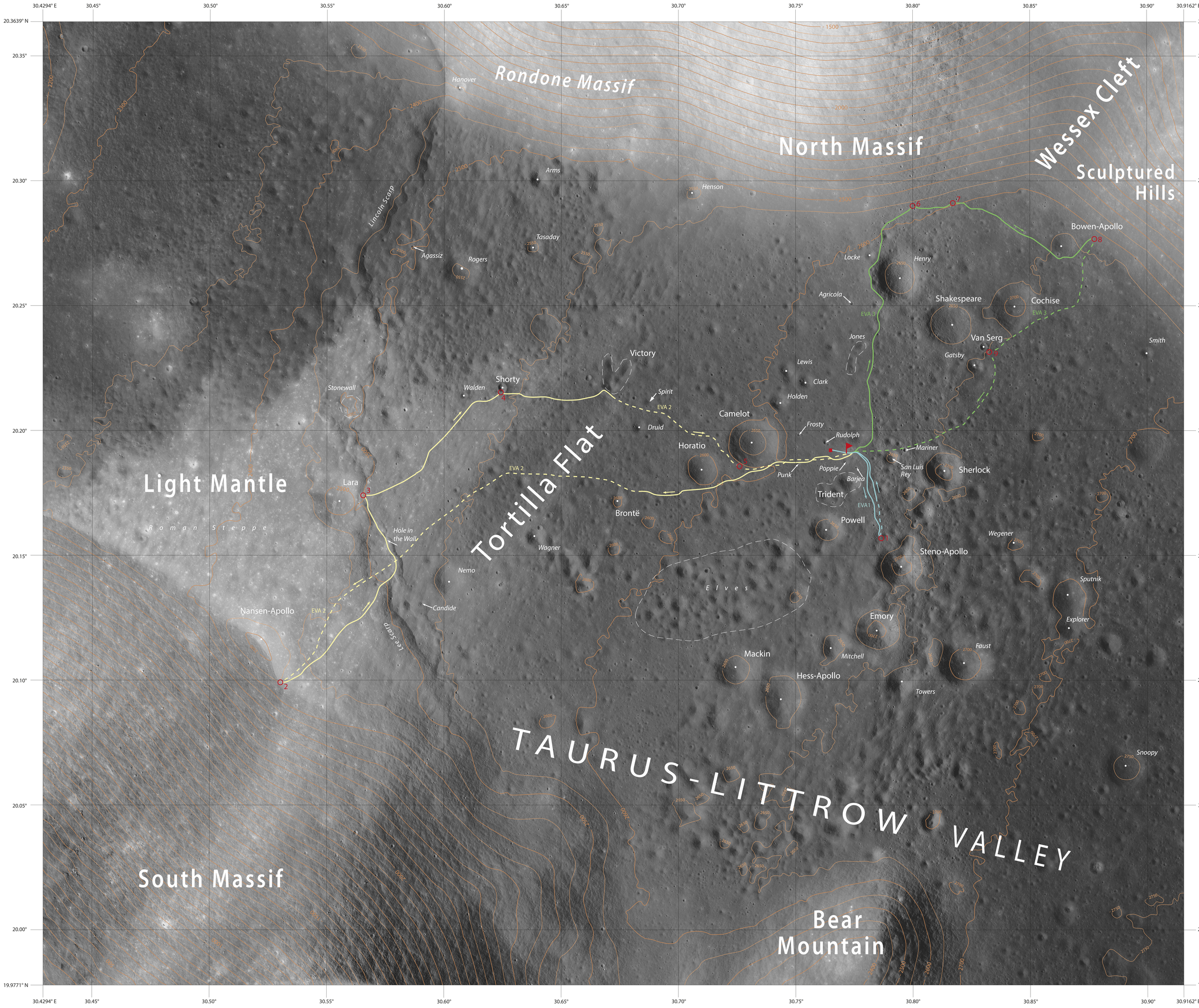
Controlled Orthoimage Mosaic

Apollo 17 Landing Site

L 15K 20.2/30.7 East COMT 2018



SCALE 1: 15 000

0 300 600 900 1500 m

General Notes

This map sheet covers the Taurus-Littrow Valley of the Earth's Moon, known for the landing site of the Apollo 17 mission. The scale is 1 : 15 000 and the source of map data is the camera experiment on the Lunar Reconnaissance Orbiter (LRO) (Vondrak et al., 2010).

