VISION FOR THE MARS EXPLORATION ROVERS PORTAL TO OBSERVATIONS, RESOURCES, AND TOOLS TO ADVANCE LEGACY SCIENCE (MER PORTAL). S. B. Cole[1], J. C. Aubele[2], W. H. Farrand[1], S. Lu[3], K. L. Lynch[4], C. Schröder[5], R. A. Yingst[6], A. J. S. Rayl[7], and the MER PORTAL Team. [1]Space Science Institute, Boulder, CO, scole@spacescience.org, [2]New Mexico Museum of Natural History & Science, Albuquerque, NM, [3]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, [4]Lunar and Planetary Institute/USRA, Houston, TX, [5]University of Stirling, UK, [6]Planetary Science Institute, Tucson, AZ, [7]The Planetary Society, Pasadena, CA.

Introduction: The Mars Exploration Rovers (MER) mission was the first long-duration surface exploration of another world. When *Spirit* and *Opportunity* launched nearly 20 years ago, the original team expected to operate the rovers for 90 sols (martian days) and then analyze their data. Instead, *Spirit* and *Opportunity* roved Mars for 2210 and 5111 sols, respectively, accumulating a combined 20 years of daily data from multiple instruments. Several million MER data products reside on the Planetary Data System (PDS), waiting to advance legacy science. Many members of the Mars science community who were not involved in the mission would like to analyze MER data but are unable to do so due to difficulties finding and evaluating data products on their targets of interest, and a lack of context and caveats for the data products they do find [1].

Members of the original MER team are nearing or entering retirement, and over a decade ago, many shifted to the Mars Science Laboratory and Mars 2020 rover teams. It is vital to record the MER team's institutionalized knowledge while it is as fresh as possible in their minds, cognizant of the fact that details have already started to fade or be supplanted by the later missions' institutionalized knowledge. The MER Portal to Observations, Resources, and Tools to Advance Legacy Science (PORTAL) will ensure that researchers have what they need to analyze MER data.

A Resource for MER Novices: The MER Analyst's Notebook (MER AN) [2, 3] is an excellent tool for researchers who are well acquainted with the mission, with data searchable by instrument, Sol (day of mission), contact science target and feature names, location along the rover's traverse, *etc.*; MER team members use it extensively, as do some non-team members [1]. However, the site notes that "[a]nyone is welcome to use the Notebook, but keep in mind that the primary audience is the planetary science community. That means there are lots of technical bits that may be confusing to casual users." The MER PORTAL will enable casual users and novice MER researchers to discover and use MER data (see Fig. 1), enabling innovative science from the mission's data for decades to come. Its primary components include:

User Guides. We will document the MER rover, instruments, and data analysis techniques, developing focused documentation and educational materials. Our

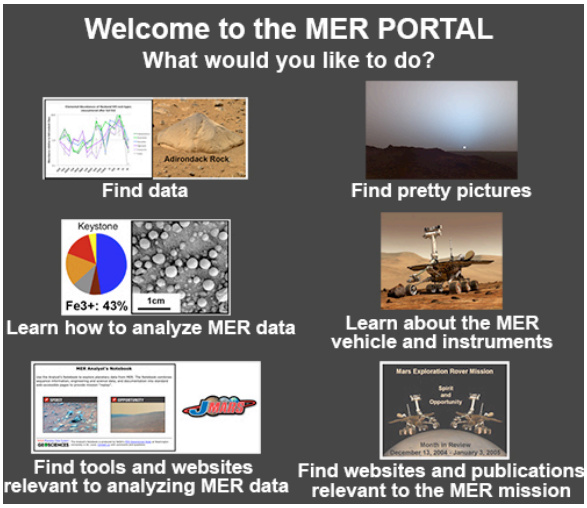

Figure 1. Mockup of the MER PORTAL website. Users will be able to learn about the MER rovers and how to access and analyze MER data, find pretty pictures, and access relevant tools and websites.

data analysis User Guides for the Panoramic Camera (Pancam), Navigation Camera (Navcam), Microscopic Imager (MI), Miniature Thermal Emission Spectrometer (Mini-TES), Alpha Particle X-ray Spectrometer (APXS), and Mössbauer Spectrometer (MB) instruments, and the Rock Abrasion Tool (RAT), will provide information akin to the guidance a professor would give their graduate students about analyzing MER data.

Science-based search of MER data. Researchers will be able to search for geologic, atmospheric, and rover-related content apparent in image data; and will be able to search for data products by object type (float rock, outcrop, bright soil, meteorite, *etc.*), composition and compositional class, location, observation type (*e.g.*, Mini-TES elevation sky and ground, Tau (atmospheric opacity), Navcam dust devil "movie", *etc.*), and the informal names of individual rocks and soils. In addition to expanding access to planetary scientists who were not on the MER team, this will remove barriers for researchers worldwide, faculty at many institutions and two-and four-year colleges, high school to college level students, and museum visitors.

