NASA SP-7003 (02)

LUNAR SURFACE STUDIES

A CONTINUING BIBLIOGRAPHY

WITH INDEXES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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NASA SP-7003 (02)

LUNAR SURFACE STUDIES

A CONTINUING BIBLIOGRAPHY

WITH INDEXES

A Selection of Annotated References to Unclassified Reports and Journal Articles introduced into the NASA Information System during the period February, 1965–January, 1966.

Scientific and Technical Information Division
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. APRIL 1966

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INTRODUCTION

With the publication of this second supplement, NASA SP-7003 (02), to the Continuing Bibliography on "Lunar Surface Studies" (SP-7003), the National Aeronautics and Space Administration continues its program of distributing selected references to reports and articles on aerospace subjects that are currently receiving intensive study. All references have been announced in either *Scientific and Technical Aerospace Reports (STAR)* or *International Aerospace Abstracts (IAA)*. They are assembled in this bibliography to provide a reliable and convenient source of information for use by scientists and engineers who require this kind of specialized compilation. In order to assure that the distribution of this information will be sustained, Continuing Bibliographies are updated periodically through the publication of supplements which can be appended to the original issue.

The subject of Lunar Surface Studies is one which encompasses several scientific fields. As a consequence, this bibliography contains references to a variety of specific topics including the theory of lunar origin, the lunar atmosphere, and the physical characteristics of the body such as its topography, geology, cartography, and stratigraphy. Techniques of lunar observation, measurement, and analysis, e.g., photography, photometry, and spectrophotometry, are amply covered, and pertinent references to the instrumentation and equipment used in lunar investigation have also been included.

Each entry in the bibliography consists of a citation and an abstract. The listing of entries is arranged in two major groups. Report literature references are contained in the first group and are subdivided according to their date of announcement in *STAR*. The second group includes published literature references, subdivided according to their date of announcement in *IAA*. All reports and articles cited were introduced into the NASA information system during the period February, 1965–January, 1966.

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(continued)

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For further details please consult the Introductions to *STAR* and *IAA*, respectively.

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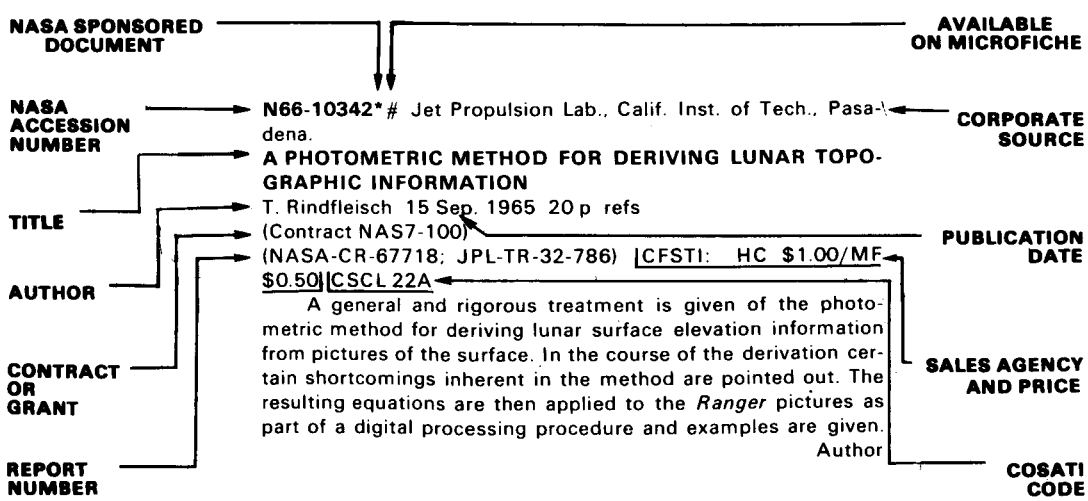
TYPICAL CITATION AND ABSTRACT



LUNAR SURFACE STUDIES

a continuing bibliography/with indexes APRIL 1966

1965

STAR ENTRIES

N65-13784*# Interior Dept., Washington, D.C. United States Geological Survey
ASTROGEOLOGIC STUDIES, SUMMARY Annual Progress Report, Aug. 25, 1962–Jul. 1, 1963
Jun. 1964 52 p
(NASA Order R-66)
(NASA-CR-59125) OTS: HC $3.00/MF $0.50

Summaries of studies on lunar and planetary investigations, crater and solid state investigations, cosmochemistry and petrography, and studies for the space flight program are presented. The studies are reported fully in other volumes of the annual report. R.L.K.

N65-13802# Naval Research Lab., Washington, D.C. Atmosphere and Astrophysics Div.
THE MEAN DISTANCE TO THE MOON AS DETERMINED BY RADAR Interim Research Report
B. S. Yaplee, S. H. Knowles, A. Shapiro, K. J. Craig, and D. Brouwer, (Yale U. Obs.) 16 Sep. 1964 13 p refs
(NRL-6134; AD-607354) OTS: $0.50

The distance to the moon was measured by radar with a basic resolution of ±150 m. The measured distance from the observing station to the nearest point of the moon was corrected for the earth's rotation and the motion of the moon. In addition, the libration of the moon changes the nearest point of reflection with time. As observations were made over many months, several returns from the same lunar area were obtained. The monthly variations in distance due to lunar topography were used to derive an equivalent radar topographical map around the central region of the moon. This map provided the necessary corrections to account for lunar topographical variations. All the measured distances after applying the above corrections were used in a least square solution with the best known constants. The solution yielded a value of 384 400 km ±1.2 km for the mean distance to the moon. Author

N65-13842# Grumman Aircraft Engineering Corp., Bethpage, N.Y. Research Dept.
SOIL BEHAVIOR IN A LOW AND ULTRAHIGH VACUUM
J. D. Halajian Dec. 1964 48 p refs Presented at the Ann. Meeting of the Am. Soc. of Mech. Engr., Lunar Base Session, N.Y., Dec. 1964
(RE-197J)

The behavior of simulated lunar soils is investigated by utilizing recent advances in vacuum technology and known principles of soil mechanics and surface chemistry. The effect of the gaseous and adsorbed phases on the behavior of the solid particles is evaluated in separate experiments. It is found that the absence of either phase has a hardening effect on soils. This is demonstrated by increased bearing strength of "fluff" at 10^{-3} torr, and extensive sticking of tumbling dust particles at 10^{-10} torr. The latter phenomenon is attributed to the depletion of adsorbed films. The experimental evidence favors a clean-surface rather than an electrostatic mechanism of adhesion but is not conclusive. Improved experimental techniques are suggested to overcome a number of difficulties that have hampered the quantitative measurement of soil adhesion and friction in vacuo. Author

N65-13894 Joint Publications Research Service, Washington, D.C.
EFFECTIVE TEMPERATURE OF THE LUNAR SURFACE DUE TO REFLECTION OF COSMIC RADIOEMISSION FROM IT
A. M. Starodubtsev *In its* Izv. VUZov: Radiophys., Vol. VII, No. 3, 1964 25 Nov. 1964 p 6–15 refs (See N65-13892 04-07) OTS: $6.00

The effective temperature of the lunar surface is calculated by using the reflection of cosmic radio emission at frequencies of 100, 200, and 400 Mc. As a lunar model, a sphere with an ideally smooth surface of material was examined whose dielectric constant was between 1.5 and 4. From calculations, it follows that with an increase in the angle-of-ascension of the moon, the average brightness temperature varies slightly, and only in the region of the angles $\alpha = 280°$ does some temperature increase occur; the degree of polarization of the radiation reflected from the lunar surface is almost independent of the frequency, and for $\Sigma = 1.5$ does not exceed 12% and averages out to about 2% to 5%. Author

N65-14197# National Bureau of Standards, Washington, D.C.
A STUDY OF LUNAR SURFACE RADIO COMMUNICATION
L. E. Vogler 14 Sep. 1964 126 p refs
(NBS-Monograph-85) GPO: $0.70

The problem of point-to-point radio communication on the moon is discussed, and equations and curves are presented to estimate power requirements in lunar communication systems. Assuming a smooth surface, consideration is given to ground wave attenuation over both layered and nonlayered grounds, antenna ground losses in situations where ground screens are impractical, noise level estimates in the receiving system, and the effects on propagation of possible lunar ionospheres. An example of the calculation of required power for a particular communication system is given. Author

N65-15114# Army Missile Command, Huntsville, Ala. Redstone Scientific Information Center
THE SPECTRAL-POLARIZATION CHARACTERISTICS OF THE LUNAR SURFACE
V. G. Tejfel 23 Oct. 1964 5 p refs Transl. into ENGLISH from Astron. Tsirkuliar Akad. Nauk SSSR (Kazan), no. 205, 1959 p 7-8
(RSIC-312; AD-609159)

A spectrographic survey of the lunar surface near the quadratures was performed with the polaroid angled at 0°, 60°, and 120°. The monochromatic values of the polarization degree were calculated by Fesenkov's formula. The degree of the polarization in the spectra of the lunar details changed with the monochromatic magnitude of their albedos. Polarization measurements of the lunar earthlight showed a decrease by 5% to 7% of the wavelength in the interval 400mμ to 620mμ. G.G.

N65-15120# Army Missile Command, Huntsville, Ala. Redstone Scientific Information Center
PETROGRAPHIC INVESTIGATION OF THE LUNAR SURFACE BY JOINT USE OF PHOTOMETRIC AND COLORIMETRIC OBSERVATIONS
V. V. Sharonov Dec. 1964 19 p refs Transl. into ENGLISH from Astron. Zh. (Moscow), v. 31, no. 5, 1954 p 442-452
(RSIC-344; AD-609693)

A statistical comparison between the lunar surface and the earth's rocks and materials with respect to color and luminosity was made. It was established that a simultaneous similarity for the distribution curves according to brightness and color between the moon on the one hand and the earth's rocks and meteorites on the other was not obtained. The various assumptions introduced in order to explain the color characteristics of the lunar surface are discussed. The most reliable is the hypothesis according to which the lunar surface is covered by a porous vesicular slag formed from bedrock under the action of explosions accompanying the meteorite impacts. Author

N65-15284# Texas Instruments, Inc., Dallas.
TECHNIQUES FOR LUNAR WATER EXPLORATION Final Report
J. K. Westhusing and C. Crowe 30 Sep. 1964 529 p refs
(Contract AF 19(628)-3287)
(AFCRL-64-814; AD-608957)

Evaluation of technique applicability requires the formulation of models of the lunar subsurface and specification of lunar rock types and their possible mineralogic, chemical, and physical properties. Eight subsurface models and nine rock types are postulated. Lunar rock properties are estimated by evaluation of terrestrial rock measurements and possible modifications produced by lunar genesis and environment. Optimum combinations of surface and orbital methods are selected by comparing calculated or estimated survey responses across the models. Practical difficulties such as weight, power and volume restrictions, implanting of electrodes, and drilling are also considered. In practice, data obtained by combinations of methods should be interpreted simultaneously to assure definition of a geologic or structural explanation applicable to all data. The methods recommended for orbital reconnaissance and surveying are phototelevision, infrared, radar altimetry and magnetic. Those recommended for surface exploration are gamma ray, television, infrared, gravity, magnetic, and electromagnetic. Comprehensive data concerning all equipment types considered are presented. Author

N65-15288# Lowell Observatory, Flagstaff, Ariz.
PHYSICAL RESEARCHES ON THE BRIGHTER PLANETS Final Report
William M. Sinton 30 Sep. 1964 20 p refs
(Contract AF 19(604)-5874)
(AFCRL-64-926; AD-609547)

Observational studies of the planets and the moon through the use of photography, photoelectric photometry, infrared radiometry, and infrared spectroscopy were made. The resulting data include the measurements of the thickness of dust on the floors of 16 lunar craters; the infrared radiometric temperatures of Mercury, Venus, Mars, Jupiter, Saturn, and Uranus; and extensive photoelectric photometry of Mars. Some of the important conclusions that have been previously published are included. Author

N65-15407*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
AN X-RAY SPECTROGRAPH FOR LUNAR SURFACE ANALYSIS
Albert E. Metzger 16 Oct. 1964 34 p refs
(Contract NAS7-100)
(NASA-CR-60340; JPL-TR-32-669) OTS: $2.00/MF $0.50

The performance of a proposed X-ray spectrograph for the in situ analysis of powdered samples of lunar material is described. The instrument employs electron beam excitation, with dispersive crystal resolution in a fixed-channel geometry. A nondispersive capability by means of pulse height analysis is also included. Stable X-ray emission has been achieved by lowering the electrical resistivity of the sample. Thermal measurements show that heating of the sample by the electron beam is not excessive. Variations in particle size and shape have been found to affect the response, but these become serious only in extreme cases. The processes of interelemental X-ray absorption and enhancement are discussed and are illustrated by curves of response as a function of composition. Experimental results using both synthetic and natural rock materials are presented for the dispersive and nondispersive modes. Author

N65-16264*# Geological Survey, Washington, D.C.
ASTROGEOLOGIC STUDIES: SUMMARY Annual Progress Report, Jul. 1, 1963–Jul. 1, 1964
Nov. 1964 35 p refs With map supplement
(NASA Order R-66)
(NASA-CR-60509) OTS: HC $2.00/MF $0.50

Reported are the summaries of three separate works on: (1) lunar and planetary investigations; (2) crater and solid-state investigations; and (3) cosmic chemistry and petrology. A map supplement is included. R.E.S.

N65-16265*# Geological Survey, Washington, D.C.
ASTROGEOLOGIC STUDIES. PART A: LUNAR AND PLANETARY INVESTIGATIONS Annual Progress Report, Jul. 1, 1963–Jul. 1, 1964
Nov. 1964 144 p refs
(NASA ORDER R-66)
(NASA-CR-60510) OTS: HC $4.00/MF $1.00

These lunar and planetary investigations contain the preliminary results of detailed geologic mapping on a 1:1 000 000 scale of 5 new quadrangles in the equatorial belt of the moon. Several major stratigraphic units in the Imbrian and pre-Imbrian systems are described. Four papers discuss problems of origin and evolution of various types of craters and features associated with the craters such as rilles and rays. As a part of the lunar geologic investigations, detailed studies of the infrared emission and reflected visible radiation from the moon are in progress; a description of a systematic program of photoelectric and photographic photometry and the relation of the visible lunar photometric function to the infrared emission are given. Author

N65-16266*# Geological Survey, Washington, D.C.
ASTROGEOLOGIC STUDIES. PART B: CRATER INVESTIGATIONS Annual Progress Report, Jul. 1, 1963–Jul. 1, 1964
Nov. 1964 194 p refs
(NASA-CR-60515) OTS: HC $5.00/MF $1.25

Crater investigations contain the results of field and laboratory studies of shock and crater phenomenology. The effect of shock on rock materials forms the subject of four reports: (1) the shock wave synthesis of stishovite, (2) the physical properties of shock-formed plagioclase from a meteorite, (3) some characteristics of natural glasses and high pressure phases that serve as evidence for their origin by meteorite impact, and (4) the effect of shock on the radiogenic argon content of granite. One report concerns the shock equation of state on two rocks from Meteor Crater, Arizona. Two reports deal with experimental craters: one is concerned with a field study of craters formed by missile impact, and the other, with a study of craters formed in porous-cohesive targets by hypervelocity projectiles. Work on three naturally formed craters is reported. This includes a new topographic map of Meteor Crater, Arizona, made to serve as a base for the geologic work; a geologic study of a meteorite crater and associated rays of ejecta at Henbury, Australia; and field and laboratory studies of the Flynn Creek structure, Tennessee. Author

N65-16267*# Geological Survey, Washington, D.C.
ASTROGEOLOGIC STUDIES. PART C: COSMIC CHEMISTRY AND PETROLOGY Fifth Annual Progress Report, Jul. 1, 1963 to Jul. 1, 1964
Nov. 1964 123 p refs
(NASA Order R-66)
(NASA-CR-60516) OTS: HC $4.00/MF $1.00

Cosmic chemistry and petrology include reports on aerodynamic features, geologic occurrences, chemical composition and metallic spherules of tektites, methods of chemical analysis of tektites and other extraterrestrial material, and the luminescence of achondritic meteorites. Author

N65-17222*# Radio Corp. of America, Princeton, N. J. Astro-Electronics Div.
LUNAR ORBITER CAPSULE STUDY Final Report
3 Aug. 1962 333 p refs Revised ed. Prepared for JPL
(Contracts NAS7-100; JPL-950340)
(NASA-CR-60748; AED-1542) OTS: HC $7.00/MF $1.75

This design analysis of a lunar orbiter, to accomplish the tracking and television experiments within the allowed payload for a Ranger spacecraft, considers the two major tasks of the television mission and the selenodetic mission, and the separate sets of restraints which they impose on the orbit. It was concluded that this design is feasible and that the required development time is dependent on the design of the attitude control subsystems, and the retropropulsion subsystems. G.G.

N65-17489# Joint Publications Research Service, Washington, D. C.
LIGHT REFLECTION FROM THE LUNAR SURFACE
L. A. Akimov 25 Feb. 1965 8 p Transl. into ENGLISH from Tsirkulyar Astron. Obs. (Kharkov), no. 26, 1963 p 43–46
(JPRS-28888; TT-65-30387) OTS: $1.00

In the investigation of the photometric characteristics of the lunar surface, it was found that the law of light reflection to that conclusion are summarized. The prediction of discretization comes from the eigenvalues of the partial differential equation that determines the function ψ, a single-valued bounded solution of the inhomogeneous Klein-Gordon equation, and from the conjecture that the jump in energy density is the same for all galaxies in a given subclass. This paper is devoted to the mathematical and physical properties of the eigenfunctions themselves. The physical predictions resulting from the eigenfunctions relate to the geometric morphology of galaxies, and hence are more closely associated with observed properties. D.S.G.

N65-17490# Joint Publications Research Service, Washington, D. C.
STRUCTURE OF THE LUNAR SURFACE
N. P. Barabashov 25 Feb. 1965 9 p refs Transl. into ENGLISH from Tsirkulyar Astron. Obs. (Kharkov) no. 26, 1963 p 14–19
(JPRS-28889; TT-65-30388) OTS: $1.00

Measurements of lunar brightness and of light reflected from various laboratory samples are compared in tables. It is concluded that the lunar surface cannot be covered by very fine unconsolidated material or dust, that the law of reflection from the lunar surface differs considerably from the law for the volcanic ash investigated, and that the lunar surface also does not resemble volcanic slag. It is asserted that the surface is covered either by an extraordinarily spongy layer with very thin but opaque walls separating the individual pores, or by pointed and closely spaced opaque fragments consisting of greatly fractured tuff-like volcanic rocks that do not have mirror properties. D.E.W.

N65-18374 Arnold Engineering Development Center, Arnold Air Force Station, Tenn.
SUITABLE LUNAR LANDING SYSTEM CONSIDERING THE BEARING CAPACITY AND FAILURE MODE OF LUNAR SURFACE MATERIALS
John D. Peters *In* AFSC 11th Ann. AF Sci. and Eng. Symp. [1964] 34 p refs (See N65-18373 08-34)

Research done indicates that the surface of the moon consists of a very low density, porous material probably comparable to dust. The surface may have a thin sintered crust caused by surface sputtering initiated by solar winds and electromagnetic bombardment. This paper discusses the results of the research and proposes a lunar surface model that agrees with the known data and examines the behavior of this surface material under loads imposed by a lunar landing vehicle. Failure criteria are defined and the mechanisms of failure examined. This paper suggests methods of designing landing gear and locomotion systems for vehicles employed in lunar landings and surface exploration, capable of negotiating very rough terrain and operating equally well on both soft and hard surfaces. Author

N65-18450*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
THE LUNAR ORBITER
I. Taback and E. A. Brummer [1965] 21 p ref Presented at the AIAA Unmanned Spacecraft Meeting, Los Angeles, 1–3 Mar. 1965
(NASA-TM-X-56116) OTS: HC $1.00/MF $0.50

The Lunar Orbiter spacecraft, designed around a photographic payload to provide Apollo landing information, will be launched in 1966, using an Atlas Agena launch vehicle. Described here is the mission plan, photographic coverage, and the spacecraft configuration and systems. R.L.K.

