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Geological interpretation and analysis of surface based, spatially referenced planetary imagery data using PRoGIS 2.0 and Pro3D.

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Abstract

We apply the capabilities of the geospatial environment PRoGIS 2.0 and the real time rendering viewer PRo3D to geological analysis of NASA's Mars Exploration Rover-B (MER-B Opportunity rover) and Mars Science Laboratory (MSL Curiosity rover) datasets. Short baseline and serendipitous long baseline stereo Pancam rover imagery are used to create 3D point clouds which can be combined with super-resolution images derived from Mars Reconnaissance Orbiter HiRISE orbital data, and super-resolution outcrop images derived from MER Pancam, as well as hand-lens scale images for geology and outcrop characterization at all scales. Data within the PRoViDE database are presented and accessed through the PRoGIS interface. Simple geological measurement tools are implemented within the PRoGIS and PRo3D web software to accurately measure the dip and strike of bedding in outcrops, create detailed stratigraphic logs for correlation between the areas investigated, and to develop realistic 3D models for the characterization of planetary surface processes. Annotation tools are being developed to aid discussion and dissemination of the observations within the planetary science community.

1. Introduction

The FP7-SPACE PRoViDE (Planetary Robotics Vision Data Exploitation) project has been developed to exploit the wealth of orbital, probe and rover derived planetary surface imagery data taken from the dozens of missions which have successfully travelled to other planetary bodies in the Solar System. A database of processed planetary datasets has been developed [7] and PRoGIS 2.0 is the spatial entry point into which these products have been brought into a common geospatial context [2]. Access to a complete set of 3D products has been provided with additional analysis capabilities within PRo3D [6]. This paper presents methodologies used to quantitatively exploit these datasets for geological analysis on Martian test examples.

2. Geological application of PRoGIS 2.0

Orbital data is accessible through PRoGIS 2.0, in which HiRISE, CTX, HRSC and specially processed Super-Resolution HiRISE imagery [5] have been co-registered with Mars Orbiter Laser Altimeter (MOLA) data and combined with updated rover traverses. Rover Pancam, Mastcam, and Navcam imagery is accessible using the fulcra footprints of each dataset which enable the simple identification of rover imagery by location and view direction. This enables selection of specific datasets, which are relevant to geological analyses.

Images from overlapping fulcra are combined within PRoGIS 2.0 to create photomosaics and panoramas, which, together with super-resolution outcrop images, can be used for initial 2D outcrop interpretations.

3. Geological application of PRo3D

3D point clouds are created using short and long baseline rover stereo imagery, primarily from the Pancam and Mastcam sensors. Interpretations of main unit boundaries, second order stratigraphic boundaries and internal sedimentary structures are digitised directly onto the 3D point clouds. Strike and dips are calculated along bounding surfaces and bedding planes to determine sedimentary and structural geometric relationships as well as the predominant transport directions. This information is useful for determining the sediment flow directions and sediment source regions.

4. Case studies - Victoria Crater, Yellowknife Bay and Shaler

The measurement tools within Pro3D have been initially tested on outcrops around the rim of Victoria Crater, a ~ 750 m wide, moderately degraded crater located at 2.05°S, 5.50°W, in the Meridiani Planum equatorial region of Mars. It was visited by the MER-B Opportunity Rover, between Sols 952 and 1293 of operation. 100 – 150 m of erosional widening [3] has produced outcrops of pre-impact aeolian deposits < 15 m high, which form the upper dry section of a dry-wet-dry depositional sequence known as the Burns Formation [1]. Fully 3D outcrops exposed in the promontories of the crater wall show 3 – 7 m thick bedsets of large-scale cross-bedding, which have been interpreted as an ancient aeolian dune system [4]. The true 3D dimensions of these bed sets can be determined combining the dip and strike and distance measurement tools.

The tools described were also applied to analysis of data from the MSL Curiosity rover observations at Yellowknife Bay and Shaler outcrops which record evidence of fluvial and lacustrine environments on early Mars. Direct grain size measurements using the Mastcam and MAHLI instruments, as well as dip and strike measurements of bounding surfaces and cross-bedding laminations were possible within PRo3D.

5. Summary and Conclusions

PRoGIS is a highly effective tool for locating and identifying useful datasets for geological measurement and analysis. Pro3D provides the capabilities for quantitative 3D measurement of those features, allowing for a far greater understanding of layer geometries, palaeotransport directions, and temporal relationships. Regional integration of these results within PRoGIS can be used to greatly enhance the understanding of past and present surface processes on Mars.

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