



that the absorption of solar energy near the terminator is less than had been previously assumed in calculations of heating and cooling during a lunation. The studies indicate that the terminator reflectivity is 16% greater than the subsolar reflectivity.

### Crater Investigations

The Hugoniot curve for Coconino Sandstone has been determined for the pressure range 0-150 kilobars. Shock speeds in this pressure region range 3.0-4.0 km/sec. In this pressure region for Moenkopi Sandstone, the shock with speeds ranging from 2.7-3.0 km/sec follows an elastic precursor with a speed of 3.1 km/sec.

### Cosmic Chemistry and Petrology

The red luminescing material in the Norton County enstatite achondrite has been identified as forsterite ( $Mg_2SiO_4$ ) by x-ray diffraction analysis. Emission spectrographic analysis showed a manganese content of 400ppm, apparently enough to activate the luminescence. Luminescent forsterite makes up about 3 per cent of the total Norton County material, which limits the luminescent efficiency of the total meteorite to 1-2 per cent if the luminescent efficiency of the forsterite is 50 per cent.

### Unmanned Lunar Exploration Studies

#### Ranger Investigations

H. A. Pohn has completed a preliminary topographic map of a part of the last Ranger VII photograph (P 979). The map area measures 100 feet by 75 feet; the scale is 1:80, and the contour interval is 0.5 feet. The map was derived by a modification of the computerized photometric slope measuring technique previously applied to telescopic lunar photographs. The map provides vital information on slope distributions at the one foot scale which determines in part the suitability of the lunar surface for landing both unmanned and manned spacecraft.

## Surveyor Investigations

A field test of a Surveyor spacecraft television camera began during the first week of August, and nine photogrammetric surveys have been completed. The tests have revealed that the reseau marks on the vidicon tube were not visible in 90 per cent of the photographs. The inability to identify the reseau on the photographs indicates a serious weakness in the photogrammetric potential of the existing camera system and modifications have been recommended.

## Manned Lunar Exploration Studies

### Geological Training Program for Astronauts

The Astronaut Office gave final approval in late September to a schedule of six lectures to be held in Houston and six field trips as the training series for the second term of the Astronaut program in geology. The first field trip will be held near Bend, Oregon, under the direction of A. C. Waters.

### Lunar Geophysical Methods Investigations

Seismic field operations were conducted in the Flagstaff area on basaltic cinders, blocky lava and on the Kaibab Limestone. The work was carried out to determine the surface and near-surface seismic properties of these rocks. Velocities of 950 feet per second were recorded for the cinders, slightly lower than that of air which is approximately 1100 feet per second, and may be the lowest seismic velocities ever recorded. Attenuation of seismic energy in the cinders and in some of the lava is as much as two orders of magnitude greater than that recorded for normal igneous sedimentary rocks. These attenuations may be the highest ever recorded.

2. Significant changes in status of projects

The Solid States Investigations Project, recently reoriented in scope, will concentrate its efforts for the Vela Uniform Program on Project Dribble.

## 5. Personnel

Personnel transferring to Flagstaff during reporting period:

James D. Crossen, Civil Engineering Technician, September 9, from Topographic Division, Menlo Park, California.

Howard D. Givens, Cartographic Draftsman, September 13, from Branch of Technical Illustrations, Menlo Park, California.

Yukio Yamamoto, Civil Engineer (Surveying), September 14, from Topographic Division, Menlo Park, California.

Personnel entering on duty at Flagstaff since last reporting period:

Patrick J. Barosh, Geologist, August 31

Selfa M. Gallegos, Clerk-Stenographer, September 21

William O. Grieve, Electronic Maintenance Technician, September 30

Dare O. Hough, Clerk-Stenographer, September 14

Lawrence C. Rowan, Geologist, August 26

Frances O. Wetherhold, Editorial Assistant, September 28

Charlotte A. Wheeler, Geologic Field Assistant, September 25

James H. Whitcomb, Geophysicist, September 9

James W. Van Divier, Cartographic Draftsman, September 28

## 6. Conferences and scientific meetings attended at home or abroad

E. M. Shoemaker attended International Astronomical Union Conference meetings in Hamburg, Germany, where he delivered a paper on preliminary analysis of Ranger photography.

Harold Masursky addressed the seminar for the Director of Goddard Space Flight Center, Greenbelt, Maryland, on lunar research.

Harold Masursky held a discussion of the use of lunar geologic maps in planning advanced lunar exploration traverses for Ernst Stuhlinger's Research Projects Division at Marshall Space Flight Center, Huntsville, Alabama.