N65-18937*# Arizona Univ., Tucson. Lunar and Planetary Lab.
COMMUNICATIONS OF THE LUNAR PLANETARY LABORATORY, VOLUME 3, NO. 40: THE SYSTEM OF LUNAR CRATERS, QUADRANT II

D. W. G. Arthur, Alice P. Agnieray, Ruth A. Horvath, C. A. Wood, and C. R. Chapman
(Grant NsG-161)
(NASA-CR-57208) CFSTI: HC $3.00/MF $0.75

The designation, diameter, position, central-peak information, and state of completeness are listed for each discernible crater in the second lunar quadrant with a diameter exceeding 3.5 km. The catalog contains more than 2000 items and is illustrated by a map in 11 sections. Author

N65-18944*# Stanford Univ., Calif. Radioscience Lab.
RESEARCH AT THE STANFORD CENTER FOR RADAR ASTRONOMY Semiannual Report, No. 4, 1 Jul.–31 Dec. 1964
V. R. Eshleman Jan. 1965 11 p refs
(Grant NsG-377)
(NASA-CR-57184) CFSTI: HC $1.00/MF $0.50

Research covered includes theoretical and experimental radio and radar studies of lunar and planetary ionospheres, atmospheres, and surfaces, and radar studies of the sun and interplanetary medium. Specific projects cover a radar-occultation method for the study of planetary atmospheres, possible models for the atmosphere of Mars, magnetohydrodynamic waves in interplanetary space, a solar radar program, studies of cislunar gas, and data processing. D.E.W.

N65-19313# Lincoln Lab., Mass. Inst. of Tech., Lexington.
DRAFT PROGRAM DESCRIPTION FOR RADAR AND RADIOMETRIC LUNAR SURFACE STUDIES
P. B. Sebring, ed. 20 Nov. 1964 53 p refs *Its* Group Report 1964–65
(AD-609384)

A radar and radiometry study of the surface of the moon has revealed basic data on the lunar surface. Radar mapping showed that major craters are strong scatterers, which implies the presence of solid rock. Data on backscatter gain allow calculation of the reflection coefficient, from which an approximate dielectric constant of 2.8 was derived. This constant, along with thermal data obtained by radiometry, suggests a surface bulk density of about 50%. The nature of future microwave radar, optical radar, and radiometry studies of the moon was determined from these earlier results; the proposed studies are described. J.M.D.

N65-19656# Aeronautical Chart and Information Center, St. Louis, Mo.
CARTOGRAPHIC REDUCTION OF RANGER VII MISSION
Dec. 1964 16 p
(ACIC-TP-16; AD-609262)

A series of five charts was prepared from the photographic data produced by the Ranger VII mission. These charts are described. Characteristics of the data are given, including cameras, calibration, scanning sequence, telemetry, and the orbit and trajectory of the Ranger vehicle. Processes of data reduction included the preparation of a photographic mosaic and relief drawings, the measurement of shadows, and the computation of relative heights. Techniques of preparing and using stereoscopic views of the lunar surface are described. D.E.W.

N65-19768*# Ohio State Univ., Columbus. Antenna Lab.
[STUDIES OF THE RELATIONS BETWEEN THE RADAR SCATTERING PROPERTIES OF "MOON-LIKE" SURFACES AND THEIR SURFACE FEATURES] Semiannual Summary Report, 1 May–31 Oct. 1964
Robert C. Taylor 10 Feb. 1965 4 p refs
(Grant NsG-213-61)
(NASA-CR-57313) CFSTI: HC $1.00/MF $0.50

This report summarizes the work carried out on studies of the relations between the radar-scattering properties of moon-like surfaces and their surface features. Three areas of study were pursued to provide fundamental data concerning the determination of the physical characteristics of a surface with emphasis on the lunar-type surfaces from the electromagnetical scattering characteristics. These areas of study are (1) theoretical studies of the two-frequency radar experiment and other experiments that might prove of value, (2) measurement of the complete scattering properties of moonlike surfaces on the model range, and (3) measurement of the scattering properties of the moon. Author

N65-19775*# IIT Research Inst., Chicago, Ill. Technology Center
STUDIES OF LUNAR SOIL MECHANICS, Final Report, Jun. 15, 1963–Dec. 15, 1964
E. Vey and J. D. Nelson Feb. 1965 142 p refs
(Contract NASr-65(02))
(NASA-CR-57281) CFSTI: HC $4.00/MF $1.00

This program investigated properties of simulated lunar soils in lunar environment. Experiments were performed on samples of quartz and olivine powders and fine and coarse grained quartz sand having various grain size distributions. Vacuum levels ranged from atmospheric pressure to the low 10^{-11} torr range with temperatures from approximately 250° to 0° F. The vacuum in the pores of a soil sample could be two to three orders of magnitude less than the chamber vacuum. However, the dominant factor affecting the soil properties was the amount of adsorbed gas removed from the soil grains. Removal of adsorbed gas caused development of attractive interparticle forces which caused an increase primarily in the apparent cohesion at room temperature with further removal of gas under elevated temperatures causing an increase primarily in the angle of internal friction. Low temperatures also caused an increase in apparent cohesion under vacuum. In the olivine powder, the vacuum caused an increase in apparent cohesion at elevated temperatures. In sand, ultrahigh vacuum and elevated temperatures increased the angle of internal friction. Author

N65-19900*# National Aeronautics and Space Administration, Washington, D. C.
LUNAR SURFACE STUDIES A Continuing Bibliography, Apr. 1964–Jan. 1965
Mar. 1965 61 p refs
(NASA-SP-7003(01)) CFSTI: HC $1.00/MF $0.75

Contained in this bibliography are references to a variety of specific topics including the theory of lunar origin, the lunar atmosphere, and the physical characteristics of the body such as its topography, geology, cartography, and stratigraphy. Techniques of lunar observation, measurement, and analysis, e.g., photography, photometry, and spectrophotometry, are amply covered, and pertinent references to the instrumentation and equipment used in lunar investigation have also been included. R.W.H.

N65-20315 Grumman Aircraft Engineering Corp., Bethpage, N. Y.
DEVELOPMENT OF AN OMNIDIRECTIONAL ACCELEROMETER
L. E. Dunbar *In* NRL Shock and Vibration Bull. Feb. 1965 p 41–44 (See N65-20313 10-14)

A program to develop to prototype form an accelerometer sensitive only to the magnitude of applied acceleration is discussed. The program's intent is to apply the device as a lunar soil penetrometer. The principle and design are directly applicable to shock-mount evaluation and other similar needs of the packaging industries in which the direction of the sensed acceleration is of no concern. The instrument achieves this through flexural elements and produces a high level dc output signal. In the breadboard model, on which tests will be performed, the instrument occupies a 3 × 3 × 3-inch volume. The production unit is expected to have one-fourth the bulk. The design goal is 2% overall accuracy, a 50-g range, and a natural frequency of 100 cps. Author

N65-20421*# Parametrics, Inc., Waltham, Mass.
LOW LEVEL RADIATION ALTIMETER SYSTEM STUDY
L. L. Bird and C. A. Ziegler 15 Oct. 1963 81 p refs
(Contract NAS9-1490)
(NASA-CR-57637) CFSTI: HC $3.00/MF $0.75

Several nuclear radiation techniques were studied as possible means for altitude measurement above the lunar surface, for the range of 0 to 50 ft. Both direct (sources ejected and located on the surface during measurement) and indirect (source aboard the vehicle) systems were considered. Indirect charged particle systems were rejected because of attenuation effects in the rocket exhaust gas, while neutron systems were ejected because of the large amount of hardware required. A gamma backscatter system, using photons of moderate energy (60 keV) was found to be very promising since the source strength requirement (~12 curies) is practical and the weight of the source and detector could be small (~5 lbs.). Author

N65-20442# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering
EXPLOITATION OF LUNAR WATER RESOURCES
Michael Vincent Vasilik (M.S. Thesis) Aug. 1964 85 p refs
(GSF/MECH-64-41; AD-610226)

This report discusses the technical feasibility of exploiting natural lunar water resources. Brief consideration is given to utility, possible abundances, and location of hydrous deposits. The criteria for design of new equipment or adaptation of existing equipment are specified. Based on these criteria, various proposed designs of extraction, electrolysis, and liquefaction equipment are evaluated. Particular emphasis is given to the effects of reduced lunar gravity on operation and design. Extraction equipment under discussion includes separators, evaporators, condensers, compressors, and pumps. Rotating, vortex, membrane, vapor, and porous electrode electrolysis cells are considered. A rotating cell with a palladium cathode appears to be the most promising. For liquefaction of oxygen and hydrogen, engine expansion is found preferable to Joule–Thomson expansion. Author

N65-20898# Army Map Service, Washington, D. C.
HORIZONTAL AND VERTICAL CONTROL FOR LUNAR MAPPING. PART ONE: METHODS
Marvin Q. Marchant Aug. 1960 40 p refs
(TR-29; AD-262889)

Methods for the determination of first- and second-order lunar control are presented in this report. At the time of publication the process of determining the first-order control was almost completed. Author

N65-21020# Army Missile Command, Huntsville, Ala. Redstone Scientific Information Center
SPECTROPHOTOMETRIC OBSERVATIONS OF LUNAR CRATERS
N. P. Barabashov and V. I. Yezerskii Jan. 1965 10 p refs
Transl. into ENGLISH from Izv. Komis. po Fiz Planyet (USSR), no. 3, 1961 p 50–55
(RSIC-361; AD-612878)

Data on differences in the spectral reflectance of separate sections of lunar craters were obtained to study morphological peculiarities of different lunar regions and to determine any changing or active processes. The central hill, eastern and western ridges, and the bottom eastward and westward from the central hill were examined by precise orientation of the spectrograph. No significant anomalies in the reflectance of the separate sections of the craters were observed. After applying an averaging procedure, a slight increase in the spectral reflections of the central hill as compared to the increase of wavelengths of the crater Alphonse was found. The central hill was somewhat redder ($\sim 0^{M}.08$) than the crater. The differences found between the craters and hills of Copernicus and Eratosthenes were within the limits of errors. The curve for Theophilus is analogous to that of Alphonse, whereas a reverse dependence is found for the crater Posidonius. M.P.G.

N65-21130# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering
LUNAR EXCAVATION TECHNIQUES IN ROCK
Joseph John O'Kobrick (M.S. Thesis) Aug. 1964 126 p refs
(GSF/MECH-64-38; AD-610225)

Excavation techniques are studied to determine suitable methods for excavating rocks, like basalt, on the moon under lunar environmental conditions. Desired features are low weight, versatility, reliability, and efficiency. Areas considered are drilling, blasting, and rock moving. A down-the-hole, rotary-percussive tool appears to be the most suitable drill. Other possibilities are shaped charge, rotary, percussive, and shot drills. Chemical high-energy and nuclear explosives are examined for blasting effectiveness. Multiple hole placement of chemical explosives has considerable utility, while nuclear devices can excavate larger quantities of rock with less payload. Suitable rock-moving equipment includes cable-controlled dragline buckets, lightweight hoes, tractor-shovels, bulldozers or dozer-rippers, and conveyor belts. Author

N65-21224 Library of Congress, Washington, D.C. Aerospace Technology Div.
EPHEMERIDES FOR POSITION DETERMINATIONS ON THE MOON'S SURFACE
Edward Gelins *In its* Foreign Sci. Bull., Vol. 1, No. 3, Mar. 1965 p 30–34 refs (See N65-21218 11-34) CFSTI: HC $3.00/MF $0.50

Ephemerides for lunar position determinations have been compiled, together with instructions on their use. The new term "lunar sidereal time" was introduced, and the length of the lunar sidereal hour was determined and compared with terrestrial sidereal time. A special automatic theodolite was designed for use on the lunar surface for selenographic position determinations. Author

N65-21388*# Bern Univ. (Switzerland).
RARE GAS MEASUREMENTS IN METEORITES AND POSSIBLE APPLICATIONS TO THE LUNAR SURFACE
Peter Eberhardt Jun. 1964 75 p Submitted for Publication
(Grant NsG-157)
(NASA-CR-62101) CFSTI: HC $3.00/MF $0.75

Rare gas measurements on meteorites are shown to be useful in determining the history of meteorites and their surroundings, and future applications of these measurements to lunar history studies are discussed. From rare gas measurements on numerous meteorites, analyses were made of radioactive decay of long-lived isotopes, spallation-produced rare

gases, short-lived isotopes, fusion-produced isotopes, and trapped gases; these analyses are said to be useful in determining the time of the individual meteorite's formation, its thermal history, history of cosmic radiation, and the interval between nucleosynthetic processes and formation of meteorite parent bodies. It was concluded that most of the stone meteorites studied were formed 4.5×10^9 years ago. Radioactive age determination of lunar surface features, and of the moon itself, are discussed. Three methods are described for measuring the history of the particle radiation field in the solar system. Erosion, formation of stable and radioactive spallation isotopes, and diffusion loss, are discussed with respect to lunar surface histories. J.M.D.

N65-21460*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
THE DESIGN OF THE RANGER TELEVISION SYSTEM TO OBTAIN HIGH-RESOLUTION PHOTOGRAPHS OF THE LUNAR SURFACE
Donald H. Kindt and Joseph R. Staniszewski 1 Mar. 1965 29 p refs
(Contract NAS7-100)
(NASA-CR-62189; JPL-TR-32-717) CFSTI: HC $2.00/MF $0.50

The design of the television system incorporated into the Ranger spacecraft, which obtained the first high-resolution closeup photographs of the lunar surface on July 31, 1964, is described. The entire system design is presented, including both the ground recovery system and the flight system. The 380-lb flight system includes six cameras, sequencers, command-control circuitry, two transmitters, telemetry system, batteries, power supplies, and thermal control surfaces. Emphasis is given to the design of the cameras, the sequencing and logic required for the various commands, and the transmitter configuration. Such characteristics as camera parameters (sensitivity, line density, spectral response, resolution), the programing of the camera readouts to utilize the available transmitter bandwidth, and the transmission of the outputs of the two transmitters simultaneously over one high-gain antenna are presented. A brief description is given of the mission flight sequence, along with some of the constraints and unknown factors that influenced the design of the television system. The design of the ground recovery system is presented. Author

N65-21770*# Douglas Aircraft Co., Santa Monica, Calif. Missile and Space Systems Div.
EXPERIMENTAL INVESTIGATION OF ULTRA-HIGH VACUUM ADHESION AS RELATED TO THE LUNAR SURFACE Third Quarterly Progress Report, 1 Jan.–31 Mar. 1965
J. A. Ryan 26 Jun. 1964 48 p
(Contract NAS7-307)
(NASA-CR-62220) CFSTI: HC $2.00/MF $0.50

Reliable data for ultrahigh vacuum frictional-adhesional behavior of silicates with possible significance to the lunar surface are reported. These data indicate a definite load dependence for the adhesion as well as a mineral dependence, and give indications (for given faces in contact) of a crystallographic orientation sensitivity. Adhesion forces in excess of 0.4 gm were detected. Adhesion vs. load data were obtained in vacuum, and at atmospheric pressure, on runs made with orthoclase [001] contacting orthoclase [001], orthoclase [001] contacting hypersthene [110], orthoclase [001] vs. albite [001], and orthoclase [001] vs. pure aluminum. Sample surfaces were studied, and roughness plots were made. The nature of the homogeneous surface charging, mosaic charging, dispersion, and ionic-covalent acting forces is discussed. Modifications made to improve the ultrahigh vacuum system included an electron heating-bombardment system for the high temperature bakeout system, a sample holder to obtain parallelism after pumpdown, a device for rezeroing the balance while at vacuum, and a suspension system to overcome vibration problems. L.S.

N65-22162*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
RANGER VII. PART II: EXPERIMENTERS' ANALYSES AND INTERPRETATIONS
Raymond L. Heacock, Gerard P. Kuiper, Eugene M. Shoemaker, Harold C. Urey, and Ewen A. Whitaker 10 Feb. 1965 156 p refs
(Contract NAS7-100)
(NASA-CR-62347; JPL-TR-32-700) CFSTI: HC $5.00/MF $1.00

Analysis of photographs and records transmitted by Ranger VII on July 31, 1964, is presented along with a series of the photographs. Topics of analysis are gross structure of lunar maria, colors and the mesostructure of the maria, structure of Mare Cognitum, structure of crater rays, classes of craters and depressions, structure of the mare floor, frequency of lunar craters, small-scale lineaments on the Ranger VII photographs, the mare ridges, scientific significance of the Ranger VII mission, cratering as the dominant surface process, model of fine structure, erosion, secondary craters, rocks in craters, perfect and imperfect craters, wrinkles on the lunar surface, dimples, valleys, and cracks. The mission is summarized, with respect to the experimenter team, television description, impact area selection, and publication of data. J.M.D.

N65-22451# Little (Arthur D.), Inc., Cambridge, Mass.
STUDIES OF THE PHYSICAL CHARACTERISTICS OF PROBABLE LUNAR SURFACE MATERIALS, PART II Final Report
Peter E. Glaser, ed. Nov. 1964 134 p refs
(Contract AF 19(628)-421)
(AFCRL-64-970(II); AD-613965)

This report presents theoretical and experimental studies to determine the physical properties of probable lunar surface materials in a simulated lunar environment. To accomplish these goals, the following tasks were performed: (1) installation of two ultrahigh-vacuum systems; (2) preparation of and synthesis of materials to simulate the rock compositions most likely to be present on the moon; (3) analysis and experimentation on the surface effects on adhesion; (4) analysis and experimentation on electrostatic effects; (5) studies of radiation damage; and (6) analysis and measurement of thermal properties in a high vacuum. Author

N65-22568# Library of Congress, Washington, D. C. Aerospace Technology Div.
SURFACE CHARACTERISTICS OF THE MOON, MARS, AND VENUS. ANNOTATED BIBLIOGRAPHY
1 Mar. 1965 81 p ref
(ATD-P-65-12; AD-458260) CFSTI: HC $3.00/MF $0.75

An annotated bibliography of the surface characteristics of Mars, Venus, and the Moon is presented with emphasis on light polarization and albedo measurement techniques as well as radio-astronomical studies. Information on tektites is also presented. The report covers 125 research studies from the years 1960 to mid-1963. More recent findings from about mid-1963 through mid-1964 are included in appendixes A to C. G.G.

N65-22972*# Northrop Space Labs., Huntsville, Ala.
APOLLO LOGISTICS SUPPORT SYSTEMS MOLAB STUDIES. GROUND WAVE PROPAGATION ON THE LUNAR SURFACE FOR A LUNAR MOBILE LABORATORY

J. D. Hughlett, Jr. Jun. 1964 44 p refs
(Contract NAS8-11096)
(NASA-CR-61045) CFSTI: HC $2.00/MF $0.50

The results of a ground wave propagation study for an over-the-lunar-horizon communication system are presented. It was found that a frequency in the medium range vertically polarized offered the best application to over-the-horizon type lunar surface communication system. This polarization was chosen because the moon could have a short-circuiting effect on the electrical intensity of the horizontal polarized wave which would offer resistance to this component of the vertical wave. The characteristics of the moon as a conductor can be described in terms of conductivity and dielectric constants. Although no experimental data are available on lunar soil characteristics, the values of conductivity and dielectric constants selected were 10^{-3} to 10^{-4} mhos/meter, and 2.0, respectively. The rf power requirements, antenna efficiency, optimum frequency, and system weight are reported. E.E.B.

