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

July 31, 1965

MEMORANDUM

TO : V. R. Wilmarth

FROM : E. M. Shoemaker

SUBJECT: Monthly report for Director and Secretary

1. Highlights and Noteworthy Results

Astrogeologic studies

Lunar and Planetary Investigations

The following preliminary lunar geologic maps have been completed: Rupes Altai Quadrangle, by L. C. Rowan; Cleomedes Quadrangle, by Alan Binder; Mare Undarum Quadrangle, by Harold Masursky; and Colombo Quadrangle, by D. P. Elston.

Recently there has been considerable controversy over the origin of the mineral cohenite $(Fe,Ni)_3C$ which occurs in iron meteorites. Frank Cuttitta reports that Ringwood has used its occurrence as evidence of high hydrostatic pressures in the original meteorite parent body; Lipschutz and Anders have denied such pressures.

A series of isothermal sections between 750° and 550° C has been constructed by Robin Brett for the system Fe-Ni-C. The diagrams suggest that: (a) the presence of a few tenths of a percent carbon may reduce the temperature at which kamacite separates from taenite by more than

50° C. Hence the presence of carbon in iron meteorites may be partly responsible for the supercooled nucleation of kamacite in meteorites reported by recent authors; (b) cohenite may form over the temperature range 723-550° C. For compositions approximating those of metallic meteorites, the greater the carbon or the nickel content of an alloy, the lower the temperature of formation of cohenite.

Cohenite is found almost exclusively in meteorites containing from 6 to 8 wt. percent Ni. On the basis of Brett's diagrams and kinetic data, it is proposed that cohenite which formed in meteorites with lower Ni decomposed during cooling, and cohenite cannot form in meteorites with higher Ni content.

The presence of cohenite indicates neither high nor low pressures in meteorites which contain it. The absence of cohenite in iron meteorites requires pressures below about 15 kb at temperatures below about 600° C.

Terrain Analysis

The final report and a 1:2,000,000 scale lunar terrain map are being prepared for technical review. Statistical slope data presently being acquired from Ranger VIII frames at resolutions from 1 to 1000 meters will be incorporated in regression analyses for predictive techniques.

A lunar terrain simular is being compiled for Marshall Spaceflight Center, Huntsville, Alabama, from the four highest resolution frames from Ranger VIII P3 and P4 cameras.

Surveyor Investigations

H. E. Holt, E. C. Morris, J. F. McCauley, J. T. O'Connor, and L. C. Rowan have located 74 landing sites for the Surveyor spacecraft. These and additional sites will be used in the programming of the future Surveyor and Orbiter missions.

H. E. Holt has investigated the polarimetric potential of the Surveyor spacecraft television camera. The plane and degree of polarization of light reflected from the lunar surface can be determined by using three oriented polarizing filters in the filter wheel of the Surveyor television camera. The sensitivity and accuracy of the detection technique depends on the stability, dynamic range and gray level discrimination of the television camera recorder system. This technique can detect the presence and orientation of polarizing light components constituting as little as 5% of the reflected light.

Lunar Orbiter

The problem of detailed albedo discrimination is being further investigated since completion of the 1:5,000,000 scale isopleth map. Current efforts are being directed toward a 1:2,000,000 scale map with 11 isopleths in the equatorial zone.

Kenneth Watson has completed a computer program for the IBM 1620 at Arizona State College that provides the means of calculating true slope components in the phase plane. Arrangements have also been made for immediate access to an X-Y plotter for topographic profile construction. These techniques are directly applicable to Lunar Orbiter photography.

Manned lunar exploration studies

Apollo Extension Systems Geologic Methods

A concentrated field effort consisting of geophysical surveys and geologic mapping was begun in the Castle Butte area of the Hopi Buttes for forthcoming FY66 Manned Lunar Explorations Investigations field tests.

Lunar Field Geophysical Methods

A rubidium vapor magnetometer has been received and field tested. Modifications to the Mobile Geological Laboratory are being made for installation of the magnetometer. A magnetic observatory is being established and should be in operation within a month. The Earth's total magnetic field will be continuously monitored when the magnetometer is not in use in the field.

