

## AGPA: Integrating field Geology and Geophysics for Planetary Analogues

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The exploration of Solar System bodies relies heavily on remote sensing and mapping [e.g. 1]. The approach is complemented by in-situ analyses and sample return. The combination of cross-validating data is of great importance for planetary landing site data analysis as well as for planetary analogues [e.g. 2-4]. Integrating remote sensing and geophysical data can prove useful to constrain surface and subsurface structure of planetary landing sites and their terrestrial analogue counterparts [5-7].

The 2017 ESA astronaut training campaign extension PANGAEA-X [3, 4] hosted several experimental suites. One of them is AGPA [5], standing for **A**ugmented field **G**eology and **G**eophysics for **P**lanetary **A**nalogues.

AGPA comprises a flexible suite of remote sensing and geophysical experiments including drone photogrammetry and LIDAR [6] as well as geoelectrics [7] and active, passive seismic [8] investigations. AGPA also supported the integration of training data collection and analogue field geology procedures with geophysical in-situ and remote sensing. The resulting technique and data combination is synergistic and can be applied to both science and operational aspects.

Sub-centimetric surface imaging and topographic reconstruction of the main analogue site [6] was obtained. The resulting models, integrating both stereogrammetry and ground-based LIDAR proved useful for the morphometric characterisation of surface materials and structures as well as for constraining the shallow subsurface geometry of vents (Figure 1). These data are being integrated with traditional cave surveying datasets, in order to produce a comprehensive surface-subsurface model.

Subsurface structures and not directly accessible lava tubes have been investigated through concurrent use of surface imaging and subsurface sounding (Figure 2). Results include constraining the position and size of lava tubes (Figure 3) and cross-validation with in-tube lidar as performed by various teams during the PANGAEA-X campaign [see 3].

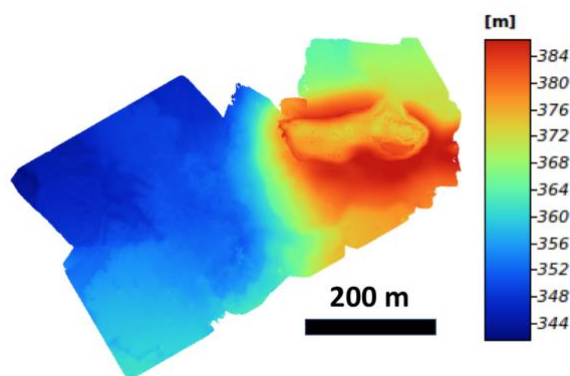


Figure 1: Exemplary result of drone-based stereogrammetric reconstruction of the Tinguaton cone topography [6]

The integrated use of both surface imaging and subsurface geophysics can be synergistic [5], useful for cross-validation and improved geologic interpretation. The approach can be applied on a planetary analogue target, such as lava tubes, or future planetary cases, such as Lunar or Martian landing sites with the need to characterise, map and explore the subsurface, e.g. through lava tubes, collapses and caves.

AGPA raw data are progressively available on public repositories such as Zenodo [9]. Datasets, both raw

and processed are going to be shared on public data repositories too, in order to support cooperation, data re-use and reproducibility. The data discovery and access of planetary analogue data is possible via EuroPlanet VESPA (Virtual European Solar and Planetary Access) [10], to be further expanded. The approach could be used also within similar activities [e.g. 11]

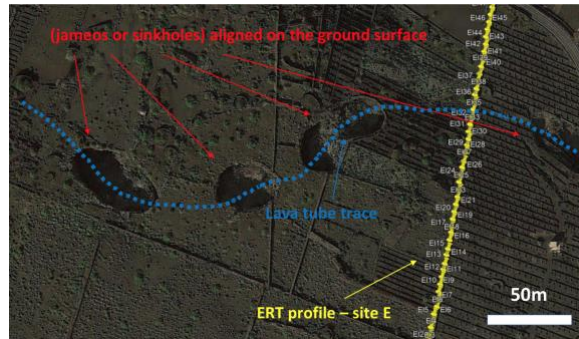


Figure 2: Location of one of the geo-electric profiles over a lava tube system (background imagery Google Earth) [7].

