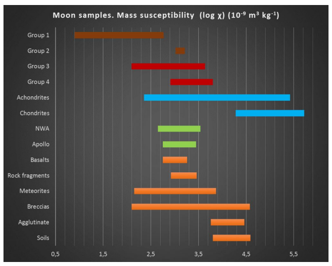

Figure 1: Mass susceptibility of rocks from the Moon. The units for the mass susceptibility are in 10-9 S.I. The graph represents the log of the magnetic susceptibility, i.e.: log(χ(m3/kg)).

3. Proposed Solution

The instrument suite will combine complex susceptometry to existing compact vector magnetometers for planetary exploration in order to provide complete non-invasive in-situ magnetic characterization. Figure 2 shows the block diagram of the proposed multi-sensor instrument.

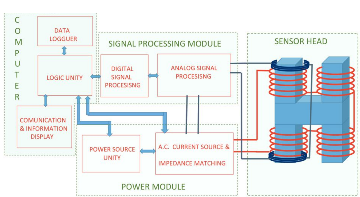

Figure 2: Block diagram of the multi-sensor instrument.

The multi-sensor instrument includes a recurrent vector magnetometer, a novel susceptometer and highly innovative power supply system. The sensor head includes the magnetometer and the susceptometer. The susceptometer is a ferrite with H shape. This shape allows the susceptometer to perform a differential measurement, which increases the sensitivity to measure the imaginary part of susceptibility, which is expected to be very low in most of the rocks.

To achieve the goal to measure the complex susceptibility of rocks with sufficient sensitivity, the instrument is designed with a zero method based on a temporal measurement. This implies the introduction of an original and innovative system to both generate and retrieve the signals at different frequencies resolving at least one part in a million to cover the wide range of susceptibility of natural rocks. An important challenge also concerns an efficient generation of the power that is needed to apply high magnetic fields able to penetrate the rocks during rover missions. At this point the proposed solution addresses this by using magnetic amplifiers to generate the power needed for these systems for application in space. Such technology is well known but the large dimensions of such devices have so far prevented their application to space and planetary exploration. The latest generation of magnetic amplifiers has however greatly matured and progressed towards miniaturization.

4. Summary and Conclusions

This work aims to solve the limitations currently existing in space instrumentation by means of providing a new portable and compact multi-sensor instrument for use in space, science and planetary exploration to solve some of the open questions on the crustal and more generally planetary evolution within the Solar System.

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References

[1] Díaz-Michelena, M. & Kilian, R. (2015). Magnetic signatures of the orogenic crust of the Patagonian Andes with implication for planetary exploration. Physics of the Earth and Planetary Interiors, 248: 35-54.

[2] Rosenblatt, P. (2011). The origin of the Martian moons revisited. Astron. Astrophys. Rev., 19: 1 – 26.

[3] Duxbury, T., C., Zakharov, A.V., Hoffmann, H. & Guinness, E.A. (2014). Spacecraft exploration of Phobos and Deimos. Planetary and Space Science 102: 9 – 17.

[4] NEWTON consortium, "NEWTON H2020 D2.1: Definition of instrument requirements and architecture. Design guidelines", March 2017, On-line: http://www.h2020-newton.eu/index.php/deliverables.