

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Center of Astrogeology
601 East Cedar Avenue
Flagstaff, Arizona 86001

January 30, 1967

MEMORANDUM:

TO : Assistant Chief Geologist for Engineering Geology

FROM : Chief, Branch of Astrogeology

SUBJECT: Monthly report for Director and Secretary

4. Outside publications reported during month:

Howard, K. A., 1966, Large-scale recumbent folding in the metamorphic rocks of the Northern Ruby Mountains, Nevada (abs.): Geol. Soc. America Sp. Paper 87, p. 210.

Willey, R. L., 1967, "Far-infrared stellar astronomy," International Astronomical Union Symposium No. 24 (Birkenhead: Willmer Brothers limited), pp. 267-273.

5. Personnel

The following employees entered on duty

Flagstaff, Arizona

Richard E. Hoffman, Physical Science Aid, Flagstaff, Arizona
Jo Anne Jordan, Geologic Field Assistant, Flagstaff, Arizona
Matthew E. Paidakovich, Physical Science Aid, Flagstaff, Arizona

Cambridge, Massachusetts

Joel S. Watkins, Geophysicist

Transfers

Joseph A. Dushek, Management Analyst, transferred to the
Navajo Army Depot, Flagstaff, Arizona
Betty J. Norheim, Clerk (Typing), transferred to NASA,
Washington, D. C.

Resignations

Nellie S. Bradford, Physical Science Aid, Flagstaff, Arizona
Carl A. Carlson, Physical Science Aid, Menlo Park, California
Margaret A. Miley, Office Machine Operator, Flagstaff, Arizona
Joseph T. O'Connor, Geologist, Flagstaff, Arizona
Eugene I. Smith, Geologic Field Assistant, Albuquerque, N. M.

6. Scientific meetings and conferences attended at home or abroad

E. M. Shoemaker and A. H. Chidester conferred with W. E. Stoney at the Manned Spacecraft Center in Houston, Texas.

E. M. Shoemaker attended the Planetology Subcommittee meeting at the University of California at San Diego.

E. M. Shoemaker participated in the lunar names meeting of the International Astronomical Union held at the National Academy of Sciences in Washington, D. C.

E. C. T. Chao attended a conference on tektite-like micro-copic glass from deep sea sediments at Goddard Space Flight Center.

E. C. Morris, principal investigator for the Earth-Moon libration experiment, participated in a press conference at Cape Kennedy for principal investigators on Gemini XII orbital flights.

J. W. M'Gonigle conferred with personnel of the Manned Spacecraft Center, Houston, Texas regarding current progress in the production of geologic equipment for Early Apollo and test programs in connection with the Apollo Lunar Surface Scientific Simulation Program.

J. W. M'Gonigle attended the sixth Apollo Lunar Surface Experiments Program Interface meeting at the Manned Spacecraft Center, Houston, Texas

H. D. Ackermann and R. H. Godson conferred with P. H. Miller and H. R. Snodgrass, General Atomics, San Diego, California, on the seismic detection of cavities using controlled vibratory source.

J. R. Murphy visited Dr. A. F. Gangi, Massachusetts Institute of Technology, Cambridge, Massachusetts, and discussed equipment for seismic model studies.

J. R. Murphy visited Rev. J. Devane, S. J., Weston Observatory, Weston, Massachusetts, and discussed the feasibility of constructing a wireless transmitting geophone.

D. H. Dahlem and G. G. Schaber visited Frank Tindall at the Duval Company Mine, Tucson, Arizona, regarding atomic absorption analysis of silicate rocks. Dahlem and Schaber visited Roger Dutt at the Agricultural Experiment Station, University of Arizona at Tucson regarding the atomic absorption analysis of silicate rocks.

