

MER CONTACT SCIENCE TARGETS: ARCHIVED DATABASE AND INCLUSION IN THE ANALYST'S NOTEBOOK. T. C. Stein¹, R. E. Arvidson¹, S. J. Van Bommel¹, K. L. Wagstaff², E. Riloff³, F. Zhou¹, E. A. Guinness¹, ¹McDonnell Center for the Space Sciences, Department of Earth and Planetary Sciences, Washington University in St. Louis, 1 Brookings Drive, CB 1169, St. Louis, MO 63130, tstein@wustl.edu, arvidson@wustl.edu, vanbommel@wustl.edu, zhou@wustl.edu, ²Jet Propulsion Laboratory, California Institute of Technology, kiri.l.wagstaff@jpl.nasa.gov, ³University of Utah, riloff@cs.utah.edu.

Introduction: The Mars Exploration Rovers (MER) mission surface operations began in January 2004 and ended in May 2011 (Spirit) and February 2019 (Opportunity) [1]. Throughout the mission, the science team made numerous measurements of targets using the Alpha-Particle X-ray Spectrometer (APXS), Mössbauer (MB), Microscopic Imager (MI), and Rock Abrasion Tool (RAT) arm-based instruments, assigning an informal name to each target. During the MER mission closeout phase, a database of contact science targets was created to capture location information of these measurements. The database was scheduled for February 2020 release by the Planetary Data System (PDS) Geosciences Node (<https://pds-geosciences.wustl.edu/>) with incorporation into the MER Analyst's Notebook (AN) (<https://an.rsl.wustl.edu>) [2]. Links between targets and specific archived data products are incomplete due to the lack of round-trip tracking.

MER mission contact science targets: Throughout the Spirit and Opportunity rover surface operations, MER science team members identified and named locations of interest for carrying out contact science measurements. These locations were defined in a loose hierarchy of feature and target in which a relatively broad feature contained one or more specific targets. Features and targets also were defined for remote sensing measurements by the mast-based instruments Mini-Thermal Emission Spectrometer and Panorama Cameras, and a similar archiving effort is planned to capture those targets. Names given by the science team are not formally recognized by the International Astronomical Union.

A list of contact science targets was not available from the project at the end of the MER mission. At the beginning of the mission, targets were defined by team members using the Science Activity Planning (SAP) tool from which the rover planners could retrieve specific location information for commanding the spacecraft. When SAP was replaced by the Maestro planning tool, target locations were communicated to the rover planners separately, with the result that targets were not always added to Maestro.

Developing the target database: Initial work identified resources for enumerating the contact science targets: partial lists from SAP and Maestro along with thousands of sol reports from rover planners, science operations working group documentarians, and the mis-

sion managers. From these, we compiled a list of observation targets, using the Basilisk information extraction system [3] to scan these reports and highlight possible target names for human review. Basilisk was trained using a seed target list generated from the planning tools and from instrument lists and plan summaries in the Analyst's Notebook. It learned frequently occurring English patterns in which targets are mentioned, such as "images of X". Applying these patterns yielded many additional candidate targets.

To minimize the time required to review the candidate target names, we used the brat web-based text annotation system (Fig. 1) [4].

A team of human reviewers used brat to browse Basilisk's candidate targets in the context in which they were found and then approve or remove each candidate as appropriate. After reviewing 1502 Mission Manager reports, we obtained a list of 326 MER-A and 638 MER-B targets. In addition, several target aliases were discovered, including typos (e.g., "Boabab" for "Baobab"), punctuation variants (e.g., "Lemon-Rind" for "Lemon_Rind"), and phonetic variants (e.g., "Stewart_Island" for "Stuart_Island"). These target references would have been missed using a strict matching search. Approximately 1.5 days total was spent by the review team on this step.

The resulting list of targets from the Basilisk system was integrated with target lists from instrument teams and planning reports to create a master list of targets.

Compiling target metadata. Having the list of targets, two questions needed to be answered: what science data were acquired, and where was the target? Activity lists from the APXS, MB, MI, and RAT instrument teams were used to match targets to science activities and to find the sols of data acquisition. Target location relative to the rover was gleaned from rover planner reports and cross-checked against planning tool lists when available. The rover location (site and drive) for each target was sourced from the AN.

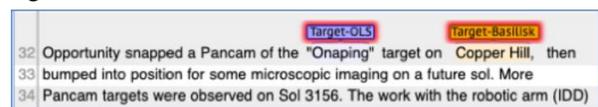


Fig. 1. Screen snippet showing Mission Manager Report text within the brat system. Annotations show targets identified from the Analyst's Notebook (labeled "OLS") and Basilisk system.

