IN REPLY REFER TO:

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

June 30, 1967

Memorandum

To : Assistant Chief Geologist for Engineering Geology

From : Acting Chief, Branch of Astrogeology

Subject: Monthly report for Director and Secretary

1. Highlights and noteworthy results

Astrogeologic studies

E. M. Shoemaker and E. C. Morris examined in detail two prominent strewn fields of rocky debris around two craters, 13 m across and 15 m across, at the Surveyor III landing site. One of these craters has a sharp raised rim, the other a more subdued, rounded rim. The rocks associated with the subdued crater have twice the mean roundness value of the rocks associated with the sharp, raised rim crater, and the blocks around the subdued crater are significantly more deeply buried below the lunar surface than those around the crater with the sharp raised rim. The size-frequency distribution function for the fragments in each of the strewn fields of blocks resembles the size-frequency distribution for fragments ejected from impact craters formed in strong rocks, such as Meteor Crater, Arizona.

Observations and measurements by E. M. Shoemaker and H. E. Holt reveal that disturbances of the lunar surface produced by Surveyor III, like those produced by Surveyor I, expose darker material at a depth of a few centimeters or less. The fine-grained fragmental debris at a depth of only a fraction of a millimeter probably is 20 to 30 percent lower in albedo than material on the optically observed surface. All coarse fragments protruding above the general level of the surface have a higher albedo than the fine-grained matrix of the surface.

R. M. Batson and K. B. Larson have determined by resection the exact location of the Surveyor III television camera within a previously located crater on Lunar Orbiter III frame H 154. This determination is believed to be accurate within 0.5 meters and is being used to prepare a topographic map of the site by methods analogous to field surveying.

4. Outside publications reported during month:

Brett, Robin, and Henderson, E. P., 1967, The occurrence and origin of lamellar troilite in iron meteorites: Geochim. et Cosmochim. Acta, v. 31, p. 721-730.

Brett, Robin, and Henderson, E. P., 1967, the occurrence and origin of lamellar troilite in iron meteorites (abs.): Meteoritics, v. 3, p. 102-103.

Milton, D. J., 1967, Slopes on the Moon: Science, v. 156, p. 1135.

Other reports

Moore, H. J., 1967, The use of ejected blocks and secondary impact craters as penetrometers on the lunar surface, in Preliminary Geologic Evaluations on Apollo Landing Analysis of Areas Photographed by Lunar Orbiter III: Langley Working Paper 407, Appendix A, p. 108-121, 4 figs.

Roberts, F. G., 1967, Comparison of ejecta from a lunar crater and a terrestrial crater, in Preliminary Geologic Evaluations on Apollo Landing Analysis of Areas Photographed by Lunar Orbiter III: Langley Working Paper 407, Appendix B, p. 122-124, 4 figs.

5. Personnel

The following employees entered on duty

Flagstaff, Arizona

Martin T. Corner, Physical Science Technician
Delbert F. Flagg, Jr., Geologic Field Assistant
Edward S. Gaffney, Geologic Field Assistant
Robert A. Henry, Student Aid
Joanne N. Higley, Clerk-Typist
James E. Jackson, Student Aid
Keith E. Johnson, Geologic Field Assistant
Paulette Juniel, Student Aid
Dorothy L. Kubach, Clerk-Stenographer
Norbert L. Langbecker, Student Aid
Mary Jo McCain, Student Aid
Connally E. Mears, Geologic Field Assistant
Charles A. Rourke, Student Aid

Rhode Island

Ronald S. Saunders, Geologist

Bozeman, Montana

William A. Vischer

Transfers

Jeannie Baugh, Clerk-Typist, transferred from Navajo Army Depot, Flagstaff, to the Technical Reports Unit, Flagstaff, Arizona.
Gloria B. Shirley, Clerk-Stenographer, transferred from McGuire Air Force Base, New Jersey, to Flagstaff, Arizona.