N65-23291*# Ling-Temco-Vought, Inc., Dallas, Tex. Military Electronics Div.
LUNAR CONTOUR MAPPING SYSTEM (LUCOM) Final Report, 5 Aug. 1964–18 Mar. 1965
G. M. Goldberg, W. C. Hallmark, and R. H. Myers 31 Mar. 1965 354 p refs
(Contract NAS9-3269)
(NASA-CR-65001; Rept.-4-31200/5R-30) CFSTI: HC $7.00/MF $1.75

Results of this Phase I LUCOM investigation indicate that (1) a practicable radar sensor can be designed for operation at 80 nautical miles above the lunar surface; (2) the data could be converted into digital form and transmitted back to earth for processing; (3) methods and techniques can be conceived for recreating the profiles and using them to map local features; (4) altimetry readings can be used, in combination with associated Apollo data, to recompute a more accurate lunar figure; and (5) the total system can be designed within the physical limits imposed by the Apollo environment. Author

N65-23326*# Stone (Ralph) and Co., Inc., Los Angeles, Calif.
INVESTIGATIONS OF LUNAR SAMPLING AND SAMPLE RETURN METHODS
E. T. Conrad et al [1965] 66 p refs
(Contract NAS9-3549)
(NASA-CR-65000) CFSTI: HC $3.00/MF $0.75

Return of samples of lunar material acquired by Apollo astronauts implies many unique objectives. Minimum contamination from the packaging system and from outside influences are primary requirements. Configurations studied were generally limited to 8 X 11-1/2 X 19 in. drawer-like outer containers and flexible inner bags of various polyester film and aluminum foil laminates. Results indicated the feasibility of a packaging approach involving partial compartmentation of the sample box and ingress of large and small sample bags through a port in the top. Redundant metallic seals generally met the vacuum requirements, but placed an added burden on the latching mechanism to apply a sufficiently high unit force to effect a positive closure. Limited time available to the astronaut for sampling and restricted container volume place significant constraints on the maximum number of individually packaged samples. To improve payload efficiency and return maximum weight it was found that with the bag configurations tested, samples smaller than 2 in. should be packaged in groups of three or more. Author

N65-23807* National Aeronautics and Space Administration, Washington, D. C.
REVIEW OF CONTEMPORARY DATA CONCERNING THE MOON
B. Yu. Levin and Ye. L. Ruskol *In its* Probl. of Cosmogony, Vol. VIII May 1965 p 127–169 refs (See N65-23800 '13-30) CFSTI: HC $6.00/MF $1.50

Contemporary data concerning the motion of the moon, its atmosphere, photometric characteristics, surface temperature, nature of the surface layer, relief, origin of the moon, its thermal history and internal structure are reviewed. Author

N65-24184*# Arizona Univ., Tucson. Lunar and Planetary Lab.
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY, VOLUME 2, NO. 36–39
Gerard P. Kuiper 1964 73 p refs
(Grant NsG-161-61)
(NASA-CR-62820) CFSTI: HC $3.00/MF $0.75

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1. RADIAL STRUCTURES SURROUNDING LUNAR BASINS. II: ORIENTALE AND OTHER SYSTEMS; CONCLUSIONS W. K. Hartmann p 175–191 refs (See N65-24185 13-30)
2. COMPARISON OF THE INFRARED SPECTRUM OF MARS WITH THE SPECTRA OF SELECTED TERRESTRIAL ROCKS AND MINERALS Alan B. Binder and Dale P. Cruikshank p 193–196 refs
3. ON THE DISTRIBUTION OF LUNAR CRATER DIAMETERS William K. Hartmann p 197–203 refs
4. ANALYSIS OF LUNAR LINEAMENTS. I: TECTONIC MAPS OF THE MOON R. G. Strom p 205–216 refs (See N65-24186 13-30)

N65-24185* Arizona Univ., Tucson. Lunar and Planetary Lab.
RADIAL STRUCTURES SURROUNDING LUNAR BASINS. II: ORIENTALE AND OTHER SYSTEMS; CONCLUSIONS
William K. Hartmann *In its* Communications of the Lunar and Planetary Lab. 1964 p 175–191 refs (See N65-24184 13-30) CFSTI: HC $3.00/MF $0.75

A new analysis of mare basins begun by Hartmann (1963) is concluded. The radial systems of the oldest basins are the least developed, while those of the young basins—Mare Imbrium and Mare Orientale—are the most prominent. It is therefore hypothesized that conditions for producing radial lineaments were optimum during the relatively short period when the mare basins were flooded. Many lineaments are spatially associated with this flooding. The basins are probably the sites of great impacts which were accompanied by radiating fractures. Most lineaments are interpreted as the expressions of tectonic adjustments in the stressed crust along these fractures as a result of heating of the subsurface. Most of the adjustment appears to be by vertical motion. There is little evidence for horizontal motion or for gouging of radial valleys by flying fragments. Reviews of the nonradial grid patterns and of the small radial systems around some recent craters are included. Author

N65-24186* Arizona Univ., Tucson. Lunar and Planetary Lab.
ANALYSIS OF LUNAR LINEAMENTS. I: TECTONIC MAPS OF THE MOON
Robert G. Strom *In its* Communications of the Lunar and Planetary Lab. 1964 p 205–216 refs (See N65-24184 13-30) CFSTI: HC $3.00/MF $0.75

Lineaments within 60° of the moon's center of face have been mapped in detail. Four global lineament systems and radial systems associated with four circular maria are delineated. The majority of polygonal crater rims, linear portions of central peaks, crater chains, and certain linear mare ridges are related to the lineament systems. Spatial relationships of

the lineament systems and other data indicate that the global systems resulted from compressive stresses in the moon's crust which were oriented in a north-south direction. Possible causes of these stresses are (1) the gradual subsidence of the tidal bulge, (2) expansion and contraction of the moon, (3) lunar body tides, (4) convection currents within the moon as postulated by Runcorn, and (5) a shift of the moon's axis of rotation. Author

N65-24469# Army Map Service, Washington, D. C.
HORIZONTAL AND VERTICAL CONTROL FOR LUNAR MAPPING. PART TWO: AMS SELENODETIC CONTROL SYSTEM 1964
Sam Breece, Marian Hardy, and Marvin Q. Marchant Mar. 1964 161 p refs
(TR-29; AD-460485)

The largest fundamental selenocentric control adjustment ever obtained from astronomical research was completed. The control contains almost twice as many points as, and covers 30% more area than, any previous adjustment. There are 256 points in an equal-area distribution over the portion of the moon visible from the earth. The average point was measured on six photographic plates. The rms horizontal and vertical uncertainties of the system are, respectively, ±1094 and ±858 meters. The data will be refined through a determination of the radius and figure of the moon based on the new control system. Author

N65-24717*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
ENGINEERING LUNAR MODEL OBSTACLES (ELMO)
J. R. Olivier and R. E. Valentine 8 Mar. 1965 56 p
(NASA-TM-X-56451; TR-145-D) CFSTI: HC $3.00/MF $0.50

This report presents an analytical procedure for determining the energy required by a lunar roving vehicle for negotiating small obstacles. Some results of a limited parametric analysis generated by use of this procedure are included. Energy requirements are calculated for a typical vehicle to illustrate the use of the data, and to establish a base line value. Author

N65-24774*# National Aeronautics and Space Administration, Washington, D. C.
DESCRIPTIONS OF OBSERVATIONS OF LUNAR VOLCANOES IN THE 18TH AND EARLY 19TH CENTURIES [OPISANIYA NABLYUDENIY VULKANOV NA LUNE v XVIII I NACHALE XIX vv]
T. N. Klado Jun. 1965 15 p refs Transl. into ENGLISH from Istoriko-Astron. Issled. (USSR), v. 6, 1 Jan. 1961 p 263-278
(NASA-TT-F-310) CFSTI: HC $1.00/MF $0.50

The outstanding theories of the last 200 years on the question of the existence of lunar volcanoes, from Herschel to present are presented. The propositions of leading investigators are compared as represented by their own documents and letters, in which they defend their own propositions, describe their research methods and findings, and refute or defend others. Explanations are offered in perspective, to disprove past theories defending lunar volcanism. Author

N65-25285# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.
A STUDY OF RADAR PROBING OF THE LUNAR SUBSURFACE
D. J. Germignani Oct. 1964 248 p
(RE-186)

The feasibility of exploring the consistency of rock layers beneath the surface of the moon by analyzing reflected microwaves excited by a radar system installed in a lunar orbiting satellite was studied. Presented are results of a study of a simplified model which disposes of variables as the nature of reflected fields due to a narrow pulsed incident field in the vicinity of a stratified or continuous lossy half-space, and the existence of a low conductivity within the lunar subsurface in order to allow penetration of electromagnetic waves for subsurface analysis, without losing the essential features of the problem. S.C.W.

N65-25698# Boeing Scientific Research Labs., Seattle, Wash. Mathematics Research Lab.
THE NON-HOMOGENEITY OF THE MOON Mathematical Note No. 399
C. L. Goudas Mar. 1965 13 p refs
(DI-82-0421; AD-613645)

Fourier expansions of the lunar profile at libration angles different than zero were found for total eclipse measurements, and compared to the Fourier expansion of the limb for full-moon measurements. It was concluded that the lunar limb as presented by photographic observations is very different from its form, based on the assumption that the moon is everywhere homogeneous. G.G.

N65-26232# Air Force Cambridge Research Labs., Bedford, Mass. Space Physics Lab.
STUDIES OF THE CHARACTERISTICS OF PROBABLE LUNAR SURFACE MATERIALS Special Report No. 20
John W. Salisbury and Peter E. Glaser (Arthur D. Little, Inc.) Jan. 1964 320 p refs Prepared in cooperation with Arthur D. Little, Inc.
(Contract AF 19(628)-421)
(AFCRL-64-970; AD-613018)

This report presents the findings of a cooperative effort by scientists of the Lunar Planetary Research Branch of the Air Force Cambridge Research Laboratories and of Arthur D. Little, Inc., on theoretical and experimental studies to determine the nature and most probable physical form of materials on the lunar surface. The accomplish these goals, the following efforts were performed: (1) installation of an ultra-high-vacuum system to simulate the probable lunar environment, (2) selection of material samples to simulate the probable lunar surface, (3) experimentation on and analysis of these materials in a high vacuum, (4) studies of the behavior of clean surfaces in a high vacuum, (5) measurements of electrostatic phenomena in a high vacuum, (6) measurement of thermal properties in a high vacuum, and (7) spectroscopic studies. Author

N65-27587# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
EXPERIMENTS IN TELEVISION PHOTOGRAPHY OF THE MOON IN THE 0.8-1.1 AND 0.8-2.3 μ RANGE
N. F. Kuprevich 30 Mar. 1965 17 p refs Transl. into ENGLISH from Izv. Astron. Observ. (Paulkovo), v. 23, no. 2, 1963 p 110-114
(FTD-TT-65-90/1+2; AD-614395)

The article describes the results of observing the surface of the moon in the spectral range of 0.8-2.3μ by means of a television system. Comparison is made between infrared photographs and those taken earlier by other authors in the visible range. It was discovered that with an increase in wavelength into the infrared region of the spectrum the photos exhibited an increase in contrast and revealed lunar surface details not

detected on ordinary photographs. It is proposed that the increase in contrast and the appearance of new details in the lunar surface image may be explained by a decrease in luminescent radiation in the infrared rays. Author

N65-27663# Boeing Scientific Research Labs., Seattle, Wash. Mathematics Research Lab.
LUMINESCENCE OF THE LUNAR SURFACE Mathematical Note No. 391
Zdenek Kopal Feb. 1965 41 p refs Submitted for Publication
(DI-82-0410)

Factors involved in the luminescent phenomena from the lunar surface are discussed. Three categories of incident radiation from the moon are considered: scattered sunlight which can be seen from the earth's surface, absorbed and re-emitted sunlight whose waves cannot penetrate the earth's atmosphere and cannot be seen from the ground, and other high energy uv and X-ray quanta and corpuscular radiation from the sun. It is postulated, and observations indicate support, that the recombination of atoms from the third category does not occur by a single transition process as in the other two categories, but by a cascade process giving rise to luminescent emission at longer wavelengths, which can penetrate the atmopshere of the earth and be observable on the ground. Solar influence, direct or indirect, on lunar brightness is cited, and the 11 year solar cycle is related to the luminar luminosity. Observational evidence indicates that the luminescence of the moon occurs and recurs in certain regions on its surface, suggesting strong localization of the luminophor of unknown chemical structure. L.S.

N65-28089*# Texas A&M Univ., College Station. Activation Analysis Research Lab.
AN INVESTIGATION OF COMPUTER-COUPLED, AUTOMATIC, REMOTE ACTIVATION ANALYSIS FOR LUNAR SURFACE ANALYSIS Semiannual Report, Nov. 1, 1964–Apr. 30, 1965
Manchery P. Menon, ed. 1 May 1965 65 p refs
(Grant NsG-256-62)
(NASA-CR-63059) CFSTI: HC $3.00/MF $0.75 CSCL 07D

CONTENTS:

1. TOLERANCE LEVELS OF INTERFERENCE FROM ONE ELEMENT TO THE OTHER IN 14 MEV NEUTRON ACTIVATION ANALYSIS OF SIMULATED MOON MATRIX M. Y. Cuypers 22 p refs (See N65-28090 17-06)
2. DETECTOR RESEARCH C. F. Lam 12 p refs (See N65-28091 17-14)
3. PRELIMINARY STUDIES ON THE POSSIBLE USE OF SINGLE CHANNEL ANALYZERS FOR THE 14 MEV NEUTRON ACTIVATION ANALYSIS OF THE MAJOR ELEMENTS IN ROCK SAMPLES P. Jimenez and L. E. Fite 11 p refs (See N65-28092 17-06)
4. INSTRUMENTAL ACTIVATION ANALYSIS OF METEORITES, SIDEROLITE AND TEKTITE USING 14 MEV NEUTRONS M. P. Menon 11 p refs (See N65-28093 17-06)

N65-29191*# California Inst. of Tech., Pasadena. Seismological Lab.
[EXPERIMENTAL INVESTIGATION OF DEVICES FOR SEISMIC STUDIES OF THE LUNAR SURFACE] Final Report, Oct. 1, 1963–Dec. 31, 1964
31 Dec. 1964 41 p
(Grant NsG-535)
(NASA-CR-63950) CFSTI: HC $2.00/MF $0.50 CSCL 17J

This report is a summary of experimentation conducted in studying the deployment of instrumentation into large arrays by a method applicable to use on the lunar surface. Particular emphasis was placed on its use for extension of an array of geophones or explosive charges to perform a seismic refraction study of lunar layering to depths of approximately 500 feet. N.E.A.

N65-29454*# Cornell Univ., Ithaca, N. Y. Center for Radiophysics and Space Research.
THE IMPLICATIONS OF THE RANGER MOON PICTURES
T. Gold 11 Aug. 1964 9 p refs
(Grant NsG-382)
(NASA-CR-58463; CRSR-176) CFSTI: HC $1.00/MF $0.50 CSCL 03B

The Ranger pictures leave no doubt that erosion is a major effect in shaping the lunar surface. Evidence for errosion occurrence on the lunar surface is presented. The Ranger pictures appear to show mostly a uniform, fine-grained material of low structural strength near the surface and in the first few meters depth. They show no hint of any transition to a different material below, such as a change in the appearence of deeper craters or an occasional out-crop of something looking like rock. It is therefore most likely that one is seeing the same type of material at all the depths excavated by the craters, but very probably in progressively greater compaction and cementation at the greater depth. The Ranger pictures have strengthened the case for dust as the main constituent of the lunar lowlands by not showing any rock formations. N.E.A.

N65-29491*# Arizona Univ., Tucson.
THE WAVELENGTH DEPENDENCE OF POLARIZATION. III: THE LUNAR SURFACE Final Report
T. Gehrels, T. Coffeen, and D. Owings 31 Jul. 1964 2 p Prepared jointly with Indiana Univ., Bloomington
(Grant NsG-493)
(NASA-CR-58739) CFSTI: HC $1.00/MF $0.50 CSCL 03B

Photometric and polarimetric observations of the moon and other objects were obtained. Reductions were greatly facilitated by the use of digitized equipment. Calculations were made on the Mie theory of brightness and polarization predicted for spherical particles with a range of size and refractive index. The calculations were used on the particles in the surface layer of the moon. The results of the observations and the Mie calculations are presented. R.N.A.

N65-30050*# Grumman Aircraft Engineering Corp., Bethpage, N.Y. Grumman Research Dept.
PHOTOMETRIC MEASUREMENTS OF SIMULATED LUNAR SURFACES
J. D. Halajian Jan. 1965 121 p
(Contract NAS9-3182)
(NASA-CR-65083; RM-262) CFSTI: HC $4.00/MF $1.00 CSCL 03B

A photometric investigation of natural specimens at 0°, 30°, and 60° viewing angles, and of geometric solids covered by a backscattering powder is described. Furnace slag, volcanic ash, coral, foam, carborundum, and metallic meteorite are among the specimens considered, and the results are given in graphical form. Artificial and controlled models were used in an attempt to develop an intuitive and, if possible, an analytical grasp of how the geometrical properties of the lunar surface, or any surface, emerge from its photometric properties. The effects of surface roughness, albedo, grain size, and porosity were also investigated, and graphical results are presented. Results confirmed the conclusion that it is unnecessary to postulate a layer of dust on the moon in order to account for lunar photometric data; neither can the presence of lunar dust be ruled out on the basis of these data. C.T.C.

N65-30070# Army Missile Command, Huntsville, Ala. Redstone Scientific Information Center.
COMPARISON OF COLOR AND COEFFICIENTS OF BRIGHTNESS OF DIFFERENT REGIONS ON THE LUNAR SURFACE WITH SOME TERRESTRIAL ROCKS
N. P. Barabashev and A. T. Chekirda Apr. 1965 11 p refs Transl. into ENGLISH from Astron. Zh. (Moscow), v. 33, no. 4, 1956 p 549-555
(RSIC-403; AD-616537)

A comparison of the color and the coefficients of brightness of typical lunar formations with those of some terrestrial substances was made by photographic observations with five light filters: infrared, red, green, blue, and ultraviolet. It was shown that the reflecting power of the lunar surface for the solar spectrum increases towards the red and infrared parts of the spectrum. Of the substances investigated, red quartz porphyry, quartz sandstone, auripigmentum, and volcanic tuff and ashes are most similar to the lunar surface. Average colors of various lunar formations, and the differences in stellar magnitudes for the various regions of the lunar surface, in relation to a white screen, are tabulated. C.T.C.

N65-30658# Cornell Aeronautical Lab., Inc., Buffalo, N. Y.
SOME MORPHOMETRIC PROPERTIES OF THE LUNAR SURFACE—A PRELIMINARY INVESTIGATION FROM LUNAR AERONAUTICAL CHARTS
Richard J. Pike 21 Aug. 1964 120 p refs *Its* Internal Res. No. 86-141
(CAL-VS-1985-C-1; AD-616899)

A numerically-expressed and relatively objective system of topographic description which was used to delimit homogeneous 'terrain regions' in Central Europe is applied to the lunar surface, hoping to delimit reasonably homogeneous topographic regions, and then use the numerical descriptions of these regions to infer, statistically, the configuration of the lunar surface at a scale far below that from which the basic data were taken. The principal objective is to be a prediction of surface roughness, an estimation of the configuration of the microterrain upon which projected manned vehicles would have to land or over which they would maneuver. TAB

N65-30883# Air Force Cambridge Research Labs., Bedford, Mass. Space Physics Lab.
AN INTRODUCTION TO THE GEOLOGY OF THE MOON
Special Report No. 23
Luciano B. Ronca May 1965 37 p refs
(AFCRL-65-357; AD-617721)

An introduction to the study of the moon is presented from a geological point of view. The most important theories on lunar features are presented and discussed, and new interpretations are proposed. Lunar physiography, stratigraphy and tectonics are described. The most important physiographic features are craters, terrae, maria, rilles, wrinkle ridges, rays, halos, mountain ranges, and alpine valleys. From the physiography it is possible to speculate on the geologic processes acting on the moon. These are "space weathering", meteoritic impact, volcanism, ballistic transportation and sedimentation, electrostatic transportation, and tectonism. The stratigraphy has been determined by applying the law of superposition. The column consists of the Pre-Imbrian, Imbrian, Procellarian, Eratosthenian, and Copernican Systems. The future of lunar exploration is discussed. Author

N65-31020# Boeing Scientific Research Labs., Seattle, Wash. Mathematics Research Lab.
THE SELENODETIC CONTROL SYSTEM OF THE ARMY MAP SERVICE
C. L. Goudas Feb. 1965 55 p refs *Its* Mathematical Note No. 390
(DI-82-0409)

Values of the coefficients J_{ij} and J'_{ij} of the expansion into surface harmonics of the lunar surface as presented by the Selenodetic Control System of the Army Map Service are derived. Data for the Marginal Zone are taken from the maps of Watts and Hayn and the measurements of Davidson and Brooks, and the far lunar side is assumed to be symmetrical to the near one. It is found that the present results agree with those derived from the data of Schrutka-Rechtenstamm and are close to the figures for a homogeneous Moon as far as the second zonal and sectorial terms are concerned. There is less agreement in the third surface harmonic and even less in the fourth. The results have little resemblance to those derived from Baldwin's data on exactly the same assumptions. It appears that at present the Selenodetic Control System of the Army Map Service should be rated as the best existing source, followed by the data of Schrutka-Rechtenstamm. Author

N65-32112*# Colorado Univ., Boulder. Lab. for Atmospheric and Space Physics.
FINE STRUCTURE OF THE ABSORPTION CROSS-SECTION OF GASES IN THE ULTRAVIOLET AND AN ANALYSIS OF THE RAY SYSTEM OF THE LUNAR CRATER TYCHO
Scientific Report No. 3, Sep. 1963–Apr. 1964
Martin Sedlacek May 1964 32 p refs
(Contract NASr-86)
(NASA-CR-56924) CFSTI: HC $2.00/MF $0.50 CSCL 03B

The design of an instrument to measure the energy spectrum of electrons, and a theoretical investigation of the Tycho ray system on the moon are considered. The experimental apparatus consists of three main parts: (1) the vacuum-monochromator and the light source; (2) ionization chamber and electron spectrometer; and (3) detector and counter. The fine structure of the absorption process was revealed. The very long rays of the Tycho system are considered. There is evidence, that Tycho's position with respect to the axis of rotation was changed after the deposition of the rays. The system shows left and right-handed curvature with a distince symmetry, indicating that Tycho once was near or even on the equator. It was shown that one can calculate the time which elapsed since the formation of the Tycho system. R.W.H.

