

EXPANDING ACCESS AND USABILITY OF SPACECRAFT DATA: THE MARS EXPLORATION ROVERS PORTAL TO OBSERVATIONS, RESOURCES, AND TOOLS TO ADVANCE LEGACY SCIENCE (MER PORTAL). S. B. Cole¹, J. C. Aubele², W. H. Farrand¹, S. Lu³, K. L. Lynch⁴, and the MER PORTAL Team. ¹Space Science Institute, Boulder, CO, scole@spacescience.org, ²New Mexico Museum of Natural History & Science, Albuquerque, NM, ³Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, ⁴Lunar and Planetary Institute, Houston, TX (Now at NASA Headquarters, Washington, D.C)

Introduction: Throughout the 21st Century, the amount of data returned by NASA spacecraft has increased to the point that it exceeds the capacity of mission team members to analyze it. During this same time period, computing power and internet access within the U.S. and across the world have increased to the point that expensive facilities are no longer required to analyze even large amounts of data. This opens the possibility of planetary spacecraft data analysis to workers who are not on and do not have collaborations with spacecraft teams, and/or who work at institutions that lack large research budgets.

Due to *Spirit*'s and especially *Opportunity*'s longevity, the two-rover, originally 90-sol (martian day) Mars Exploration Rover (MER) mission acquired a total of 20 years of daily data from multiple instruments at two extended sites on the martian surface, resulting in too much data to be analyzed by MER Team members alone. These data can, and should, be analyzed by scientists who were not on the MER Team, but only if these researchers can find data of scientific interest to them and learn the caveats, context, and appropriate analysis methods for the data and data products. The goal of the MER Portal to Observations, Resources, and Tools to Advance Legacy Science (MER PORTAL) is to enable *everyone* to find and use MER data.

Addressing community needs: In 2020 we conducted a survey of the community [1] to gauge the interest in a user-friendly, science-focused search interface to MER data. Our participant recruitment plan included a poster [2] at the 51st Lunar and Planetary Science Conference (LPSC2020) which presented preliminary results and invited additional participants. Despite the lack of in-person recruiting in March 2020, a sufficient number of participants completed the survey to assess community needs. Results indicated that a wide range of workers would like to use MER data, but are currently unable to do so (see Figure 1).

We are designing the MER PORTAL to rectify this disparity. The PORTAL will address issues raised by the Planetary Data Ecosystem Independent Review Board (PDE IRB) [3] by providing:

- A portal to data, documents, software tools, and supporting information, in a format suitable for the broadest range of users looking for planetary data, that will assist in the retrieval of NASA science data

- Metadata describing data quality, enabling users to assess suitability for their applications
- Focused educational and documentation materials that meet the highest-priority needs identified in our assessment of the community

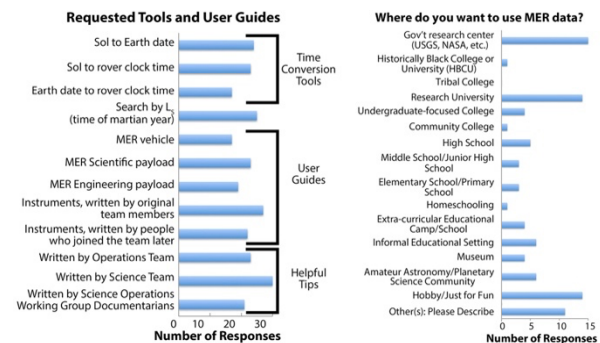


Figure 1. Results from our survey of the Mars community [1] indicate a broad interest in MER data and the need for tools and user guides to facilitate data analysis.

Current status: We were awarded a PDART21 grant to begin development of the MER PORTAL. By the end of this award, our prototype website (see Figure 2) will include:

User Guides. We are creating user guides to enable the non-MER Mars community to work with MER image and spectroscopic data. These include both data analysis manuals and overviews of the MER vehicle and instrument hardware. The former are based on interviews with the ~30 members of our project team who worked on the MER mission and will share the MER team's institutionalized data context and analysis knowledge with the planetary community. We are currently producing Data Analysis User Guides to the Panoramic Camera (Pancam), Microscopic Imager (MI), Miniature Thermal Emission Spectrometer (Mini-TES), Alpha Particle X-ray Spectrometer (APXS), and Mössbauer Spectrometer (MB) instruments that are aimed at experienced researchers who are new to MER data analysis. We plan to eventually extend our User Guides to include versions that are appropriate for different audiences such as college classes, undergraduate researchers, K-12 teachers, and the interested public.

MER Image Interpretation Guidebook. We are producing a manual that will introduce novice MER

researchers, students, and the general public to Gusev (*Spirit*) and Meridiani (*Opportunity*) field geology. This handbook is designed to teach undergraduates with limited geologic knowledge to identify geologic, atmospheric, and rover-related objects and phenomena in MER images.