Resignations

Wayne E. Harry, Cartographic Aid, Menlo Park, California
Janet M. Herskovitz, Physical Science Aid, Flagstaff, Arizona
Frances G. Robertson, Physical Science Aid, Menlo Park, California

6. Scientific meetings or conferences attended at home or abroad

The Branch of Astrogeology met with officials of the National Aeronautics and Space Administration for a presentation of results of fiscal year 1967 programs and a final program review of fiscal year 1968 operations. The following people attended the meeting: Leonard Reiffel, Verl R. Wilmarth, Robert P. Bryson, Edward M. Davin, Donald A. Beattie, Richard J. Allenby, Arthur T. Strickland, Willis B. Foster and Alexander J. Schwarzkopf of NASA Headquarters, Washington, D. C.; Ausley B. Carraway, Curtis C. Mason, Ray Clemence, and Robert O. Piland from Manned Spacecraft Center, Houston, Texas; Charles Slager from the Department of Defense, Washington, D. C.; Bruno Sabels and Fred Schmitt from Bellcomm, Inc., Washington, D. C.

E. M. Shoemaker participated as a member of the Board of Directors at the meeting of the Rocky Mountain Educational Laboratory in Jackson, Wyoming.

E. M. Shoemaker participated in the meeting of the Planetary Missions Board, National Aeronautics and Space Administration, in Washington, D. C.

E. M. Shoemaker participated in the Surveyor Scientific Evaluation Advisory Team meeting at the Jet Propulsion Laboratory in Pasadena, California.

E. M. Shoemaker received an honorary Doctor of Science degree from Temple University, Philadelphia, Pennsylvania.

R. L. Wildey attended the 124th meeting of the American Astronomical Society at Yerkes Observatory, Williams Bay, Wisconsin.

R. M. Batson, S. S. C. Wu, M. J. Grolier, W. T. Borgeson, and L. C. Rowan attended a meeting at Manned Spacecraft Center, Houston, Texas concerning the photoclinometric and photogrammetric reduction of Lunar Orbiter data.

J. J. Wooldridge attended a seminar workshop in recent advances in microdensitometry at the University of Chicago, Illinois.

J. J. Wooldridge attended a seminar in densitometry of the Rochester Institute of Technology which was held in Chicago, Illinois.

D. J. Roddy visited the Air Force Institute of Technology at Wright-Patterson Air Force Base, Ohio to complete a review of masters theses and serve on thesis defense committees for AFIT students in space science option.

Harold Masursky and D. E. Wilhelms participated in a meeting at Langley Research Center, Hampton, Virginia to select final sites to be photographed by Lunar Orbiter Mission V. Masursky then attended a meeting of the Surveyor-Orbiter Utilization Committee in Washington, D. C. where final approval was given to the site selections.

G. A. Swann and M. H. Hait visited Grumman Engineering, Bethpage, Long Island, New York, for a demonstration of a small television camera mounted on a pressure suit helmet, and participated in discussions of ALSEP deployment and lunar vehicle simulators.

G. A. Swann, M. H. Hait and G. E. Ulrich visited Manned Spacecraft Center, Houston, Texas, for metabolic work in the 1/6 g simulator, and to experiment with mock-ups of an instrumented staff.

D. L. Schleicher and Ivo Lucchitta attended a field trip led by Wolfgang Elston at the Mogollon Plateau circular structure, southwest New Mexico.

7. Talks or papers presented at meetings

Speaker and organization	Subject
R. L. Wildey American Astronomical Society Williams Bay, Wisconsin	Physical categories of the moon's nocturnal hotspots
Elliot C. Morris Optimist Club Flagstaff, Arizona	The moon through the eyes of Surveyor III
D. J. Roddy Rotary Club Gainesboro, Tennessee	The Flynn Creek Crater --recent progress
D. J. Roddy Rotary Club Gainesboro, Tennessee	Geologic philosophy in mineral and petroleum exploration
R. D. Regan Mathematics Class Flagstaff High School Flagstaff, Arizona	The importance of mathematics
R. D. Regan St. Joseph Boys' Camp Morman Lake, Arizona	Apollo space program
R. D. Regan Air Force Officers from Wright Patterson Air Force Base Flagstaff, Arizona	Geophysics on the moon
H. L. Krivoy Museum of Northern Arizona Seminar Flagstaff, Arizona	"Hawaiian volcanoes: astronaut field trip" film
R. E. Sabala Engineering Drafting School Denver, Colorado	The operation of the Branch of Astrogeology and function of the Technical Illustrations Unit.

