SEEKING VENUS ON EARTH: THE VERITAS/DLR ANALOG FIELD CAMPAIGN.

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Introduction: A keystone to understanding formation and evolution of terrestrial planets in the Solar System and beyond, Venus is covered with familiar features, chiefly volcanic and tectonic in nature. Despite this commonality, the fashion with which such morphological features are arranged has challenged interpretations, and a consensus on the geologic history and geodynamical model for Venus still eludes us. Several factors have complicated the analysis of Venus data. Remote sensing of the surface from orbit has only been achieved for very few wavelengths in the electromagnetic spectrum. The disparity in spatial scale between our best image, topographic, and geophysical data is hampering. Survivability of hardware at the surface has been extremely challenging, though evolving technology has made it increasingly feasible.

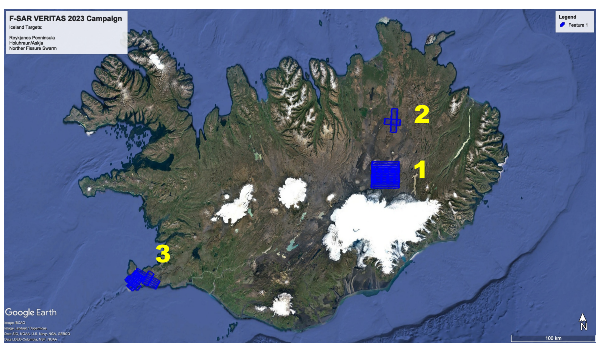

Figure 1 – *Google Earth map of Iceland with the VERITAS-DLR analog campaign regions of interest (ROI's) in blue: (1) Holuhraun/Askja, (2) Northern Volcanic Zone Fissure Swarm, and (3) Reykjanes /Fagradalsfjall.*

To circumvent these constraints and best prepare for the upcoming Venus missions in the late 2020's and early 2030's, it is paramount to study Venus-analog features found on Earth. Using the same techniques on both planets tests our processing of data and their interpretation against the extensive knowledge of these analogs present in the literature and augmented by our field data.

Experience with terrestrial analogs, which arise from a wide variety of geological phenomena, enhances our ability to analyze planetary data and create and test viable geologic hypotheses [e.g., 1]. Analogs were studied to support interpretation of Magellan data [2-4]. Analogs have also played a substantive, if not essential, role in the exploration and study of Mars [e.g., 5].

In conjunction with colleagues at the German Aerospace Center (DLR)'s Airborne SAR Missions Group and colleagues in Iceland, the VERITAS Science Team is planning a field- analog campaign to Iceland in the late northern summer of 2023. This campaign will entail both airborne and surface components. DLR's F-SAR airborne radar [6] will image the surface, while a team of U.S. and European VERITAS co-investigators will characterize salient surface properties at different imaged sites. This effort focuses on a variety of targets (Figure 1) relevant to volcanic, tectonic, and impact cratering features on Venus while concurrently employing state-of-the art SAR and field techniques.

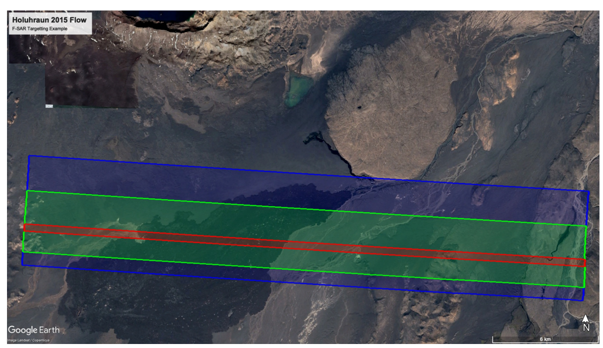

Figure 2 – *Example of F-SAR targeting showing ranges of incidence angle from 6,500 m altitude and neglecting local effects of topography for an approximately E-W line: VERITAS range (red), Magellan range (green), full F-SAR range (blue). Dark lava flow in the lower-left quadrant is the 2014/2015 Holuhraun flow.*