Lesson plans. We are developing a set of undergraduate classroom-ready in-class activities that make use of our MER Image Interpretation Guidebook. Co-I Jayne Aubele is collaborating with faculty at the Southwestern Indian Polytechnic Institute (SIPI), with whom she has longstanding relationships, to develop and pilot the lesson plans.

Links to useful online tools and websites. We are compiling a list of online tools and websites, recommended by members of the MER Team, that are relevant to MER data analysis and the MER mission. We will include research tools such as the [MER Analyst's Notebook](#), websites highlighting MER data such as the [Pancam Instrument Website](#), and historically relevant websites such as blogs written by MER Team members.

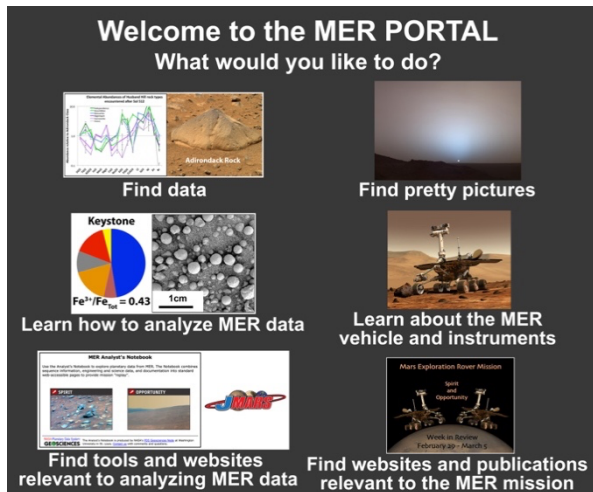


Figure 2. Mock-up of the MER PORTAL homepage

In addition to the above products which we will produce with our current award, we are conducting the initial phases of development for our comprehensive MER data science-based search tool, through the System Requirements Review (SRR) milestone, to establish that all requirements are defined, testable, and consistent. This complex search tool will couple an intuitive and accessible user interface with databases containing metadata correlating data acquired on individual targets by different instruments; the [Mars Target Encyclopedia](#) [4, 5] and other databases contributed by members of our team; and a catalog of the geologic, atmospheric, and hardware features apparent in MER images. Members of our team have previously collaborated to catalog

features in Pancam image data using an automated machine learning (ML) classifier [6, 7]; current results can be explored at the [PDS Image Atlas](#) and [Zenodo](#).

Equity, Diversity, Inclusion, and Accessibility:

By creating and providing resources for MER data discovery and analysis, we open Mars to most of this world, providing a pathway to broaden participation in the planetary sciences. The MER PORTAL project prioritizes accessibility, and we are designing our website and content to be accessible to people with a wide range of abilities and disabilities. Our Accessibility Consultant, a geoscientist who identifies as a person with disabilities, is a paid member of the MER PORTAL team and has been involved in the project from the start. He will ensure that accessibility features conforming to the Web Content Accessibility Guidelines (WCAG) [8], including alt-text for images, keyboard navigation, and compatibility with screen readers, are built into the MER PORTAL.

We hope to release our preliminary website in both English and Spanish in 2025.

Future Work: While our current endeavor is focused on the MER mission, we hope PORTALS will become a standard component of the Planetary Data Ecosystem for planetary spacecraft missions. We will open source our website and database backend and hope to enable other missions to develop their own PORTALS.

We invite members of the MER team who are not currently on the MER PORTAL team to join us. We invite self-identified members of the Mars community – experienced Mars researchers; Earth geologists who (or whose students) have an interest in Mars; faculty at primarily undergraduate institutions (PUIs), Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), and community colleges; schoolteachers; and Mars or MER enthusiasts – to beta-test our products and give us feedback. We invite members of other spacecraft teams to consider how a PORTAL would benefit their mission.

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References: [1] Cole S. B. *et al.* (2020) *LPSC LI*, Abstract #1709. [2] <https://www.hou.usra.edu/meetings/lpsc2020/eposter/1709.pdf>. [3] PDE IRB (2021), Final Report, <https://smd-cms.nasa.gov/wp-content/uploads/2023/05/PDEIRBFinalReport-1.pdf>. [4] Wagstaff K. L. *et al.* (2022) *LPSC LIII*, Abstract #1231. [5] Wagstaff K. L. *et al.* (2018) *30th AAAI/IAAI-18* <https://cdn.aaai.org/ojs/11412/11412-13-14940-1-2-20201228.pdf>. [6] Lu *et al.* (2021), *LPSC LII*, Abstract #1779. [7] Zhao *et al.* (2020), MER Opportunity and Spirit Rovers Pancam Images Labeled Data Set (Version 1.1.0), <https://zenodo.org/record/4302760>. [8] <https://www.w3.org/TR/WCAG21/>