8. Visitors

Visitors	Visited and purpose
C. W. Kohlenberger Autonetics Anaheim, California	D. E. Wilhelms--discussed lunar transient phenomena
Dr. W. S. Partridge Director of Research University of Utah Salt Lake City, Utah	Elliot C. Morris--discussed Branch research activities
Dr. Wilmott Hess Manned Spacecraft Center Houston, Texas	P. R. Brett--discussed the establishment of a geochemical research group in Houston
Professor Brian J. Skinner Yale University New Haven, Connecticut	P. R. Brett--discussed current work
Ken Williams Australian National University Canberra, Australia	P. R. Brett--discussed problems of ore deposition
Dr. J. F. Lovering Australian National University Canberra, Australia	P. R. Brett--discussed meteorite petrology
T. Meloy and C. Boone Melpar Corp. Falls Church, Virginia	M. B. Duke--discussed zonal centrifugation in density gradients as a possible mineral separation tool
R. J. Anstead Goddard Space Flight Center Greenbelt, Maryland	M. B. Duke--discussed scanning electron microscopy
A. J. Tousimis Biodynamics Research Corp. Rockville, Maryland	M. B. Duke--discussed electron microprobes and scanning electron microscopy
W. J. Reed National Bureau of Standards Washington, D. C.	M. B. Duke--discussed prefabricated clean laboratory
H. Rechen, W. P. Kirk, and F. Rueter U. S. Public Health Service Rockville, Maryland	M. B. Duke--discussed the possibility of using Public Health Service air filter network to look for debris following meteorite falls

V. Macrees and R. Norville Materials Analysis Corp. Palo Alto, California	M. H. Carr, L. C. Calk, and N. J. Page--discussed microprobe analysis of small particles
Kendrick Frazier, Managing Editor News Report National Academy of Sciences Alexandria, Virginia	Tour of facilities by H. G. Stephens
Dr. Venetta Kell Northern Arizona University and High School Teachers of Arizona, New Mexico and Texas	Tour of facilities by Russell Wahmann and A. E. Dale
Air Force Officers Wright Patterson Air Force Base Ohio	Tour of facilities by H. G. Stephens, A. E. Dale and Russell Wahmann
Members of Church of God Phoenix, Arizona	Tour of facilities by J. R. McCord, A. E. Dale, Russell Wahmann, R. M. Batson and R. A. Mills
Astronomy Club Albuquerque High School Albuquerque, New Mexico	Tour of facilities by H. G. Stephens, Russell Wahmann and A. E. Dale
High School Mathematics Students Meeting at Northern Arizona Unv. Flagstaff, Arizona	Tour of facilities by H. G. Stephens, Russell Wahmann and A. E. Dale
Geology Class University of Houston Houston, Texas	Tour of facilities by A. E. Dale
Airstream Trailer Club members Phoenix, Arizona	Tour of facilities by H. G. Stephens and Russell Wahmann
Foreign Exchange High School Students	Tour of facilities by H. G. Stephens, C. J. Rolle and Russell Wahmann

General Information

Astrogeologic studies

A study has begun of the Gosses Bluff structure, Northern territory, Australia, in cooperation with the Australian Bureau of Mineral Resources. Gosses Bluff is expected to be one of the most informative of the crypto-explosion type impact (?) structures. It is similar to Sierra Madera, Texas in size and structural expression, but it is in a predominantly clastic rather than a carbonate sequence. Breccia containing apparently shock-metamorphosed fragments crop out extensively around the central uplift. D. J. Milton has gone to Australia to begin field mapping and will be joined next month by P. R. Brett.

Field work was resumed by D. E. Stuart-Alexander on the Mule Ear diatreme in Utah. Detail examination of the stratigraphic section represented by rock fragments contained in the diatreme is currently in progress.

