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Vulcano (Italy) lava fields as Mars and Venus analogs: field and laboratory characterization

Mickael Baqué[1], Giulia Alemanno[1], Solmaz Adeli[1], Enrica Bonato[1], Mario D'Amore[1], Stephen Garland[1], Klaus Gwinner[1], Charlotte Herrmann[1], Jörn Helbert[1], Patrick Irmisch[2], Alessandro Maturilli[1], Alessandro Pisello[3], Frank Sohl[1], Katrin Stephan[1], Laurenz Thomson[4], and Vikram Unnithan[4]

[1]Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany
[2]Institute of Optical Sensor Systems, German Aerospace Center (DLR), Berlin, Germany
[3]Department of Physics and Geology, University of Perugia, Perugia, Italy
[4]Department of Physics & Earth Sciences, Jacobs University Bremen, Germany

Introduction

The volcanic settings of the Eolian Islands, Italy, offer access to various types of volcanic terrains, with diverse morphology and mineralogy. This study focuses on Vulcano, whose last eruption is dated to 1890 but still shows volcanic activity [1]. The dry landscape and easy access to layers of older and more recent volcanic material, in addition to the possibility of investigating secondary minerals, make this site a very promising analog for our neighbor planets; Mars and Venus. Building on previous expeditions, we have acquired experience and knowledge about the potential of these analog environments and their habitability [2 - 4]. Our objectives for the June 2022 field campaign are: to investigate the surface roughness and active surface processes, as well as spectral characterization of volcanic material (Venus analog) and secondary minerals (Mars analog) with both field and lab instruments (detailed hereafter). We are also interested in the astrobiological aspects of these environments, which could represent early Venus/Mars, pertaining to the questions of life detection, using spectroscopy techniques, and habitability, looking at microbial colonization.

In-situ Instrumentation

Field measurements are collected with the following portable instrumentation:

- VEM (Venus Emissivity Mapper) Field Prototype - simulating the VEM and VenSpec-M instruments that will fly on the next VERITAS NASA and EnVision ESA missions to Venus, respectively [5]. The prototype is composed of a commercial camera and optics with narrow filters at 850, 910, 990 and 1000 nm, corresponding to four spectral windows in the Venus atmosphere where it is possible to obtain mapping of Venus' surface features.
- Portable Raman - the RaPort handheld Raman instrument by EnSpectr equipped with a 532 nm excitation laser (same wavelength as used for the ExoMars rover) operating at <60 mW laser power, has a spectral range of 120 - 4000 cm^{-1} (> 2.5µm) at 6-9 cm^{-1} spectral resolution and a spot size of around 0.5 mm.
- Portable XRD/XRF Terra - is a portable X-ray diffraction/ X-ray Fluorescence instrument born

from the need to perform XRD analysis on the Mars Science Laboratory (MSL) and is being now widely applied for Earth on field applications.
- Mini-PAM - instrument used to detect the presence of chlorophyll and photosynthetic activity.
- Portable spectro-radiometer (PSR+3500) operating in the visible and near-infrared spectral range (350 – 2500 nm) with a spectral resolution between 3 and 8 nm and a measurement spot size of 3 by 3 mm and is best used for mineralogical investigations.
- The Integrated Positioning System (IPS, developed at DLR) combines stereo camera, inertial and GNSS measurements for localization, 3D reconstruction and inspections in unknown environments. Equipped with a thermal imaging camera (Optris PI 640, spectral range of 8 - 14 µm), the hand-held prototype is investigated for exploration and thermal mapping of fumarolic fields [6].

Laboratory analysis

Further measurements on collected samples from Vulcano are performed at the Department of Planetary Laboratories (PLL)[7] at the German Aerospace Center (DLR, Berlin, Germany) in the:

- Planetary Spectroscopy Laboratory (PSL) - by mean of three Bruker Vertex80V FTIR spectrometers at PSL we can measure bi-directional bulk sample spectroscopy of the collected samples completely under vacuum in the whole spectral range from UV to FIR (0.25 µm to at least 25 µm spectral range). A Bruker Hyperion 2000 FT-IR microscope allows mapping smaller grains from VIS to MIR (0.4 to at least 16 µm spectral range) with a spatial resolution down to 50 µm.
- Raman-Mineral- Biology Detection Lab (RMBD) - equipped with a confocal WITec alpha 300 system, a piezo-driven scan table, a UHTS□300 spectrometer with an ultrafast EMCCD detector and a frequency-doubled Nd:YAG laser at 532□nm excitation wavelength. The spot diameter at the sample is ~2.5□µm and the spectral resolution of the spectrometer 4–5 cm^{-1} at 600 l/mm grating.
- Planetary Analog Simulation LABoratory (PASLAB) and Mars Simulation Facility-Laboratory (MSF) - selected samples are further tested in our simulation facilities able to recreate Mars and other planetary environmental conditions by a controlled gas mixing system (up to 5 gasses, e.g. $CO_2/N_2/Ar/CH_4/O_2$) with H_2O, a resulting pressure of 6 – 10 mbar (Mars) and up to 1 bar (Earth-like conditions) and diurnal cycles of radiation (190 nm – 2200 nm), humidity (rh % 0 to 100) and temperature (-70°C to 130°C).

Discussion

This is the sixth time a field campaign coupled to a summer school takes place on Vulcano. It is a remarkable site to test and train instruments, rovers, or data processing techniques of high interest for planetary science (for instance, testing the potential of portable LIBS and VIS/NIR spectrometers [2-4] or mapping using drone and camera data [8]). The comparison between field and laboratory measurements, as well as with data acquired from previous field campaigns to the same site, provides useful hints on the further understanding and characterization of these terrestrial sites as planetary analogs. Moreover, it plays an important role in enhancing the capabilities of these in-situ techniques for the characterization of extraterrestrial environments in the view of the analysis and interpretation of orbital and in-situ planetary data. In terms of habitability and the search for life, the identified extreme and unique environments present at Vulcano inform us on strategies and protocols on how to detect life elsewhere.

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