7. Talks or papers presented at meetings

<u>Speaker and organization</u>	<u>Subject</u>
Eugene M. Shoemaker Fourth Grade Marshall School Flagstaff, Arizona	Exploration of the moon
E. M. Shoemaker Celebration of H. H. Nininger's 80th birthday Arizona State University Tempe, Arizona	Meteorites and craters
E. M. Shoemaker Dedication of Space Sciences Building University of Arizona Tucson, Arizona	Surveyor I investigations
M. L. Troyer Dedication of Space Sciences Building University of Arizona Tucson, Arizona	Program of the Branch of Astrogeology
N. J. Trask Amateur Astronomers San Jose, California	Geology of the moon
N. J. Trask Technical Seminar Lockheed Sunnyvale, California	Geology of the moon; some first results from Lunar Orbiter
Robert D. Regan Sunnyslope High School Phoenix, Arizona	Lunar exploration and the Branch of Astrogeology
Robert D. Regan Flagstaff Jaycees Flagstaff, Arizona	Lunar exploration
Robert D. Regan Science Class of Thomas School Flagstaff, Arizona	Astronaut training

8. Visitors

<u>Visitors</u>	<u>Visited and purpose</u>
Dr. Homer E. Newell NASA Headquarters Washington, D. C.	Tour of Branch facilities conducted by E. M. Shoemaker and Branch personnel
Sandy Kramer, Geoffery Beauchamp, and Tom Perles Lockheed Sunnyvale, California	H. J. Moore and N. J. Trask-- discussed lunar orbiter pictures
F. Hörz Ames Research Center Moffett Field, California	E. C. T. Chao--discussed crater structures and impact metamorphosed rocks
J. A. O'Keefe Goddard Space Flight Center Greenbelt, Maryland	E. C. T. Chao--discussed Aouelloul glass
William Cannell Aeronautical Chart and Information Center Flagstaff, Arizona	J. F. McCauley and R. E. Eggleton --discussed the character of USGS needs for base maps for Lunar Orbiter geologic mapping
Russell Morash and Bill Lundgren WGBH-TV-FM Boston, Massachusetts	E. M. Shoemaker and R. E. Eggleton--discussed the content of a documentary movie on the scientific results of space probe photography to be made by WGBH for NASA
Bruno Sables Bellcomm, Inc. Washington, D. C.	J. W. M'Gonigle--discussed the Early Apollo program of the USGS
William R. Bosche Walt Disney Productions Burbank, California	Ivo Lucchitta and J. W. M'Gonigle --discussed the use of lunar geolo- gical equipment in a film feature
William LeCroix, Ernie Weeks and Harrison H. Schmitt Manned Spacecraft Center Houston, Texas	R. H. Godson--test of Brassboard Recording System for lunar staff experiment
John Zimmer Bendix Corporation Ann Arbor, Michigan	" " "

Robert L. Kovach and Bruce
McCallister
Stanford University
Stanford, California

R. H. Godson--test of Brassboard
Recording System for lunar staff
experiment

Leonard Orsak
Develco, Inc.
Palo Alta, California

" " "

Stanley Hall
Stanford University
Stanford, California

Robert D. Regan--discussed
installation and operation of a
receiving station at the Geophysical
Observatory for signals from the
Application Technology Satellite

Science Classes
South Mountain High School
Phoenix, Arizona

Tour of Branch facilities conducted
by Hal G. Stephens

General Information

Astrogeologic studies

In considering the small, circular craters, 30 meters in diameter and smaller, scattered over larger, softer, and more irregular craters on the high resolution photographs of Orbiter II, N. J. Trask has found that the areal distribution of these small craters fits a Poisson distribution in four samples so far considered. This result suggests that the craters are mostly primary impact craters with a random distribution.

An explanation of lunar slopes with convex bulges near the toe, photographed by the Orbiters, has been advanced by D. J. Milton. Such slopes are consistent with slides of coarse fragmental debris if sliding is initiated by seismic activity rather than by disturbances at the surface.

The preliminary photogeologic map of the Sabine DM region (Ranger series) by N. J. Trask has been completed.