Archiving the database. The contact science target database for each rover is archived in tabular form at the PDS Geosciences Node. The table provides detailed information about each target, such as the general location, broad feature name (derived from sol reports and instrument team activity lists), and target type (one of rock, scuff, soil, or trench). The rover position, as site and drive, and location metadata (x, y, z and u, v, w values relative to site frame) when the target was defined are also included. Finally, the table shows instrument activity associated with each target by sol and whether an alias target name was used by the instrument team. Details are included in the PDS product label.

Validation of the contact science target database was provided by MER science team members who participated in each step of its development. Integration of the target database into the MER AN, which included plotting the targets on rover images (discussed below), also provided further validation.

Integration into the Analyst’s Notebook: In addition to the PDS archive, the contact science targets database was included in the MER AN with the February 2020 release.

Selecting finder frames. For each target, a representative image showing the target in context is selected as a finder frame. Ideally, a Navigation Camera or Panorama Camera image is used. Candidate images must be taken from the same rover site location where the target was defined. Each target’s ground coordinates and image metadata, the CAHVOR image model is used to

auto-locate target positions within an image [5]. Preference is given to full-size (1024 by 1024 pixels) images with the target appearing near the center of the frame. In addition, the distance from the camera to the target position in an image is calculated to avoid near-field shadows. The Notebook image measurement tool is used to validate finder frame selection.

Finding targets in the Notebook. Mission summaries include the target list, supplemented by image thumbnails of each target. Targets also have been integrated into the sol summaries within the AN, in which data, documents, and plans are shown for each sol. The Notebook search function supports target-based searches as well.

When viewing a target in the AN, a finder frame provides visual context. Additional images of the target, taken at the same site and within 50 meters distance, are also available (Fig. 2). An effort is underway to link targets directly to archive data products.

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References:

[1] Crisp, J.A., et al. (2003) doi:10.1029/2002JE002038. [2] Stein, T.C. et al. (2010), LPS XLI, Abstract #1414. [3] Thelen, T. and Riloff, E. (2002), doi:10.3115/1118693.1118721. [4] Stenertorp, P., et al. (2012), doi:10.5555/2380921.2380942 [5] Di, K., and Li, R. (2004), doi:10.1029/2003JE002199.

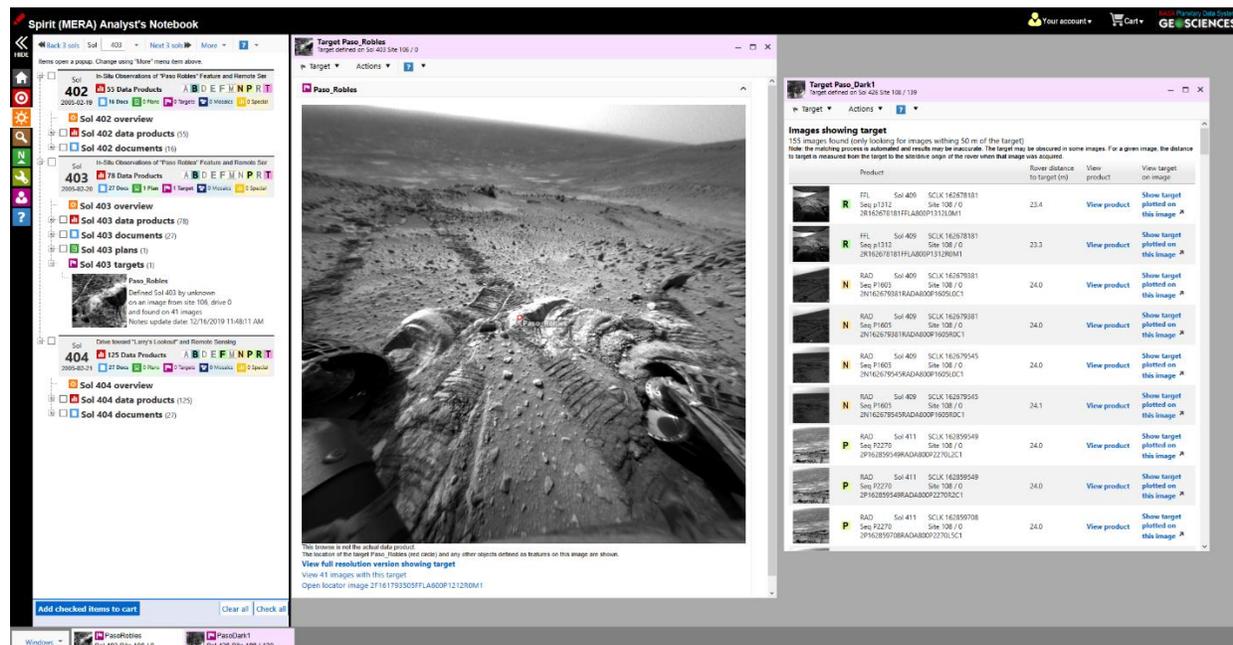


Fig. 2. MER Analyst’s Notebook for Spirit showing targets Paso_Robles (plotted on a finder frame for context) and Paso_Dark1 (with list of images showing the target).