Field work was started on the Lunar Crater, Nevada, basalt cinder cones and maar craters. Samples of ultramafic inclusions in some flows and cinder cones were collected by N. J. Trask and base materials for mapping are on order. Trask is responsible for mapping flows and cinder cones that contain ultramafic rocks, and for the general petrography of the volcanic rocks. D. H. Scott is responsible for mapping the main part of the basalt volcanic field, and for geophysical study of the subsurface.

By close examination, more than 100 craters and large blocks can be recognized on both Surveyor III and Lunar Orbiter III pictures. Because the number of these features is so large, it is possible to use the information obtained by the two different sets of pictures to produce a topographic map of the landing site by measuring horizontal distances on the Orbiter photographs and vertical angles on the Surveyor pictures.

A preliminary version of a map prepared by this method was compared with one made by H. E. Holt and S. G. Priebe by photoclinometric measurement of frame H154. The slopes as estimated by the photoclinometric technique are slightly too steep and the depth of the main crater, obtained by this method, is therefore too deep. Adjustment of the slopes derived by the photoclinometric technique to fit the slopes measured with the aid of the Surveyor III pictures will provide an improved solution for the functional relationship between densities measured from the Lunar Orbiter III negative and the lunar surface luminance. The map prepared by photoclinometry, however, provides a much better definition of the surface and shape of the rim crest of the main crater than can be obtained using the Surveyor III pictures because the actual rim of the crater is not visible on the Surveyor III pictures.

H. A. Pohn reports that an analysis of the Orbiter IV photographs shows three distinct morphologies in the youngest craters. These morphologies are correlative with crater size. The smallest class, of which Euclides is a type example, contains almost all craters up to a diameter of 20 km. This crater class is characterized by a round shape in map view. Terraces are generally absent; floors are flat and usually without central prominences. These craters appear to have ejecta fields which are largely composed of angular to subangular blocks.

The intermediate size class, about 16-45 km diameter and characterized by the craters Bürg and Römer, have a subangular shape with rim crests aligned in a general "lunar grid" direction. Terraces are numerous, largely continuous, and have a "soft" appearance, as if they are composed of relatively fine materials. Flat floors are rarely present; the typical crater of this class has a prominent central peak which dominates the crater from wall to wall. Ejecta blankets appear to be somewhat modified by "grid" directions; however, the actual blanket is quite subdued.

The largest class (40 km and larger) of young craters is typified by the craters Tycho and Aristoteles. These craters are subrounded overall with distinct crenulations on the rim crest. Terraces are numerous, discontinuous, and are much less subdued in appearance than those of the intermediate type. Floors are flat to moderately hummocky and although one central peak may dominate (as in the case of Tycho) most craters exhibit numerous small central prominences. Distribution of ejecta blankets is strongly modified by "lunar grid" directions. The blankets are very hummocky, although many craters exhibit what appears to be a thin veneer of extremely fine-grained ejecta which gives an "out of focus" appearance to the blanket.

There is some overlap in size among the morphologic crater classes,and a few of the craters which have been studied represent transitional types. Anaxagoras is transitional between the large and intermediate types, and Thebit A is transitional between the intermediate and small types. Of more than 250 examples that have been analyzed only 4 craters are of the transitional type.

The major factors in the correlation of the size of young craters with shape probably are existing lunar fracture patterns and strength of lunar target materials. Further study presently is under way to attempt to determine the reason for the distinct transitions in crater types which occur at approximately 20 and 45 km.

Preliminary study of Orbiter IV photographs of the Orientale basin by J. F. McCauley has helped confirm earlier work suggesting that it is the youngest of the large lunar impact basins. The concentric scarps and surrounding ejecta blanket appear to be little

modified by later events. Detailed geologic study of the basin from Orbiter IV photography should provide many important new clues to the stratigraphy around the older more modified basins, particularly in the eastern hemisphere.

