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

January 31, 1969

Memorandum

To : Assistant Chief Geologist for Engineering Geology

From : Deputy Assistant Chief Geologist for Astrogeology

Subject: January Report for Director and Secretary

HIGHLIGHTS AND NOTEWORTHY RESULTS

Astrogeologic Studies Branch

Lunar and Planetary Geologic Mapping

Regional Lunar Geologic Mapping.--M. J. Grolier reports that he spent the period December 10 through January 12 in Menlo Park, California, working on a map of the Geminus quadrangle of the Moon. He expects the map to be finished by February 15.

Geologic Support for Planetary Missions.--J. D. Alderman reports that he, G. R. Taylor of Langley Research Center, Hampton, Virginia, and Philco-Ford Corporation personnel, Newport Beach, California, participated in a demonstration of the refurbished Houston "Fax Camera" as required by the Langley Research Center facsimile camera evaluation program.

The camera operation appeared to be flawless; however, the facsimile ground reproducer left much to be desired. The quality of data resulting from the reproducer was so poor that no tests could be conducted by the U.S. Geological Survey. Philco-Ford Corporation is in the process of refurbishing the reproducer to improve quality and will furnish preliminary imagery for analysis and evaluation.

Lunar Engineering Geology

Lunar Terrain Analysis.--R. J. Pike reports that 18 new lunar areas have been selected for photoclinometric analysis and presently are being processed. These samples are to be used to ascertain the suitability of imagery from Lunar Orbiter Missions IV and V as sources of quantitative topographic data. Rough- and steep-upland and fresh-crater terrains have been included.

Lunar Trafficability.--W. J. Rozema has completed power spectral density analyses for 18 lunar topographic samples previously obtained through the Langley II program and for 10 terrestrial and model terrain samples. The lunar data are representative primarily of the maria. Upland areas have not yet been sampled well enough to yield reliable surface roughness values.

Explosion Craters.--D. J. Roddy reports that shatter cones have been formed in several craters produced in Defense Atomic Support Agency experiments near Cedar City, Utah. One of the craters, about 2.5 m across and 0.5 m deep, was formed in quartz diorite by a 1,000 lb sphere of TNT detonated on the ground surface. A well-developed, complete shatter cone, about 30 cm across at the base and 20 cm high, was formed on the floor of the crater. Bearing and dip measurements plotted for this cone and several other cone segments found on the crater floor give cone axes that project through the center of the TNT charge. This cratering experiment clearly establishes that, a) shatter cones can be produced by shock waves and their interactions with free surfaces, b) apices of shatter cones point in the direction of the originating energy source, c) shatter cone axes are essentially normal to the shock wave front and pass through the center or near center of the originating energy source. These data allow more confident use of shatter cones as criteria for shock-wave propagation and its direction at the "cryptoexplosion" sites. A second crater, about 14 m in diameter and 3 m deep, was formed by a 100 ton TNT sphere buried 0.25 m (center 2.2 above ground); several of the larger ejecta blocks (1 m across) from this crater exhibited well-developed shatter cone surfaces with cone segments up to 0.5 m in length. No shatter cones were found in place at this crater.

Further field measurements are in progress to establish the complete spatial information for all the shatter cone surfaces at these experiments.

Impact Investigations

Gosses Bluff.--The computer-derived orientations of the axes of shatter cones at Gosses Bluff are being studied by D. J. Milton. The angle between bedding and the upward-pointing cone axes decreases from over 80° near the center to 5° at a distance of 4½ km from the center. If beds are restored to horizontal at elevations appropriate to the stratigraphic position (but ignoring the inward translation during central uplift indicated structurally), axes point to a focal zone above the center of the bluff within which foci of cones from successive strata lie above one another through an interval of about 1,700 m. and the top of the interval would be near the estimated pre-impact ground surface. The vertical spread may reflect greater inward translation of the rocks from the deeper strata now exposed nearer the center. Alternatively, the shock front (assumed normal to the cone axes) may not have propagated as an expanding hemisphere.

Some of the dispersion of the cone axes within single units is clearly related to rotation of beds about more than one axis during deformation. However, differences of cone orientation between nearby localities indicate that, at least locally, the hypothesis that cones form normal to a smoothly advancing shock front cannot be strictly maintained.

Sierra Madera.--K. A. Howard and Ming Ko (Computer Center Division) have recalculated shatter-cone orientations by computer. Using the simplest rotation for restoring beds to pre-uplift positions (Howard, K. A., Offield, T. W., 1968, Science, v. 162, p. 261), the least-squares focus of shatter cones is directly over the center of the structure and within 100 ft of the boundary between Permian and Cretaceous rocks. Using a more complicated rotation (Manton, W. I., 1965, N. Y. Acad. Sci. Ann., v. 123, p. 1017), the focus is less well centered and has a higher standard deviation.