Kenneth Watson met with an advisory group at Arizona State College to discuss their proposed program in atmospheric physics and astronomy.

A. H. Chidester and D. E. Wilhelms met with A. C. Waters and several NASA geologists at Bend, Oregon, to arrange the first field trip (to be conducted by A. C. Waters) of the current term of the Astronaut Training Program in geology.

A. H. Chidester and T. H. Foss (NASA geologist) met with Neal Armstrong and Charles Bassett, both of the Astronaut Office, to arrange the schedule of lectures and field trips in the second term of the Astronaut Training Program in Geology.

W. A. Roberts and H. H. Schmitt conferred with personnel of NASA Headquarters, Marshall Space Flight Center, and General Motors Corporation on the design and fabrication of the Lunar Mission Development Vehicle. Later, a meeting with personnel of the Navajo Army Depot, Flagstaff, Arizona, was held to discuss possible maintenance and repair of this vehicle by the Army facilities there.

Personnel of NASA Headquarters, Marshall Space Flight Center, Grumman Aircraft, W. A. Roberts of the U. S. Geological Survey and two independent boat building firms met to discuss the construction, interior design and acquisition of a Lunar Excursion Module mockup.

R. H. Barnett and E. C. Phillippi conferred with personnel of the Manned Space Flight Center to discuss the Apollo mission communication.

R. H. Barnett, D. P. Elston, and E. C. Phillippi were shown a ranging laser system in operation at the Ft. Huachuca Army Electronics Proving Ground.

J. F. McCauley, H. A. Pohn, J. D. Alderman, conferred with engineers at RCA Astroelectronics, Hightstown, New Jersey, for the purpose of obtaining the preflight camera calibration data on the Ranger VII spacecraft.

J. F. McCauley, J. D. Alderman, conferred with the Lunar Orbiter project engineers at Langley Space Flight Center, Virginia, for the purpose of determining the photometric and photogrammetric problems involved in the analysis of the photographs to be acquired.

J. F. McCauley conferred with Dr. Floyd Thompson, Director of the Langley Space Flight Center on the results of the Ranger VII mission.

E. M. Shoemaker, Harold Masursky, and J. F. McCauley, along with Isarel Taback and L. Kosofsky, NASA, conferred with Dr. G. E. Mueller, Director of the Apollo Program, NASA, for the purpose of describing the geological, photometric, and photogrammetric techniques that can be applied to the high resolution photographs acquired by the Orbiter and Surveyor spacecraft.

7. Talks or papers presented at meetings

- E. M. Shoemaker "Flagstaff--City of Science"  
Northern Arizona Realtors Association  
Flagstaff, Arizona
- E. M. Shoemaker "Flagstaff--City of Science"  
Catholic organizations  
Flagstaff, Arizona
- J. S. Watkins "In Situ Geophysical Studies"  
Symposium on Arizona Geology  
Museum of Northern Arizona  
Research Center
- J. S. Watkins "The Branch of Astrogeology in the  
Space Program"  
Payson Rotary Club  
Payson, Arizona
- J. F. McCauley "The Nature of the Lunar Surface as  
Determined by Ranger VII"  
Milwaukee Section, American Institute  
of Aeronautics and Astronautics  
Milwaukee, Wisconsin

## 8. Visitors

Visitor	Visited and Purpose
Richard Nelson Optical Craftsman	Kenneth Watson, to discuss the telescope array for the Occultation Project.
Pat Gambuti Ralph McNeeley General Electrodynamics Corp. Garland, Texas	Kenneth Watson, to discuss the telescope array for the Occultation Project.
James D. Beard Water Superintendent Flagstaff City Water Department	J. S. Watkins to arrange for Seismic survey of the Inner Basin, San Francisco Peaks, Coconino County, Arizona.
Robert E. Canup Texaco Experiment Incorporated Richmond, Virginia	J. S. Watkins to discuss seismic operations on the Moon and evaluations of a seismic shooting device developed by Texaco.
Sven Hjelmquist Menlo Park, California	Elliot Morris to discuss the geology of and to visit Meteor Crater.
H. W. Washburn R. R. McDonald Leonard Jaffe Jet Propulsion Laboratory Pasadena, California	E. M. Shoemaker, J. F. McCauley, and L. C. Rowan to discuss the character of the lunar surface as determined by Ranger VII photographs.

## General Information

### Astrogeologic Studies

#### Lunar and Planetary Investigations

D. E. Wilhelms and D. J. Milton have begun preparation of a long range prospectus for lunar exploration at the request of the NASA Office of Manned Space Flight Center.