R. E. Eggleton has found in Lunar Orbiter photographs an ordered series of crater shapes among apparently youthful craters 10 to 500 meters in diameter. All of these craters possess sharp, raised rims. The smallest craters have smooth, steep interior slopes (walls) and no floor. Some larger craters generally have smooth, steep walls and a single hillock at the bottom. Still larger craters have progressively broader flattened floors covered by hillocks. The largest craters in the series have an annular terrace in the wall.

The craters are excavated to various depths in near-surface materials whose properties can be inferred from impact cratering experiments. The small, smooth-walled craters excavate weakly cohesive, fine-grained materials. A cohesion discontinuity is demonstrated by the terraces in the largest craters. Craters of intermediate size with hillocks on the floor extend either slightly into the lower, more cohesive layer or into a zone of coarse fragments above it. The depth to the hillock- and terrace-producing material is similar in neighboring craters and generally ranges from $1\frac{1}{2}$ to 7 meters in Lunar Orbiter frame H-202 southwest of Kepler. Similar craters exist in most Lunar Orbiter II primary sites and the mare south of Copernicus photographed in mission I site A-7.

Howard Pohn reports the following information on use of the USGS 30" telescope during calendar 1966:

Nights of use	80
Hours of use	228
Peak month (June) nights of use	14
Peak month (June) hours of use	65

Visual observing nights	62
Visual observing hours	140
Photoelectric night	18
Photoelectric hours	80
Guest nights	17
Average seeing (scale of 10)	2.70

Mapping of formation contacts at Sierra Madera by T. W. Offield, D. Cummings, and H. G. Wilshire was continued. The Gilliam-Vidrio contact on the central hill reveals a marked bilateral symmetry to the structure, and a number of sharp folds that plunge steeply away from the center of the structure. Outcrops of Tessey and Cretaceous formations on the west and southwest sides of the central hill that were hitherto unrecognized were mapped. A segment of a concentric normal fault in the cretaceous rocks of the outer ring was found in the northeastern part of the structure; this may be continuous with a similar fault mapped by King at the southwest edge of the outer ring. To date, approximately 40% of the mapping has been completed.

Polarimetry

A complete record of the moon's photometric and polarimetric behavior at a resolution of 10 FEC-ARC has been obtained for every night of a lunation via image orthicon with video tape recordings. The analog to digital conversion problem has been studied. The problem is tractable although special techniques must be used to handle the high band width of the analog data. This will probably be done at another government facility on a semi-cooperative basis. The data can then be reduced and presented in catalog form. The mathematical formulation involved in the reductions have been derived. Measurements have been made preparatory to the construction of adaptive optical devices to permit the use of the Lyot polarimeter on the Lick 36" telescope. The adaptation will be modular with a Vasilevsky proper motion camera.

R. L. Wildey had turned out the theoretical derivation of the integral partial differential equations which correctly incorporate intergrain radiation in the theory of lunation heating of the lunar surface layer.

Mission planning

Completed and transmitted to Langley Research Center preliminary geologic evaluation of six Lunar Orbiter II prime sites. These site reports were compiled by geologists at Flagstaff and Tucson and edited by R. E. Eggleton and J. F. McCauley under the general supervision of T. N. V. Karlstrom. These reports will be assembled at Langley Research Center by personnel of the Branch as part of the Orbiter II screening and evaluation reports. Completion of these site reports and screening evaluation fulfills the Survey's operational responsibilities for the Lunar Orbiter II mission.

Photogrammetry

The photo lab moved to Fourth Street in Flagstaff and several models of lunar photography have been set up there. J. B. Alderman has made arrangements with the topographic division in McLean, Virginia, Denver, Colorado and OMI Corporation to set up an analytical plotter. A model comparing two frames of convergent 24" Lunar Orbiter II photography has been set up. A 1 micron reading comparator has been assembled and is ready to go.