The Lambiotte-Taylor photoclinometry program (Photoc) developed at the Langley Research Center (NASA), Hampton, Virginia, for use on a 7094 IBM computer is now being used in the Center of Astrogeology, Flagstaff, Arizona to derive slope values from brightness values. Lunar Orbiter framelets are scanned in Flagstaff, Arizona and digitized on a Joyce-Loebl Isodensitracer. The tapes are run on the 7094 computer at the Goddard Space Flight Center, Greenbelt, Maryland under an arrangement between the Computer Division and NASA. As soon as the emulator of the USGS 360/65 computer becomes operational, the tapes will be run on USGS computer facilities in Washington, D. C. Lunar Orbiter photoclinometry became operational in Flagstaff, June 20, 1967.

Preliminary work on 5 photogrammetric models of Lunar Orbiter III photography is underway, preparatory to set-ups on Ottico Meccanica Italiana's (OMI) AP/C at Alexandria, Virginia next month.

J. W. Ridgley spent two weeks at Langley Research Center, Hampton, Virginia and at Computer Division at Washington, D. C. working on Lunar Orbiter photoclinometry programs.

T. A. Clewes spent one week at the Computer Division at Washington, D. C. familiarizing herself with the operation of the IBM 360/30 which will be installed at Flagstaff, Arizona later this summer.

P. E. Krauss completed IBM schools, DØS coding and DØS Communications Coding in Denver, Colorado. He then spent two weeks at the Computer Division in Washington, D. C. establishing and generating the Disk Operating System to be used on USGS IBM 360/30.

Compilation continues on selected Lunar Orbiter photography to establish appropriate scales and map units for maps and diagrams to be used by astronauts during first early Apollo landings.

A meeting was held at Manned Spacecraft Center, Houston, Texas to consider the recommendation that a test be devised for the purpose of evaluating Lunar Orbiter photoclinometry programs currently in use at Aeronautical Chart and Information Center (ACIC), Langley Research Center (LRC), Manned Spacecraft Center (MSC), and the U. S. Geological Survey (USGS). High density topographic profiles generated by the Army Map Service and ACIC from high resolution photography of Mission III would provide the topographic control for the sample areas. Sample areas considered were the Surveyor I and III landing sites and Lunar Orbiter site IIS-2a and 2b.

As a result of this meeting it was determined that the profiles presently being generated by the ACIC, St. Louis, Missouri, on the high resolution stereo photographs of Orbiter site IIS-2a and b have heightening accuracies of approximately 8.5 m and individual readings are spaced 20 m. Similar profiles are anticipated for the Surveyor I and II landing areas, but the Lunar Orbiter sites covering these areas have not yet been assigned to the Department of Defense (DOD) by NASA. It is not therefore realistic to anticipate receipt of data from the DOD agencies on the Surveyor areas for about 5 to 6 months. Additionally, the ACIC reported that profiles with a density significantly higher than the present 20 m spacing would require a change in their computer program.

In light of these problems it was decided that the USGS, LRC, and MSC photoclinometry programs will be tested, using topographic maps compiled by R. M. Batson (USGS) using the combined imagery of Surveyors I and III and Lunar Orbiter III. Although these map areas are small, their high degree of accuracy makes them highly desirable as standards for testing the Orbiter photoclinometry programs. Photogrammetric data from ACIC and Army Map Service (AMS) will be utilized where appropriate to this problem and as it is received.

R. E. Eggleton, J. F. McCauley and L. C. Rowan participated in the screening of Lunar Orbiter IV photographs and submitted their revisions and comments to D. E. Wilhelms for Mission V planning.

M. J. Grolier has begun a quantitative study of sinuous rilles from Orbiter photographs.

H. J. Moore and J. F. McCauley mapped trenches cut through missile impact craters at White Sands, New Mexico. The resulting cross-sections showed the floors of the craters are underlain by breccia composed of a mixture of projectile and deformed target material which has been displaced upward. Some of the fragments of deformed target material were coated with fine material derived from the projectile. A highly fractured region enveloped the breccia. Some of the highly fractured material nearest the breccia was sheeted parallel to the crater wall, suggesting arrested flow structures. Materials below the crater rim and ejecta were tilted upward and fractured. Here, two types of fractures were noted: (1) at depth closed conjugate fractures were present and, (2) near the surface open fractures parallel the bedding and original ground surface as well as at right angles to the bedding were present. In addition, data on a crater produced by a missile with a velocity of 15,000 feet per second were obtained.