N65-32117*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE LUNAR RILLS
Winifred Sawtell Cameron [1964] 8 p refs Submitted for Publication
(NASA-TM-X-54816) CFSTI: HC $1.00/MF $0.50 CSCL 03B

Presented is a discussion on the origin and classification of lunar rills. Considered are valley-like rills, normal-, sinuous-, and crater-chain-rills. Also cited are data from Ranger-VII photographs of the lunar surface. S.C.W.

N65-33536*# Harvard Coll. Observatory, Cambridge, Mass.
A COMPUTER PROGRAM TO SOLVE THE HEAT-CONDUCTION EQUATION IN THE LUNAR SURFACE FOR TEMPERATURE-DEPENDENT THERMAL PROPERTIES
Scientific Report No. 7
Jeffrey L. Linsky 15 Jul. 1965 54 p refs
(Grant NsG-64-60)
(NASA-CR-64833) CFSTI: HC $3.00/MF $0.50 CSCL 20M

A computer program is presented to solve the heat conduction equation for boundary conditions appropriate to the lunar surface during an eclipse and during a lunation. This

program allows for very general representations of the temperature- and depth-dependent thermal properties in a multilayer model. Both infrared and microwave brightness temperatures may be predicted for the Moon and similar rotating bodies in which thermal conduction and radiative transfer are the most significant forms of energy transport near the surface. Author

N65-33552 Bendix Corp., Ann Arbor, Mich. Systems Div.
APPLICATION OF A PHOTOMETRIC TECHNIQUE FOR MAPPING THE LUNAR SURFACE
M. E. Amdursky *In* Mich. Univ. Proc. of the 3d Symp. on Remote Sensing of Environment Feb. 1965 p 29–49 refs (See N65-33550 22-13)

The studies discussed in this paper have been performed to gain knowledge on how the lunar landscape might appear to an image-forming device such as a television camera and display system and how the unique back-scattering lunar photometric function may be utilized to aid in determining the existence and nature of slopes and other lunar features. A simulated lunar model which exhibits the photometric characteristics and an analysis of the accuracies achievable will be described. Means by which a computer can be used to analyze the video data are suggested. The limitations of the technique and its relative value in comparison to other map-making methods such as photogrammetry are also discussed. Author

N65-33666# Naval Research Lab., Washington, D. C.
REPORT OF NRL PROGRESS
Jun. 1965 63 p refs
(PB167681) CFSTI: $1.25

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N65-33667 Naval Research Lab., Washington, D. C.
DECAMETER-WAVE RADAR STUDIES OF THE LUNAR SURFACE
J. R. Davis, D. C. Rohlfs, G. A. Skaggs, and J. W. Joss (RCA Serv. Co., Inc., Camden, N. J.) *In its* Rept. of NRL Progr. Jun. 1965 p 7–16 refs (See N65-33666 22-30) CFSTI: $1.25

An extended series of decameter-wave measurements of the total radar cross section of the moon has corroborated a previous NRL suggestion that this parameter has a substantially larger value in the decameter region than at shorter wavelengths. Examples are given of the ionospheric effects which require decameter-wave measurements conducted over a transionospheric path to be regarded with caution. A beginning study of possible discrete scattering centers located in regions toward the limb of the moon is described. Author

N65-33862*# Boston Univ., Mass.
THE ZONE OF SUPERSONIC FLOW CAUSED BY LARGE METEORITES STRIKING THE LUNAR SURFACE Research Report No. 15
M. P. Batra Mar. 1965 40 p refs *Its* Astron. Contrib. Ser. II, No. 40
(Grant NsG-246)
(NASA-CR-67002) CFSTI: HC $2.00/MF $0.50 CSCL 22A

We have applied the blast-wave theory, utilizing the self similarity technique, for solving the equations of the Fluid-Mechanical model. The penetration of the meteorite to the depth when its velocity becomes acoustic has been found to be equal to 4 to 6 meteorite diameters, depending upon the impact velocity and the mass of the meteorite. This confirms the prediction made by Baldwin for the penetration of the meteorite in the formation of craters with Central Mountain peak. This limit of penetration is called the 'sonic-crater depth' The sonic-crater depth also happens to be approximately equal to the depth of Central Mountain peak from the level ground. The sonic-crater depths can be scaled for different velocities, different masses and different substances using Bjork's scaling laws. The sonic depth, after having been scaled for iron and tuff, agrees fairly well with that computed by Bjork for the meteor crater Arizona. We have also confirmed the 2/3 power law of Eicheiberger & Gehring and Walsh & Tillotson. Author

N65-33965*# Consultants and Designers, Inc., Arlington, Va.
ALTERATION OF LUNAR SOIL'S POLARIZING PROPERTIES BY THE ACTION OF SOLAR PROTONS [L'ALTERATION DES PROPRIETES POLARIMETRIQUES DU SOL LUNAIRE PAR L'ACTION DE PROTONS SOLAIRES]
Audquin Dollfuss and John E. Geake 23 Sep. 1965 6 p refs Transl. into ENGLISH from Comp. Rend. Acad. Sci., Selenographie (Paris), v. 260, 10 May 1965 p 4921–4923
(Contract NAS5-3760)
(NASA-TT-F-9901; ST-LPS-CC-10389) CFSTI: HC $1.00/MF $0.50 CSCL 03B

The photometric and polarimetric characteristics of lunar soil can be modified by solar wind-produced proton bombardment. Some of the mineral matters in powdered state acquire under proton bombardment polarizing properties almost identical to those of lunar soil. Author

N65-34232*# Nuclide Corp., State College, Pa.
THE DISTINCTION OF ROCK TYPES ON THE BASIS OF THEIR MASS SPECTRA, WITH SPECIAL REFERENCE TO LUNAR-SURFACE APPLICATIONS
Werner G. Deuser Washington, NASA, Sep. 1965 18 p refs
(Contract NASw-1062)
(NASA-CR-310) CFSTI: HC $1.00/MF $0.50 CSCL 08G

It is shown that the rock types most commonly expected to be encountered on the lunar surface can for the most part be readily distinguished, chemically, by plotting their relative concentrations of Fe, Mg and Al on a ternary variation diagram. The necessary data for characterizing an unknown as to rock

type can be quite easily extracted from complete or partial mass spectra such as may be obtained by means of a robot mass spectrometer on the lunar surface. For most compositions, determination of only two nuclide or element ratios will characterize the sample. For others, the determination of one additional ratio or comparison with a few standard spectra previously obtained in the laboratory may be necessary to classify the unknown in terms of the chemistry of terrestrial or meteoritic equivalents. No quantitative assay of element concentrations is necessary for such a first classification. Author

N65-34925# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
COSMIC RESEARCH, VOLUME 3, NO. 3
18 Aug. 1965 276 p refs Transl. into ENGLISH of the book "Kosmicheskiye Issledovaniya, Tom III, Vypusk 3" Moscow, Izd. Nauka, 1965 p 347–504
(FTD-TT-65-828/1+2; AD-619986)

Research on space vehicle trajectories and orientation in gravitational fields, measurement of atmospheric density and radiation, and the influence of spaceflight on bacteria and plantlife is reported. For individual titles see N65-34926–N65-34947.

N65-34934 Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
THE PHYSICAL PROPERTIES OF THE LUNAR SURFACE
Ye. L. Ruskol *In its* Cosmic Res., Vol. 3, No. 3 18 Aug 1965 p 76–103 refs (See N65-34925 23-30)

Results of investigations into properties of the lunar surface, conducted during the past two-three years, are reviewed. Data are presented on the characteristics of the lunar surface, averaged over the entire disk of the moon, as well as on local nonuniformities. Results of laboratory simulation of lunar surface conditions are described. The paper examines the relationship between the data on the thermal regime of the upper lunar layers and the problem of the escape of gases from beneath the lunar surface and the history of the lunar atmosphere.
Author

N65-34950*# Jet Propulsion Labs., Calif. Inst. of Tech., Pasadena.
LUNAR AND PLANETARY X-RAY DIFFRACTION PROGRAM Progress Report of Research and Development, Jul. 1964–Mar. 1965
H. C. Speed, J. A. Dunne, and D. B. Nash, ed. 1 Jun. 1965 191 p refs
(Contract NAS7-100)
(NASA-CR-67178; JPL-TM-33-218) CFSTI: HC $5.00/MF $1.25 CSCL 20F

Papers are presented which summarize scientific research and instrument development during the interval from July 1, 1964 to March 1, 1965 in the Lunar and Planetary X-Ray Diffraction Program at the Jet Propulsion Laboratory. For individual titles see N65-34951–N65-34971.

N65-34957* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
GUIDELINES FOR THE DEVELOPMENT OF A LUNAR SAMPLE PREPARATION SYSTEM
D. B. Nash *In its* Lunar and Planetary X-ray Diffraction Program 1 Jun. 1965 p 51–69 refs (See N65-34950 23-14) CFSTI: HC $5.00/MF $1.25

The problem of sample preparation for the X-ray diffractometer is discussed and the guidelines for proper selection and handling of lunar rock samples for X-ray analysis are summarized. Also, minimum sample requirements, sampler-design constraints, and model lunar surfaces for testing sampler mechanisms are presented. Particle size, grain shape, preferred orientation, porosity, homogeneity, thickness, contamination, fractionation, and excessive temperature are considered. The design constraints considered are (1) A minimum of two lunar samples and one Earth standard are to be provided. (2) Pulverization must be simultaneous with sample acquisition. (3) Particles should not be screened for particle size separation. (4) Gravity should not be relied upon for the movement of the sample. (5) Power requirements, weight, and complexity of the system should be as low as possible. E.E.B.

N65-34958* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
DRILLING TEST PROGRAM
G. M. Hotz *In its* Lunar and Planetary X-Ray Diffraction Program 1 Jun. 1965 p 71–78 (See N65-34950 23-14) CFSTI: HC $5.00/MF $1.25

A rock-drill development program was conducted concurrently with an investigation into means of sample acquisition, transport, and transfer for a sampling system for a lunar X-ray diffractometer to be used on unmanned landers. Both rotary and rotary-impact drilling were investigated. Rotary drilling was found to be an adequate means of fragmenting hard rock but a marginal processing method under the limitations imposed. Rotary-impact drilling proved to be much more dependable and efficient means of fragmenting and reproducibly processing hard rock. A mechanical rotary-impact breadboard drill of low power requirements and high efficiency was developed. Constraints, design goals, test procedures, and test results are discussed. It was concluded that a drill designed for the program should have the following characteristics: (1) 40 W power rating; (2) penetration rate of 0.6 inch/min; (3) normal force of 40 lb; (4) impact rate of 200 impacts/min; (5) impact energy per blow of 1 to 1 1/2 ft-lb; (6) bit rotational speed of 20 rpm; (7) bit diameter of 1/2 inch; and (8) tungsten carbide cutter material. E.E.B.

N65-36207# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Grumman Research Dept.
POLARIMETRY AND THE LUNAR SURFACE A Literature Survey
W. G. Egan Apr. 1965 61 p refs
(RM-271)

Light reflected by illuminated materials exhibits polarization, with properties dependent upon the nature of the surface and the angles of incidence and observation. This is caused by reflection, scattering, diffraction, single and double refraction, and absorption, with all processes occurring simultaneously. A survey was made of the literature on planetary polarization, with particular emphasis on that of the lunar surface, and the results are presented herein. Following a short introduction and history, a brief synopsis of polarization theory and photometric definitions is presented. A description of measuring devices ensues, with data presented on lunar observations and laboratory measurements. Particular emphasis is placed on the work of the French group (Lyot, Dollfus), but not to the exclusion of the Russian workers. The conclusion summarizes the present state of the art, and outlines areas where further investigation is required. An extensive bibliography is included.
Author

N65-36318# Manchester Univ. (England). Dept. of Astronomy.
LUNAR COORDINATES AND THEIR DETERMINATION Interim Scientific Report No. 1
Zdeněk Kopal 3 May 1965 57 p refs
(Grant AF-EOAR-64-49)
(AFCRL-65-589; AD-620242)

The methods of determining the apparent lunar coordinates of a point of the surface of the Moon from a photographic plate are derived from first principles. The theory of the determination of relative heights of features on the lunar surface is rigorously formulated, together with the necessary formulae to account for the effects of solar limb darkening. A more general theory applicable to the case of photographs taken from a spacecraft is also derived. Finally, a comprehensive account of the rotation of the Moon and optical librations is given. Author

N65-36554*# Cornell Univ., Ithaca, N. Y. Center for Radiophysics and Space Research.
EFFECTS OF SEVERAL PARAMETERS ON THE OPTICAL PROPERTIES OF SOME ROCK POWDERS, WITH APPLICATIONS TO THE MOON
Hsiu Yung Chen Chow Jun. 1965 49 p refs
(Grant NsG-382)
(NASA-CR-67554; CRSR-200) CFSTI: HC $2.00/MF $0.50 CSCL 08G

The effect of several parameters on the optical properties of some rock powders were investigated to reduce the range of materials suspected of composing the moon's surface. Experiments showed that photometric and polarometric properties of rock powders are critically dependent on particle size and hydrogen ion irradiation dose; surface compaction and chemical composition have less effect. A moderately compacted powdered surface with a particle size distribution which peaks between 1 and 10 microns and irradiated by hydrogen ions for a dose about 90 coul/cm^2, possesses optical properties similar to those of the moon. Varying the chemical composition changes the optical curves slightly; however, by minor adjustments of size distribution and dose, the lunar type curves can be obtained from many different types of rock powders. It is not possible to decide whether the different photometric characteristics of the mares, highlands, and craters are due to differences in chemical composition or to different times of exposure to the solar wind. R.N.A.

N65-36715# RAND Corp., Santa Monica, Calif.
A STOCHASTIC MODEL OF THE FORMATION AND SURVIVAL OF LUNAR CRATERS. II: APPROXIMATE DISTRIBUTION OF DIAMETER OF ALL OBSERVABLE CRATERS
A. H. Marcus (Case Inst. of Tech.) Aug. 1965 41 p refs
(Contract AF 49(638)-700; Proj. RAND)
(RM-4681-PR; AD-620227)

It is assumed that the number density of lunar craters evolves because of the arrival of new craters and the obliteration of earlier craters by the formation of more recent ones nearby. Approximations are developed which permit the calculation of the expected number density of all observable lunar craters as a function of crater diameter and of time. This result is applied to the meteoroidal impact hypothesis for the origin of lunar craters. It is shown that obliteration alone is not sufficient to explain observed crater diameter distributions. Author (TAB)

N65-36783# RAND Corp., Santa Monica, Calif.
A STOCHASTIC MODEL OF THE FORMATION AND SURVIVAL OF LUNAR CRATERS, III: FILLING AND DISAPPEARANCE OF CRATERS
A. H. Marcus Aug. 1965 37 p refs
(Contract AF 49(638)-700; Proj. RAND)
(RM-4682-PR; AD-620228)

A previous model is extended to include the effects of the disappearance of craters due to filling by dust or lava. Both the age distribution and expected number density of lunar craters are obtained as functions of crater diameter and of time. These results are applied to the meteoroidal impact hypothesis of the origin of lunar craters. Good agreement is obtained with observed number densities on the lunar continents and maria. It is assumed that the rate of filling of craters on the continents corresponds to the rate of meteoritic accretion, and the rate of filling on the maria is 50 to 100 times larger than on the continents, corresponding to filling of mare craters by lava. Author (TAB)

N65-36811# Boeing Scientific Research Labs., Seattle, Wash. Mathematics Research Lab.
THE SELENODETIC CONTROL SYSTEM OF THE AERONAUTICAL CHART AND INFORMATION CENTER OF THE U. S. AIR FORCE
C. L. Goudas Jun. 1965 36 p refs *Its* Math. Note No. 413
(DI-82-0443)

Values of the coefficients J_{ij} and J'_{ij} of the expansion into spherical harmonics of the surface of the moon as presented by the selenodetic control system of the Aeronautical Chart and Information Center (ACIC), U. S. Air Force, are derived. Data for the marginal zone are taken from the maps of Watts and Hayn, and the measurements of Davidson and Brooks. It is found that the present values are in good agreement with those derived on the basis of the same data by Schrutka-Rechtenstamm and the Army Map Service. The ACIC Control System approximates best the figure of the moon as this is derived from the study of its physical libration on the assumption of homogeneity. Author

1966
STAR ENTRIES

N66-10342*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
A PHOTOMETRIC METHOD FOR DERIVING LUNAR TOPOGRAPHIC INFORMATION
T. Rindfleisch 15 Sep. 1965 20 p refs
(Contract NAS7-100)
(NASA-CR-67718; JPL-TR-32-786) CFSTI: HC $1.00/MF $0.50 CSCL 22A

A general and rigorous treatment is given of the photometric method for deriving lunar surface elevation information from pictures of the surface. In the course of the derivation certain shortcomings inherent in the method are pointed out. The resulting equations are then applied to the *Ranger* pictures as part of a digital processing procedure and examples are given. Author

N66-10373# Boeing Scientific Research Labs., Seattle, Wash. Mathematics Research Lab.
THE SELENODETIC CONTROL SYSTEM OF THE AERONAUTICAL CHART AND INFORMATION CENTER OF THE U. S. AIR FORCE
C. L. Goudas Jun. 1965 34 p refs *Its* Mathematical Note No. 413
(DI-82-0443)

Values of the coefficients J_{ij} and J'_{ij} of the expansion into spherical harmonics of the surface of the Moon as this is presented by the Selenodetic Control System of the Aeronautical Chart and Information Center, (ACIC), of the U. S. Air Force, are derived. Data for the Marginal Zone are taken from the maps of Watts and Hayn and the measurements of Davidson and Brooks. It is found that the present values are in good agreement with those derived on the basis of the same data derived by Schrutka-Rechtenstamm and the Army Map Service. The ACIC Control System approximates best the figure of the Moon as this is derived from the study of its physical liberation on the assumption of homogeneity. Author

N66-10482# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.
SEARCH FOR A LUNAR SURFACE MODEL. VOLUME II: POLARIMETRY
W. G. Egan May 1965 28 p refs
(RM-276)

In this memorandum, it is indicated that the observed polarization of the electromagnetic radiation (in the range from 0.36 to 1 micron) reflected by the lunar surface yields information from which may be inferred the properties of the layer of the material on the moon that interacts with this radiation. Reported are some initial results of polarimetry work. A large scale photometer previously used for photometry was modified to permit precision measurements of per cent polarization and position of the plane of polarization. Supplementing these measurements, a theoretical program has been initiated utilizing a multiple scattering approach based on detailed material properties. Also, a program has been started to provide detailed specification of materials studied, and the experimental apparatus employed. Author

N66-10609*# Stanford Univ., California. Radioscience Lab.
RESEARCH AT THE STANFORD CENTER FOR RADAR ASTRONOMY Semiannual Report No. 5, 1 Jan.–30 Jun. 1965
V. R. Eshleman Jul. 1965 11 p refs
(Grant NsG-377)
(NASA-CR-67794) CFSTI: HC $1.00/MF $0.50 CSCL 03B

Radar astronomy research is presented on cislunar gas studies, planetary atmospheres and ionospheres, detection of interplanetary shock waves, solar radar studies, and polarization of decametric radiation from Jupiter. R.N.A.

N66-10703*# Northrop Space Labs., Huntsville, Ala.
LUNAR DUST/DEBRIS HAZARDS ASSOCIATED WITH THE MANNED FLYING SYSTEM
R. L. Stark, F. B. Tatom, L. M. Bhalla, and H. W. Hsu Huntsville, Ala., NASA. Marshall Space Flight Center, Oct. 1965 34 p refs
(Contract NAS8-20082)
(NASA-CR-61106) CFSTI: HC $2.00/MF $0.50 CSCL 22A

The results are presented of a preliminary investigation to determine the nature of potential hazards associated with the impingement of the exhaust gases of the Manned Flying System (MFS) on a dust- and/or debris-covered lunar surface. An engineering model is established based on the results of preceding investigations. The behavior of individual particles of dust, set in motion by jet impingement, is predicted. The results indicate that there is a possibility of dust/debris directly striking the MFS only at very low altitudes (less than six feet) with impingement craters of small radii (less than 4.5 feet). The distance out to which particles are thrown is considerable, however, ranging as high as 1200 miles, and the possibility does exist that particles may strike personnel or equipment on the lunar surface in the vicinity of the landing site of the MFS. The possibility also exists that, during the descent or ascent of the MFS in the proximity of sheer, vertical surfaces, projected particles may ricochet off such surfaces and then strike the MFS. Author

N66-10995 Air Force Cambridge Research Labs., Bedford, Mass.
THE LUNAR ENVIRONMENT
John W. Salisbury, Donald H. Eckhard, and Mahlon S. Hunt *In its* Handbook of Geophys. and Space Environment 1965 16 p refs (See N66-10976 02-13)

A detailed discussion is presented on various aspects of the lunar environment. Included are examinations of the lunar atmosphere, thermal environment, magnetic field, composition, surface and subsurface structure, resources, motion, gravity field, and suggested values of lunar constants. R.N.A.

