UNITED STATES
DEPARTMENT OF THE INTERIOR
BRANCH OF ASTROGEOLOGY
601 East Cedar Avenue
Flagstaff, Arizona 86001

August 31, 1965

MEMORANDUM

TO: V. R. Wilmarth

FROM: E. M. Shoemaker, Chief

SUBJECT: Monthly Report for Director and Secretary

1. Highlights and noteworthy results

Astrogeologic studies

Lunar and Planetary Investigations

The following preliminary lunar geologic quadrangles were completed during August: Mare Serenitatis by M. H. Carr, Seleucus by H. J. Moore, and Petavius by D. E. Wilhelms.

Geologic mapping of the Mare Serenitatis Quadrangle by M. H. Carr has revealed several geologic units younger than the Procellarum Group, all associated with rilles and all with very low albedos. The dark material surrounding the Sulpicius Gallus rilles covers both the Fra Mauro Formation and the Procellarum Group. The new unit has no observable relief except for low rims along the rilles. Another dark unit occurs in the region of the Menelaus rilles. The edge of the unit is marked by a low scarp, and part of the unit is characterized by low hills and ridges. A similar dark unit, bounded by a low scarp, occurs around the Littrow rilles. All these dark units are thought to be volcanic on the basis of their relations with rilles, their sharp, scarplike contacts, and their lack of association with large craters. Their ages range from Eratosthenian to Copernican.

The technique of scanning electron microscopy has been investigated for the cosmic dust project by E. J. Dwornik. The technique, which measures secondary (low energy) electrons emitted by a sample scanned by a very small (500 A) flying electron spot, appears to offer distinct possibilities for dust studies as well as a host of other problems of

geological interest. The scanning electron microscope extends the range of magnification obtainable with the optical microscope by a factor of about 100 and eventually 1,000. A set of photomicrographs showing the detailed morphology of small particles, microfossils, fine-grained sediments and various surfaces has been prepared as a report for the U. S. Geological Survey Annual Review.

M. B. Duke has had mineral separates from achondrites analyzed spectrographically. Regularities in the distribution of minor elements in the basaltic meteorites (eucrites-howardites-mesosiderites) are attributed to magmatic differentiation. The minor-element concentrations in pyroxenes of the hypersthene achondrites are similar to those of basaltic meteorite pyroxenes. Pyroxene in the diopside achondrite and in the Shergotty meteorite has much larger contents of siderophile elements Ni and Co than those of the basaltic meteorites. This is probably a result of crystallization under higher oxygen partial pressure where, unlike the basaltic meteorites, metallic iron was not stable. Separation of metal in the magmatic phase of the basaltic meteorites has effectively depleted them in siderophile elements.

Physical and chemical properties investigation

Gas permeability measurements have been made on 50 core samples obtained from two core holes drilled near the Odessa Meteorite Craters. Although the permeability measurements have not as yet been calibrated, the permeability data suggest that samples of the Cretaceous basement sands under the main Odessa Meteorite Crater have significantly lower permeability than does the Cretaceous basement sandstone away from the crater. Liquid permeability and mercury capillary pressure measurements are in progress on these samples.

Preparation of chemical standards for analysis of Sb, Cr, Ni, Fe, Hg, and Cd by atomic absorption techniques has been completed. Semiquantitative spectrographic analyses for subsurface core samples from the vicinity of the Odessa Meteorite Craters have been obtained and are

being analyzed. Atomic absorption measurements of the Mn, Mg, Zn, Ne, and Ca content of the core samples near the Odessa craters have been obtained and the data are being analyzed.

A number of craters produced by 1-lb charges of C-4 explosive buried at different scaled depths in the Niobrara Limestone (Cretaceous) near Pueblo, Colorado, are being studied. Preliminary analysis of the cratering data indicates that the shape and size of the craters were controlled by the original distribution of fractures in the limestone and by lithologic variations as well as by the scaled depth of the explosions.

5. Personnel

Celine Merrill, PST, has joined the Branch to assist E. C. T. Chao in tektite and impactite studies.

The following employees entered on duty in Flagstaff:

D. J. Emmons, physical science technician;
G. N. Thompson, geologic field assistant;
M. I. Van Gaasbeek, clerk-typist;
M. E. Vega, geologic field assistant;
S. Shou Chou Wu, civil engineer.

