THE VERITAS 2023 ICELAND ANALOG CAMPAIGN – DIELECTRIC PERMITTIVITY AND SAMPLING.

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Introduction: The Venus Emissivity, Radio Science, InSAR, Topography and Spectroscopy (VERITAS) Discovery mission will map the surface with NIR spectroscopy using the VEM instrument and SAR using X-band (4 cm) with the VISAR instrument [1]. The VERITAS Science team conducted a field analog campaign in Iceland over two weeks in August 2023 in collaboration with the German Aerospace Center (DLR), employing both an airborne radar mapping effort and an in-situ surface characterization task [2]. The latter serves as ground truth to the radar data by providing concurrent measurements of the parameters that control radar backscatter, such as topography, roughness, and dielectric permittivity. Here we report on in-situ permittivity measurements, sampling, and laboratory measurements.

In-Situ Measurements: Surface characterization consisted of 41 5×5 m patches in two regions of interest (ROIs) imaged by the DLR airborne multiband F-SAR system [3]: the Askja volcanic deposits and the Holuhraun flow, and the 2021-2023 Fagradalsfjall lava flows. These patches capture a range of surface textures and compositions, including both rock and fines. To preserve the surface within each patch for surface roughness measurements, we measured permittivity adjacent to a patch. We employed a HydraGo permittivity probe (electronics box and probe head with 3 electrode prongs). Because the team had a single permittivity probe and the prongs can only be inserted into soils/sediments, we obtained such measurements only at patches in Askja/Holuhraun ROI (Dyngjusandur and Vikursandur sands, Askja tephra) that presented soils/sediments for probing (Fig.1). The electrodes were fully inserted normal to the surface, avoiding any lateral motion and ensuring good coupling with the sediment (Fig. 2). We collected 200 probe measurements, with values of the real part of permittivity (dielectric constant) ranging between 4 and 12. This variability is likely due to variation of water content.

Sampling: To determine the contribution of moisture and permittivity more accurately, we sampled rock and fines at all patches. In each sampling, we collected from the immediately adjacent material that was representative of what was seen in the patch. Sampling of fines was done both at the surface and at a depth of 20 cm, and material was immediately placed in 50- or 200-ml polypropylene bottles with threaded caps to preserve moisture (Fig. 2). Rocks were collected from the surface and immediately wrapped in low-density polyethylene film to preserve moisture (Fig. 3).

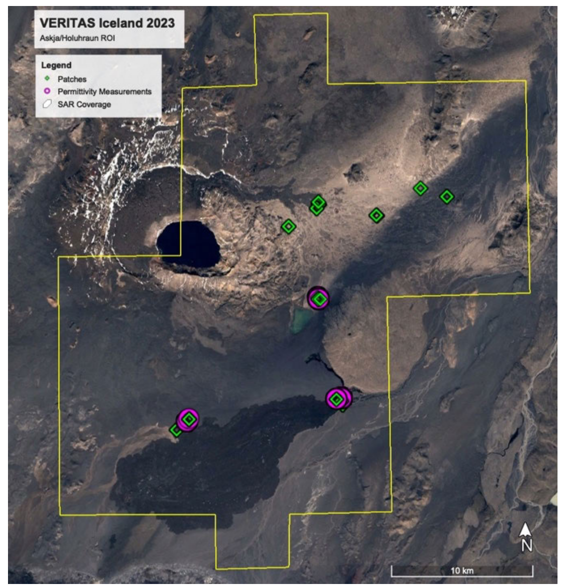

Fig. 1 *– Location of the in-situ permittivity measurements (magenta circles) with respect to the characterization patches (green diamonds) and the F-SAR coverage (yellow polygon) of the Askja/Holuhraun ROI. (Image from Google Earth)*

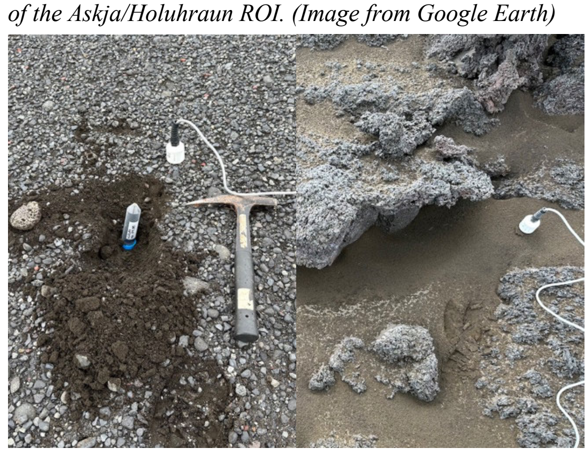

Fig. 2 *– (Left) Probing and sediment sampling at a patch on Dyngjusandur. (Right) Probing on sediments collecting on top of the Holuhraun flow. Diameter of probe head (white cylinder with wire) is 42 mm.*