Contextual information and data quality indicators. We will provide data acquisition contextual infor-

mation such as metadata indicating if the RAT had brushed or ground the object, data quality indicators such as integration time for APXS and MB observations and comments noted by the operations team; and metadata to enable searches by *e.g.*, the wavelengths of filters used in Pancam observations; the data product's DOI if one has been assigned; and indicators for Pancam stereo, 13-filter, and mosaic observations.

Data visualization tools. The MER PORTAL will provide interactive tools requested by the community [1], including a Graphing Tool for inspecting APXS and MB data and appraising the signal-to-noise ratio (S/N) of data products; a Time Converter Tool to convert between, *e.g.*, rover clock time, Local True Solar Time, Sol, Earth date, and L_S (time of the Martian year); and a Mapping Tool to annotate where data products were acquired along the rover's traverse.

Annotated bibliography of online tools and resources. We will compile annotated bibliographies of the many websites and tools relating to MER data analysis, images with broad appeal, and the mission.

Our Team: The MER PORTAL's nearly 40-member team is composed primarily of people who have worked on the MER mission, some for the majority of their career. In addition, we have Mars scientists with no connection to the MER mission, to ensure that our User Guides are comprehensive and aimed at the appropriate audiences; formal and informal educators; machine learning and database specialists; a technical writer; an investigative reporter, who will help design our interview questions; a web developer; an accessibility consultant; and a systems engineer, who will direct the development of the complex database that will be the basis of our science-based search.

Phase 1: The first phase of the MER PORTAL has been awarded a PDART21. During the next 3 years, we will develop:

User Guides and team member interviews. Our highest priority is to record the institutionalized knowledge of the dozens of members of our team who worked on MER; we will preserve this knowledge and present it in our User Guides. We will interview our scientists and engineers, some of whom were involved at the start of the mission, some who joined during the many mission extensions, and some whose involvement spanned the entire mission. In Phase 1 we will produce data analysis manuals for the Pancam, MI, Mini-TES, APXS, and MB instruments; and overviews of the MER vehicle and instruments, including information on the different types of data products and where to find them, aimed at novice MER researchers. We intend to produce additional User Guides, based on the wide range of interviews we will record in this work, in future investigations with additional funding.

Image interpretation training materials and lesson plans. We will create MER Image Interpretation Training Materials that will introduce novice MER researchers, students, and the general public to Gusev (*Spirit*) and Meridiani (*Opportunity*) field geology; and we will develop undergraduate in-class activities for immediate use. Co-I Aubele has long-standing relationships with individuals from several Indigenous tribal nations and will work with a teacher from the Southwestern Indian Polytechnic Institute (SIPI) to develop Lesson Plans for formal and informal education based on the Training Materials.

Curated list of online tools and resources. We will compile a list of online tools and websites recommended by our MER team members. We will include research tools such as the MER AN, Arizona State University's spectral library, and the upcoming MER In-Situ Global Observation Localization Dataset (MERIGOLD) [4]; websites highlighting MER images such as the Pancam Instrument website and NASA's *Spirit* and *Opportunity* Image Gallery; and historically relevant websites such the *Spirit* and *Opportunity* Week (and later Month) in Review archive, blogs written by MER team members during and about the mission, and sociological studies of the mission team.

Database infrastructure and website. We will develop the infrastructure necessary for our future science-based search. Our preliminary website will present the materials we produce in Phase 1.

Equity, Diversity, Inclusion, and Accessibility (EDIA): EDIA is a core value in the MER PORTAL project: our goal is to make MER data fully accessible to everyone including experienced Mars researchers, students, high school teachers assigning enrichment projects, space enthusiasts, and people with a range of abilities and disabilities. Our Accessibility Consultant, a geoscientist who identifies as a person with disabilities, will ensure that we go beyond the minimum requirements of the Americans with Disabilities Act (ADA). Both the Accessibility Consultant and the SIPI teacher are paid members of the MER PORTAL team.

More than one-third of our leadership tier (the PI and Co-Is) are people of color, 53% of the team are women and/or people with feminine gender expression, and at least 13% of team members identify as having a disability and/or chronic illness(es).

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References: [1] Cole S. B. et al. (2020) *LPS LI*, Abstract #1709. [2] Stein T. C. et al. (2010) *LPS XLI*, Abstract #1414. [3] Stein T. C. et al. (2020) *LPS LI*, Abstract #1942. [4] Abarca H. and Calef F. III (2021) *5th Planetary Data and PSIDA*, Abstract #7101.