Earth-Moon libration investigation

Eleven photographs were taken of the L₄ libration point of the earth-moon system by the crew of the Gemini XII mission. These pictures were taken in an effort to determine the possible existence of a dust cloud orbiting the earth. Because of mechanical failure of the camera, only two pictures were recovered in which star fields could be recognized. The crew had difficulties in stabilizing the spacecraft during the exposures, due to thruster problems, which caused the star fields to be badly smeared in the pictures. Microphotometer studies were made of the pictures but no conclusive results were obtained.

Surface planetary exploration

Surveyor

A complete catalog of all Surveyor I pictures has been prepared. Photographic and geometric parameters can be determined quickly and easily for any given picture. The catalog consists of a set of analytical mosaics of pictures taken on both lunar days, but does not include shadow pictures taken by overseas stations. These will be added when time permits. Each frame of the analytical mosaic is annotated with the Greenwich Mean Time at which the picture was taken, and the photographic and geometric parameters are listed by GMT on an accompanying table or catalog sheet.

The frame parameters listed in the catalog are as accurate and complete as was possible to make in the time available. Azimuths and elevations were derived from the sequence program and from the mosaics. The azimuths and elevations have been thoroughly checked. Focus and filter settings were derived from survey sequences planned during the mission, survey logs and computer generated ID printouts.

Improved mosaics of 18 Surveyor I sectors have been assembled from approximately 600 pictures. The quality of improved mosaics of pictures taken under high sun is poor because the low contrast pictures require more careful hand dodging than low sun pictures; therefore, the low sun mosaics are being made first.

LUNAR GEOLOGIC MAPS
 REPORT FOR MONTH OF January 1967

	PRELIMINARY MAPS						FINAL MAPS									
	ACIE Bases Received	Author's, Geological Work in Progress	Cartography - Scribing & Assembly in Progress	1st Composite Completed	1st Explanation Completed	Map in Technical Review (Branch)	2nd Composite Completed	2nd Explanation Completed	Geology Revision in Progress	Cartography - Final Map Prep	Map in Technical Review (Branch)	Submitted to APJ	Director's Approval Received	Map Materials Transmitted to BTL	Transmitted to BMR	Published
Equatorial Belt																
ARISTARCHUS LAC 39	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BYRGIUS LAC 92	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CLEOMEDES LAC 44	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
COLONBO LAC 79	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
COPERNICUS LAC 38	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FRACASTORIUS LAC 97	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
GRIMALDI LAC 74	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HEVELIUS LAC 56	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
JULIUS CAESAR LAC 60	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
KEPLER LAC 57	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LANGRENUS LAC 80	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LETRONNE LAC 75	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MACROBIUS LAC 43	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MARE HUMORUM LAC 93	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MARE SERENITATIS LAC 42	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MARE UNDARUM LAC 62	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MARE VAPORUM LAC 59	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MONTES APENNINUS LAC 41	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MONTES RIFARIUS LAC 76	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PETAIVIUS LAC 98	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PITATUS LAC 94	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PTOLEMAEUS LAC 77	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PURBACH LAC 95	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RUPES ALTAI LAC 96	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SELFCIUS LAC 38	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TARANTIUS LAC 61	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
THEOPHYLUS LAC 78	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TIMOCARIS LAC 40	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Northern Hemisphere (32°N - 64°N)																
ARISTOTELES LAC 13	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CASSINI LAC 25	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EUDORUS LAC 26	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
GEMINUS LAC 27	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J. HERSCHEL LAC 11	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PLATO LAC 12	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RUNKER LAC 23	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SINUS IRIDUM LAC 24	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Southern Hemisphere (32°S - 64°S)																
CLAVIUS LAC 126	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HOMER LAC 127	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MADROLYCUS LAC 113	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HEBETA LAC 114	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SCHICKARD LAC 110	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SCHILLER LAC 125	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TYCHO LAC 112	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WILHELM LAC 111	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
North Polar Cap																
ANAXIMANDER LAC 2																
BAILLAUD LAC 1																
BEYON LAC 4																
PHILOLAUS LAC 3																
South Polar Cap																
BAILLY LAC 136																
CABRUS LAC 124																
MANZINIUS LAC 138																
NEWTON LAC 137																
HELSHOLTZ																