The following employees were transferred to the Branch:

C. E. Hazlewood, photographer, from Topographic Division, Menlo Park, California; and T. N. V. Karlstrom, geologist, from the Branch of Military Geology, Washington, D. C.

The following employees received professional ratings:

P. G. Ables, chemist, and H. A. Pohn, geologist.

6. Conferences and Scientific Meetings Attended at Home or Abroad

E. C. Phillippi conferred with Bob Jones, physicist, and Dave Hixon, geologist, at Marshall Space Flight Center, regarding the Apollo staff camera work statement and specifications.

J. D. Alderman and W. T. Borgeson visited Daniel Tompkins and P. M. Sutton, Aeronutronics, Newport Beach, California, to discuss laser developments and applications.

W. T. Borgeson visited Richard Lugn, Menlo Park, California, to assist in modifying an ER-55 projector to obtain better image quality for a Ranger VIII stereomodel FA 567 - FA 569. The improvement in resolution and depth of field gives a model with better defined imagery. Recompilation now under way should be more reliable than previous plots.

J. F. McCauley visited the Jet Propulsion Laboratory, Pasadena, California, to discuss Surveyor landing site selections with Laboratory and NASA personnel.

A. R. Kelly visited Ralph Eicher, Computations Branch, Denver, Colorado, to refine and complete the statistical slope calculations.

E. C. Morris and H. E. Holt presented a preliminary list of lunar landing sites for Surveyor missions to the Surveyor Program Chief and other interested persons at NASA headquarters.

J. F. McCauley presented the revised list of the Surveyor landing site selections, as coordinated with that of the Jet Propulsion Laboratory, along with the selection rationale to the Surveyor-Orbiter Utilization Committee, NASA headquarters, Washington, D. C.

E. C. Morris, H. E. Holt and R. E. Altenhofen visited the Surveyor spacecraft assembly areas at Cape Kennedy to evaluate the feasibility for obtaining stereometric photographs of the fully assembled spacecraft prior to installation upon the Atlas Centaur booster.

7. Talks or Papers Presented at Meetings

Speaker and Organization	Subject
D. E. Wilhelms - Peninsula Astronomical Society Los Altos, California	Geology of the Moon

8. Visitors	Visited and purpose
J. M. Goldberg, NASA Headquarters, Arlington, Virginia	G. A. Swann - manned lunar exploration studies for FY 66.
R. E. Jones and Dave Hixon, Marshall Space Flight Center, Huntsville, Alabama	G. A. Swann - work on request for proposal for lunar geological instrumentation; H. G. Stephens - stereometric camera design for lunar exploration.
C. C. Mason and Earl LaFevers, Manned Spacecraft Center, Houston, Texas	G. A. Swann and H. G. Stephens - suited Apollo tests, and view report films concerning Apollo field tests and task analysis projects.
R. W. Aiken, Texaco Experiment, Inc., Richmond, Virginia	A. H. Chidester - demonstrate to personnel of the manned lunar exploration studies the use of instrumentation originally developed for Surveyor.
J. D. Bledsoe, Teledyne, Inc., Earth Science Division, Pasadena, California	Robert Regan - time and motion studies for Apollo extension systems.
Ken Anderson, Adage	Robert Regan - digital recording techniques for rubidium vapor magnetometer.
Don Montgomery, Cognizant Engineer on Surveyor Project, and T. H. Bird, Cognizant Scientist on Surveyor Project, Jet Propulsion Laboratory, Pasadena, California	R. H. Barnett - microwave television transmission; E. C. Phillippi, regarding screening flight film Pegasus SA-8 and SA-9.
Dick Palmer, Field Engineer, Consolidated Electrodynamics Corp.	R. H. Barnett - set up CEC VR-3600 tape recorder.
Harry Berberian, Field Engineer, We stinghouse Corp.	R. H. Barnett - lunar geological exploration systems.
John Cernius and Marvin Eisen, Marshall Laboratories	R. H. Barnett - lunar geological exploration systems.
L. Dellwig and M. E. Bickford, University of Kansas	Gerald Schaber - radar imaging program.