G. L. Martin has begun a study of small craters on Lunar Orbiter photographs which show fractures and displacements characteristic of slope failure. Application of the principles of soil mechanics to the size and slope data from the craters is expected to define some of the engineering properties of the lunar surface materials.

Monitored, high precision analyses are in the final stages for determining the major-element content of a suite of 19 samples of impact metamorphosed rocks from the Bosumtwi Crater, Ghana.

M. B. Duke began to make mineral separations of one kilogram of chondritic meteorite, most of which has been crushed to less than 300 mesh sieve size. The purpose of the separation are: (1) to prepare concentrates for determination of cosmic irradiation history, (2) to prepare pure mineral concentrates for a variety of chemical analysis techniques, (3) to prove that so large a quantity of dust can be processed using the mineral separation procedures under investigation in the cosmic dust project.

Monitored, high precision analyses have been completed for 16 basalts and xenoliths from Crater 160, San Francisco Volcanic Field, Coconino County, Arizona.

Field mapping of the Sierra Madera, Texas, structure was completed, and compilation of the results on the topographic base map is underway.

E. C. T. Chao and C. W. Merrill visited several mineral localities in the New York, Connecticut, and Canada for the purpose of collecting large crystals of rock-forming minerals. Visits to the Bancroft area and the Yates Uranium Mine of Canada were made accompanied by Louis Moyd, Curator of Mineralogy of the National Museum of Canada. All samples collected have or will have the full information on the mineral assemblage, geologic occurrence and geologic history. About a ton of samples were brought back or are in shipment. These are:

Sample	Locality	Single Crystal size (up to)
Olivine	Pikanock River Bigelow township	3/4" x 2"
Diopside	Yates Uranium Mines and Lime Crest Quarry, Newton, N. J.	3" x 4"
Augite (?)	Lime Crest Quarry, Newton, N. J.	1½" x 3"
Tremolite	Greenview, Ont.	2" x 4"
Hornblende	Faraday Mine Bancroft, Ont.	6" x 10"
Biotite	Davis Hill, Ont.	2" x 10"
Orthoclase	Benson Mine, Newton Falls, N. Y.	2" x 3"

Albite	Strickland Quarry Portland, Conn.	3" x 5"
Ilmenite	Within 1 mile north of Faraday Mine, Ont.	4" x 5"
Magnetite	Within 1 mile north of Faraday Mine, Ont.	3" x 6"
	Mineville Mine, N. Y.	1/4" x 1/2"
Sphene	Bancroft, Ont.	3" x 4"
Apatite	Dacey's Mine, north of Hull	4" x 8"

A large number of these samples are potentially excellent for use as mineral standards for the electron probe. Complete physical, optical and X-ray data will be obtained prior to submitting the suitable ones for shock-wave experiments.

The specific gravity of experimentally shocked calcic labradorite from Lake County, Oregon has been determined by E. C. T. Chao by a sink-float method with a precision of 0.001 or better:

	Specific gravity	
Unshocked control sample	2.723	± 0.001
Shocked to 140 kb.	2.721	± 0.001
Shocked to 280 kb.	2.618	± 0.001

The reduced bulk density of the shocked sample is partly due to vitrification.

The detailed optical properties are being measured using the spindle stage. X-ray powder data of single grains of the sample shocked to 140 kb show characteristic streaky reflections as compared to sharp spots of the unshocked sample. The sample shocked to 280 kb consists essentially of glass. X-ray and optical studies are both in progress.

Quantitative spectrographic analysis of trace element profiles in sample of air fall pumice and flow deposits from a magma chamber in the Jemez Mountains, New Mexico continue. In order to obtain a more complete picture of elemental differentiation from a single magma chamber, selected samples from a single air fall pumice are also being included in the study.

