VIRTUAL ANALOG ENVIRONMENTS: EXPLORING LIDAR DATA IN VIRTUAL REALITY.

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Introduction: New technologies allow us to explore traditional field in new, sometimes unexpected ways. Virtual Reality (VR) is a tool that can be used to investigate, explore, and analyze LiDAR data (among others) in an immersive 3D environment to obtain an in-the-field-perspective of the data.

Nothing will ever replace the necessity and value of geologic field work **[1]**. However, field deployments can be affected by time, weather, instrument failures and not every objective can be accomplished within the set time constraint. Some field sites may be too remote and/or too expensive to reach again. For long term projects, there may be a longtime between field deployments, plus an ever-growing collection of data to analyze and synthesize over the years.

Recreating geologic field sites in VR allows scientists to revisit a remote field site and explore a suite of instrument data from an in-the-field-perspective again and again without leaving the office. Here, we recreate a lava tube in VR, based on field data we collected between 2014 and 2016 in Idaho **(Fig. 1)**.

Figure 1. LiDAR data of the Indian Tunnel lava tube at Craters of the Moon served as the foundation for this VR landscapes project.

Background: The NASA Goddard Virtual Reality/Augmented Reality Lab has developed a prototype VR project of a virtual lava tube, using a LiDAR model of Indian Tunnel located at Craters of the Moon National Monument and Preserve in Idaho (USA) by the SSERVI FINESSE team **[2]**. This VR pilot poject was developed between Nov. 2016 – Oct. 2017. We plan to build on this project in 2018 by incorporating new tools, data sets of new field locations, and integrate the data into a different sotware engine.

Data: The LiDAR data of the lava tube was collected using a Riegl VZ-400 laser scanner **[2]**. Images from a Nikon camera mounted on top of scanner are used to colorize the pointcloud to obtain a true color view. To create the VR environment, the point cloud data was exported as x-y-z-r-b-g plus reflectance values as a text file, which was then imported into the Unity game design **[3]** using a custom script. The complete lidar model of the lava tube contains ~900 million points. Due to limitations in Unity, we were only able to import ~22 million points into a single, high-resolution VR scene. HTC Vive and Oculus Rift VR headsets are used to view the data **(Fig. 2)**.

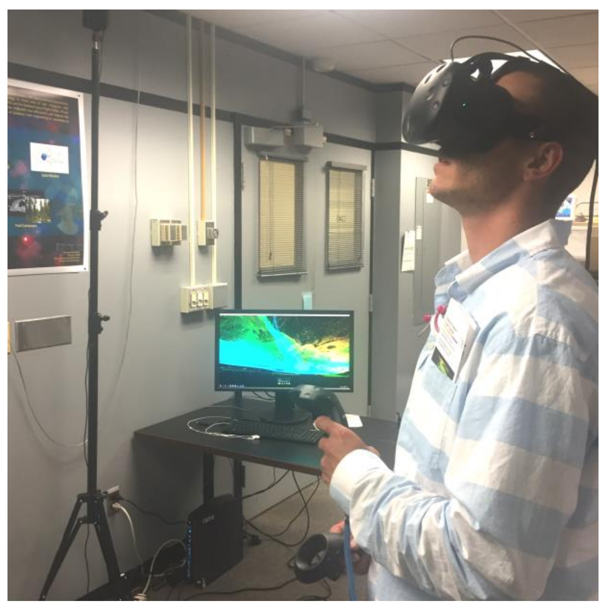

Figure 2. HTC Vive headset is worn to immerse the user inside the lidar data of the lava tube shown on the computer screen. Handcontrollers allow the user to access menus and move through the scenes.

Results: The VR demo begins with the user flying over the lava tube with the point cloud colorized by elevation **(Fig. 3)**. The data is a subset of the full 900 million points and allows the user to explore the basic morphology of the entire lava tube system. While flying through the tube, the user can use the location menu **(Fig. 3)** to teleport to high resolution lidar scenes. Once in the higher resolution scene, the user can select how to render the data (elevation, reflectance, true color) from the view options menu **(Fig. 4)**. Not shown is the science tool kit we developed to measure distances and areas within the scene.