N66-11771*# Cornell Univ., Ithaca, N. Y. Center for Radiophysics and Space Research.
OPTICAL PROPERTIES OF THE MOON'S SURFACE
Bruce W. Hapke Jun. 1965 34 p Presented at the Conf. on the Nature of the Surface of the Moon, Goddard Space Flight Center, Greenbelt, Md., Apr. 1965
(Grant NsG-382)
(NASA-CR-67973; CRSR-198) CFSTI: HC $2.00/MF $0.50 CSCL 03B

A discussion is given of the optical properties of the moon's surface, and what can be deduced concerning the outermost millimeter or so of the lunar surface when these properties are combined with appropriate laboratory studies. Such parameters as brightness, color, radiation, and composition are considered. Strong indications are that the surface is covered with a layer of fine dust of unknown thickness. Tentative indications are that the differences in the photometric properties of the light and dark areas are at least partly due to real differences in the composition, and not just to differences in exposure age. Photometric characteristics are given in graphical form, and include normal albedo, backscatter ratio, polarization, color, and brightness. C.T.C.

N66-11876*# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.
PHOTOMETRIC MEASUREMENTS OF SIMULATED LUNAR SURFACES
J. D. Halajian Jul. 1965 180 p refs
(Contract NAS9-3182)
(NASA-CR-65169; RE-219) CFSTI: HC $5.00/MF $1.00 CSCL 22A

The primary purpose of these investigations is to infer certain physical properties of the lunar surface from terrestrial specimens that reproduce the lunation curves of the moon at representative longitudes. An improved photometer capable of examining 3-inch diameter areas at all phase angles, including 0°, has been developed and used to measure the brightness versus phase relationship of "natural," "artificial," and "controlled" models. Good photometric agreement with the moon at 0°, 30° and 60° longitudes is obtained with "natural" specimens including fine dust, coarse volcanic cinders, furnace slags, sea corals, metallic meteorites, etc. Contrived models confirm the importance of low albedo and high porosity as key photometric properties and suggest that the surface of the moon is nearly uniformly covered with an "underdense" microporous material having innumerable, random, sharp edges and overhanging members. Author

N66-12050# Manchester Coll. of Science and Technology (England). Physics Dept.
LABORATORY SIMULATION OF LUNAR LUMINESCENCE Annual Summary Report No. 1
J. E. Geake Apr. 1965 11 p refs
(Contract AF 61(052)-798)
(AFCRL-65-656; AD-620507)

The luminescence of possible lunar surface materials, including a range of different types of meteorite, is investigated. A beam of protons is used to excite luminescence. The luminescence spectrum is analyzed by means of a photoelectric grating spectrophotometer. TAB

N66-13364*# Arizona Univ., Tucson.
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY, VOLUME 3, NUMBER 50
D. W. G. Arthur et al 1965 163 p refs
(Grant NsG-161)
(NASA-CR-68590) CFSTI: HC $5.00/MF $1.00 CSCL 03B

The designation, diameter, position, central peak information, and state of completeness are listed for each discernible crater with a diameter exceeding 3.5 km in the third lunar quadrant. The catalog contains about 5200 items and is illustrated by a map in 11 sections. Author

N66-14001*# Minnesota Univ., Minneapolis. Dept. of Electrical Engineering.
REPORT OF AUGUST 1965 TYCHO MEETING
[1965] 448 p refs Meeting held in Boulder, Colo., Aug. 1965
(Contract NSR-24-005-047)
(NASA-CR-68896; TG-1) CFSTI: HC $7.48/MF $2.25 CSCL 22A

The results of the TYCHO Study Group conference on the lunar surface are reported and include its conclusions and recommendations, aspects and comments on present knowledge of the lunar surface, a summary of lunar surface research contributions, and the background of the TYCHO Study Group. The appendices contain the research contributions which include papers on lunar internal temperatures, lunar surface erosion by meteor impact, lunar radar studies, lunar volcanism, photography on the moon's surface, dust levitation on the lunar surface, the potential and electric field at the lunar surface, interpreting brightness and polarization curves of the moon, electromagnetic and thermal properties of the moon's surface, evidence for a particulate matter in space and its potential accretion rate by the moon and Earth, mechanisms for lunar luminescence, structure of the lunar dust layer, and some considerations concerning radar returns from the lunar limb. R.N.A.

N66-14322# Manchester Univ. (England). Dept. of Astronomy.
RESEARCH INTO METHODS OF DETERMINING THE RELATIVE HEIGHTS OF PHYSIOGRAPHIC FEATURES OF THE MOON Final Report
G. A. Mills 29 Jan. 1965 17 p ref
(Contract AF-61(052)-524)
(AFCRL-65-431; AD-623669) CFSTI: HC $1.00/MF $0.50

The relative merits of two alternative methods for determining the shape of the Moon are considered. It is concluded that the terminator method is inferior to the libration method because of the law of reflection of light from the surface of the Moon is not well known and cannot be ignored. Author (TAB)

N66-14550# Boeing Scientific Labs., Seattle, Wash. Mathematics Research Lab.
THE NATURE OF SECONDARY CRATERS PHOTOGRAPHED BY RANGER VII Mathematics Note No. 430
Zdenek Kopal Sep. 1965 42 p refs
(DI-82-0475; AD-623299) CFSTI: HC $2.00/MF $0.50

A mathematical theory of the ejection of secondary fragments from the focus of primary impacts on the Moon has been developed for the case of a spherical bounding surface. An application of the results to the frequency–distribution of the secondary lunar craters in the region of Mare Cognitum, as determined from photographs secured by Ranger VII in July 1964, leads to a conclusion that the sum total of the mass required to produce all observed craters or crater-like formation in Mare Cognitum overlying Tycho's rays by secondary impacts of particles ejected from Tycho would—if spread evenly over the surface—cover the ground by a layer of debris about half a metre in thickness at the distance of 1000 km from the focus of ejection; and the volume of the material thus splashed out all over the Moon would exceed the volume excavated by the primary impact at least ten to twenty times. On the strength of this evidence a hypothesis is advanced that a large fraction of depressions, smaller than 1 km in size, counted as craters due to secondary impacts, are in reality subsidence formations, possibly triggered by 'moonquakes' which must occur in the wake of all major primary impacts on the Moon. Author (TAB)

N66-14644# Air Force Cambridge Research Labs., Bedford, Mass. Lunar-Planetary Research Branch.
STRUCTURES INSIDE A LUNAR CRATER PHOTOGRAPHED BY RANGER VII
Vern G. Smalley and Luciano B. Ronca Nov. 1965 19 p refs

Frame number 199 of Ranger VII's camera A reveals three structures in a 235 meter diameter crater. The three features were analyzed in three different ways, using three-dimensional clay models, tonal contour maps, and over-exposed-underdeveloped prints. The conclusion that the structures are the result of an impact appeared unlikely due to the presence of steep walled structures and topographic lows. The endogenous theory is favored and it is suggested that mechanisms such as rootless volcanic activity, real volcanic activity, or venting volatiles are responsible for this feature. E.E.B.

N66-14959*# Arizona Univ., Tucson.
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY, VOLUME 3, NO. 41-49
1965 77 p refs
(Grants NsG-161; NsG-487)
(NASA-CR-69204) CFSTI: HC $3.00/MF $0.75 CSCL 03A

Research activities pertaining to lunar and planetary sciences are reported. The period of revolution of Miranda, a satellite of the planet Uranus, was reevaluated from plate measurements obtained by an 82-inch reflector telescope; the orbit of Comet 1947 VI (Wirtanen) was calculated to be elliptical on the basis of an improved least squares adjustment of the elements; preliminary drawings of lunar limb areas are depicted; and photographs of volcanic sublimates on earth with relevance to the lunar surface, are presented. In addition, numerical calculations for a wide angle filter lens were made; and experimental investigations on electrostatic filter lenses with wide image angles were made. Also discussed are the transmittances of some optical materials for use between 1900 Å and 3400 Å. The geographic coordinates of an observatory station were determined. L.S.

N66-14962*# Ohio State Univ. Research Foundation, Columbus. Antenna Lab.
TWO EXPERIMENTS YIELDING LUNAR SURFACE INFORMATION EMPLOYING POLARIZED RADAR WAVES
Donald E. Barrick 15 Aug. 1965 62 p refs *Its* Rept.-1388-17
(Contract NsG-213)
(NASA-CR-69202) CFSTI: HC $3.00/MF $0.75 CSCL 03A

Two experiments are discussed which permit the determination of the local statistical backscattering properties of the lunar surface or the surface of another planet. The first experiment employs the return from a range ring of the moon, i.e., the fact that a transmitted radar pulse of the proper length illuminates only a certain well-defined annular portion of the lunar surface at a time. The second experiment makes use of the doppler spreading of a discrete CW incident wave upon the lunar surface which is moving (rotating and translating) in a predetermined manner. The value in obtaining these local statistical backscattering properties is that they can be compared directly to similar properties of a variety of surface samples from the earth. From this comparison one can learn more about lunar surface composition, roughness, and average dimensions of surface features without having to rely upon the assumption of a certain model or theory of scattering in the formulation of the problem. Author

N66-14968*# Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div.
STUDY OF THE FEASIBILITY OF AN EARLY LUNAR FLARE Final Report

Jul. 1964 139 p
(Contract NAS7-281)
(NASA-CR-69194; SM-47954) CFSTI: HC $4.00/MF $1.00
CSCL 22A

Static and dynamic compatibility, mixture-ratio combustion, air combustion, impact, and spectroscopic tests were conducted on candidate materials for establishing the technical feasibility of using a high-temperature chemical flare concept for determining the approximate chemical and physical characteristics of simulated lunar surface materials. The combustion test results indicate that a slightly aluminum-rich mixture-ratio gives the best performance, and when extrapolated to lunar flare size, should give a light yield adequate for observation from earth. Soil penetration tests together with spectroscopic tests confirm the fact that light yield decreases with an increase of depth showing the importance of having a low area-density flare to minimize this effect. Results obtained in light gas gun impact tests indicate that flare initiation does occur when impacting a hard or soft target at lunar impact speeds. Other analyses of test results are also made, and recommendations are given. L.S.

N66-15055*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A STUDY OF LUNAR LANDING SITES AND ASSOCIATED STAY TIMES

Laurence W. Enderson, Jr. Washington, NASA, May 1965 38 p refs
(NASA-TN-D-2795) CFSTI: HC $2.00/MF $0.50 CSCL 22A

A study utilizing the results of a patched conic approximation was conducted to determine the possible landing sites and associated stay times on the lunar surface that are compatible with the lunar-orbit-rendezvous technique. Particular emphasis is placed on landing sites that allow a return to the established lunar orbit at all times during the exploration period. Three different landing and take-off maneuvers are considered as well as the effect of variations of the energy and inclination of the earth-to-moon transfer trajectory. Consideration is given to maneuvers that permit the most flexibility in selection of landing sites as well as maneuvers that allow the longest stay time on the lunar surface for a given total plane-change capability. The results of this study indicate that the landing sites and associated stay times are strongly dependent on the inclination of the established lunar orbit as well as the specific landing and take-off maneuvers that are employed. If the inclination of the established lunar orbit is constrained to equal the sum of the landing-site latitude ϕ and the plane-change capability δ, much versatility exists in the selection of possible landing sites on the lunar surface and in the corresponding stay times. Employment of a plane-change capability during the take-off maneuver allows extended exploration periods and provides an inherent safety factor for the mission. Author

1965
IAA ENTRIES

A65-15054 #
MAGNETIC SHIELDING OF THE LUNAR SURFACE FROM THE SOLAR WIND AS A FUNCTION OF LUNAR MAGNETIC MOMENT.
L. Aronowitz and S. N. Milford (Grumman Aircraft Engineering Corp., Research Dept., Bethpage, N.Y.).
Journal of Geophysical Research, vol. 70, Jan. 1, 1965, p. 227-229. 12 refs.

Discussion of the shielding a possible lunar magnetosphere might provide the lunar surface from the solar wind. Calculations of the Earth's magnetosphere are scaled to determine the shielding effects of a lunar magnetosphere. It is found that a lunar magnetic moment even 1/10,000 of that of the Earth could drastically reduce the solar wind's interaction with the lunar surface, as well as its interaction with the lunar atmosphere. P.K.

A65-15096
HOW SOON TO THE MOON?
George E. Mueller (NASA, Office of Manned Space Flight, Washington, D.C.).
Grumman Horizons, vol. 4, no. 2, 1964, p. 4-11.

Evaluation of the Apollo program time schedule by comparison of its time phasing with other major research and development programs, with a discussion of the cost aspects of a program stretch-out and the effect of the space environment on the schedule. It is considered that the progression in the Apollo development cycle is phased in a logical manner without the need for major state-of-the-art breakthroughs, and that the overall time allotted for Apollo of about eight years is significantly greater than that for any comparable programs. It is shown that a decelerated program would increase rather than decrease costs mainly because fixed operating, personnel, and facilities costs would increase. In discussion of space environmental effects, those of meteoroids, radiation, and the lunar surface are each examined in some detail. Results of six years of manned and unmanned space exploration are cited as evidence that, for the first two, the hazards are negligible, and in some cases may have been overestimated. With reference to the lunar surface, such information as is available at present is outlined, and planned additional unmanned exploratory flights are briefly described. It is concluded that a 3-yr stretchout would increase costs by 15%, and a 6-yr stretchout by 30%. F.R.L.

A65-15141
SOURCE OF EVOLUTION OF GAS FROM THE LUNAR CRATER ALPHONSUS.
Alvin J. Cohen (Pittsburgh, University, Dept. of Earth and Planetary Sciences, Pittsburgh, Pa.).
Nature, vol. 201, Mar. 7, 1964, p. 1015, 1016. 6 refs.

Note dealing with Kozyrev's observation of Swan bands being emitted by C_2 molecules emanating from the lunar crater Alphonsus on the west shore of Mare Nibium, and his hypothesis that the gas periodically issuing from Alphonsus is a result of volcanic eruption. Some observations made by the author are developed into a more plausible mechanism than volcanic eruption for the outgassing observed. The proposed mechanism is essentially one suggested by Urey, in which the black areas on the crater floor of Alphonsus are attributed to explosion of acetylene, that could produce graphite and hydrogen. The source of the acetylene is seen to be a stable solid carbide, such as calcium carbide. V.P.

A65-15341 #
ON THE CENTRAL PEAK IN LUNAR CRATERS.
Z. Kvíz (Prague, Technical University, Prague, Czechoslovakia).
Astronomical Institutes of Czechoslovakia, Bulletin, vol. 15, no. 6, 1964, p. 227-230.

Mathematical analysis to support the hypotheses of Stanjukovič and Link that central peaks may arise in lunar craters as a result of meteorite impacts. Small openings in the peaks are not seen to contradict the meteoric origin of the craters: under favorable conditions, peaks with holes in their centers may form if the depth to which the meteorite penetrates into the surface layer is small. Also studied is the ratio of the penetration depth to the radius of the zone of vaporized material, as a function of the velocity of the meteorite. This ratio is found to be a maximum when the fall is vertical and the velocity exceeds the critical velocity (3 to 5 km/sec) for material vaporization by a factor of 4.5; low values occur at velocities close to critical and at large zenith distances of the meteorite path.
(Author) W.M.R.

A65-15637
ORIGIN OF THE LUNAR CRATERS.
Brian J. Ford.
Spaceflight, vol. 7, Jan. 1965, p. 13-17. 20 refs.

Presentation of a hypothesis of the origin of lunar craters that conforms to neither the volcanic theory nor the meteorite theory. It is supposed that, in the early stages of the formation of the Earth-Moon system, both bodies were more closely associated in space and at much higher temperatures than at present. The state of affairs, it is believed, would have been ideal for the generation of a large electrostatic imbalance between the Earth and the Moon and for the subsequent transfer of electrostatically charged particles. It is thought that the impact of these charges could produce the observed distribution of craters on the lunar surface. Observation of craters (some with central peaks) produced in mild steel by means of a spark-machining apparatus reveals similarities that are seen as strong supporting evidence. Ranger 7 photographs and photographs of craters in mild steel are included. D.H.

A65-15693
NONUNIFORMITY IN THE PROPERTIES OF THE TOP LAYER OF THE LUNAR SURFACE.
V. S. Troitskii (Gor'kovskii Gosudarstvennyi Universitet, Radiofizicheskii Institut, Gorki, USSR).
(Astronomicheskii Zhurnal, vol. 41, July-Aug. 1964, p. 724-732.)
Soviet Astronomy, vol. 8, Jan.-Feb. 1965, p. 576-582. 24 refs.
Translation.
[For abstract see Accession no. A64-27457 23-05]

A65-17766
A STOCHASTIC MODEL OF THE FORMATION AND SURVIVAL OF LUNAR CRATERS. I - DISTRIBUTION OF DIAMETER OF CLEAN CRATERS.
Allan Marcus (California, University, Berkeley, Calif.).
Icarus, vol. 3, Dec. 1964, p. 460-472. 27 refs.
NSF Grants No. GP-10; No. GP-117.

Construction of a model of the phenomena underlying the observable distribution of diameters of lunar craters. Three important aspects of crater formation and destruction are considered: (1) the stochastic mechanism underlying the birth of new craters, (2) the damaging of older craters by new craters in the same location, and (3) the formation of secondary craters. The model for primary craters is based on ten assumptions such as perfectly circular craters, Poisson distribution of primary-crater centers, and upper and lower limits to physically realizable crater sizes. Other aspects of the problem that are covered include: the distribution of secondary craters in various regions, the observational identifiability of distributions, and notes on extending the model.
D.H.

A65-17769
MORPHOLOGICAL ASPECTS OF THE LUNAR CRUST.
S. Miyamoto (Kyoto University, Kwasan Observatory, Kyoto, Japan).
Icarus, vol. 3, Dec. 1964, p. 486-490. 5 refs.

Analysis of morphological features revealed by Ranger-7 photographs. The most important factors for the interpretation of the lunar surface features are viscosity of the original magma and thickness of the original crust. Morphological features revealed by Ranger 7 suggest: (1) that the original magma in Mare Nubium is basic and characterized by a rich gas content, (2) that the magmatic differentiation took place at the time of crustal formation, and (3) that craters and other surface features were molded by quiet rather than catastrophic processes. Morphological characteristics directly corresponding to petrological properties of magma are considered in some detail for large-scale tectonics. (Author) D.H.

A65-17770
A MODEL OF THE LUNAR SURFACE.
Thomas Gehrels (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).
Icarus, vol. 3, Dec. 1964, p. 491-496. 24 refs.
Navy-supported research.

Proposal of a working hypothesis, known as the "ping pong" model, which suggests that the lunar subsurface is smooth and firm with little or no dust and that it has an overlying cloud of 0.06-mm thickness consisting of ionized accreted interplanetary particles spaced apart with radii of 0.8 μ. The present model of the top layer of the lunar surface was developed from interpretations of new photopolarimetric observations by Gehrels, Coffeen, and Owings. Radar observations are also considered. D.H.

A65-17942
COEFFICIENTS OF EMISSION IN THE INFRARED REGION OF THE SPECTRUM AND DIFFERENCES IN THE PARAMETER $\gamma = (k\rho c)^{-1/2}$ FOR THE SEA AND CONTINENT REGIONS OF THE LUNAR SURFACE.
M. N. Markov and V. L. Khokhlova (Academy of Sciences, Physics Institute and Astronomical Council, Moscow, USSR).
(Akademiia Nauk SSSR, Doklady, vol. 157, Aug. 1, 1964, p. 826-829.)
Soviet Physics - Doklady, vol. 9, Feb. 1965, p. 621-624. 9 refs.
Translation.

Experimental investigation of the spectral energy distribution over the sea and continent regions of the lunar surface by measuring the color temperature as the ratio of the emission fluxes in two spectral intervals. In this connection, the atmospheric "windows" at 8 to 13 μ and 3.6 μ are used. The second interval for determining the temperature of the lunar surface illuminated by the Sun is situated in the shortwave section of the Planck curve. In particular, the radiation emission from the lunar surface is measured in two spectral regions during the solar eclipse of August 7, 1963. Measurements of the thermal radiation from the unilluminated part of the Moon are also conducted. J.R.

A65-18967
PHYSICS OF THE MOON AND PLANETS [FIZIKA LUNY I PLANET].
Edited by I. K. Koval'.
Kiev, Naukova Dumka, 1964. 140 p. In Russian.

CONTENTS:

A65-18968 #
POLYCHROMATIC POLARIMETRY OF SOME LUNAR AREAS [MNOGOTSVETNAIA POLIARIMETRIIA NEKOTORYKH UCHASTKOV LUNY].
V. V. Avramchuk.
IN: PHYSICS OF THE MOON AND PLANETS [FIZIKA LUNY I PLANET].
Edited by I. K. Koval'.
Kiev, Naukova Dumka, 1964, p. 3-15. 16 refs. In Russian.