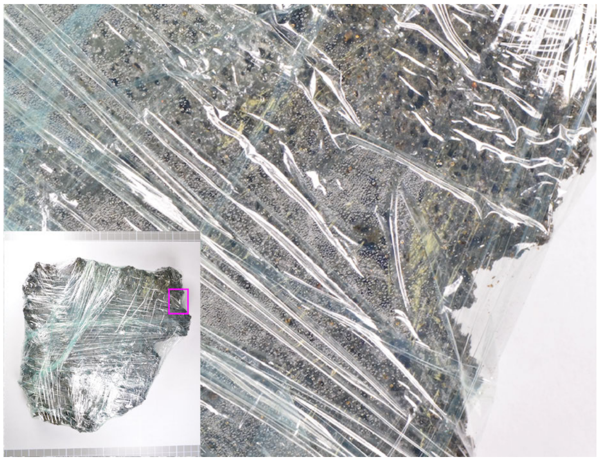

Fig. 3 – (Lower left) Insert shows a basaltic sample removed from Ziploc but still fully wrapped on photographic bench; grid is 1-cm in scale. (Background image) Zoomed portion of the inset image (magenta quadrilateral) showing abundant condensation on the interior surface of the wrapping.

Laboratory Characterization: Upon arrival and removal from the transport container, all packaged samples were initially photographed, weighed, and returned to storage. Each sample was then unpackaged, weighed, photographed, and placed in a convection oven at 50°C for drying (Fig. 4). After two days in the oven, samples were removed from the oven, weighed, and returned to the oven. After two consecutive mass measurements showed no change, the last measurement was marked as final and subtracted from the initial mass measurement to determine moisture content by difference. Note that because the packaging material contains condensation, its dry mass was also accounted for. In all samples analyzed to date, water contents are <10 wt%.

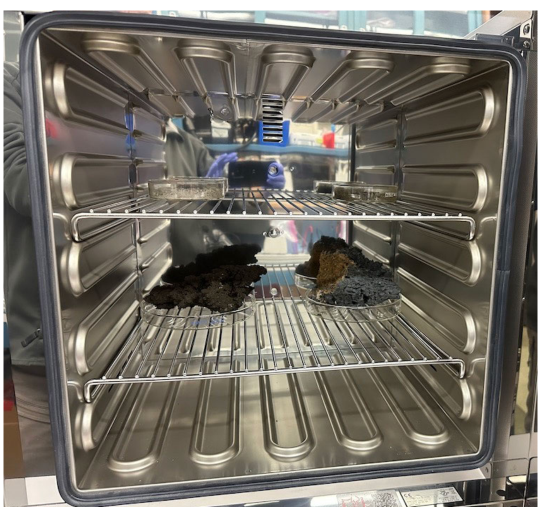

Fig. 4 – Fines (top rack) and rocks (lower rack) resting in petri dishes and within a convection-driven oven ready for drying at 50°C.

A control group has been established for the different 50-ml and 200-ml containers. Water loss from these containers is on the order of 2.4×10^{-4} g/day for the 50-ml tube and 4.8×10^{-4} g/day for the 200-ml bottle, or 14 and 28 mg, respectively for the storage time between field collection and the initial laboratory characterization. These are only an approximation because loss is likely dependent on relative humidity, temperature, and atmospheric pressure. In any case, this correction factor will be used to adjust the moisture content of the fines/sediment samples once all are characterized.

Future Work: Determination of sample water loss during storage for rocks is less trivial because it depends on size, shape, and porosity of the rocks. We will select two or three representative samples, wet and wrap them, and then use them as control.

Following the moisture content work, we will select a subset of dried sediment and rock samples for permittivity measurements. These measurements will use a resonant cavity apparatus calibrated for 2.4 GHz, similar to S- and X-band frequencies used in the VERITAS Iceland radar mapping [2, 5]. These measurements will leverage the apparatus and techniques developed under a NASA PDART grant to JPL [4], also being presented in this Conference. The measurements can be used to model the effect of water content on permittivity via mixing models and compared with permittivity measurements of the same samples when wetted.

When coupled with roughness and topographic data collected in the field [6], field/lab permittivity data should constrain the dielectric contribution to radar backscatter observed in the F-SAR VERITAS Iceland 2023 data.

Acknowledgements: Funding for the Iceland campaign comes from NASA to JPL/VERITAS, NASA to Goddard/GIFT, and DLR. Laboratory support comes from VERITAS and NASA's PDART grant to M. Barmatz.

References: **[1]** Smrekar S. (2022) *IEEE Aerospace Conf.*, 10.110/AERO53065.2022.9843269. **[2]** Nunes et al. (2024), *LPSC 55*. **[3]** Horn R. et al. (2017) *18th Intl. Radar Symp.*, 10.23919/IRS.2017. 8008092. **[4]** Barmatz et al. (2024), *LPSC 55*. **[5]** Hensley et al. (2024), *LPSC 55*. **[6]** Cascioli et al. (2024), *LPSC 55*.