Western Washington University
Western CEDAR

Geology Faculty Publications | Geology

12-15-2023

Mastcam multispectral database from the Curiosity rover's traverse in the Gale crater, Mars (sols 2302-3672)

Alivia Eng
Western Washington University; Georgia Institute of Technology, aliviaeng@gmail.com

Melissa S. Rice
Western Washington University, melissa.rice@wwu.edu

Michael St. Clair
Million Concepts

Chase C. Million
Million Concepts

Sierra Brown
Million Concepts

See next page for additional authors

Follow this and additional works at: https://cedar.wwu.edu/geology_facpubs

Recommended Citation

Eng, Alivia; Rice, Melissa S.; St. Clair, Michael; Million, Chase C.; Brown, Sierra; Seeger, Christina; Adair, Lee; Hughes, Cory; Evans, Acacia A.; and Frizzell, Katelyn, "Mastcam multispectral database from the Curiosity rover's traverse in the Gale crater, Mars (sols 2302-3672)" (2023). *Geology Faculty Publications*. 106.
https://cedar.wwu.edu/geology_facpubs/106

This Dataset is brought to you for free and open access by the Geology at Western CEDAR. It has been accepted for inclusion in Geology Faculty Publications by an authorized administrator of Western CEDAR. For more information, please contact westerncedar@wwu.edu.

Authors

Alivia Eng, Melissa S. Rice, Michael St. Clair, Chase C. Million, Sierra Brown, Christina Seeger, Lee Adair, Cory Hughes, Acacia A. Evans, and Katelyn Frizzell

This dataset is available at Western CEDAR: https://cedar.wwu.edu/geology_facpubs/106

Mastcam multispectral database from the Curiosity rover's traverse in the Gale crater, Mars (sols 2302-3672)

Data Processing

The Mastcam instrument on NASA's Curiosity rover is a pair of multispectral, stereoscopic cameras that provide broadband red/green/blue (RGB), narrowband visible to near-infrared color (VNIR, 445-1013 nm wavelength range) (Bell et al., 2017). Using pre-flight calibration coefficients from radiance products available via the NASA Planetary Data System (PDS), we calibrated Mastcam multispectral observations to radiance factor units (I/F, or "IOF," where I is equal to the measured scene radiance and πF is the solar irradiance received at the surface at the time of the observation). From these IOF products, we compiled a database of Mastcam spectra from Curiosity's exploration of Glen Torridon, Greenheugh pediment, and the clay-sulfate transition from sols 2302 to 3672 of the mission. This database includes a total of 267 observations and builds upon that of Rice (2022) for sols 0-2302.

For each Mastcam multispectral observation, we characterized the spectral variability in the scene through a visual inspection of natural color red, green, blue (RGB) images, enhanced color images derived by stretching narrowband images, and decorrelation stretch (DCS) products (Gillespie et al., 1986). The stretched image products were produced programmatically by the Automated Spectral Data Functions ('asdf') workflow (St. Clair et al., 2022). We identified end members within each scene as groupings of pixels that exhibited distinct colors in the false color and DCS products and also represented geologically-distinct surfaces.

We extracted a representative spectrum of each end member by manually selecting pixels from regions of interest (ROIs) in the right and left Mastcam images separately, taking care to select the same regions of the surface. We utilized the "best practices" described by Rice et al. (2022). In the resulting ROI spectra, we represent error values in IOF as the standard deviation among the selected pixels; this is a measure of the homogeneity of the pixel values within the ROI, and is generally much larger than the instrumental error (Bell et al., 2017).

We compiled each endmember spectrum with extensive metadata. Observation-level metadata were taken directly from the Mastcam images' Planetary Data System version 4 (PDS4) headers, and geographic information was taken from localization data provided for each rover position in the PDS. Each spectrum was manually assigned a number of ROI-specific fields to categorize their rock and soil properties.

File Formats

CSV, FITS, PNG

Dataset Description: ROI_files.zip

Regions of Interest (ROIs) from which all spectra in the database (Mastcam_multispectral_database.csv) were extracted. All files are compressed FITS files. Filenames are given as "roi_SOLXXXX_mcamYYYYY_NNNL_MMMR.fits.gz," where XXXX is the sol number, YYYYY is the sequence identifier number, NNN is the

remote sensing mast position index for the left Mastcam, and MMM is the remote sensing mast position index for the right Mastcam.

Dataset Description: ROI_context_images.zip

Context images for Regions of Interest (ROIs) for each Mastcam multispectral observation in the database (Mastcam_multispectral_database.csv). All images are PNG files. ROIs are shown as polygons overlain on natural color red, green and blue (RGB) images from Mastcam L0 and R0 filters. The ROI color in each image corresponds to a unique spectrum in the database. Filenames are given as "context_image_C_solXXXX_mcamYYYYY_NNNL_MMMR.png," where C is the camera (left or right), XXXX is the sol number, YYYYY is the sequence identifier number, NNN is the remote sensing mast position index for the left Mastcam, and MMM is the remote sensing mast position index for the right Mastcam.

Dataset Description: Composite_images.zip

Enhanced color and decorrelation stretch composite images for all observations in the database (Mastcam_multispectral_database.csv). All images are PNG files. The left Mastcam composites are made with the L6 (1012 nm), L1 (527 nm) and L2 (445 nm) filters.The right Mastcam composites are made with R6 (1013 nm), R1 (527 nm), and R2 (447 nm) Filenames are given as "COMP_C6_C1_C2_solXXXX_mcamYYYYY_NNNL_MMMR.png," where COMP is the composite type ("dcs" or "enhanced_color"), C is the left or right camera filters (L or R), XXXX is the sol number, YYYYY is the sequence identifier number, NNN is the remote sensing mast position index for the left Mastcam, and MMM is the remote sensing mast position index for the right Mastcam.