Brief discussion of the physical meaning of Umov's effect as interpreted by Rosenberg. A presumption is advanced that, for the lunar case, the dependence of polarization on the wavelength is due to some effect other than Umov's. The results of polarization measurements in eight cross sections of the spectrum ranging from 355 to 600 mμ are presented. It is shown that in the case of a phase of + 12° to 13° the polarization of the areas considered increases toward the red part of the spectrum. For other phases the degree of polarization is an almost monotonically varying function of the wavelength, which increases intensely in the UV light. A relationship is established between the maximum degree of polarization and albedo in narrow fractions of the spectrum. J.R.

A65-18969 #
SPECTROPHOTOMETRY OF DETAILS ON THE LUNAR SURFACE [SPEKTROFOTOMETRIIA OB'EKTOV LUNNOI POVERKHNOSTI].
M. N. Mironova.
IN: PHYSICS OF THE MOON AND PLANETS [FIZIKA LUNY I PLANET].
Edited by I. K. Koval'.
Kiev, Naukova Dumka, 1964, p. 16-29. 9 refs. In Russian.

Presentation of the results of spectrophotometric measurements of selected details on the lunar surface, obtained with a spectrograph in combination with a reflector (D = 70 cm). It is shown that curves of spectral coefficients obtained for various lunar details are similar to those for basaltic tuff. The reflecting properties of crater details (floor, central peak, and walls) are shown to differ slightly. The greatest difference is observed between the central peak and the floor of the Alphonsus crater. For the Aristarchus crater, a rise in radiation intensity in the wavelength regions of λ = 425 and 505 mμ is found, which is explained by the luminescence of rocks covering the crater floor and the walls. J.R.

A65-18970 =
SPECTRAL INVESTIGATIONS OF THE LUNAR SURFACE [SPEKTRAL'NYE ISSLEDOVANIIA LUNNOI POVERKHNOSTI].
A. N. Sergeeva.
IN: PHYSICS OF THE MOON AND PLANETS [FIZIKA LUNY I PLANET].
Edited by I. K. Koval'.
Kiev, Naukova Dumka, 1964, p. 30-45. In Russian.

Analysis of 56 spectrograms of the lunar surface obtained in the period of 1958 to 1960. For 200 different lunar details differences in color in relation to a selected region in the Mare Serenitatis are detected. It is concluded that brightness distribution in the spectra of the details investigated differs from that of the spectrum of the reference region by less than 10%. For some details in the red part of the spectrum, these relative deviations are as high as 15 to 18%. The mean square error of the observations is 30%, the error being greater in the red region of the spectrum due to low dispersion. Due to the relatively low values of deviations, it is concluded that the real color contrast of lunar details is too small to be detected with any confidence by spectrophotometric techniques. J.R.

A65-19102 =
BEARING CAPACITY OF THE LUNAR SOIL.
J. D. Nelson and E. Vey (Illinois Institute of Technology, Research Institute, Chicago, Ill.).
American Society of Mechanical Engineers, Winter Annual Meeting, New York, N. Y., Nov. 29-Dec. 4, 1964, Paper 64 - WA/AV-13. 8 p.
Members, $0.50; nonmembers, $1.00.
Research supported by the Bendix Systems Div.

A study of the effects of the lunar environment on the bearing capacity of simulated lunar soil. Load-penetration relationships were determined experimentally for bearing pads and penetrometers having various cone angles and rates of penetration. Relationships between the two were studied under atmospheric conditions and vacuum levels up to 1×10^{-7} torr. On the basis of the limited data which can be derived from laboratory duplication of lunar environment, the authors conclude that a fine-grained lunar soil will exhibit a substantially greater shear strength than it would under terrestrial environmental conditions, resulting in a relatively higher bearing capacity. Since this increase in shear strength is principally a result of an increase in the apparent cohesion, it is expected that the lower bound of the bearing capacity when computed from penetrometer measurements made in situ will be close to the actual value. D.M.

A65-20087 #
COLOR EXCESSES AND INDICES OF CERTAIN CRATERS OF THE MOON ACCORDING TO ELECTROPHOTOMETRIC MEASUREMENTS [IZBYTKI I POKAZATELI TSVETA NESKOL'KIKH KRATEROV LUNY PO ELEKTROFOTOMETRICHESKIM IZMERENIIAM].
K. I. Kozlova and Iu. V. Glagolevskii.
IN: OBSERVATIONS OF THE MOON, MARS, URANUS, AND THE STARS - OPTICAL PROPERTIES OF PLANTS [NABLIUDENIIA LUNY, MARSA, URANA I ZVEZD - OPTICHESKIE SVOISTVA RASTENII].
(AKADEMIIA NAUK KAZAKHSKOI SSR, SEKTOR ASTROBOTANIKI, TRUDY. VOLUME 8.)
Edited by G. A. Tikhov.
Alma-Ata, Izdatel'stvo Akademii Nauk Kazakhskoi SSR, 1960, p. 125-129. 5 refs. In Russian.

Description of observations of craters of the Moon. The crater Manilius served as reference region. The instruments used and the procedure followed are described briefly. The color excesses and color indices of the craters are determined from formulas given in the article. It is concluded that there are slight differences in the color of the craters studied, that the normal photoelectric color indices of the craters vary from $+0.^{m}717$ to $+0.^{m}890$, and that the mean color index of 14 craters with respect to Manilius amounts to $+0.^{m}830$. A.B.K.

A65-20088 #
SPECTROPHOTOMETRY OF THE SURFACE OF THE MOON. II - CATALOG OF COLOR INDICES OF LUNAR OBJECTS [SPEKTROFOTOMETRIIA POVERKHNOSTI LUNY. II - KATALOG POKAZATELEI TSVETA LUNNYKH OB'EKTOV].
V. G. Teifel'.
IN: OBSERVATIONS OF THE MOON, MARS, URANUS, AND THE STARS - OPTICAL PROPERTIES OF PLANTS [NABLIUDENIIA LUNY, MARSA, URANA I ZVEZD - OPTICHESKIE SVOISTVA RASTENII].
(AKADEMIIA NAUK KAZAKHSKOI SSR, SEKTOR ASTROBOTANIKI, TRUDY. VOLUME 8.)
Edited by G. A. Tikhov.
Alma-Ata, Izdatel'stvo Akademii Nauk Kazakhskoi SSR, 1960, p. 130-151. 16 refs. In Russian.

Description of the method and results of determining the color indices of 262 small areas of the lunar surface. The procedure for making observations and processing data is described in some detail. A catalog of color indices of lunar objects is presented and discussed. It is concluded that small details of the surface of the Moon do not reveal color differences substantially greater than those observed in fairly extensive lunar objects. Color contrasts on the lunar surface are said to be small and to give differences not exceeding $0.^{m}21$ for normal color indices. The normal color indices of lunar objects are said to lie between the limits $+0.^{m}76$ and $+0.^{m}97$. The interdependence between the color and brightness of details of the lunar surface noted by many investigators is said to be confirmed. A.B.K.

A65-20089 #
SPECTROPHOTOMETRY OF THE SURFACE OF THE MOON. III - DIFFERENCES IN THE SPECTRAL PROPERTIES OF LUNAR FORMATIONS [SPEKTROFOTOMETRIIA POVERKHNOSTI LUNY. III - RAZLICHIIA SPEKTRAL'NYKH SVOISTV LUNNYKH OBRAZOVANII].
V. G. Teifel'.
IN: OBSERVATIONS OF THE MOON, MARS, URANUS, AND THE STARS - OPTICAL PROPERTIES OF PLANTS [NABLIUDENIIA LUNY, MARSA, URANA I ZVEZD - OPTICHESKIE SVOISTVA RASTENII].
(AKADEMIIA NAUK KAZAKHSKOI SSR, SEKTOR ASTROBOTANIKI, TRUDY. VOLUME 8.)
Edited by G. A. Tikhov.
Alma-Ata, Izdatel'stvo Akademii Nauk Kazakhskoi SSR, 1960, p. 152-164. 8 refs. In Russian.

Analysis of spectrograms of 90 areas of the lunar surface. The main conclusion of the spectrophotometric and spectrocolorimetric investigations of the lunar surface carried out by the author is that color contrasts of the outer cover of the Moon are very slight, although they can be detected by repeated measurements of the color of each individual object. Spectral differences between lunar objects are said to be no more noticeable than colorimetric differences and to manifest themselves only in the form of slight changes in the slope of the spectral curves. A.B.K.

A65-20090 #
CERTAIN CONSIDERATIONS ON THE STATE OF THE LUNAR SURFACE [NEKOTORYE SOOBRAZHENIIA O SOSTOIANII LUNNOI POVERKHNOSTI].
V. G. Teifel'.
IN: OBSERVATIONS OF THE MOON, MARS, URANUS, AND THE STARS - OPTICAL PROPERTIES OF PLANTS [NABLIUDENIIA LUNY, MARSA, URANA I ZVEZD - OPTICHESKIE SVOISTVA RASTENII].
(AKADEMIIA NAUK KAZAKHSKOI SSR, SEKTOR ASTROBOTANIKI, TRUDY. VOLUME 8.)
Edited by G. A. Tikhov.
Alma-Ata, Izdatel'stvo Akademii Nauk Kazakhskoi SSR, 1960, p. 165-170. 9 refs. In Russian.

Discussion of the color-brightness dependence of certain areas of the lunar surface. A theory concerning the formation of bright spots and bands on the present surface of the lunar seas is proposed. An attempt is made to determine whether the observed optical properties of the lunar surface are the result of a processing of

terrestrial-type rocks under the action of exogenic factors. It is concluded that while lunar rocks of the early period of the history of the Moon may have been similar in optical properties to terrestrial acid and basic magmatic rocks, they were first subjected to the action of endogenic processes, and it was only later that they were affected by meteorites and other exogenic processes.

A.B.K.

A65-20656 #

PHOTOMETRIC INVESTIGATION OF THE POSSIBLE PRESENCE ON THE MOON OF AN OUTER LAYER OF VOLCANIC ORIGIN [FOTOMETRICHESKOE ISSLEDOVANIE VOPROSA O NALICHII NA LUNE POKROVOV VULKANICHESKOGO PROISKHOZHDENIIA].

V. V. Sharonov (Leningradskii Gosudarstvennyi Universitet, Astronomicheskaia Observatoriia, Leningrad, USSR).

Astronomicheskii Zhurnal, vol. 42, Jan.-Feb. 1965, p. 136-144. 16 refs. In Russian.

Study of the dark top blanket of soil in the vicinity of active terrestrial volcanoes in an effort to find an approximate equivalent of the lunar surface. The mean albedo of the Moon (0.09) is much lower than that of ordinary igneous or sedimentary rocks. The photometric data were obtained by expeditions to the Kamchatka Peninsula and to Simushir Island. It was found that in albedo and color characteristics, volcanic sands, slags, and lapilli are indeed similar to some details on the Moon, as confirmed by spectrophotometric data. However, the reflection characteristic (solid-angle wavelength distribution of the reflected light) is symmetrical about the origin, and, therefore, volcanic ash cannot be abundant on the lunar surface. Although fields of lapilli (and, especially, coarse lava flows that are covered by a crust of porous slag) exhibit the same elongation of the reflection characteristic in the direction of the light source as does the Moon, albeit to a lesser degree, the weight of evidence from thermoelectric, radio-astronomical, and radar observations and the photometric uniformity of the lunar surface are seen to favor the hypothesis that exogenic factors operative over the whole satellite - e.g., meteoric bombardment - are responsible for the observed features of the Moon.

(Author) W.M.R.

A65-21166 #

SIMPLE TECHNIQUE OF APPROXIMATION FOR MEASURING THE HEIGHT OF LUNAR MOUNTAINS [EINE NÄHERUNGSMETHODE ZUR MESSUNG DER HÖHEN VON MONDBERGEN MIT EINFACHEN MITTELN].

Alfred Suckow.

Astronomie und Raumfahrt, no. 5/6, 1964, p. 172-177. 7 refs. In German.

Description of a simple technique, intended for the amateur observer, of calculating the elevation of lunar mountains. A simple formula is derived which yields reasonably accurate values. The equipment includes a telescope with a 50-mm objective, an 80X ocular with cross hairs, an ordinary watch, a star calendar with data on lunar distances and declinations, a lunar map with selenographic coordinates, a four-place trigonometric table, and a slide rule.

V.Z.

A65-21355

LUNAR RESOURCES.

John Bensko (NASA, Marshall Space Flight Center, Research Projects Laboratory, Huntsville, Ala.) and Reynold Q. Shotts (Alabama, University, School of Mines, University, Ala.).

IN: ADVANCES IN SPACE SCIENCE AND TECHNOLOGY. VOLUME 7.

Edited by F. I. Ordway, III.

New York, Academic Press, Inc., 1965, p. 147-214. 67 refs.

Introduction to the subject of the use of extraterrestrial resources. The topics considered are: (1) selenology; (2) possible propellant substances indigenous to the Moon; (3) modes of concentration of lunar propellant substances; (4) lunar environment in relation to engineering operations; (5) methods of discovery and evaluation of deposits of lunar propellants or their components; (6) mineral propellant component extraction; (7) propellant synthesis and processing; and (8) propellant storage, transfer and transportation. Basic considerations are offered on the possible variations in geological and geochemical conditions of the Moon, with any problems which arise as a result of the environment in mining and extracting processes, and with the problems of the utilization of these resources on the lunar base. Emphasis is placed on the readily usable (or processable) life-support and propellant substances that may be found on or near planetary or lunar surfaces. Attention is given not only to the question of what resources may be found, but to the question of their form, mode of occurrences, discovery and evaluation, and recovery and processing.

M.M.

A65-22458 #

A NOTE ON "THE ANALYSIS OF RADAR ECHOES FROM THE MOON."

D. G. Rea, N. Hetherington, and R. Mifflin (California, University, Space Sciences Laboratory, Berkeley, Calif.).

Journal of Geophysical Research, vol. 70, Mar. 15, 1965, p. 1565.

Grant No. NsG 101-61.

Extension of earlier work in which a geometric-optics model (rather than a physical-optics model) was used to interpret the 68-cm radar echoes from the Moon. Values of the average slope, rms slope, average normal, and rms normal, found by using the geometric-optics model, are somewhat higher than values of these roughness parameters determined by the physical-optics approach. It was felt that the difference could be attributed to one of three causes: (1) different data due to different orientations of the Moon during the radar studies, (2) differences in the manner of subtracting the "diffuse" component to leave only the "quasi-specular" component, or (3) a fundamental shortcoming of the geometric-optics model in which diffraction is ignored. It has been pointed out by Hagfors that the definition used for the surface averages differs from that used by previous workers in that these workers used a probability referred to the mean surface rather than to the actual surface. Use of the mean-surface probability substantially reduces the values obtained for Cases 1 and 2; - e.g., the average slope for Case 1 was reduced from 21° to 15°. However, since Cases 3 and 4 are only slightly affected and since it was argued that something between Case 3 and Case 4 was most probable, the essence of the conclusions derived from the geometric-optics model remains unchanged.

D.H.

A65-22929 #

LUNAR ENGINEERING [INŻYNIERIA KSIĘŻYCOWA].

Zdzisław Brodzki.

Instytut Lotnictwa, Biuletyn Informacyjny, Apr. 12, 1965, p. 26-30. In Polish.

Review of the principal lunar features deduced from an analysis of lunar probe data. Some competitive hypotheses on the formation of the Moon are discussed, and the peculiarities of lunar surface features are noted. Problems associated with building on the Moon are examined in the light of physical conditions that differ widely from those encountered on the Earth, including shielding against radiation and meteorite impact. The large number of parameters that has to be considered is illustrated by a discussion of a proposed fixed lunar station.

V.P.

A65-23260

COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 2 (Numbers 36-39).

Tucson, University of Arizona Press, 1964. 78 p.

CONTENTS:

A65-23261 #
RADIAL STRUCTURES SURROUNDING LUNAR BASINS. II - ORIENTALE AND OTHER SYSTEMS - CONCLUSIONS.
William K. Hartmann.
IN: COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 2 (Numbers 36-39).
Tucson, University of Arizona Press, 1964, p. 175-191. 28 refs.
Grant No. NsG 161-61.

Completion of an analysis of the basins of lunar maria begun by the author in 1963. The radial systems of the oldest basins were found to be the least developed, while those of the young basins, Mare Imbrium and Mare Orientale, are the most prominent. It is therefore hypothesized that conditions for producing radial lineaments were optimum during the relatively short period when the basins were flooded. Many lineaments are spatially associated with this flooding. The basins are probably the sites of great impacts which were accompanied by radiating fractures. Most lineaments are interpreted as the expressions of tectonic adjustments in the stressed crust along these fractures as a result of heating of the subsurface. Most of the adjustment appears to be by vertical motion. There is little evidence for horizontal motion or for gouging of radial valleys by flying fragments. The discussion includes reviews of the nonradial grid patterns and of the small radial systems around some recent craters. (Author) D.H.

A65-23263 #
ON THE DISTRIBUTION OF LUNAR CRATER DIAMETERS.
William K. Hartmann.
IN: COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 2 (Numbers 36-39).
Tucson, University of Arizona Press, 1964, p. 197-203. 10 refs.
Grant No. NsG 161-61.

Analysis of the data of Arthur et al. on lunar Quadrants I and II (northern hemisphere), including a comparison of the distributions of different "age" classes of craters and a discussion of the implications for crater and mare formation. In the first two lunar quadrants, the diameters (D) of both "young" and "old" craters follow the frequency distribution, $d(\log F)/d(\log D) \simeq -2.1$. For the "youngest" craters, this function remains valid down to D = 8 km. It is probable that throughout the period of crater formation, this relationship was valid for newly formed craters; certainly this is the case at the larger diameters. There is a deficiency of small craters which increases toward the "oldest" classes; there appears to be a process that has eroded very old small craters. The assumption that lunar craters were formed by impacts of bodies having the presently observed asteroidal or meteoritic mass distribution closely predicts the distribution of observed lunar crater diameters. (Author) D.H.

A65-23264 #
ANALYSIS OF LUNAR LINEAMENTS. I - TECTONIC MAPS OF THE MOON.
Robert G. Strom.
IN: COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 2 (Numbers 36-39).
Tucson, University of Arizona Press, 1964, p. 205-216. 15 refs.
Grant No. NsG 161-61.

Description of detailed maps of significant lines of the lunar landscape which reveal the hidden architecture of the rock basement. Lineaments within 60° of the center of the Moon's face have been mapped in detail. Four global lineament systems and radial systems associated with four circular maria are delineated. The majority of polygonal crater rims, linear portions of central peaks, crater chains, and certain linear mare ridges are related to the lineament systems. Spatial relationships of the lineament systems and other data indicate that the global systems resulted from compressive stresses in the Moon's crust which were oriented in a north-south direction. Possible causes of these stresses are: (1) the gradual subsidence of the "tidal bulge," (2) expansion and contraction of the Moon, (3) lunar body tides, (4) convection currents within the Moon as postulated by Runcorn, and (5) a shift of the Moon's axis of rotation. (Author) D.H.

A65-23490
SMALL-SCALE STRUCTURE OF THE LUNAR SURFACE.
P. E. Glaser and A. E. Wechsler (Arthur D. Little, Inc., Cambridge, Mass.).
Icarus, vol. 4, Apr. 1965, p. 104, 105. 10 refs.

Attempt to simulate the structure of the lunar surface, based on information obtained by the Ranger spacecraft and from photometric data. The thermal properties of loose expanded perlite, which is produced from naturally occurring volcanic glassy deposits, were measured and evaluated, taking into account possible effects of hypervelocity micrometeoroid impacts. It is considered that if loose perlite is sintered, a material is formed which fits the requirements imposed by data obtained from observations and laboratory experiments. F.R.L.

A65-23739
LUNAR RESULTS FROM RANGERS 7 TO 9.
Gerard P. Kuiper (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).
Sky and Telescope, vol. 29, May 1965, p. 293-308. 5 refs.

Discussion of the results obtained on the basis of Ranger data combined with earlier Earth-based photography. It appears that the Moon lacks a cover of cosmic dust even 1 mm thick, which would have obliterated the various sharply defined color provinces and other photographic detail. The maria are lava flows or a succession of them. Seven flows have been mapped in a limited region of Mare Imbrium; these are shown on a Lunar and Planetary Laboratory map. Much progress has been made in the interpretation of both positive features (mountains, hills, and ridges) and negative features (craters, depressions, and rilles) on mare floors. Examples of apparent karst-type topography are described, and for comparison a photograph of a snow-covered landscape in southern Indiana is presented and discussed. Crater rays and the fine structure of the mare floor are covered in detail. Illustrations include five ground-based photographs, sixteen Ranger photographs, a photograph of a scale model based on high-resolution Ranger-7 photographs, and a map made by the USAF Aeronautical Chart and Information Center. D.H.