H. G. Wilshire, K. A. Howard, and T. W. Offield report that the Sierra Madera final manuscript is now about 25 percent completed, including both text and illustrations.

Photogrammetry-Photoclinometry

S. S. C. Wu reports that one model of Hasselblad photography obtained from the Lunar Receiving Laboratory in Houston, Texas, has been successfully tested on the analytical plotter. A form-line map with a contour interval of 5 cm has been compiled. This photography is intended to simulate the actual photography which will be taken on the early lunar landing missions. No ground controls can be used. A gnomon device placed in the field of view and appearing on each photo is designed to serve as the control for absolute orientation.

During the processing of absolute orientation, an initial estimated length of the shadow of the gnomon is computed from the sun angle and the length of the gnomon to solve the horizontal scaling and rotation; approximate elevations according to the ground features are estimated for three arbitrarily selected points in the model to solve the vertical leveling. After the first iteration of absolute orientation is computed, ground XYZ coordinates of both the top and the bottom of the gnomon are measured. Since the gnomon is vertical to the datum, the X and Y coordinates of the top and bottom of the gnomon should have the same value in the datum plane if the model is correctly leveled. Also, the difference of Z coordinate values of the top and the bottom of the gnomon should equal the calibrated length of the gnomon itself, if the model is exactly scaled. The second or succeeding iterations of absolute orientation are processed with corrected approximations derived from X, Y, and Z errors of the first iteration.

In the near future, a program for the IBM 360/30 computer will be written to compute analytically the data necessary for controls of absolute orientation. Alternatively, the analytical plotter program of absolute orientation may be rewritten to solve the iterative computations automatically.

Upon request of D. J. Milton, six models on conventional aerial photographs of Gosses Bluff, Australia, have been completed to extend control. The conventional aerial photographs are very easily set up on the analytical plotter, and high accuracy was obtained for the six models.

Spot scales over the entire format for 30 high-resolution, high-tilt photographs from Lunar Orbiter Mission III have been computed by F. J. Schafer for H. J. Moore. An overlay for each photograph has been made to serve as an index of scale variation over the entire photograph.

The digitization of the Mann Comparator has been completed. This equipment now has the capability to type out on a typewriter and simultaneously punch out on IBM cards measures in any format by rewiring the patch panel. The comparator has been used quite extensively in support of the photoclinometry and various photogrammetric projects. It is anticipated that abundant data will be accumulated in the calibration procedures to be derived for the facsimile system.

Points for R. L. Wildey's librated selenographic grid at a scale of 1:2,500,000 have been plotted on the XYZ plotter. Plots of isodensitracer data and other small jobs also have been done on the plotter.

Lunar and Planetary Physics

D. W. G. Arthur reports that since the International Astronomical Union no longer publishes abstracts of papers in its draft reports, a communication problem has arisen, especially in the field of selenodetic research. The president of I. A. U. Commission 17 has therefore requested Dr. Theo Weimer, Paris Observatory, to organize a working group to facilitate the interchange of information on the figure, rotation and orbital motion of the Moon. D. W. G. Arthur has been appointed to this group.

D. W. G. Arthur has been appointed to the Mariner Mars '69 Cartographic Working Group.

Surface Planetary Exploration Branch

Apollo Investigations

Mission Planning.--T. N. V. Karlstrom reports that final decisions were made by the Early Apollo Map Committee on the design of the maps to be flown in the Data Package of the first landing mission. Survey recommendations on geologic map design were accepted by the committee and will be followed in producing the Data Package maps for the first lunar landing mission.

Compilations of operational geologic maps for Early Apollo landing areas II-P-2 (by D. E. Stuart-Alexander, M. H. Hait, Jr., and G. A. Swann) and II-P-6 (by J. W. M'Gonigle and M. N. West) have been completed and transmitted to the Science Mapping Branch, Manned Spacecraft Center, Houston, Texas. Compilation of site III-P-13 has been completed by Jerry Harbour and R. L. Sutton and compilations are well along for site II-P-8 by G. G. Schaber and N. J. Trask and for site III-P-11 by P. J. Cannon and T. N. V. Karlstrom. It is anticipated that the U.S. Geological Survey will meet its schedule of providing NASA with operational geologic maps of the five landing sites considered for the first landing mission before the end of this month.