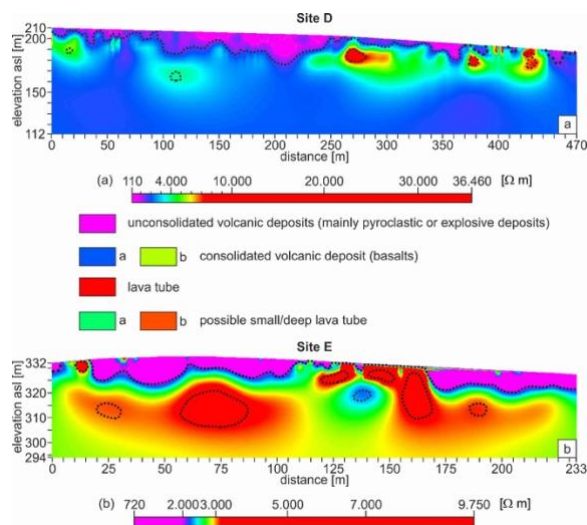


Figure 3: Geo-electric imaging of lava tubes. Surface topography surveyed with RTK-GPS [7].

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## References

- [1] Massironi, M., et al., Towards integrated geological maps and 3D geo-models of planetary surfaces: the H2020 PLANetary MAPPING project, Geophysical Research Abstracts, Vol. 20, EGU2018-18106, 2018.
- [2] Garry, W., Bleacher, J., eds. (2011) Analogs for Planetary Exploration. No. 483 in GSA Special Paper, 567 pp. The Geological Society of America, Boulder.
- [3] Sauro, F., et al. "Training Astronauts for Field Geology: The ESA PANGAEA Training and PANGAEA-eXtension Testing Analogue." LPSC XLIX, #2083. 2018.
- [4] Bessone et al.: Testing technologies and operational concepts for field geology exploration of the Moon and beyond: the ESA PANGAEA-X campaign, Geophysical Research Abstract, Vol. 20, #EGU2018-4013, 2018
- [5] Rossi, A. P., et al: Augmented field Geology and Geophysics for Planetary Analogues, Geophysical Research Abstract, Vol. 20, #EGU2018-4013, 2018
- [6] Unnithan, V., et al. Mapping scoria cones: planetary analogue studies using Drone photogrammetry and Lidar data from Lanzarote, Geophysical Research Abstracts, Vol 20, #EGU2018-16801, 2018
- [7] Torrese, P., et al. Reconstructing the subsurface of planetary volcanic analogues: ERT imaging of Lanzarote lava tubes complemented with drone stereogrammetry, surface and in-cave LiDAR and seismic investigations, Geophysical Research Abstracts, Vol 20, #EGU2018-14285, 2018
- [8] Ortenzi, G. et al.: AGPA @ Pangaea-X: remote sensing and geophysical investigation of lunar and planetary geology at Lanzarote, Canary Islands (Spain). Physics of Volcanoes, Kiel, Germany, 2018.
- [9] Unnithan, V., et al. Drone-based photogrammetric survey raw data from ESA PANGAEA-X 2017 planetary analogue campaign - Data collected on 2017-11-19 [Data set]. Zenodo, DOI: 10.5281/zenodo.1084885, 2018.
- [10] Minin, M., VO access to AGPA first dataset, [http://epn1.epn-vespa.jacobs-university.de/tableinfo/pangaea\\_x\\_2017.epn\\_core](http://epn1.epn-vespa.jacobs-university.de/tableinfo/pangaea_x_2017.epn_core), accessed May 2018
- [11] Frigeri, A., et al., The Scanmars radar on board AMADEE-18 analogue mission to Mars, this meeting, 2018