A65-24360
ORIGIN OF LINEAR ELEMENTS ON MARE HUMORUM.
John W. Salisbury, Vern G. Smalley, and Luciano B. Ronca (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Bedford, Mass.).
Nature, vol. 206, Apr. 24, 1965, p. 385-388. 5 refs.

Analysis of the linear rilles, wrinkle ridges, and rays on the lunar surface on and around Mare Humorum. The rilles and wrinkle ridges in this area are found to be arranged in definite and similar patterns. Most of the rays on the mare also form a pattern which, except for its east-west component, is similar to that of the wrinkle ridges and rilles. This similarity of orientation indicates a similar internal lunar origin for these features, possibly related to the lunar crustal fracture pattern. The results also suggest that there may be more than one type of ray, as well as more than one type of crater, on the surface of Mare Humorum. P.K.

A65-24419 #
COMMENTS ON THE PHOTOGRAPHS OBTAINED BY RANGER 7 [KOMENTARZ DO ZDJĘĆ, UZYSKANYCH Z POMOCA PRÓBNIKA RANGER 7].
E. H. Walker.
(Międzynarodowy Kongres Astronautyczny, 15th, Warsaw, Poland, Sept. 7-12, 1964.)
Astronautyka, vol. 8, no. 1, 1965, p. 3-6. In Polish.

Interpretation of photographic material obtained by Ranger 7 as to the composition of the lunar surface. In particular, a photograph made from a distance of 5.8 km of a crater containing a large rock fragment is used to draw conclusions on the composition of the subsurface of the Moon. V.P.

A65-24794 #
RADAR BACKSCATTER FROM THE SURFACE OF THE MOON.
Petr Beckmann (Colorado, University, Dept. of Electrical Engineering, Boulder, Colo.).
Journal of Geophysical Research, vol. 70, May 15, 1965, p. 2345-2350. 11 refs.

Comparison of the experimentally measured dependence of the mean radar power backscattered from the lunar surface on the angle of incidence (delay time) with the theoretical formula based on a lunar surface consisting of a superposition of several normal random processes of different structures. The theoretically derived curve accounts for shadowing and matches the experimental data over almost the entire range of angles of incidence to within ±1 db. The wavelength dependence is also consistent with the observed data as far as they are available. The analysis yields a value of 11° for the rms slope of the lunar surface. (Author) M. M.

A65-25018 #

DISTRIBUTION OF SMALL LUNAR CRATERS BASED ON RANGER 7 PHOTOGRAPHS.

Burton P. Miller (General Motors Corp., Defense Research Laboratories, Santa Barbara, Calif.).

Journal of Geophysical Research, vol. 70, May 1, 1965, p. 2265, 2266.

Fitting of a straight line of the form $N = \log A + B \log D$ (N is the cumulative number of craters per unit area having diameter greater than D, and A and B are parameters determined by least-squares regression) to crater size-frequency data based on the last close-up of the lunar surface transmitted by Ranger 7. In a previous statistical study based on telescopically observable craters (the smallest craters used in the regression were 1.75 km in diam.), values of $A = 855$ and $B = -1.6$ (i.e., $N = 855\ D^{-1.6}$) were obtained for both the maria and the highlands, and extrapolation led to the conclusion that less than 0.05% of the surface of maria is covered with 1- to 10-meter, vehicle-sized craters. Ranger 7 gives $N = 35,000\ D^{-1.856}$. Thus, it is found that a decidedly greater fraction (but still less than 1.5%) of the surface is covered with craters likely to cause serious problems for lunar vehicles.

W. M. K.

A65-25693 #

CHARACTERISTIC LIGHT-SCATTERING CURVES FOR CERTAIN MAGMATIC ROCKS [INDIKATRISY RASSEIANIIA NEKOTORYKH MAGMATICHESKIKH GORNYKH POROD].

N. S. Orlova.

Leningradskii Gosudarstvennyi Universitet, Astronomicheskaia Observatoriia, Trudy, vol. 21, 1964, p. 74-94. 8 refs. In Russian.

Laboratory investigation of 23 samples of terrestrial magmatic rocks to determine their laws of reflection of incident light. The brightness factors for granite, basalt, diabase, volcanic slags, volcanic tuffs, slaggy lavas, and lapilli were measured with the aid of a visual photometer for various combinations of angles of incidence and of reflection. It is found that, from the point of view of characteristic light reflection, the lunar surface most closely resembles volcanic slaggy products. (Author) W. M. R.

A65-25695 #

SPECTROPHOTOMETRIC COMPARISON OF THE LUNAR SURFACE WITH CERTAIN VOLCANIC FLOWS [OPYT SPEKTROFOTOMETRICHESKOGO SOPOSTAVLENIIA POVERKHNOSTI LUNY S NEKOTORYMI VULKANICHESKIMI POKROVAMI].

I. I. Lebedeva.

Leningradskii Gosudarstvennyi Universitet, Astronomicheskaia Observatoriia, Trudy, vol. 21, 1964, p. 99-102. 5 refs. In Russian.

Examination of published data on the spectral reflectivity of the lunar maria and continents and a comparison with corresponding data for diverse samples of terrestrial rocks from the Kamchatka Peninsula and the Kurile Islands. The samples were studied with the aid of a photoelectric spectrophotometer in the region λ 450 to 590 mμ. Within the limits of natural dispersion, the reflectivity curves for lapilli, volcanic sand, and brown volcanic slags are found to coincide with the corresponding curves for the lunar surface. It is concluded that pyroclastic materials of this type may well exist on the Moon. (Author) W. M. R.

A65-26047

THE SELENODETIC CONTROL SYSTEM OF THE U.S. ARMY MAP SERVICE.

C. L. Goudas (Boeing Co., Scientific Research Laboratories, Mathematics Research Laboratory, Seattle, Wash.).

Icarus, vol. 4, May 1965, p. 188-206. 16 refs.

USAF-sponsored research.

Derivation of the values for the coefficients J_{ij} and J'_{ij} of the expansion into surface harmonics of the lunar surface presented by the Selenodetic Control System of the Army Map Service. Data for the Marginal Zone are taken from the maps of Watts and Hayn and the measurements of Davidson and Brooks, and the far lunar side is assumed to be symmetrical to the near one. It is found that the present results agree with those derived from the data of Schrutka-Rechtenstamm and are close to the figures for a homogeneous Moon as far as the second zonal and sectorial terms are concerned. There is less agreement in the third surface harmonic, and even less in the fourth. The results have little resemblance to those derived from Baldwin's data on exactly the same assumptions. It appears that at present the Selenodetic Control System of the Army Map Service should be rated as the best existing source, followed by the data of Schrutka-Rechtenstamm. (Author) D. P. F.

A65-26048

SECULAR CHANGES IN METEORITIC FLUX THROUGH THE HISTORY OF THE SOLAR SYSTEM.

William K. Hartmann (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).

Icarus, vol. 4, May 1965, p. 207-213. 13 refs.

Grant No. NsG 161-61.

Analysis of lunar craters as records of meteoritic impacts. The form of the mass distribution curve of meteoritic and asteroidal objects in the Earth-Moon neighborhood is found to have remained essentially constant since the formation of the oldest lunar features approximately 4.5×10^9 years ago. The space density of this material and its rate of infall onto planetary surfaces have decreased in this period. The decrease was rapid before the lunar maria formed, and the flux has remained more nearly constant since then.

(Author) D. P. F.

A65-26229 #

RADIO EMISSION AND DIFFERENCES IN THE UPPER LAYER OF "MARIA" AND "CONTINENTAL" REGIONS OF THE MOON [O RADIOIZLUCHENII I RAZLICHIIAKH VERKHNEGO POKROVA "MORSKIKH" I "MATERIKOVYKH" OBLASTEI LUNY].

B. Ia. Losovskii and A. E. Salomonovich (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Akademiia Nauk SSSR, Plenum Komissii po Fizike Planet Astrosoveta, Jan. 1964.)

Astronomicheskii Zhurnal, vol. 42, Mar.-Apr. 1965, p. 390-397. 14 refs. In Russian.

Relative-brightness measurements of the radio emission contrasts of different regions of the lunar disk by means of high-resolution radio telescopes. Maria and continental regions were surveyed at 8 mm with a PT-22 telescope. The results indicate a comparatively small (1.5 ± 0.5%) average difference in the brightness temperature during a lunation. The amplitude of periodical variations in contrast did not exceed 3%. The conclusion is drawn that the characteristics of the upper layers of the compared regions are similar. The excess of the night temperature near Mare Serenitatis over that of the continental surface in the neighborhood of Sacrobosco was found to be $\sim 8°$. This is seen to be evidence of a 25% difference in the parameter $\gamma = (k\rho c)^{-1/2}$ of the material of these regions. W. M. R.

A65-26272

LUNAR AND PLANETARY SURFACE CONDITIONS (Supplement 2 to ADVANCES IN SPACE SCIENCE AND TECHNOLOGY). Edited by F. I. Ordway, III (NASA, Marshall Space Flight Center, Huntsville, Ala.).

N. A. Weil (Cummins Engine Co., Inc., Research Div., Columbus, Ind.).

New York, Academic Press, Inc., 1965. 222 p.

$10.00.

This book is a collection of available theoretical knowledge and experimental evidence on the surface conditions obtaining on the Moon and on the terrestrial and outer planets. Existing knowledge of these conditions is critically reviewed, the most probable alternatives are identified, and new hypotheses are advanced where they are considered warranted. Because there exists a close association between the space scientist and the technical specialist who must place a functioning data-collection system on these planetary surfaces, the author has attempted to compose the text so that it

can be used with equal facility by scientific or professional personnel engaged in space research, by educators, or by graduate students in aerospace disciplines. In an introduction, the prevalent hypotheses on the origin and age of the solar system are presented; these are followed by a brief description of the methods of acquiring lunar and planetary data, either from fixed terrestrial observatories or from instrumented or manned space probes. In the chapter devoted to the Moon, sections deal sequentially with the atmosphere, temperature conditions, subsurface stratification, field intensities (gravitational, electric, and magnetic), and with the biological conditions existing on the lunar surface. New information is presented on the density of the lunar atmosphere under quiescent or high-flux transient conditions, on the topography of the lunar surface, and on the probable proportion of crater-covered areas in the highlands and on the maria. A critical examination is made of the surface-forming mechanisms on the Moon, with predictions for the stratification, temperature profile, and composition (both chemical and meteoritic) of subsurface layers. The question of indigenous lunar life is reviewed and discarded. Equally detailed treatments are given of the surface conditions of the terrestrial planets, the Jovian planets, and Pluto. When these planets are situated at vast distances, are not easily observable, or possess cloud-mantled atmospheres, information about their surfaces is less complete than information about the surfaces of the Earth's nearer planetary neighbors. D.H.

A65-26524

THE MOON - ITS ENVIRONMENT AND WHAT IT MEANS FOR INSTRUMENTATION.

M. A. Broner and G. A. Lander, Jr. (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Sunnyvale, Calif.).

ISA Journal, vol. 12, May 1965, p. 53-58. 13 refs.

Discussion of considerations for the design of instrumentation needed to explore the Moon. Environmental considerations are reviewed, including those associated with the lunar atmosphere and with the chemical composition and structure of, and radioactivity and meteoroids at, the lunar surface. Considerations associated with requirements for biomedical instrumentation, for experiments on the physical properties of the Moon and of the lunar surface, and for instruments to sample the characteristics of the lunar environment are described. P.K.

A65-26789

DETAILED PHOTOELECTRIC PHOTOMETRY OF THE MOON.

Robert L. Wildey (California Institute of Technology, Div. of Geological Sciences; Carnegie Institution of Washington and California Institute of Technology, Mount Wilson and Palomar Observatories, Pasadena, Calif.) and Howard A. Pohn (California Institute of Technology, Div. of Geological Sciences, Pasadena, Calif.).

Astronomical Journal, vol. 69, Oct. 1964, p. 619-634. 16 refs. Grant No. NsG 56.

Photoelectric measurements in U, B, and V of a number of lunar features extending over a range in both morphological type and selenographic coordinates. The observations extend from 28° in phase angle before full Moon to 28° after. They have been measured during several lunations so that a continuous brightness-vs-phase curve is precluded by the differences in libration. This is a necessary technique for obtaining that component of brightness variation that arises from variations in the local altitude of the Earth above the lunar horizon. The nature of the photometric function corresponding to the average behavior of nearly all the observations has been investigated and found to substantiate the previous conclusions, based on an analysis of photographic observations according to an entirely different approach, that the functional dependence on the phase angle and the solar and terrestrial elevation angles can be well approximated by a dependence on (g, α). A numerical comparison with earlier photographic results has not been made. Deviations from the average photometric function have been correlated with stratigraphic class and hence, probably, with age. Correlations of geometrically normalized brightness with stratigraphy, characteristic slope, and color index are presented. A conjectural hypothesis relating these correlations to the evolution of the lunar surface is offered for further study. (Author) D.P.F.

A65-26915

HIGH-ENERGY RADIATIONS FROM THE PLANETS AND THE MOON.

S. Hayakawa (Nagoya University, Physical Institute, Nagoya, Japan).

(Società Italiana di Fisica, Scuola Internazionale di Fisica Enrico Fermi, Corso 24, Varenna, Italy, June 4-16, 1962.)
IN: SPACE EXPLORATION AND THE SOLAR SYSTEM [LE RICERCHE SPAZIALI E IL SISTEMA SOLARE].
Edited by B. Rossi.
New York, Academic Press, Inc., 1964, p. 298-311. 10 refs.

Study of the implications of the discovery that the surface structure of the Moon and planets can be studied by observing high-energy radiations emitted from their surfaces. The flux intensities of several components expected from a standard smooth solid surface are calculated. The components of interest are characteristic X rays and nuclear radiations excited by cosmic rays and other high-energy particle bombardment. The components can be detected with the aid of a spacecraft in planetary orbit or flyby. X-ray microanalysis and the neutron activation technique are discussed in their application to planetary physics; with the former method, the contents of heavy elements in a thin top layer can be investigated, while with the latter, the distribution of light elements in a thick layer can be determined. W.M.R.

A65-27035

THE INTERPRETATION OF THERMAL EMISSION FROM THE MOON.

Harold Weaver (California, University, Radio Astronomy Laboratory, Berkeley, Calif.).

IN: SOLAR SYSTEM RADIO ASTRONOMY; NATO ADVANCED STUDY INSTITUTE OF THE NATIONAL OBSERVATORY OF ATHENS, CAPE SOUNION, GREECE, AUGUST 2-15, 1964, LECTURES. [A65-27020 16-30]
Lectures sponsored by the NATO Science Committee.
Edited by Jules Aarons.
Athens, Ionospheric Institute of the National Observatory, 1965, p. 295-354. 31 refs.
Contract No. Nonr-222(66); Grant No. NsG 225-62(S-2).

Analysis of IR and radio observations of electromagnetic radiation emitted by the Moon. The heating as a function of positior and time of the lunar surface as it is irradiated by the Sun is examined, as is the cooling of the surface during the lunar night. The conduction of surface-absorbed heat into the lunar interior and the resulting lunar subsurface thermal structure, and the energy radiated by the Moon from its surface and interior are considered. The IR and radio measurements yield data on thermal and electrical parameters of the Moon and on characteristics of the lunar surface. The results are discussed in relation to various models of the Moon. P.K.

A65-27036

LUNAR RADAR REFLECTIONS.

Gordon Pettengill (Cornell University, Arecibo Ionospheric Observatory, Arecibo, Puerto Rico).

IN: SOLAR SYSTEM RADIO ASTRONOMY; NATO ADVANCED STUDY INSTITUTE OF THE NATIONAL OBSERVATORY OF ATHENS, CAPE SOUNION, GREECE, AUGUST 2-15, 1964, LECTURES. [A65-27020 16-30]
Lectures sponsored by the NATO Science Committee.
Edited by Jules Aarons.
Athens, Ionospheric Institute of the National Observatory, 1965, p. 355-369. 37 refs.

Review of radar studies of the Moon. The radar cross section of the Moon, as measured over a frequency range of about 10 octaves, is found to be 0.07 of the geometrical (disk) cross section. The angular scattering law deduced for the Moon is described. The measurements are used to derive values of surface dielectric constant and bulk density. Depolarization measurements and the range-Doppler mapping of surface reflectivity are also treated. P.K.

A65-27043 #

LUNAR CHARTING.

John G. Eriksen (USAF, Aeronautical Chart and Information Center, St. Louis, Mo.).

Air University Review, vol. 16, May-June 1965, p. 76-90.

Description of a lunar-charting program initiated in 1960. It is noted that, in spite of the obstacles involved, a series of charts, mosaics, and atlases of the Moon has been produced. Collectively, they constitute the best graphic representation of the Moon available. The graphics and the methods used in producing them are described. M. M.

A65-27709 #
LUMINESCENCE OF THE LUNAR SURFACE [LUMINESCENCJA POWIERZCHNI KSIEZYCA].
Stanisław R. Brzostkiewicz.
Urania, vol. 36, June 1965, p. 166-175. In Polish.

Discussion of two methods used to study the luminescence of the lunar surface. One is based on observations of local variations (increases) in surface luminescence during lunar eclipses, and the other on comparing the contours of some lines (particularly Hα, K, and H lines) in the solar spectrum with the corresponding lines in the spectra of various ridges on the lunar surface. Some results obtained by different investigators using these methods are examined. V. P.

A65-27715
THE CENTRAL PROBLEM OF SELENOGEOLOGY [DIE ZENTRALE FRAGE DER SELENOGEOLOGIE].
K. von Bülow (Rostock Universität, Rostock, East Germany).
Scientia, vol. 100, Jan. 1965, p. 5-9. In German.

Discussion of the problem whether lunar craters are of volcanic nature or were formed by meteoritic impact, from the point of view of selenogeology - a science that investigates the moon by geological methods, on the basis of numerous analogies between the earth and the moon. It is shown that in many cases it is possible to distinguish between craters of volcanic and meteoritic origin by certain features of their configuration, and these features tend to support the volcanic hypothesis in the vast majority of cases. Another argument in support of this hypothesis is that it can explain all lunar surface elements without recourse to numerous assumptions such as are needed with the impact hypothesis. It is also noted that analogs of lunar landscapes are to be found in volcanic regions of the earth, particularly in Iceland and Hawaii. V. P.

A65-28743
A PHOTOMETRIC INVESTIGATION OF THE PRESENCE OF OUTER LAYERS OF VOLCANIC ORIGIN ON THE MOON.
V. V. Sharanov (Leningradskii Gosudarstvennyi Universitet, Astronomicheskaia Observatoriia, Leningrad, USSR).
(Astronomicheskii Zhurnal, vol. 42, Jan.-Feb. 1965, p. 136-144.)
Soviet Astronomy, vol. 9, July-Aug. 1965, p. 105-112. 16 refs.
Translation.
[For abstract see Accession no. A65-20656 10-30]

A65-29112
THE LUNAR ORIGIN OF TEKTITES.
J. J. Gilvarry (NASA, Ames Research Center, Moffett Field, Calif.).
Icarus, vol. 4, July 1965, p. 317, 318. 16 refs.
Research supported by the National Academy of Sciences.

Discussion of a theory which postulates the presence of a lunar hydrosphere, with a duration of 1 to 3×10^9 years, as explaining the lunar origin of terrestrial tektites. Gilvarry's observations in support of the theory of a lunar hydrosphere are cited; Nininger proposed that the tektites are fragments of rock fused initially by meteoric impact on the moon and ejected from the lunar surface by the force of the explosion. Inasmuch as the chemical composition of tektites is similar to that of argillaceous sedimentary rocks, Nininger's theory can only be valid if Gilvarry's observations are correct. However, certain anomalies in the isotopic composition of these tektites imply that they must have undergone major chemical fractionation within the last 100×10^6 years, which implies a small concentration of water on the lunar maria during this period; this hypothesis seems highly questionable. D. P. F.

A65-29372 #
QUANTIFYING TERRAIN ROUGHNESS ON LUNAR AND PLANETARY SURFACES.
Milton Schloss (Bendix Corp., Bendix Systems Div., Ann Arbor, Mich.).
American Institute of Aeronautics and Astronautics, Annual Meeting, 2nd, San Francisco, Calif., July 26-29, 1965, Paper 65-389. 12 p. Members, $0.50; nonmembers, $1.00.

Investigation of curvature as a surface roughness characteristic to attain a simple quantitative description technique which can be used in parametric design procedures. To compare slope and curvature surface descriptions, two contour maps are analyzed - an 80 by 80-ft section of the moon's surface and a map of the Bonita Lava Flow near Flagstaff, Ariz. Analysis of the moon map data is performed, and a conventional set of slope distribution curves and a set of curvature statistics are developed. Comparison of these shows that the curvature technique is much less complex and allows a direct quantitative evaluation of the relative roughness of different terrains. B. B.

