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Use of Ground Penetrating Radars in Planetary Rovers

N. Sharath[1], C. M. Poornima[2], M. R. Usha[3]
[1,2,3]*Student, Department of Electronics, Dr. Ambedkar Institute of Technology, Bangalore, India*

***Abstract*: This paper presents an overview on the use of ground penetrating radars in planetary rovers.**

***Keywords*: penetrating radars, planetary rovers.**

1. Introduction

Ground-penetrating radars (GPR) collects data on underground features via radio waves, which are transferred into the subsurface that eventually reflect off divergent structures and layers (Degenhardt et. al. [2]). A planetary example of a ground-penetrating radar is STRATA, however, it was not selected for the missions despite being invented and proposed for missions in the Mars science laboratory. GPR is not an invasive tool that can substitute or supplement for activities such as drilling, which are used to define information about topographies below the ground. To explore several meters below the ground will depend on the amount of frequency applied. Therefore, Lesser frequencies command better penetration while producing lower resolution and higher frequencies result in an enhanced resolution, but less penetration. GPR is predominantly used for the discovery of features, particularly those that can support in understanding an area's ancient history. For instance, submerged fluvial channels underneath a present desert as Bir Kiseiba in Egypt (Grant et al. 4). Bir Kiseiba is found in Egypt, it is a neolithic archaeological location dating about 11,000 to 5,000 BP and lies west of the Nile river roughly 250km of lower Nubia (Grant et al. [4]).

The successful application of ground-penetrating radar in Bir Kiseiba and various supplementary terrestrial sites with correspondences to Martian topographies helps in the setting of the framework for impending planetary use of the instrument. The reason for GPR radar's efficiency in Egypt is due to extreme aridity, which enhances the competency of the radar to differentiate geologically individual layers. In Bir Kiseiba Egypt, three separate layers were segregated to the ground surface; soils formed by running water, windblown deposits, and bedrocks. During the experiment, all three separate elements produced distinctive reflections spotted by the radar. However, dry surfaces on Mars and the Sahara Desert have different mineralogical compositions and climate histories, and thus, researchers anticipate the surfaces might respond equally to the radar. Additionally, water systems that are buried beneath the earth can be revealed from a depth of 10m to 15 m and it is projected that even in Mars they can be revealed at similar depth (Grant and Carlton). It is for the above notion that STRATA, which was proposed initially for the ground-penetrating radar on MSL (Mars Science Laboratory) was grounded. Assessing aqueous history and habitation of an area on Mars are among the main goals of the Mars Science Laboratory mission. The STRATA mechanism would use a 400 megahertz impulse to outline stratigraphy at a given spatial resolution of 10m to 15 m depth (Grant, John and Carlton). Then GPR application would focus on pinpointing, recording, and evaluating the antiquity of aqueous deposition besides providing the background for other Mars Science Laboratory instruments to measure or assess the biological capability of the section under investigation. On the other hand, extra work on depicting the GPR signatures of similar planetary materials is ongoing. The work is sponsored as a part of the NLSI (National Lunar Science Institute), therefore, focussing on gathering of GPR data in areas on Earth that the superficial materials are similar to those that are on the planets and the Moon (Degenhardt et al.).

GPR is a great technique since within certain parameters it recognizes the variations between materials. It is not reliant on the presence of a specific type of material but reacts to the deviations in electromagnetic properties between materials. As long as there is a variation either in magnetic responses or electrical properties, any target is actually capable of being detected. Moreover, it is imperative to recognize that GPR cannot differentiate the following characteristics: nature of the targeted material, color, density, Small objects covered either by the proximity of the comparable material or larger ones, the kind of utility represented, and the date of exact archeological remains unless there is additional information. It is also possible to understand some of this data by auxiliary means, typically above externally provided material or ground markers. For instance, the radar operator can be standing on a blacktop surface and still be able to perceive on-screen a sequence of regularly spread out hyperbolas contained by the subsequent layer down after the surface. The modeling suggests the being of regularly set apart reinforcement bars, which could conclude that there is a coating of protected concrete.

Furthermore, in utility discovery, tracing the trajectory of a cable, dust, or pipe to a ground indicator, a known water supply, drainage point, or an electricity substation will permit the nature of the above utilities to be known. It might be possible to detect metal or air gaps on the basis of echo effects and amplitude (signal strength). Patterning in the three-dimensional layout of the ground-penetrating radar data could give hints to the presence of certain types of feature, however, the radar facts itself does not provide this information. Generally, every radar signal is an artifact of change and any of the impediments of similar signal response can be the outcome of different mixtures of materials. The theory of density is an actual problem because of its facts usually in GPR reports. Subsequently, density is not a piece of electromagnetic reaction, and thus, no radar is able to measure it. As a result, it is wrong to label GPR markers as being less or denser. Moreover, working out precisely whatever the radar is responding to regarding the framework of a particular location is one of the encounters of reading GPR data. Usually, obtaining an accurate understanding of the radar's response depends on examining the display in the radar's data, both as perceived in a vertical view, two dimensional view, horizontally, promising, and extracted from a three dimensional data set. It also implies not only considering the irregular signals only but also looking at their steadiness from one set of data to the next data set. However, if a situation is to be created for signals of similar strength as representing the matching materials, there is a need to provide evidence to support it.

Elsewhere, considering the surface operations on Mars, the operations phase encompasses the rover's time piloting scientific research at the Gale Crater found on Mars. After getting to the surface of Mars, which is also referred to as the red planet, MSL (Mars Science Laboratory) had a key mission time to explore. The time under investigation is one Martian year by which, it would carry on its operations at slightest taking 687 Earth days, therefore, surviving a single Martian season in the process (Grant et al.). The rover is presently in its second lengthy mission. MSL has higher authorization and greater agility than any former rover sent to the surface of Mars. Traveling a distance of 5km to 20km (approximately 3 miles to 12 miles) from its landing site while exploring Mars (Grant et al.). The rover is to collect, distribute, grinding, and analyze roughly 70 samples of rock and soil (Grant et al. 9). Before the rover makes its first movement from the landing zone, engineers must first ensure that it is in good shape to proceed with the tests.

After entering, descending, and landing on the site, the MSL rover ventured forward on its first drive on 22nd August 2012. Going forward nearly 4.5 m (15 feet), turning 120 degrees then withdrawing about 2.5m (8 feet). Nonetheless, before making its first drive, mission controls on Earth needed to ensure that the surface directly underneath the rover's wheels is stable and did not present any immediate hazard. The engineers also were required to complete set out of the mast, the sampling system, the High Gain Antenna, test the communications links, and ensure a few other instructions before placing the well-known "pedal to the metal." (Benedetto et. al.). Finally, a number of geophysical methods are open for characterization and the investigation of the shallow subsurface. Commonly used are seismic refraction, reflection methods, and electrical methods besides a multichannel study of gravity, surface waves, magnetic, ground penetrating radar (GPR), and electromagnetic induction. Mars is among the terrestrial planet under study due to interesting evidence obtained from superficial features such as the evidence regarding the presence of water. External features on Mars comprise of mountains, plains, impact crater, dust cover, and lava flows. The article reveals a GPR technique that is recommended for planetary missions that explore the underground of Mars. GPR, as discussed in the paper, is a contemporary technology that offers a high-resolution image for near superficial structures. Due to a simple operating system, small size, high resolution, and lightweight, high the ground penetrating radar is supposed to be the top tool for the examination of the hydrology of Mars and near-surface features.

2. Conclusion

This paper discussed the use of ground penetrating radars in planetary rovers.

References

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