A gravity test range has been established and will be used to calibrate and test our gravimeter.

Lunar Field Surveying Methods

A feasibility study on a large-scale lunar mapping system was begun.

Control surveys started on the Castle Butte test site July 7 are expected to be completed by the end of the month. The completion is contingent on receipt of the remaining photography from Mark Hurd.

Scientific Task Analysis and Biogeological Investigations

In cooperation with the Documentation Unit, films showing typical geologic field operations are being prepared. These films are of interest to manufacturers of space suits. The results of the time and information data from Apollo II and III have been completed and are ready for subjective evaluations in terms of the quality and quantity of information obtained.

Electronics Investigations for Lunar Field Systems

Mobile radios were received and installed. The 80-watt output power has greatly increased communications reliability.

Command Data Reception and Analysis Center video and audio distribution system components have been installed. The system will be complete and operating by August 1.

The interval between field tests is being used to overhaul and calibrate all field and lab systems and associated test equipment.

Telemetry system design is essentially complete. Final design will be completed in August and procurement will be initiated. Radio repeater system design is essentially complete and is awaiting a copy of Bureau of Land Management contract before procurement. Mobile Geological Laboratory and Trespasser electronic systems designs are progressing and will be completed by next report period.

3. New Projects

D. J. Milton and Sybil Halpern, Department of History, Stanford University, were married July 23, 1965, at Palo Alto.

Apollo Geological Methods--J. W. M'Gonigle, acting Project Chief; Apollo Extension Systems Methods--G. A. Swann, Project Chief; Advance Systems Geological Methods--J. T. O'Connor, Project Chief; Scientific Task Analysis and Biogeological Investigations--P. G. Ables, Project Chief; Lunar Field Imaging Systems--E. C. Phillippi and H. E. Holt, Project Chiefs; Lunar Vehicle Systems, Field Operations and General Support-- R. A. Mills, Project Chief.

4. Publications Reported during July

O'Connor, J. T., 1965, A classification for quartz-rich igneous rocks based on feldspar ratios: U. S. Geol. Survey Prof. Paper 525-B, p. B-79 - B-84.

5. Personnel

H. H. Schmitt was transferred to NASA, Houston, as a scientist-astronaut and will take training at Williams Air Force Base, Chandler, Arizona.

R. E. Commeau has joined the Cosmic Dust Project as a physical science technician.

J. W. M'Gonigle joined the Apollo Geological Methods Project.

D. L. Schleicher and G. G. Schaber joined the Apollo Extension Systems Geological Methods project. M'Gonigle and Schleicher are recent graduates of Pennsylvania State University and Schaber of the University of Cincinnati (Ph.D., Geology)

N. G. Bailey was transferred from In Situ to the Apollo Extension Systems Geological Methods project.

J. D. Hendricks, Physicist, entered on duty in July and will work on the Scientific Task Analysis Project. R. A. Schley is employed WAE for the summer for the Scientific Task Analysis Project.

6. Conferences and Scientific Meetings Attended at Home or Abroad

D. P. Elston, H. H. Schmitt, G. A. Swann and J. T. O'Connor attended NASA's Summer Study in Woods Hole, Massachusetts.

H. G. Stephens and J. R. McCord attended the Astronaut Training exercise in Katmai, Alaska; and H. G. Stephens and T. J. W. Lee attended the Astronaut Training exercise in Iceland.

P. G. Ables and G. A. Swann met with the personnel of NASA Headquarters and the Crew Systems of Manned Spacecraft Center at Houston to discuss scientific task analysis for FY66.

E. C. Phillippi met with Ed Walthfall, project engineer of RCA for Voyager 1969. He was briefed on and received RCA proprietary documents pertaining to Voyager design philosophy.

H. E. Holt and E. C. Morris attended a conference at NASA headquarters for the selection of Surveyor landing sites.

J. S. Watkins served as secretary to the Geophysics Working Group at the NASA Lunar Exploration Summer Conference in Woods Hole, Massachusetts.