Dataset Description: Mastcam_multispectral_database.csv

NAME	Target name associated with the Mastcam-Z sequence, appended with "_XofY" for mosaic observations (where X is the pointing number and Y is the total number of pointings in the mosaic)
SOL	Martian day of Curiosity's mission
LTST	Local True Solar Time when the sequence began on Mars, in units of seconds past midnight
SEQ_ID	Mastcam sequence identifier number
ROVER_ELEVATION	Elevation of the rover in meters
INCIDENCE_ANGLE	Incidence angle for the center of the image when the sequence began on Mars, calculated from the Solar Elevation field in the Mastcam image header
EMISSION_ANGLE	Emission angle for the center of the image when the sequence began on Mars, calculated from the Instrument Elevation field in the Mastcam image header
PHASE_ANGLE	Phase angle for the center of the image when the sequence began on Mars, calculated from the Solar Elevation, Instrument Elevation, Instrument Azimuth and Solar Azimuth fields in the Mastcam image header
LAT	Rover latitude
LON	Rover longitude

ODOMETRY	Rover distance traveled in meters
SCLK	Spacecraft clock time
COLOR	Color assigned to the Region of Interest from which pixels were averaged to extract the Mastcam spectrum; colors correspond to those shown in the context images
FEATURE	Type of surface feature (rock, soil)
FEATURE_SUBTYPE	Type of rock or soil (dusty rock, Dust Removal Tool (DRT) target, broken rock, vein, drill fines, dump pile, nodule-rich rock)
GROUP	Stratigraphic position (for rock targets only)
FORMATION	Stratigraphic position (for rock targets only)
MEMBER	Stratigraphic position (for rock targets only)
FLOAT	Designation of rocks as “in-place,” “float” (not attached to outcrop) or “unclear”
UNITS	Reflectance units used; IOF is the “radiance factor,” which can be converted to “reflectance factor” (*R**) by dividing by the cosine of the solar incidence angle
L2	Reflectance at 445 nm
R2	Reflectance at 447 nm
L0B	Reflectance at 481 nm
R0B	Reflectance at 483 nm
L1	Reflectance at 527 nm
R1	Reflectance at 527 nm
R0G	Reflectance at 551 nm
L0G	Reflectance at 554 nm
R0R	Reflectance at 638 nm
L0R	Reflectance at 640 nm
L4	Reflectance at 676 nm
L3	Reflectance at 751 nm
R3	Reflectance at 805 nm
L5	Reflectance at 867 nm
R4	Reflectance at 908 nm
R5	Reflectance at 937 nm
L6	Reflectance at 1012 nm
R6	Reflectance at 1013 nm
L2_STD	Standard deviation at 445 nm
R2_STD	Standard deviation at 447 nm
L0B_STD	Standard deviation at 481 nm
R0B_STD	Standard deviation at 483 nm
L1_STD	Standard deviation at 527 nm
R1_STD	Standard deviation at 527 nm
R0G_STD	Standard deviation at 551 nm
L0G_STD	Standard deviation at 554 nm
R0R_STD	Standard deviation at 638 nm
L0R_STD	Standard deviation at 640 nm
L4_STD	Standard deviation at 676 nm
L3_STD	Standard deviation at 751 nm
R3_STD	Standard deviation at 805 nm

L5_STD	Standard deviation at 867 nm
R4_STD	Standard deviation at 908 nm
R5_STD	Standard deviation at 937 nm
L6_STD	Standard deviation at 1012 nm
R6_STD	Standard deviation at 1013 nm
FILTER_AVG	Average reflectance of all filters
STD_AVG	Average of the standard deviations for all filters
REL_STD_AVG	Average of the standard deviations for all filters relative to their reflectance values

References

Bell, J. F., III, Godber, A., McNair, S., Caplinger, M. A., Maki, J. N., Lemmon, M. T., et al. (2017). The Mars Science Laboratory Curiosity rover Mastcam instruments: Preflight and in-flight calibration, validation, and data archiving. *Earth and Space Science*, **4**(7), 396–452. https://doi.org/10.1002/2016EA000219.

Gillespie, A., Kahle, A., & Walker, R. (1986). Color enhancement of highly correlated images. I. Decorrelation and HSI contrast stretches. *Remote Sensing of Environment, 20*(3), 209–235. https://doi.org/10.1016/0034-4257(86)90044-1.

Rice, M. S. (2022), Mastcam multispectral database from the Curiosity rover's traverse in Gale crater, Mars (sols 0-2302). WWU Geology Faculty Publications, 104. https://doi.org/10.25710/rqr0-8x75.

Rice, M. S., Seeger, C., Bell, J., Calef, F., St. Clair, M., Eng, A., et al. (2022). Spectral diversity of rocks and soils in Mastcam observations along the Curiosity rover's traverse in Gale crater, Mars. Journal of Geophysical Research: Planets, 127, e2021JE007134. https://doi.org/10.1029/2021JE007134.

St. Clair, M., Million, C., Rice, M. S. (2022). marslab software suite. https://zenodo.org/badge/latestdoi/498892781.