The polarimeter was successfully installed on 12" refractor of Lick Observatory and first observations made. Large scatter in measurements so far, but seeing has been poor, and observer (one) still unaccustomed to instrument.

H. W. Stellmaker is building a very low noise preamplifier for use in the Infrared Project. This preamplifier will decrease the system noise level by a factor ten and may permit the observation of lunar temperatures below 90°K.

R. E. Wallace, Julius Schlocken, M. I. Crittenden, and G. I. Smith are geologically mapping lunar areas that may be used as Apollo landing sites as part of the Terrain Study. Their work will involve visual observations of the Lick Observatory 36" refracting telescope. E. H. Bailey will use the recent Ranger VII photography in his study of a possible landing area near the spacecraft impact point.

N. J. Trask, Jr. has reported for duty at Menlo Park and will start mapping the Pitatus quadrangle of the Moon. At the Flagstaff office, A. H. Chidester will start mapping the Altai Scarp quadrangle of the Moon; H. A. Pohn the Macrobius quadrangle; H. E. Holt the Purbach quadrangle; and L. C. Rowan the Fracastorius quadrangle.

The lunar camera for the Coude system of the 120-inch reflecting telescope has been completely redesigned to incorporate a wedge-shaped shutter to compensate for the unequal illumination of the lunar surface.

G. E. Kron has taken excellent pictures of the Moon with the electronics camera, an image intensification device attached to the 36-inch telescope at Mt. Hamilton. These pictures are the first that have been taken by astronomical images tubes that exceed ordinary direct photography in quality.

H. J. Moore has begun to analyse the size distribution of fragments produced by impact of 3/16" basalt spheres at velocities up to 8,000tps with 2" basalt spheres.

## Manned Lunar Exploration Studies

### Manned Geophysical Methods Investigations

The In Situ Physical Properties project began work on three areas in the Mono Craters area in Eastern California. The areas consisted of pumice, ash, and cinders, and tuffs. All of the rocks in these areas are intermediate to felsic in composition in contrast to the mafic composition of the volcanic rocks near Flagstaff.

In cooperation with Robert E. Canup of the Texaco Experiment Incorporated, the In Situ Geophysical crew spent three days evaluating a firing device developed by Texaco for firing squibs. Although the energy transduced into the ground by the squibs is less than that transduced by either a blasting cap or a hard blow of a hammer, the firing device has the advantages in that it does not fragment, jump about, or blow pieces of rock about during the explosion. Additional squibs with higher capacities will be tested in the near future.

The Apollo geophysical field crew has completed field work for time and motion studies of a gravity meter and a portable transistorized seismograph at three sites in the Flagstaff area. Times required for the various operations are being studied in order to determine the variability of time as a function of terrain roughness, operator experience, and operator fatigue.

### Manned Lunar Exploration Investigations

Field sites were selected for Manned Lunar Exploration at the Bonito Flow, the S. P. Flow, the Kana-a Flow, Meteor Crater, Hopi Buttes, all in northeastern Arizona, at the Moses Rock Diatreme in southeastern Utah and at Mono Craters, California. These field sites are to be utilized for time and information studies of field tasks and operations of a geological,

geophysical, and surveying nature, and for the development of integrated lunar scientific mission for single stations of limited areal extent (APOLLO) and for multi-station reconnaissance type traverses (MOLAB).

Time and information studies for geological, geophysical, and surveying tasks have been conducted. Geological studies, using nine semi-trained geologists, have been made at the Bonito Flow, the S. P. Flow, Meteor Crater, and Moses Rock diatreme. Much of the effort was devoted to the development of guides for outcrop and terrain description. Preliminary field simulation tests have shown a need for guides for systematic data acquisition under the physical and mental limitations experienced under suited conditions. The results of the geological time and information studies are currently being evaluated.

Geophysical time and information studies have been conducted using a gravity meter. The operation at each gravity station was divided into six basic tasks, including travel time between 100-foot station intervals. The mean time for completing the six tasks for each station 120.8 seconds, with a standard deviation of 20.9 seconds. Time and information studies were conducted of standard surveying procedures using two theodolites of different design. Operating times for set-up, polaris observation, and measurement of horizontal and vertical angles to a non-predetermined set of points were timed.

About 9,000 feet of 16mm movie film was exposed to document the geological, geophysical, and surveying operations for the time and information studies for Manned Lunar Exploration Investigations. Operations were documented at four sites: 1) Bonito Flow, 2) S. P. Flow, 3) Meteor Crater; and 4) Moses Rock diatreme. The film was also used to document the geomorphologic and geologic character of the test terrain and to record details of lithology typical in specific areas.