LRO is the first mission in the series of NASA's Lunar Precursor Robotic Program (LPRP) and was launched June 18th, 2009. It employs seven instruments to globally map the Moon in color and 3D, provide high-resolution images, locate potential lunar resources, and characterize the radiation environment. The Lunar Reconnaissance Orbiter Camera (LROC) consists of three imaging subsystems (Robinson et al., 2010). The two Narrow Angle Cameras (NAC-L and NAC-R) are monochrome push-broom scanners with an instantaneous field-of-view (IFOV) of 10 µrad (50 cm ground resolution from the nominal 50 km orbit). The electronics are built around the Kodak KLI-5001G line array, a 5064-element CCD with 7 µm pixels. The LROC NACs are aligned side-by-side with a small overlap to enable NAC-L/R-mosaics providing a wider field-of-view (2 × 2.85°) in the cross-track direction. The multispectral Wide Angle Camera (WAC) is a push-frame imager with five visible wavelength filters (415 to 690 nm) with an IFOV of 1.498 mrad (75 m ground resolution from the nominal 50 km orbit) and two UV filters (320 and 360 nm) with an IFOV of 9.672 mrad (384 m ground resolution from a 50 km orbit). The LROC WAC uses a Kodak KAI-1001 CCD. This detector has 1024 × 1024 pixels, 9 µm in size.

Overview Map and Image Index

The overview map is a scaled LROC WAC mosaic (Speyerer, et. al, 2011) of the near side of the Moon, the Global Morphologic Map (0.1 km/ pixel original resolution). The location of quadrangle 43 (Batson, 1990) is marked in orange (see the three images below).

The orthomosaic was generated using the LROC NAC images:

Index number	Image name	Orbit number	Spatial resolution [m/ pixel]
1	M137353046LE	05375	0.50
2	M137353046RE	05375	0.50
3	M152669024LE	07633	0.40
4	M152669024RE	07633	0.40
5	M134985003RE	05026	0.50
6	M168000580LE	09892	0.25
7	M168000580RE	09892	0.25
8	M119652859LE	02767	0.40
9	M119652859RE	02767	0.50
10	M109032389RE	01202	0.50

Geodetic Control

For the LRO mission, spacecraft position and camera pointing data are available in the form of SPICE kernels. SPICE is a data system providing ancillary data such as spacecraft and target positions, target body size/shape/orientation, spacecraft orientation, instrument pointing used for planning space science missions and recovering the full value of science instrument data returned from missions [1]. Stereo- and orthoimage processing is based on the current-best camera position and pointing information integrating GRAIL refined ephemeris data, Lunar Orbiter Laser Altimeter (LOLA) (Smith et al., 2010) crossover data (Mazarico et al., 2011), and temperature corrected LROC geometry. A high-resolution (1.5 m) LROC NAC based digital terrain model (DTM) was generated for rectification purposes and for the provision of contour lines. LOLA post crossover solution tracks served as vertical reference. To be consistent with the Lunar Laser Ranging (LLR) reference frame, the coordinates of the Apollo Lunar Surface Experiment Package (ALSEP) radio transmitter (approximately 10 m lateral accuracy) given by Davies and Colvin (2000) were used as horizontal control.

Planetocentric coordinates are related to the Mean Earth/Polar Axis (ME) lunar reference system, as recommended by the International Astronomical Union (IAU) Working Group on Cartographic Coordinates and Rotational Elements (Archinal et al., 2011) and according to LRO project standards (NASA, 2008).

ALSEP transmitter at 20.19209° latitude, 30.76492° East longitude
Lunar Module (LM) at 20.19091° latitude, 30.77168° East longitude
ON Traverse station, N stands for the station number (1-9)
Route of EVA 1
Route of EVA 2
Route of EVA 3
Driving direction

The astronauts' traverse was reconstructed by referencing the Lunar Photomap 43D1S2(25) to the LROC orthoimage mosaic and adapting the traverses using ancillary information such as Apollo surface photography and short sections of rover tracks detected in LROC NAC images.

Nomenclature

The Names of geologic features, which are marked in white regular font, are approved by the IAU. For a complete list of IAU-approved names on the Moon see the Gazetter of the Planetary Nomenclature at [2]. Names of features in white italic font were suggested and used by the Apollo team, as documented in the Apollo lunar surface journal [3] and (Stooke, 2007). The center of craters are marked with a white point.