Visitors	Visited and purpose
Harold Berberian, J. J. Suggs, J. E. Allen, W. B. Browne, E. J. Donelan, Westinghouse, Washington, D. C.	J. F. McCauley - imaging system for the 1971 Voyager Mission to Mars.
Leon J. Kosofsky, NASA, Washington, D. C.	J. F. McCauley, L. C. Rowan, Kenneth Watson, E. F. Kiernan - the Lunar Orbiter program.
R. P. Bryson, NASA, Washington, D. C.	J. F. McCauley - the unmanned Lunar Orbiter investigations program.
A. L. Filice, Jet Propulsion Laboratory, Pasadena, California	J. F. McCauley - prepare presentation on Surveyor landing site selections to NASA officials.
A. W. Lowe and D. W. Holdsworth, Barringer Research, Inc., Natick, Mass.	L. C. Rowan - lunar terrain analysis.
R. P. Bryson, NASA, Washington, D. C.	L. C. Rowan - status of the lunar terrain analysis program.
C. D. Schaad, Jet Propulsion Laboratory, Pasadena, California	J. D. Alderman and J. F. McCauley - results of the Ranger photogrammetric research program.
Marshall Field, Scientific Data Systems, Phoenix, Arizona	J. D. Alderman and L. C. Rowan - digital data reduction.
Don Montgomery, Cognizant Engineer on Surveyor Project, and T. H. Bird, Cognizant Scientist on Surveyor Project, Jet Propulsion Laboratory, Pasadena, California	E. C. Morris, H. E. Holt - Surveyor TV camera calibrations.
R. W. Aiken, Texaco Experiment, Inc., Richmond, Virginia	J. S. Watkins - lunar geophysical experiments and instrumentation.
William LeCroix, Manned Spacecraft Center, Houston, Texas	J. S. Watkins - In Situ program.

General information

Unmanned lunar explorations

Lunar Orbiter

E. F. Kiernan, J. F. McCauley, and L. C. Rowan have been reviewing the Lunar Orbiter literature on systems and subsystems received this month. E. F. Kiernan is preparing a summary which outlines the most pertinent calibration requirements and mission constraints.

J. F. McCauley is preparing the Phase I Lunar Orbiter report which includes results in albedo investigations, the photoclinometric program studies and subsystems calibration requirements.

Terrain Analysis

The approximately 1100 new relative relief measurements received from the Aeronautical Chart and Information Center, St. Louis, are being compiled for individual terrain units so that a statistical analysis can be applied to these data. It is anticipated that a high degree of correlation will exist between the mean relief, X_R, and the several slope parameters being tested.

The preliminary 1:2,000,000 scale terrain analysis map is being drafted and will be reviewed and edited during the next two to three weeks. The above-mentioned relief data is being added to these maps.

Ranger Investigations

J. D. Alderman and W. T. Borgeson visited United Geophysical Corporation, Pasadena, California, to determine feasibility of using the laser scan process to improve the photogrammetric quality of the Ranger imagery. This method was successfully employed to remove TV scan lines and coherent noise from Ranger VIII frames P4 1009, 1010; P3 1010; P4 1011; FA 567, 569. However, there was image degradation due to interference fringes caused by imperfections in the optical system. In addition, the optics limit the size of reproducible resulting rotated

diapositives. Research now in progress is expected to eliminate these interference effects in the modified laser scan system. The resulting frames have been sent to GIMRADA for setup in the AP-2 plotter in order to reevaluate their photogrammetric potential.

Surveyor Investigations

At the request of the Surveyor Program Chief, NASA headquarters, approximately 44 sites were selected as possible Surveyor target sites, using the data available from the Terrain Studies program. Descriptions and evaluations of these 44 sites submitted to NASA were prepared by J. F. McCauley, L. C. Rowan, E. C. Morris, H. E. Holt and J. T. O'Connor and submitted to NASA. The work was a cooperative effort with the Jet Propulsion Laboratory, Pasadena, California, whose personnel provided trajectory and lighting data along with additional geological information for the submitted report.

Manned lunar exploration studies

Apollo Extension Systems Geological Methods

Field work has progressed rapidly in the Castle Butte area of the Hopi Buttes. The results of this work will be used for geologic and geophysical control for upcoming mission tests and simulations.

Gerald Schaber and D. P. Elston are working with the remote sensing group in NASA on lunar and earth orbiters.

Advanced Systems Geological Methods

Control mapping of Hopi Buttes test area is three-fourths complete.

Laboratory facilities have been obtained and are being modified for use. The laboratory will be for the joint use of mineralogy and petrology studies.

Lunar Field Geophysical Methods

Aeromagnetic survey maps of two 15-minute quadrangles over the Hopi Buttes area were received and are now being evaluated.