Work is continuing on the determinations of Ta and Hf in meteorites and tektites, the instrumental determination of Ba in alkali feldspars, and a procedure for the determination of Bi in silicates.

Investigation is continuing on the determination of mineral inclusions in some Thailand tektites by techniques of selected area X-ray diffraction. Instrumentation of this X-ray technique is being developed by Dr. William Parrish of the Philips Laboratory.

Surface planetary exploration

Early Apollo investigations

R. M. Batson has completed a plan for the use of a Hasselblad camera in testing of photogrammetry as a tool for geological exploration on the lunar surface. The test plan also requires the use of an analytical plotter for a total of at least 18 weeks. Materials to be used in the early tests will include pictures taken by a Gemini Hasselblad camera on loan from the Manned Spacecraft Center, Houston, Texas, and experimental phototheodolite pictures. Early Apollo prototype Hasselblad cameras will be required for later phases in the test program.

Geophysics

A regional Bouguer anomaly map of the SP Quadrangle, Arizona (15-minute series), has been completed. This map shows a prominent "high" on the western edge of the quadrangle and a large northeast-southwest synclinal trend across the map which is not reflected in the surface geology.

Preliminary seismic field work in preparation for making test craters at Cinder Lake, Arizona has been completed. The craters range between 10 and 25 feet in diameter. A hammer containing lead shot was developed as a seismic energy source for these crater studies and it appears to work nicely. This device eliminates the bothersome air waves generated by shallow explosive sources.

Ranger geologic maps

Report for the month of

June 1967

RLC Number	Author's geologic work in progress--% complete	Map compilation by drafting	Review of preliminary map	Preliminary copy to JPL	Final version in Technical Review	Final map to APU	Director's Approval	Transmitted to BMR	Published
2	80								
3	15								
7	100	x	x	x					
9	100	x	x	x					
14	100	x	x						
15	100	x	x						

LUNAR GEOLOGIC MAPS

REPORT FOR MONTH OF June

			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 [illegible]	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								
CLEOMEDES LAC 44	X	100	X	X	X	X	X	X	100	X	X	100				
COLOMBO LAC 79	X	100	X	X	X	X	X	X	100	X	X	70				
COPERNICUS LAC 58	X	100	X	X	X	X	X	X	100	X	X	100	X	X		
FRACASTORIUS LAC 97	X	100	X	X	X	X	X	X								
GRIMALDI LAC 74	X	100	X	X	X	X	X	X	10							
HEVELIUS LAC 56	X	100	X	X	X	X	X	X	100	X	X	100	X	X	X	X
JULIUS CALSAR LAC 60	X	100	X	X	X	X	X	X	100	X	X	100	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	10							
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	40				
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								
MARE VAPORUM LAC 59	X	100	X	X	X	X	X	X	100	X	X	100	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	5							
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					
PURBACH LAC 95	X	100	X	X	X	X	X	X	20							
RUPES ALTAI LAC 96	X	100	X	X	X	X	X	X	10							
SELEUCUS LAC 38	X	100	X	X	X	X	X	X	100	X	X	100	X	X		
TARUNTIUS LAC 61	X	100	X	X	X	X	X	X	40							
THEOPHILUS LAC 78	X	100	X	X	X	X	X	X	100	X	X	100	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)																
ARISTOTLES LAC 13		20														
CASSINI LAC 25		100	X	X	X	X	X	X								
EUDOXUS LAC 26		100	X													
GEMINUS LAC 27		5														
J. HERSCHEL LAC 11		100	X	X	X	X	X	X								
PLATO LAC 12		100	X	X	X	X	X	X								
RUMKER LAC 23		100	X													
SINUS IRIDUM LAC 24		100	X	X	X	X	X	X	5							
Southern Hemisphere (32°S - 64°S)																
CLAVIUS LAC 126		70														
HOMMEL LAC 127																
MAUROLYCUS LAC 113		100	X	X	X	X	X	X								
RHEITA LAC 114	X	100	X	X	X	X	X									
SCHICKARD LAC 110		5														
SCHILLER LAC 125		10														
TYCHO LAC 112		35														
WILHELM LAC 111		5														