J. S. Watkins and J. H. Whitcomb visited Dart Wantland, Chief of Geophysics Branch, Bureau of Reclamation to observe tests and demonstrations conducted by General Atomics Corporation near Yuma, Arizona.

N. J. Trask met with Doris Wallenbrock of the Jet Propulsion Laboratory, Pasadena, to discuss the forthcoming report on Ranger VIII and IX.

Frank Cuttitta attended a conference at the National Bureau of Standards at Gaithersburg, Maryland. The Survey's use of the Bureau's reactor facilities was discussed.

P. R. Brett and E. C. T. Chao attended the Gordon Conference on the Physics and Chemistry of Space at the Tilton School, Tilton, New Hampshire, from June 28 to July 2.

M. B. Duke, Ralph Christian, and R. F. Commeau visited J. O. Elliot and L. Harris, U. S. Naval Research Laboratory, to inspect and discuss nuclear reactor facilities and capabilities.

7. Talks or Papers Presented at Meetings

Speaker & Organization	Subject
R. D. Regan- Grand Canyon Rotary Club, Grand Canyon, Arizona	Lunar exploration and astronaut training.
R. D. Regan- Illinois State University summer field group at Branch headquarters Flagstaff, Arizona	Lunar exploration and Branch of Astrogeology.
J. H. Whitcomb - Illinois State University students at Flagstaff, Arizona	Investigations of the Applied Geophysics section.
J. H. Whitcomb - Rotary Club, Winslow, Arizona	Branch of Astrogeology.
N. J. Trask - Summer Institute in Earth Science (NFS), Hayward State College, Hayward, California	Geology of the Moon--the view after Ranger.

8. Visitors

Visitors	Visited and purpose
C. U. Falco and J. M. Kennedy, Space General Corporation	J. S. Watkins - possible uses of radiometry during lunar exploration.
Richard Farrow, Branch of Engineering Geology	J. S. Watkins - observe operations of In Situ crew.
N. C. Costes and D. Hixon, Marshall Space Flight Center, Huntsville, Alabama	G. A. Swann and J. T. O'Connor to discuss materials testing and petrologic analysis in field tests and lunar exploration.
H. J. Harrington, University of New England, Australia	David Cummings - Branch program.
Arch Reid, University of California at San Diego and Ted Bunch, University of Pittsburgh	M. B. Duke - experiments on shock-formed natural glasses.
Carlo Rinaldi, Geologist, Geological Survey, Buenos Aires, Argentina, and Rolando Castillo, Geologist, Geological Survey, San Jose, Costa Rica	Frank Cuttitta - new developments in chemical laboratory facilities, instrumentation, and techniques for possible incorporation into their own national laboratories.
David Fogelson and Thomas Atchison, Bureau of Mines	L. C. Rowan - data pertinent to NASA-sponsored studies in extraterrestrial natural resources investigations.
R. L. Sanders, Hayes International Corp., Huntsville, Alabama.	J. F. McCauley and L. C. Rowan-lunar terrain analysis.

General Information

Astrogeologic studies

Solid State Investigations

C. H. Roach, T. S. Sterrett, and D. A. Baldwin have started work at the explosives test site near Pueblo, Colorado. Research will consist of an extensive cratering series and study of the application of strain gauges to explosively produced stress in carbonate rocks.

The following analyses were completed by the chemical section: 38 Ca and Mg analyses on DH-OC-1 and 38 Ca and Mg on DH-OC-2. Trace analyses were run on the Perkin Elmer atomic absorption unit on 34 selected core samples from Odessa Meteor Crater and drill holl no. 1, a mile away for the crater, for Mg, Mn, Zn, and Ni. K and Na will be added shortly.

A laboratory study has been started for extensive evaluation of the effects of thermal processes and electromagnetic radiation on the thermoluminescence of various rock types. Data obtained from this study will be invaluable to guide field thermoluminescence studies planned for later this year. In conjunction with this study, the Co-60 gamma irradiator has been calibrated by Gordon Johnson and Jim Thomas with the water-benzine technique. Measurements of the sample positions in the irradiation chamber indicate that a uniform dose rate of 3.1×10^5 rem/hr can be given to as many as 12 samples at one time.