Airborne Component: DLR's full-polarimetric, multi-band airborne synthetic aperture radar system [7] is capable of imaging at VERITAS (X-band) as well as Magellan and EnVision (S-band) wavelengths and at incidence angles that subsume those employed by Magellan, VERITAS, and EnVision [8-10] (Figure 2). Targeting is optimized to maximize cross-track coverage and to carefully overlap successive swaths to sample the same key surface features with both Magellan- and VERITAS-like incidence angles. Resolution of F-SAR data will far exceed the 30 m lateral (global) resolution of VERITAS and will be down-sampled for testing VERITAS analysis tools.

Surface Component: Surface measurements will serve not only as calibration and ground truth to the airborne radar data, but it will also serve as a test and guide to our data-processing techniques. At three field sites that bear relevance to Venus (Figure 1), we will measure meter-scale topography, cm-scale roughness and stratigraphy, and surface complex permittivity. These surface properties exert primary control on SAR backscatter. Multiple measurement sites, each comparable to the several meter F-SAR lateral resolution, will be characterized at each investigation location (listed below). We will also collect VIS/NIR spectra at the same measurement sites to gain insight on the potential relationships between VERITAS' VISAR and VEM datasets.

Locations:

Holuhraun/Askja. Our primary site is the Holuhraun lava flow field and the volcanic flows from Askja volcanic crater, where a variety of analog morphologies are present. The 2014-2015 lava flow field possesses an assortment of textures that modulate surface roughness and influence radar backscatter [11, 12]. A graben caused by the dike feeding this flow field is a good target for imaging small-scale tectonic features. The 1920's southern Thorvaldshraun and 1961 northern Vikrahraun fissure basaltic flows of Askja respectively overlie and are covered by light-colored rhyolitic tephra/fall sediments [13, 14]; these provide an opportunity to test the influence of airfall in modifying the radar signature. The tephra field and the windblown basaltic sand field are of interest because of potential similarities to Venusian parabola and pyroclastic deposits.

Northern Volcanic Zone Fissure Swarm. Among the fissure swarms that cross-cut Iceland as part of the rifting regime, the Northern Volcanic Zone presents a chance to study fissure swarms with a number of small-scale grabens, which have relatively large aspect ratios, modest throws, and diverse stratigraphic relationships with surrounding flows of multiple ages [15, 16]. The grabens are similar in scale and morphology to the small-scale grabens (dubbed "ribbons" by some [17]) found in tesserae on Venus, even if not as long.

Reykjanes/Fagradalsfjall. The Reykjanes Peninsula Oblique Rift contains fissure swarms, and lava flows of different ages and textures with different sediment cover. These offer an opportunity to investigate some of the same types of analogs as at the other two northern field sites. However, the newly erupted 2021/2022 Fagradalsfjall lava flows [18] present a superb opportunity to test change detection algorithms for SAR data for both VERITAS and EnVision bands because the Fagradalsfjall area was imaged by F-SAR in 2015, prior to the emplacement of the flows aforementioned.

Science Goals: The VERITAS mission has eight science goals, and the field campaign will address five that touch on solid planet processes:

1. What is the composition and origin of the major geologic terrains?
2. Is there a record of prior geologic regimes?
3. Is volcanism steady on average over long time periods like Earth or catastrophic, implying the need for variable geodynamic processes?
4. What are the major tectonic processes? Is subduction currently active?
5. Does Venus' young surface have active deformation and volcanism, and geochemical/weathering signatures of recent volcanism?

Conclusion: The VERITAS/DLR field campaign offers a unique opportunity to collect remote sensing and in-situ data that will not only prepare the team for the acquisition and analysis of VERITAS data, but will also potentially enhance the science return from other Venus missions, from Magellan to EnVision.

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