Apollo Geologic Methods.--The northwest quarter of the new crater field (Cinder Lake Number 2) has been "salted" with several hundred rock fragments of varied lithology by N. G. Bailey, Ivo Lucchitta, and J. W. M'Gonigle, assisted by E. E. Caddell and B. C. Justus. The fragments range from less than one inch to more than one foot in size, and were distributed (on the basis of a geologic model by Ivo Lucchitta) to reflect geologic events acting on a specific geologic terrane. The area will be used for simulations of Apollo-type traverses.

Walter Roeder reports that the Film Documentation Unit completed the color-sound motion picture, "When the Astronaut Speaks." The projection time for this film is 23½ minutes. This production demonstrates a proposed system for acquiring and manipulating geologic data during Apollo missions through the use of a scientific data facility. It also shows how exploration time can be condensed by swift data handling and feedback to the astronauts, thus assuring the return of the greatest amount of significant data on the most relevant geologic problems.

Post-Apollo Investigations

Data Analysis.--A data set illustrating information from a late Apollo traverse is being constructed in the Data Analysis Project. This data set will include a variety of infomation types: gravity, magnetics, oral descriptions, topography, geologic contacts, geologic cross section information, and stratigraphic columns constructed from sections revealed in trenches dug by hand. Each bit of information is coded with a traverse time number so it can be recalled through the computer at approximately the correct traverse time. This data set will be stored on disk in

Flagstaff, Arizona, and will be used in traverse simulations involving a Milgo plotter and other Astrogeologic Data Facility activities.

R. A. Mills reports that the Field Test Systems Shop has completed construction of the automatic tracking magnetometer mast on the Explorer vehicle. Heading lock-on is achieved by an arrangement of photo cells and shutters attached to an air-driven directional gyrocompass. Servo power for rotating the mast is provided by a reversible electric motor coaxially mounted on the base of the mast. Periodic updating of the gyrocompass heading will be required to maintain alinement of the magnetometer sensing head, a normal requirement for directional gyros.

Field testing and shake-down of the unit is scheduled for the last week of January at the Cinder Lake test site northeast of Flagstaff, Arizona.

INFORMAL PUBLICATIONS

Pike, R. J., 1969, Meteoritic origin and consequent endogenic modification of large lunar craters: A study in analytical geomorphology: U.S. Geol. Survey open-file report, 404 p.

Rozema, W. J., 1968, The use of spectral analysis in describing lunar surface roughness: U.S. Geol. Survey open-file report, 34 p. [1969]

Simkin, Tom, and Howard K. A., 1968, The 1968 collapse of Fernandina caldera, Galapagos Islands: Smithsonian Inst. Center for Short-Lived Phenomena, 24 p.

GEOLOGICAL SURVEY PUBLICATIONS

Howard, K. A., and Masursky, Harold, 1968, Geologic map of the Ptolemaeus quandrangle of the Moon: U.S. Geol. Survey Misc. Geol. Inv. Map I-566

OUTSIDE PUBLICATIONS

Cannon, P. J., 1968, Pleistocene stream piracy in southwestern Oklahoma: Oklahoma Geol. Notes, v. 28, no. 6, p. 183-187

McCauley, J. F., 1968, Moon probes: Silver Burdett Co., Morristown, New Jersey, 64 p.

Masursky, Harold, 1969, Lunar exploration targets: Astronautics and Aeronautics, v. 7, no. 1, p. 42-49

PERSONNEL CHANGES

Surface Planetary Exploration Branch

Edward E. Caddell, Engineering Aid, resigned, Flagstaff, Arizona
Michael G. McEntarfer, Engineering Aid, resigned, Flagstaff, Arizona

CONFERENCES AND SCIENTIFIC MEETINGS ATTENDED AT HOME OR ABROAD

D. H. Dahlem, H. J. Moore, and G. E. Ulrich participated in the evaluation of contractor's proposals for a design definition study of dual mode (manned/automated) Lunar Roving Vehicles. These proposals were submitted to George C. Marshall Space Flight Center, Huntsville, Alabama, in response to the statement of work prepared by the Lunar Roving Vehicles Working Group.

T. N. V. Karlstrom attended an Early Apollo Map Committee meeting at Manned Spacecraft Center, Houston, Texas.

D. L. Schleicher was at the Manned Spacecraft Center, Houston, Texas, during a part of the Apollo 8 mission to observe current data handling techniques and the interaction between the scientific support group and the Mission Operations Control group.

J. B. Fife attended IBM courses titled DOS (Disc Operating System) and TOS (Tape Operating System) System Control for Programmers, S/360 ALC Part II, Los Angeles, California.

J. F. McCauley attended the Group Leaders Meeting of Mariner Mars '71 TV Experiment Team at the Jet Propulsion Laboratory, Pasadena, California.

