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Mapping Structural Elements in Volcanic Terrain Using Multiple Frequencies and Polarimetric Ground Penetrating Radar: Analogy to the Martian Case

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Volcanic terrains are among the most prevalent on Mars, their structural and stratigraphical investigation by GPR providing a powerful tool for understanding the mechanisms and chronological sequence that resulted in their formation. For this reason, a broadband (0.5 - 1.5 GHz) GPR was selected as one of the primary instruments for the European Space Agency's ExoMars rover that will be sent to Mars in 2011. As part of the effort to evaluate the potential of this technique, we carried out a parametric study of several features at Craters of the Moon (COM) National Monument in Idaho (USA). This area, which includes expansive lave fields and volcanic constructs, is a hyper-arid environment with an average annual precipitation of less than $\sim$50 mm. It also displays considerable geochemical and geomorphological similarity to a variety of volcanic regions on Mars. Among the examples we investigated were a large cinder cone (Inferno Cone) and surrounding smooth- and rough-surfaced basaltic lava flows. We conducted multiple frequency 270-, 500- and 900-MHz GPR surveys, with both VV and HH polarizations, in both orthogonal and grid form in order to perform a three dimensional mapping of the consolidated core of the cinder cone beneath a thick layer (1-20 m) of tephra that accumulated as a result of different eruptive events. Analysis of the resulting data indicates maximum sounding depths of $\sim$13 m deep at 270 MHz, 8 m at 500 MHz and 5 m at 900 MHz in the unconsolidated tephra. Our gridded profiles show that the tephra distribution over the consolidated core is asymmetric, the eastern

side being covered by thicker deposits than elsewhere. Our preliminary results also suggest the potential presence of a small spatter cone beneath the eastern flank of the cone. A similar approach was used to investigate the Blue Dragon basaltic lava field located to the south of Inferno Cone. The observed penetration depths were an order of magnitude smaller due to the high density of the flow. Our polarimetric survey showed the effect of the different orientations of lava fractures on radar scattering. The size and orientation of these fractures, inferred from the radar data, were then compared to the in-situ measurements. Our data supports the utility of a broadband GPR to investigate and understand the nature of the shallow subsurface on Mars, but also highlighted the potential complexity associated with the future data interpretation.