LUNAR GEOLOGIC MAPS
Scale 1:500,000

REPORT FOR MONTH OF January 1967

PRELIMINARY MAPS

AIC NUMBER	Preliminary AIC Base Received	Published AIC Base Received	Author's Geological Work in Progress	Cartography - Scribing & Assembly in Progress	1st Composite Completed	1st Explanation Completed	Map in Technical Review (Branch)	2nd Composite Completed	2nd Explanation Completed
57C	XXXXXX		XXXXXXX						
57D	XXXXXX		XXXXXX						
58C	XXXXXX	XXXX	XXXXXX						
58D	XXXXXX	XXXX	XXXXXX	XXXXXX					
59C	XXXXXX	XXXX	XXXXXX						
59D	XXXXXX	XXXX	XXXXXX						
60C	XXXXXX	XXXX							
60D	XXXXXX	XXXX	XXXXXX						
61C									
61D	XXXXXX	XXXX	XXXXXX						
75A	XXXXXX		XXXXXX						
75B	XXXXXX		XXXXXX						
76A	XXXXXX		XXXXXX	XXXXXX	XXXXXX				
76B	XXXXXX	XXXX	XXXXXX						
77A	XXXXXX	XXXX							
77B	XXXXXX	XXXX	XXXXXX						
78A	XXXXXX	XXXX	XXXXXX						
78E	XXXXXX	XXXX							
79A	XXXXXX	XXXX	XXXXXX						
79B									

Methods for rectification of Surveyor 1 pictures of the near-field have been developed, and work has begun on a detailed near-field sketch map and rectified mosaic.

Geophysical research

The study of the scattering of seismic waves from cavities continued. A preliminary two dimensional model was investigated at the Earth Science Center at Massachusetts Institute of Technology and an apparent resonance phenomena was observed.

Use of a compressed air driven vibratory source of seismic energy to induce similar scattering from cavities was tested at the Pisgah lava tube, where the phenomena was first observed using dynamite. Very pronounced resonance was produced and additional small tubes were quickly located.

Reduction and analysis of gravity data from Meteor Crater, Zuni Salt Lake, Hopi Buttes, and Chimney Buttes was continued. Vertical magnetic data for Meteor Crater and Zuni Salt Lake was reduced on the Survey IBM 360 computer.

Mainline and subroutine computer programs for analyzing dispersion of gravity and acoustic waves in the atmosphere were written. These must yet be debugged and tested.

Testing of physical properties at In Situ analog sites continued with completion of a 131 ft. core boring at Cinder Hills.

Advanced Systems

Modification of the miniaturized Alpha K Alpha Spectrometer have been completed including the receipt of a Curium ²⁴² source. Modifications to the miniaturized diffractometer and independent current stabilization equipment have been completed and both the spectrometer and diffractometer were used in Advanced Systems Test 2.

Mineralogical programs continue to be compiled by our 1978 computer system. A least squares data reduction program for reduction of Alpha K Alpha spectrometer data is now operational. A program for converting two theta values to D values for use with three principal radiations is now ready for use and a subroutine, which converts weight percent to atomic percent from an analysis, is completed for inclusion in a general petrologic program later this spring.

A general correlation program for the correlation of data in the Astrogeologic Data Facility is available now from Systems Development Corporation in Long Beach, California. This program requires a logical and outlined data structure and will require little modification for revising the data base during the ADF operation. The program is currently written in the JOVIAL language

and is now being translated by SDC personnel into Fortran IV. The only additional equipment required in Flagstaff is a teletype terminal in the ADF and the only other expense will be the telephone communication line between Flagstaff and Long Beach during the test.