Geophysical investigation of Zuni Salt Lake in New Mexico has begun and is progressing rapidly; the seismic refraction and magnetic survey is already complete.

Lunar Field Surveying Methods

Control was completed on Moses Rock and controls on Zuni Salt Lake, New Mexico, were started.

Scientific Task Analysis and Biogeological Investigations

This project has been involved in preparing a test outline for the suited field test at Hopi Buttes scheduled for early October. Some of the proposed tasks will be done on the simulated lunar surface at Manned Spacecraft Center, Houston, in early September. Tasks will be evaluated for time required, difficulty, errors involved, and, possibly, energy required.

Electronics Investigations for Lunar Field Systems

Television via microwave from the Bonito Flow test site was demonstrated for Jet Propulsion Laboratory personnel.

A 14-in. slow-scan television display monitor was received. The Electronics Shop is constructing the necessary "black box" to permit its use at the microwave receiving end for pictures from the Surveyor format slow-scan camera system.

Difficulty in synchronizing the television film recorder to the television tape recorder was isolated to the tape recorder. Defective circuit boards were found and will be replaced by the manufacturer under warranty.

Video distribution for the Command, Data Reception, and Analysis facility (CDRA) is complete. Audio distribution is approximately 80 percent complete.

For the second time, the microwave relay on Mt. Elden was knocked out by lightning. Investigation into preventive-protective measures continues.

Lunar Field Imaging Systems

M. H. Carr, H. J. Moore, and E. C. Phillippi analyzed Pegasus Flights I and II space debris at Menlo Park.

E. C. Phillippi, with Carl Huggins, continued design of orbiting television system. This experiment would be scheduled to fly on a Saturn vehicle in 1966.

Work is continuing on assembly of slow-scan back-pack cameras and transmitters in support of Apollo Extension Systems field simulated studies.

E. C. Phillippi prepared a paper outlining TV systems for the Mars 1969 Mission.

Documentation for Lunar Field Systems

"First Scientific Traverse of the Mobile Geological Laboratory," a 16-mm color sound film, (6 min.), was completed and final release prints have been received.

"Apollo Field Operations Test IV," an 8-1/2-min. color sound film documenting the Apollo test held at Meteor Crater, is nearly complete and will be ready for final printing in early September.

Release of the films "Standard Techniques for Vertical and Horizontal Control" (20 min.) and "Report on Standard Operations of Lunar Field Geophysical Methods" (17 min.) to specified spacesuit manufacturers has been authorized by NASA personnel of the Manned Spacecraft Center.

The 16-mm automatic film processor for monochrome negative and reversal films is fully operational.

Processing for organizational units outside the manned lunar explorations program has included 800 feet of negative film for Meteorological Research, Inc., a government contracting firm doing research in cooperation with the U. S. Air Force.

16-mm film exposed at the Branch of Astrogeology observatory by the Lunar Photometry project is being processed.

D. W. Dodgen has nearly completed final engineering drawings for a field operational model of a stereometric camera design. The test model will be fabricated by the Branch instrument shop.

Lunar Vehicle Systems, Field Operations, and General Support

Construction of the Lunar Excursion Module mock-up was completed during August.

The laser survey instrument ring mount has been completed and tested.

Further modifications to the interior of the Mobile Geological Laboratory have been the installation of a third crew member seat and plotting table.

A repair and maintenance manual, including parts listings, is being assembled for the Mobile Geological Laboratory. The laboratory was on display at the Coconino County Fair, Flagstaff, Arizona from Aug. 27 through Aug. 29.

Applied geophysics

On August 24 the In Situ field crew left for field operations in the vicinity of the Mono craters, where they will investigate shear-wave propagation, coupling of various sources to the ground, and shear-wave generation. The drilling crew completed a 40-foot core hole of the granite on the Sonora Pass site and a 180-foot core hole in the cinders, ash and lapilli immediately north of the chain of Mono craters. The hole bottomed in about 20 feet of Bishop tuff, as had been predicted by the velocity and attenuation studies made there by the seismic crew last year.

The drilling crew at the time this report is being prepared are attempting to recover ice from cracks and crevices in the main chain of the Mono craters. This ice may be of Pleistocene age.

The In Situ project now has a Fourier coefficient program, an autocorrelation program, a cross-correlation program, and an attenuation calculation program running on a production basis. Over 500 seismic records have been digitized and will be analyzed by one or more of the above techniques during the current fiscal year.