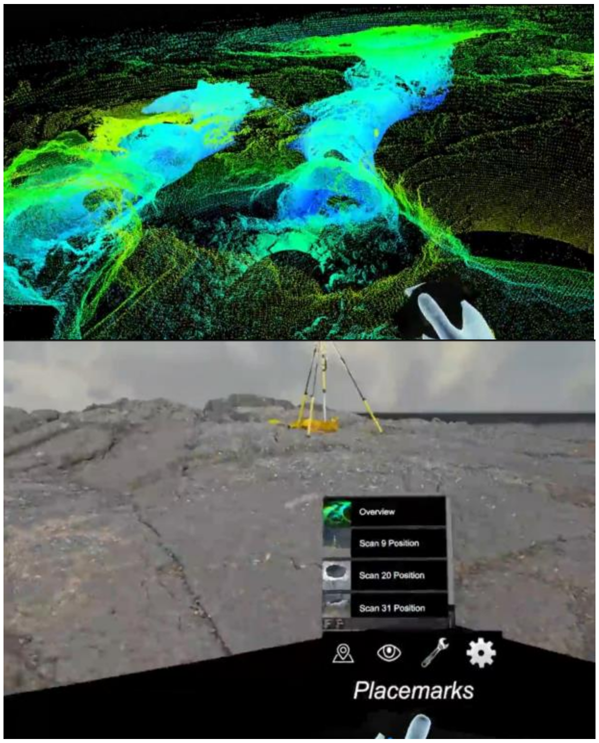

Figure 3. (top) The VR demo begins with the user flying through an overview data set of the lava tube. (bottom) User can immediately transport to a high-resolution scan listed on the placemarks menu.

Lessons Learned: Our pilot project has established a foundation showing the utility of VR for scientific analysis and exploration of LiDAR data.

- Unity software was capabale of rendering the LiDAR data, but was limited in the number of points that can be viewed in a given scene (~22 million).
- Scan resolution and point density are critical to creating a realistic environment. The data is best viewed from position of the lidar scanner. Using a backpack-mounted lidar data would mitigate this in the future.
- The science toolkit should have common capabilities that can be used across different science projects. Exporting the measurement data from VR to another format is currently an issue we are troubleshooting.

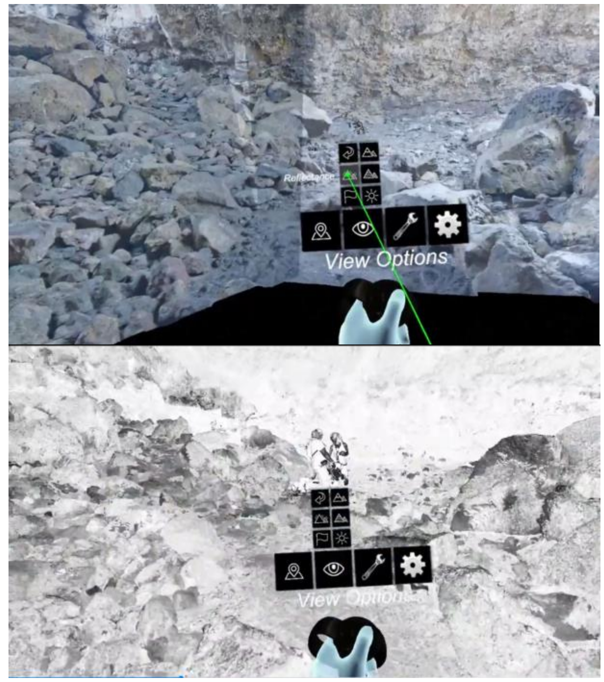

Figure 4. Higher resolution point clouds can be viewed in true color (top) or reflectance (bottom). The user points a laser (top) at the menu to make a selection.

Summary: Virtual Reality provides a number of benefits for scientific analysis of analog terrains:

- ***Cost-effective:*** Ability to revisit a remote field site multiple times from the office.
- ***Remote Collaboration:*** Science teams spread across the globe can interact in the same virtual environment of the field site.
- ***Measurements and Observations:*** Time constraints or variable weather conditions may have restricted ability to visit all of the intended sites or take measurements.
- ***Overlap Data Sets:*** User can quickly switch between different views of the data (elevation, true color, reflectance). Data from additional instruments can also be added or encoded into the environment.
- ***New Perspectives:*** User can manipulate data in VR to obtain views not possible in the field.
- ***Future Planning*:** Data from previous field deployments can be merged and synthesized to make plans of where to investigate in future deployments.

References: [1] R.P Sharp (1988) *Annual Review of Earth and Planetary Sciences*, *16*(1), 1-20. **[2]** W.B. Garry et al. (2017) 48th LPSC, Abstract 1207. [3] Unity website (2018) https://unity3d.com.