Harold Masursky and D. E. Wilhelms attended the Astronaut debriefing meeting on Apollo 8 in Houston on January 3 and 4 as members of the Lunar Science Working Group.

Harold Masursky and J. F. McCauley attended a meeting of the TV team for Mariner Mars '71 at Jet Propulsion Laboratory, Pasadena, California.

Harold Masursky attended an organization meeting on Planetary Explorers--a proposed series of small spacecraft flights to Venus and Mars, at Goddard Space Flight Center, Greenbelt, Maryland.

R. L. Wildey and Harold Masursky attended a review of imaging proposals for the Pioneer F/G flight to Jupiter at NASA Headquarters, Washington, D. C.

R. L. Wildey, D. W. G. Arthur and Harold Masursky met in Flagstaff with C. A. Lundquist and Michael Pearleman of the Smithsonian Astrophysical Observatory, Cambridge, Massachusetts to discuss cooperative work on laser ranging to the Moon. The Smithsonian Observatory will proceed with the design and construction of a neodymium laser. Mr. Wildey and Mr. Arthur will work on target selection and data analysis when the system becomes operational.

D. E. Wilhelms, N. J. Trask, Harold Masursky, E. C. Morris and G. A. Swann attended a session of the Lunar Science Working Groups on the Apollo 8 flight, Manned Spacecraft Center, Houston, Texas.

CONFERENCES AND SCIENTIFIC MEETINGS ATTENDED AT HOME OR ABROAD (cont.)

Harold Masursky attended the Mission Design Review for Mariner Mars '71 at Jet Propulsion Laboratory, Pasadena, California.

M. H. Hait, Jr., and G. A. Swann attended a demonstration of the activities to be carried out on the Apollo 11 mission at Manned Spacecraft Center, Houston, Texas.

M. H. Hait, Jr., attended the Lunar Surface Operations Planning Meeting at Manned Spacecraft Center, Houston, Texas.

TALKS OR PAPERS PRESENTED AT MEETINGS

Speaker and Organization	Subject
N. J. Trask Seminar, National Center for Earthquake Research U.S. Geological Survey Menlo Park, California	Photogeologic mapping of Early Apollo landing sites
J. F. McCauley Seminar, National Center for Earthquake Research U.S. Geological Survey Menlo Park, California	The Marius Hills region of the Moon
Harold Masursky Boeing Management Association Huntsville, Alabama	Lunar geology

VISITORS

Visitor	Visited and Purpose
Clarence J. Cassella Geology Department Northern Illinois University DeKalb, Illinois	Lunar geologists of the Menlo Park Office--to discuss lunar geologic mapping and undertake a mapping project
William G. Van Dorn Ocean Research Division Scripps Institute of Oceanography La Jolla, California	R. E. Eggleton--to discuss nature and evolution of lunar multi-ring basin structures, nature and evolution of lunar mascons, lunar shell structure
Romeo Caroletti OMI Corporation of America Alexandria, Virginia	S. S. C. Wu--to discuss and perform special maintenance on the AP/C plotter
R. E. Hutton Thompson-Ramo-Woolridge, Inc. Redondo Beach, California	R. J. Pike and G. E. Ulrich--to discuss a preliminary draft of monograph on the Lunar Surface Model.