Crater Investigations

J. F. McCauley and L. C. Rowan joined Professor Wolfgang Elston of the University of New Mexico and Peter Coney of Middlebury College for a brief field study of the Mogollon plateau structure located north of Silver City, New Mexico. The structure is roughly 75 miles in diameter and is bounded by a series of graben, which gives it a roughly circular form. The area is being mapped by Elston and Coney under a NASA contract.

Rocks in the structure consist of a complex sequence of andesite and rhyolitic ignimbrites which dip inward from ther perimeter toward a gently depressed central plane occupied by a central peak composed of late basalts. Low banded rhyolites occur along major faults both transverse and concentric to the major structure. These appear to have been viscous plugs that have flowed from the central fissure as much as several miles. A current interpretation of the origin of the structure is that it is the surface expression of a large ring-dike complex of the type common in New England. If this is the case, it represents one of the few areas where the surface volcanic rocks formed during caldron subsidence are well preserved.

Unmanned lunar explorations

A group of Illinois State University geographers and geologists who visited Branch Headquarters on July 19 were shown films and slides accompanied by short talks given by R. D. Regan, J. H. Whitcomb, A. R. Kelly and D. W. Dodgen. Afterwards they toured the building and were shown the Mobile Geological Laboratory.

About 80 young people from the Youth Opportunity Corps, Flagstaff area, were shown films and given a tour of the facilities with short explanatory talks by M. L. Troyer, Russell Wahmann and J. H. Whitcomb.

Ranger Investigation

A four-week effort by J. L. Derick supported by the Topographic Division at Arlington, Va., to develop a technique using a Wild A-5 Plotter for recovery of the Ranger VII imagery geometry, has been concluded. Six stereo model combinations were attempted: Ranger VIII - $P_4$1009-$P_3$1010; $P_4$1010-$P_3$1011; F_A567-569; F_B568-570; and Ranger VII - $P_4$970-$P_3$973; $P_4$970-F_A404. Only one combination, F_A567-F_A569, was accommodated by the Wild A-5.

A formline map at 1/16,000 scale and a 44-meter contour interval, which is considered a reliable representation of vertical displacement, was completed. The product compares favorably with the map produced by Moore on an ER-55 stereo setup at Menlo Park. The major difference between the two is a slight trough that appears in the northwest portion of Derick's map.

The effort effectively points out the need for more versatile first-order instruments. The restrictions for recovery of the Ranger geometry

are so stringent that one very precise setting of the known parameters will give a good stereo solution.

Manned lunar exploration studies

At a meeting with C. T. Huggins, Astrionics Division, George C. Marshall Space Flight Center, Huntsville, Alabama, the following subjects were discussed.

1. Review of continued development of the molecular TV camera design. Arrangements for the use of two slow-scan portable TV cameras and two wide-band 20 mc video transmitters and two wide-band 20 mc video receivers to be assembled as a back pack subsystem. This is instrumentation support for Manned Lunar Explorations Investigations Field Test V.
2. Review of molecular circuit development work. This review shows promise of an early availability of the mass spectrometer, the sun compass, and the inclinometer.

Also, this review is a fallout of research and development at the George C. Marshall Space Flight Center in molecular photodiodes, and engineering prototype proposals leading to flight instrumentation are anticipated. This cooperative effort by C. T. Huggins and E. C. Phillippi has the approval of T. A. Barr, Branch Chief RF Systems Division, Astrionics.

P. G. Ables and E. C. Phillippi attended two days of presentations at Aeroneutronics, Newport Beach, California. The following projects, including documents, were covered:

1. The study of a high resolution facsimile system experiment on the surface of the planet Mars.

2. Detailed system analysis and design philosophy for the automated biological laboratory.
3. Studies for the application of the high resolution facsimile camera.
4. Study of a survival capsule for the Lunar Survey Probe.
5. Thermal ecology, surface moisture, permafrost, and ground water on Mars.
6. A preliminary report on the geology of Mars.
7. Briefing on proprietary research and development of new membrane electronics.