Map Projection

Transverse Mercator projection
Scale is true at 30.7° East longitude
Adopted figure: sphere
Mean radius: 1737.4 km (Archinal et al., 2011)
Grid system: planetocentric latitude, East longitude

Map Sheet Designation

L	Moon (Earth's satellite)
15K	Scale 1:15 000
20.2/30.7	Center point in degrees consisting of planetocentric latitude/ East longitude
COMT	Controlled orthoimage mosaic with nomenclature and contour lines
2018	Year of publication

Image Processing

- Radiometric correction of the images
- Generation of a digital terrain model (DTM) using photogrammetric techniques (Haase et al., 2018)
- Orthorectification and map projection (Haase et al., 2018)
- Image mosaicking and controlling of the mosaic (Haase et al., 2018)

Contours

To indicate elevations, contour lines were derived from the LROC NAC DTM and placed onto the orthomosaic. The heights are geometric heights and refer to a sphere with a radius of 1737.4 km according to the IAU definition of the Moon radius (Archinal et al., 2011). In the mapped area, the elevations vary from -2771 m to -207 m. The contour labels are aligned to the contour lines so that the top of the label is always placed uphill.

Contour interval 100 m
Supplementary contour interval 50 m

Color Coded DTM

The image below represents the shaded, color coded 1.5 m/ pixel DTM of the mapped area. The legend shows the correlation between color and height above the Moon radius (R = 1737.4 km).

References

Archinal, B., A'Hearn, M., Conrad, A., Consolmagno, G., Courtin, R., Fukushima, T., Hestroffer, D., Hilton, J., Krasinsky, G., Neumann, G., Oberst, J., Seidelmann, P., Stooke, P., Tholen, D., Thomas, P., and Williams, I., 2011, Report of the IAU Working Group on Cartographic Coordinates and Rotational Elements: 2009, Celestial Mechanics and Dynamical Astronomy 109(2), 101-135, doi: 10.1007/saaa10569-010 9320-4.

Batson, R. M., 1990, Cartography, in: Greeley, R. and Batson, R. (eds.), Planetary Mapping, Cambridge Univ. Press, Cambridge, 60-75.

Davies, M. E. and Colvin, T. R., 2000, Lunar coordinates in the regions of the Apollo landers, Journal of Geophysical Research 105(E8), 20277-20280, doi: 10.1029/1999JE001165.

Haase, I., Wählisch, M., Gläser, P., Oberst, J., Robinson, M. S., 2018, Coordinates and Maps of the Apollo17 Landing Site, Earth and Space Science, submitted.

Mazarico, E., Rowlands, D., Neumann, G., Smith, D., Torrence, M., Lemoine, F., and Zuber, M., 2012, Orbit determination of the Lunar Reconnaissance Orbiter, Journal of Geodesy 86, 193-207, doi: 10.1007/s00190-011-0509-4.

NASA, 1975, Lunar Photomap, Edition 1, Sheet 43D1S2(25), Defense Mapping Agency Topographic Center, Washington, D. C..

NASA, 2008, A Standardized Lunar Coordinate System for the Lunar Reconnaissance Orbiter, LRO Project and LGCWG White Paper, Version 5.

Robinson, M. S., Brylow, S. M., Tschimmel, M., Humm, D., Lawrence, S. J., Thomas, P. C., Denevi, B. W., Bowman-Cisneros, E., Zerr, J., Ravine, M. A., Caplinger, M. A., Ghaemi, F. T., Schaffner, J. A., Malin, M. C., Mahanti, P., Bartels, A., Anderson, J., Tran, T. N., Eliason, E. M., McEwen, A. S., Turtle, E., Jolliff, B. L., Hiesinger, H., 2010, Lunar Reconnaissance Orbiter Camera (LROC) Instrument Overview, Space Science Reviews 150, 81-124, doi: 10.1007/s11214-010-9634-2.