Alfred H. Chidester

Alfred H. Chidester

REPORT FOR MONTH OF January, 1969

Branch of Astrogeologic Studies

			PRELIMINARY MAPS						FINAL MAPS							
	ACIC Bases Received	Author's Geological Work in Progress % Compl	Cartography - Scribing & Assembly in Progress	1st Composite Completed	1st Explanation Compl.	Map in Technical Review (Branch)	2nd Composite Completed	2nd Explanation Compl.	Geology Revision in Prog. % Completed	Cartography - Final Map Preparation	Map in Technical Review (Branch)	Authors' Revision in Progress, % Completed	Submitted to NPO	Director's Approval Received	Transmitted to BMR	Published
Equatorial Belt																
ARISTARCHUS LAC 39	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
BYRGIUS LAC 92	x	100	x	x	x	x	x	x	30							
CLEOMEDES LAC 44	x	100	x	x	x	x	x	x	100	x	x	40				
COLOMBO LAC 79	x	100	x	x	x	x	x	x	100	x	x	75				
COPERNICUS LAC 58	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
FRACASTORIUS LAC 97	x	100	x	x	x	x	x	x	25							
GRIMALDI LAC 74	x	100	x	x	x	x	x	x	55							
HEVELIUS LAC 56	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
JULIUS CAESAR LAC 60	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
KEPLER LAC 57	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
LANGRENUS LAC 80	x	100	x	x	x	x	x	x	50							
LETRONNE LAC 75	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
MACROBIUS LAC 43	x	100	x	x	x	x	x	x	100	x	x	80				
MARE HUMORUM LAC 93	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
MARE SERENITATIS LAC 42	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
MARE UNDARUM LAC 62	x	100	x	x	x	x	x	x	85							
MARE VAPORUM LAC 59	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
MONTES APENNINUS LAC 41	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
MONTES RIPHAEUS LAC 76	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
PETAVIUS LAC 98	x	100	x	x	x	x	x	x	70							
PITATUS LAC 94	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
PTOLEMAEUS LAC 77	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
PURBACH LAC 95	x	100	x	x	x	x	x	x	50							
RUPES ALTAI LAC 96	x	100	x	x	x	x	x	x	100							
SELEUCUS LAC 38	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
TARUNTIUS LAC 61	x	100	x	x	x	x	x	x	90							
THEOPHILUS LAC 78	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
TIMOCHARIS LAC 40	x	100	x	x	x	x	x	x	100	x	x	100	x	x	x	x
Northern Hemisphere (32°N - 64°N)																
ARISTOTELES LAC 13	x	30														
CASSINI LAC 25	x	100	x	x	x	x	x	x	100	x	x	90				
EUDOXUS LAC 26	x	100	x	x	x	x	x	x	60							
GEMINUS LAC 27	x	55														
J. HERSCHEL LAC 11	x	100	x	x	x	x	x	x	100	x	x	100	x			
PLATO LAC 12	x	100	x	x	x	x	x	x	70							
RUMKER LAC 23	x	100	x	x	x	x	x	x	50							
SINUS IRIDUM LAC 24	x	100	x	x	x	x	x	x	100	x	x	100	x			
Southern Hemisphere (32°S - 64°S)																
CLAVIUS LAC 126	x	100	x	x	x	x	x	x	50							
HOMMEL LAC 127	x	100	x	x	x	x										
MAUROLYCUS LAC 113	x	100	x	x	x	x	x	x	70							
RHEITA LAC 114	x	100	x	x	x	x	x	x	10							
SCHICKARD LAC 110	x	80														
SCHILLER LAC 125	x	100	x	x	x	x										
TYCHO LAC 112	x	100				x										
WILHELM LAC 111	x	100				x										

Ranger Geologic Mapping

Report for January

Map	Author's geologic work in progress % complete	Preliminary map to JPL	Author's revisions in progress % complete	Map in technical and editorial review	Director's approval	Transmitted to BMR	Published
RLC 3	100	x	5				
RLC 4	100	x	5				
RLC 9	100	x	100	x	x		
RLC 11	100		100	x			
RLC 14	100	x	100	x	x		
RLC 15	100	x	100	x	x		

Early Apollo site mapping

Report for Month of January

Map number	Base materials received	Preliminary map completed	Author's revisions in progress	In technical and editorial review	In drafting	Revised map transmitted to MSC (ozalid form)	Processed by TRU	Director's approval	Publication
1:100,000									
II P-2	x	x	x	x	x	x			
II P-6	x	x	x	x	x	x			
II P-8	x	x	x	x	x				
II P-13	x	x	x	x	x				
III P-11	x	x	x	x	90				
III P-12	x	x	x	x	50				
1:25,000									
II P-2	x	x	x	x	x	x			
II P-6	x	x	x	x	90				
II P-8	x	x	x	x	x	x			
II P-13	x	x	x	x	x	x			
III P-11	x	x	x	x	90				
III P-11 (reloc.)	30								
III P-12 (reloc.)									
1:5,000									
II P-2	x	x	x	x					
II P-6	x	x	x	x					
II P-8	x	x	x						
II P-8 (reloc)									
II P-13	x	x	x						
III P-11	x	x	x						
III P-11 (reloc.)									
III P-12									

Late Apollo Site Mapping

Report for Month of January

Map number	Base materials received	Author's work in progress	Processed by TRUF	In technical and ed. review	In drafting	Preliminary map completed	Author's revisions in progress	In technical and editorial review	Director's approval	Published
1:200,000										
V-51 Marius Hills		100	x	x	x	x	x			
1:250,000										
V-12 Censorinus										
V-14 Littrow										
V-30 Tycho		50								
III S-23 Fra Mauro		30								
1:25,000										
V-12 Censorinus		5								
V-14 Littrow		5								
V-30 Tycho		50								
III S-23 Fra Mauro										
V-51 Marius Hills		100	x	x	x	x	x			