Ground Penetrating Radar and its applicability in determining underground materials and subsurface structures on asteroid surfaces

My Senior Thesis addresses the importance of Ground Penetrating Radar applications in determining the presence of underground structures and buried objects. While the technology has been used extensively in the past for conducting surface scans in an archaeological context to discover structures or remains from ancient civilizations, it has also shown to be very effective in visualizing utilities in house walls. The desired resolution thereby can be achieved by different radar frequencies. I chose my Senior Thesis project because it allowed me to build on the research that has come before and put it into a new context as I was using proxy material mimicking the surface composition of carbonaceous asteroids. This allowed me to test the viability of the existing GPR technology in extraterrestrial environments, which is crucial in determining whether such instruments should be used aboard space probes and rovers in the future.

As part of my research, I acquired basalt and granite rock dust constituting the soil material as well as several meteoroid fragments composed of iron, gold and silver ore as proxy materials [1]. A plastic box was then filled with the soil material and fragments were buried under it at varying depths. Afterwards, the radar apparatus was turned on and moved across the testing area horizontally with a line spacing of approximately 2 cm. While doing so, the GPR unit continuously emitted radar signals that penetrated the sediment layers before being partially reflected back towards the ground and therefore the radar apparatus. From the recorded time difference, a computer program titled GPR-Slice allowed me to visualize structural differences in the layout of the examined site [2]. To minimize background noise, the experiment was conducted at night as mobile devices operating at similar frequencies may interfere with the emitted GPR signal. Further noise was removed by applying filters to the experimental data. Firstly, a background noise filter removed a major part of the noise in the signal and secondly, a bandpass filter enabled me to retain only the desired frequency range of 850-950 MHz. I was primarily interested in this range as my GPR antenna operated at a central frequency of 900 MHz and therefore yielded the most accurate results at that point [3].

My results showed that elements of sufficient size (diameter of approximately 5 cm) could be detected by the GPR apparatus even though the dielectric constants of the soil materials and the buried fragments were relatively similar in magnitude [4]. That meant that without having to excavate the site, it was possible to determine the approximate locations of the buried fragments. While my experiment showcased how Ground Penetrating Radar would approximately behave in an environment similar to one that could be found on an asteroid, controlling for other variables such as the low temperature and the lack of air pressure in space might be necessary to extrapolate the findings to a realistic setting [5]. This could be a matter of future research.

The application of the utilized technique in a real setting could facilitate the search for potential asteroid mining regions on future missions as the scan would provide information about underground irregularities that may stem from precious ores and materials buried beneath the surface regolith. Furthermore, the more exact determination of an asteroids subsurface composition allows us to conclude whether precious ores might be present. Such knowledge could easily lead to more efficient missions in terms of duration and thereby increase the cost-effectiveness. It may even spur more growth in the commercial sector as asteroid mining companies are provided with more information on the lucrativeness of potential mining ventures.

References

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