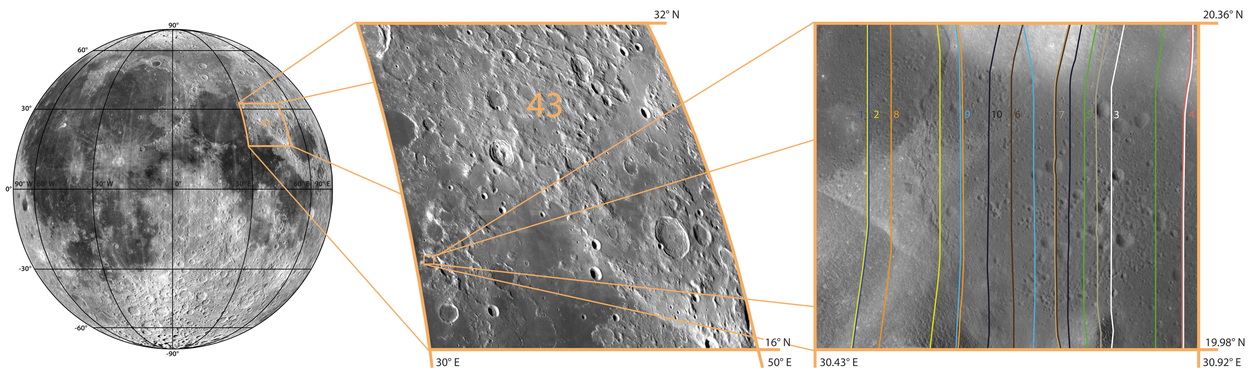
Smith, D. E., Zuber, M. T., Jackson, G. B., Cavanaugh, J. F., Neumann, G. A., Riris, H., Sun, X., Zellar, R. S., Coltharp, C., Connelly, J., Katz, R. B., Kleyner, I., Liiva, P., Matuszeski, A., Mazarico, E. M., McGarry, J. F., Novo-Gradac, A.-M., Ott, M. N., Peters, C., Ramos-Izquierdo, L. A., Ramsey, L., Rowlands, D. D., Schmidt, S., Stanley Scott III, V., Shaw, G. B., Smith, J. C., Swinski, J.-P., Torrence, M. H., Unger, G., Yu, A. W., Zagwodzki, T. W., 2010, The Lunar Orbiter Laser Altimeter Investigation on the Lunar Reconnaissance Orbiter Mission, Space Science Reviews 150, 209-241, doi: 10.1007/s11214-009-9512-y.

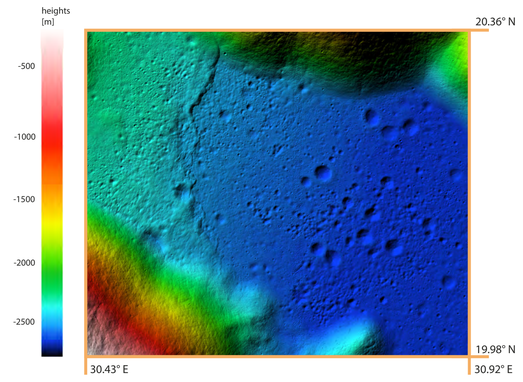
Speyerer, E. J., Robinson, M. S., Denevi, B. W., LROC Science Team, 2011, Lunar Reconnaissance Orbiter Camera Global Morphological Map of the Moon, 42nd LPSC, LPI Contribution 2387.

Stooke, P., The International Atlas of Lunar Exploration, 2007, Cambridge University Press.

Vondrak, R., Keller, J., Chin, G., Garvin, J., 2010, Lunar Reconnaissance Orbiter (LRO): Observations for Lunar Exploration and Science, Space Science Reviews 150, 7-22, doi: 10.1007/s11214-010-9631-5.

[1] https://naif.jpl.nasa.gov/naif
[2] https://planetarynames.wr.usgs.gov/
[3] https://www.hq.nasa.gov/alsj/a17/a17.html
(web references accessed 2018)





Editor

Mark S. Robinson and the LROC team, Arizona State University
Jürgen Oberst and the LROC group at the German Aerospace Center (DLR)
and the Technical University of Berlin
Please send comments, suggestions, and questions to Juergen.Oberst@dlr.de.

Image pre-processing:	Matz, K.-D., Roatsch, T.
Generation of the DTM:	Haase, I., Gläser, P., Scholten, F.
Orthoimage processing and mosaicking:	Haase, I., Maslonka, C.
Cartographic production and design:	Ankenbrand, F., Cheung, S., Kobrow, M., Wählisch, M.