Lunar Field Imaging Systems

The Sylvania Newschief portable TV camera was demonstrated at the Bonito Flow test site. In attendance were E. C. Phillippi, Orrin Mauran, R. L. Sutton, Ken Thanstrom of Sylvania, Erik Bramsoe and J. A. Palomino. Two hours of video tape recordings were made for study in ranging and a good test for a TV camera system with optics from 12 mm to 120 mm was conducted.

Requests were made by Unmanned Lunar Exploration Investigations for the following: Image systems for the Lunar Orbiter; image systems investigations for use in the Voyager 1969 mission to Mars; image systems investigations for the Mars capsule; and characteristics for Mariner 1964 TV systems.

Documentation for Lunar Field Systems

The compiling of film footage from Apollo tests II, III, and IV has begun with the cooperation of P. G. Ables and J. D. Hendricks. Selections are being made for inclusion in a film for release to suit manufacturers. A second film is also being completed for presentation to NASA during the first week of August.

During the month, two films were completed by Palmer Films and returned in the form of "answer prints": "First Scientific Traverse of the Mobile Geological Laboratory" and "Standard Techniques for Vertical and Horizontal Control."

The Documentation Unit has been authorized to cooperate with Meteorological Research, Inc., (M. R. I.) of Anaheim, California, for the processing of 16-mm black and white film. M. R. I., a government contracting firm, is doing meteorological research in cooperation with the U. S. Air Force. Daily flights are being made with Air Force B-52's in the weather study, and the immediate processing of this film facilitates the completion of the study. The first roll of film has been processed and delivered.

The motion picture processor is now considered operative in all respects for production processing. The refrigeration on the unit has yet to be properly adjusted.

Lunar Vehicle Systems, Field Operations and General Support

Construction of a Lunar Excursion Module mock-up was begun.

Project activities consisted of mobility testing of the Mobile Geological Laboratory (MGL) on loose volcanic cinders in the Sunset Crater and of the beginning of construction of ring mount installation of laser survey instrument on the MGL.

Astronaut Training

An Astronaut Training trip was conducted on the volcanic island of Iceland. Dr. Sigurdur Thorarinson, Director of the Icelandic Museum of Natural History, along with Dr. Gudmundar Signaldson, conducted the training trip. Among the areas visited were Askja, Laki, and Grindavik.

A new cordless FM transmitter/receiver communications systems to aid in the Astronaut Training trips was used with great sucess on the Alaska and Iceland Training trips.

Applied Geophysics

In Situ Physical Properties

The NASA drilling rig completed a core hole through the ejecta blanket of the south rim of Meteor Crater for petrographic and physical property studies. The hole bottomed at about 102 feet after penetrating what appear to be fragments of Coconino Sandstone, Kaibab Limestone, and Moenkopi Sandstone. The hole bottomed about 7 feet into the Kaibab.

J. Cl. De Bremaecker and Richard Kennemer have completed programming the U. S. Bureau of Standards CDC 3600 in Boulder, Colorado, to analyze In Situ seismic tapes for frequency spectrum and amplitude attenuations. Another program nearing completion will allow digital velocity filtering of records, which, in turn, will help locate and define later arrivals, such as the elusive shear waves we hope to detect in the horizontal geophones. Approximately 500 28-channel tapes re corded in the last 12 months were digitized commercially prior to processing.

The remaining In Situ personnel completed analysis of the Meteor Crater seismic data. These data, collected earlier, consist of refraction, reflection, and attenuation shots on the south rim and in the center of the crater. These data along with other In Situ data were presented at the NASA Lunar Exploration Summer Conference in Woods Hole, Massachusetts.

Ground-Water Seismology

The Ground-Water field crew spent one week with Gordon Eaton of Regional Geophysics Branch assisting with seismic studies in the Safford

Valley of southeast Arizona and another week in northwestern Arizona conducting studies in an intermontane basin near Kingman in cooperation with Water Resources Division personnel.