A65-30647
WAVELENGTH DEPENDENCE OF POLARIZATION. III. - THE LUNAR SURFACE.
T. Gehrels, T. Coffeen, and D. Owings (Arizona, University, Tucson, Ariz.; Indiana University, Bloomington, Ind.).
Astronomical Journal, vol. 69, Dec. 1964, p. 826-852. 38 refs.
Grant No. NsG-493.

Study of photoelectric measurements of brightness and polarization made on various lunar regions, using diaphragms about 10 sec of arc in diameter. In addition to UBV a UGI photometric system was used, where I has effective wavelength at 0.94 μ. The color index of lunar regions increases with phase angle α; a typical relation is $B - V = +0.84 + 0.0017 |\alpha|$. Brightness-phase relations all show a nonlinear surge close to zero phase; this "opposition effect" may be as much as a factor of 2 brightness increase from ± 5° to 0°0, phase. If so, the full moon has V = - 13.35 mag ± 0.06 (p.e.), and the geometric albedo at 5400 Å is 21% with the maria having 13% and the highlands 27%; the uncertainty is due mostly to luminescence. Luminescence was detected in the photometry and independently confirmed by the polarimetry. In 1956-1959 the lunar surface was 10 to 20% brighter than in Nov. 1963-Jan. 1964. The effect was fairly constant from day to day; it probably varies with the solar cycle. Polarization-phase curves, with a filter at 0.54 μ, were found to be similar to those of Lyot, while at 0.36 μ the polarization generally was greater and at 0.94 μ smaller. Gradual rotation of the polarization position angle, as reported in the literature, was not found; to within ± 3° precision, the electric vector maximum was either perpendicular to the plane of scattering, or lay in that plane. The opposition effect is reproduced by the theoretical photometric functions derived by Hapke for a tenuous surface texture, but a volume density of only 0.5% is indicated. The texture is remarkably uniform over the lunar globe, and it is similar to that of the asteroids. The lunar surface appears to be covered with a thin, about 0.06 mm, cloud of particles that have radius $a \gtrsim 0.8$ μ, and separation of about 8 μ. They presumably are accreted interplanetary particles. They are ionized and their charges, of the order of 10^{-8} esu, keep them separated and suspended, while partial recombination causes the observed luminescence. It appears that this surface cloud explains all photometric and polarimetric observations on the moon and asteroids. (Author) M. F.

A65-30807 #
LUNAR PROBLEMS IN SOIL ENGINEERING.
Ronald F. Scott (California Institute of Technology, Pasadena, Calif.).
American Society of Civil Engineers, Soil Mechanics and Foundations Division, Journal, vol. 91, Jan., pt. 1, 1965, p. 1-14. 14 refs.

Study of the state of knowledge of the lunar surface from an engineering viewpoint and outline of a variety of plausible soil or rock profiles to shallow depths. The engineering properties of the soil and rock materials are defined arbitrarily in terms of an idealized mechanical behavior. An attempt is made to establish ranges of material behavior in terms of quantitative properties, and the classes of soil engineering problems that might arise with

respect to operations on the lunar surface are examined. Finally, consideration is given to suitable, simple experiments that may be conducted from spacecraft on the lunar surface for the purpose of measuring the quantitative properties. (Author) M.F.

A65-30808 #
ENGINEERING PROPERTIES OF SIMULATED LUNAR SOILS.
Eben Vey (Illinois Institute of Technology, Research Institute, Soil Mechanics Section, Chicago, Ill.) and John D. Nelson (Illinois Institute of Technology, Research Institute, Chicago, Ill.).
American Society of Civil Engineers, Soil Mechanics and Foundations Division, Journal, vol. 91, Jan., pt. 1, 1965, p. 25-52. 27 refs.
Contract No. NASr-65(02).

Review, analysis, and evaluation of the most recent studies dealing with the composition and environmental conditions of the lunar surface. To provide basic engineering data on the behavior of soils under lunar environmental conditions, experiments were performed to determine the properties of soils believed to be representative of materials on the lunar surface under atmospheric pressures and vacuum levels to the 10^{-10}-torr range. Three different soil samples were used - (1) silica flour having 90% of the particles between 2 and 26 μ, (2) ground olivine having 90% of the particles between 2 and 60 μ, and (3) ground olivine having 90% of the particles between 0.7 and 15 μ. On the basis of available data from telescopic observations, radar measurements, photometric studies, albedo and color measurements, and the most recent Ranger VII pictures, these materials are shown to be reasonably good simulations of the lunar surface. The significance of the state in which these materials might exist - loose, lightly bonded, or strongly bonded with respect to the measurements of important engineering properties - is also examined. Experiments consisted of the determination of the porosity attained by the soil when deposited under various vacuum levels and the effect of vacuum on the shear-strength parameters. For soil samples prepared in the atmosphere and then placed in the vacuum chamber, it was observed that the vacuum in the soil pores was considerably less than that recorded in the chamber. Porosities attained by soil deposited under low vacuums (1 to 10^{-3} torr) were less than those attained in atmosphere, but at higher vacuum levels the porosity increased with an increase in vacuum, and in the case of silica flour for vacuums of 10^{-7} torr or higher it was greater than when deposited in atmosphere. Direct shear tests showed that the apparent cohesion and the internal friction of the silica flour increased under vacuum. The internal friction of the olivine also increased under vacuum, but its apparent cohesion appeared to decrease. The increase in porosity in both soils and the effects on the apparent cohesion were attributed to the development of interparticle forces. These forces may be either attractive or repulsive, depending on the mineralogical composition of the soil and the vacuum level. (Author) M.F.

A65-31182 #
DISTRIBUTION OF CRATERS ON THE LUNAR SURFACE.
Gilbert Fielder (London, University, Observatory, London, England).
Royal Astronomical Society, Monthly Notices, vol. 129, no. 5/6, 1965, p. 351-361. 16 refs.
Research supported by the Department of Scientific and Industrial Research.

Fresh attack on the vital problem of the origin of the lunar craters by analyzing the surface distribution of craters of given diameter. The distribution shows a general clumpiness in both the lunarite (bright regions) and the lunabase (dark regions). Craters between 30 and 40 km in diameter, situated in the lunarite, are non-randomly distributed at the 2% level of significance. This argues against the impact theory. It is found that the number-density of differently-sized craters is slightly greater in the following half of the moon than in the preceding half. This result is shown to apply equally to the lunarite and, taken separately, to the lunabase, and again argues against the theory that the craters were produced exclusively by impact. In assessing the origin of the craters on the basis of the observed frequencies and distribution of craters alone, it is concluded that the ratio of the number of impact craters to the number of endogenic craters is not very large. If only one theory is allowed, it must be that the craters are of internal origin. (Author) M.F.

A65-31280 #
ANGULAR SCATTERING LAW FOR THE MOON AT 6-METER WAVELENGTH.
W. K. Klemperer (National Bureau of Standards, Central Radio Propagation Laboratory, Boulder, Colo.).
Journal of Geophysical Research, vol. 70, Aug. 1, 1965, p. 3798-3800. 9 refs.

Study of the magnitude and scale of lunar surface roughness from radar data and of the effect of shadowing near the limb. Short-pulse radar echoes were obtained at a Peru facility. Because the Jicamarca 22-acre array is essentially a transit instrument, long echo-integration times were not possible. Although there was adequate radar sensitivity to obtain echoes right out of the limb when the whole antenna was utilized, fairly serious problems arose from the huge dynamic range required to record the echo amplitude from the leading edge properly. Accordingly, only half the available antenna area and only two of the four transmitters were used in this experiment. There were two receiving systems with linear detectors, the one set at higher sensitivity for exploring the echo amplitude near the limb. Polarization was circular to avoid problems with Faraday rotation from the F region. By phasing the two halves of the antenna array to point at different points on the east-west track of the moon, the observation period could be extended to permit about 20 db of digital integration. The parameters of the system are given in a table. M.F.

A65-32038
RADIO-FREQUENCY EMISSION AND DIFFERENCES IN THE TOP COVER OF "MARIA" AND "CONTINENTAL" LUNAR REGIONS.
B. Ia. Losovskii and A. E. Salomonovich (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).
(Astronomicheskii Zhurnal, vol. 42, Mar.-Apr. 1965, p. 390-397; Akademiia Nauk SSSR, Plenum Komissii po Fizike Planet Astrosoveta, Jan. 1964.)
Soviet Astronomy, vol. 9, Sept.-Oct. 1965, p. 307-312. 14 refs.
Translation.
[For abstract see Accession no. A65-26229 15-30]

A65-32411
WAVELENGTH DEPENDENCE OF POLARIZATION. IV - VOLCANIC CINDERS AND PARTICLES.
David L. Coffeen (Arizona, University, Tucson, Ariz.).
Astronomical Journal, vol. 70, Aug. 1965, p. 403-413. 10 refs.
Navy-supported research.

Measurement of five laboratory samples for comparison with the moon, using a Wollaston photopolarimeter with filters near 0.36, 0.53, and 0.97 μ, having the sun as light source. Three of the samples were porous dust layers of ground volcanic cinder particles smaller than 37 μ, in "fairy castle" structures. The other two were a porous but solid lava fragment, and the same fragment covered with a "fairy castle" dust layer made from the same lava. The solid lava fragment, more highly polarized than the moon, has essentially no wavelength-dependence. The wavelength- and phase-dependence of the lunar polarization is closely matched by the "fairy castle" structures. No dependence of polarization on sample orientation was found for the volcanic materials. Differential photometry was done with the same filters using a smoked MgO layer as comparison. All samples show a linear brightness increase (in magnitudes) from 50 to 20° phase, similar to the moon. The "fairy castle" structures show an appreciable opposition effect in the UV which, however, almost disappears in the green and IR. F.R.L.

A65-32576 #
PHOTOELECTRIC OBSERVATION OF THE LUNAR ECLIPSE OF JUNE 24-25, 1964.
J. Bouška and P. Mayer (Charles University, Astronomical Institute, Prague, Czechoslovakia).
Astronomical Institutes of Czechoslovakia, Bulletin, vol. 16, no. 4, 1965, p. 252-254. 8 refs.

Photoelectric measurements of the moon's surface taken during a total lunar eclipse in spectral region V. The densities determined in the penumbral shadow were practically the same as the theoretical ones; in the umbral shadow they were substantially larger than the calculated densities and reached a value of D = 5.62 near mideclipse. (Author) R.A.F.

A65-32671 #
TEKTITE STRUCTURE AND LUNAR ASH FLOWS.
John A. O'Keefe (NASA, Goddard Space Flight Center, Greenbelt, Md.) and Ernst W. Adams (Deutsche Versuchsanstalt für Luft- und Raumfahrt, Freiburg, West Germany).
Journal of Geophysical Research, vol. 70, Aug. 15, 1965, p. 3819-3829. 19 refs.

Suggestion that tektites were formed by a lunar ash flow. Theoretical calculations of pressure, temperature, and voidage (fraction of the volume not occupied by solid matter) are made for the dense phase (bulk density 0.5 to 1.0 g/cm^2) of an ash flow, assuming a steady state with the solid particles at rest, uniform temperature, and steady emission of gas from the solid matter. The problem reduces to an ordinary nonlinear differential equation of the first order; the solution is presented in nondimensional variables, together with homology relationships for the physical parameters. For a given model of internal structure, the required gas emissivity is found to vary directly with the square of the gravity. Above the dense phase, there may be a dilute phase consisting of gas with suspended particles, having a bulk density of 0.12 g/cm^3 or less. The dilute phase is relatively unimportant in terrestrial flows, but in a lunar ash flow it is likely to be the predominant mode of transport. It is found to be an isothermal pseudogas, with a scale height on the moon of a few hundred meters. This concept is consistent with the recent discoveries about the petrography of the Muong Nong tektites and the morphology of the maria.
(Author) M. F.

A65-32672 #
ACOUSTIC SIMULATION OF LUNAR ECHOES.
H. S. Hayre (Kansas State University of Agriculture and Applied Science, Dept. of Electrical Engineering, Manhattan, Kan.).
Journal of Geophysical Research, vol. 70, Aug. 15, 1965, p. 3831-3839. 15 refs.
Grants No. NsG-129-61; No. NsG-692.

Use of nonlinear modeling techniques in an attempt to model acoustically the lunar surface and other rough surfaces on a set of 16.7-cm-diam spun-aluminum spheres. Some of the large-scale lunar surface roughness features were approximately modeled using reduced wavelength scale, and the small-scale roughness was modeled by random-sized sand particles on one sphere. To investigate which type of surface roughness would simulate the lunar return, various orders of roughness and four separations of the model moon and the transducers (4-μ sec pulse at 1.02 Mc with PRF of 20) were used to obtain experimental data. These data were reduced to give such statistical information as range of fading. The mean power vs delay time was compared with Pettengill's experimental data and found to check well. The spatial autocovariance of the wrinkle-painted surface was found to be exponential as opposed to the Gaussian form.
(Author) M. F.

A65-32739
PROPERTIES AND BEHAVIOUR OF MATERIALS IN OUTER SPACE.
R. C. Godwin and W. J. Woods (Hawker Siddeley Dynamics, Ltd., London, England).
Institution of Mechanical Engineers, Conference on Vacuum Technology, London, England, Mar. 25, 26, 1965, Paper. 11 p. 6 refs.

General description of the environment of space, considering vacuum and all other significant parameters, and detailed description of the vacuum environment. The two principal effects of vacuum - surface effects and internal effects (such as fatigue) - are discussed, together with the fatigue strength of metals in vacuum. Historical work leading up to present work on crack propagation is reviewed. Surface effects, evaporation, vapor pressure, the Langmuir equation, embrittlement of plastics, lubrication, problems of friction and wear, metal-on-metal and steel-on-diamond tests, and bearing capacity of lunar surfaces are also examined.
(Author) R. A. F.

A65-33343
ROCK DEGRADATION BY ALKALI METALS - A POSSIBLE LUNAR EROSION MECHANISM.
J. J. Naughton, I. L. Barnes, and D. A. Hammond (Hawaii, University, Dept. of Chemistry and Hawaii Institute of Geophysics, Honolulu, Hawaii).
Science, vol. 149, Aug. 6, 1965, p. 630-632. 12 refs.
NSF Grant No. GP-2523.

Observation of the evolution of vapors of alkali metals from rocks melted in the laboratory under ultrahigh-vacuum conditions. These metal vapors act to comminute polycrystalline rocks to their component minerals. The resultant powder is porous and loosely packed and its characteristics may be compatible with the lunar surface as revealed by the Ranger photographs. If meteorite impact or lunar volcanism has produced vaporization or areas of molten lava, alkali erosion may have given dust of this character in adjacent solid areas.
(Author) M. F.

A65-33346 #
THE DIRECTIONAL RADIATIVE CHARACTERISTICS OF CONICAL CAVITIES AND THEIR RELATION TO LUNAR PHENOMENA.
Leslie G. Polgar and John R. Howell (NASA, Lewis Research Center, Cleveland, Ohio).
American Institute of Aeronautics and Astronautics, Thermophysics Specialist Conference, Monterey, Calif., Sept. 13-15, 1965, Paper 65-669. 8 p. 17 refs.
Members, $0.50; nonmembers, $1.00.

Analytical study of the directional absorptivity characteristics of conical cavities, undertaken in the conviction that conical cavities would provide a reasonable thermal model of the meteor craters or other cavities to be found on the surface of the moon. A beam of parallel radiation is taken as striking a right circular conical cavity at a given angle of incidence to the cone axis. The cone is assumed to have a diffusely reflecting surface and has a given cone angle. A straightforward Monte Carlo analysis of this case is used to determine the directional reflectivity of the cone. Parameters varied are the cone angle, surface absorptivity, and angle of incidence of the solar radiation. Comparison is made with the lunar characteristics. It is concluded that the directional reflectivity of a right circular cone with 30° cone angle and a surface absorptivity of 0.500 compares well with the experimental photometric results for the lunar surface. It is inferred that the lunar surface could have many cavities with steep walls, whose structure is larger than the wavelengths of visible light, but smaller than is visible to present earth-based or lunar-probe observations. It is pointed out that results for conical cavities with cone angles near those for observed lunar craters do not correlate with observed lunar photometric results, implying that these craters, even if of considerably smaller size than those observed to date, contribute little to the reflectivity characteristics of the moon in the visible portion of the spectrum.
M. M.

A65-34229
NEW YORK ACADEMY OF SCIENCES, CONFERENCE ON GEOLOGICAL PROBLEMS IN LUNAR RESEARCH, NEW YORK, N.Y., MAY 16-19, 1964.
New York Academy of Sciences, Annals, vol. 123, July 15, 1965. 891 p.

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CONVECTIVE ORIGIN OF LUNAR CRATERS. H. Tazieff (Institute of Volcanology, Paris, France), p. 526, 527. [See A65-34235 22-30]

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PROGRESS IN SELENODESY. Mahlon S. Hunt (USAF, Office of Aerospace Research, Bedford, Mass.), p. 1220-1235. 18 refs. [See A65-34276 22-30]

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A65-34230

TIDAL AND GRAVITY EFFECTS INTENSIFYING LUNAR DEFLUIDIZATION AND VOLCANISM.

Jack Green (North American Aviation, Inc., Space and Information Systems Div., Space Sciences Laboratory, Downey, Calif.).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N.Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 403-469. 118 refs.

Survey of the evidence to date supporting a defense of defluidization as a generally operative terrestrial and lunar process. Defluidization is defined as the release of fluids from the interior of a cosmic body at any given rate or place, manifesting itself by intrusive activity and volcanism. The differences in time and place that could make the moon more susceptible to outgassing are taken into account. Tidal effects, thermal considerations, gravitative effects, mantle-volume-to-surface-area relationships, defluidization products and sequence of escape, luminescence, and the surface morphology supporting defluidization are discussed. The significant differences that exist between the earth and the moon that would enhance lunar defluidization, and a comparison of the defluidization versus impact models are summarized point by point. Defluidization is thought to be a generally operative cosmogonic process which was intensified on the moon because of tidal, gravity, and vacuum effects; furthermore, meteoritic impact is considered to be a trivial process in affecting both the genesis and development of almost all major lunar surface structures. Two appendices are included; they contain expressions for calculating lunar body tides raised by the earth and a summary of reports of lunar surface changes.

M. L.

A65-34231

LUNAR DIFFERENTIATION PROCESSES.

Louis S. Walter (NASA, Goddard Space Flight Center, Greenbelt, Md.).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N.Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 470-480. 12 refs.

Theoretical study of the processes of igneous rock differentiation as applied to the moon. Four major assumptions form the basis of the study: (1) the increase in lithospheric pressure as a function of depth is less for the moon than the earth; (2) the moon has been hot enough, at some time in its history and at least locally, to melt the silicate material of which it is composed; (3) although local at any one time, this melting has taken place in most areas of the upper part of the moon, so that presently there are few places that have escaped igneous activity since the moon was formed; and (4) because of the ubiquitous nature of the melting and the gravitative attraction of the moon, the moon's rocks have lost much of the material, which at standard temperature and pressure are considered volatile (particularly water and oxygen). The assumptions are discussed in the light of effects of total pressure and water and oxygen deficiencies. It is concluded that igneous activity has differentiated a lunar crust (if it did not at the time of the moon's formation) and that such differentiation also served to concentrate the radioisotopes in the more acidic crustal fraction tending to increase the amount of volcanic activity at the surface and further degassing and dehydrating the superficial rocks. However, loss of water is considered to have the opposite effect. M. L.

A65-34232

MELTING TEMPERATURE OF COMPLEX SILICATES.

Emanuel Azmon (Northrop Corp., Northrop Space Laboratories, Hawthorne, Calif.).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N.Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 481-494. 14 refs.

Experimental study of the melting of complex silicates, related to research on lunar geology. The melting point of dunite, a rock composed of some of the highest melting rock-forming minerals (mostly SiO_2 and MgO), is investigated as a function of time pressure. It is found that dunite melts instantaneously above 1750°C, under the pressure proposed to exist within the moon's core (47 kbars), but that melting could also occur if a lower temperature were maintained for a longer time. Several theories of the moon's composition are briefly discussed, including Kuiper's, Urey's and Hoyle's. It is shown that volcanic melting of dunite may be expected to occur several hundred degrees centigrade below impact melting.

M. L.

A65-34233

BEHAVIOR OF LAVA ON THE LUNAR SURFACE.

Walter I. Dobar (Bendix Corp., Systems Div., Ann Arbor, Mich.).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N.Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 495-515. 26 refs.

Experimental investigation of a simulated magma in vacuum and a determination of selected physical properties of terrestrial rocks in a simulated lunar environment. Samples of molten silica, basalt, and granite, allowed to upwell and solidify in vacuum, are shown to yield photometric curves closely resembling the mean lunar curve. During the vacuum upwelling, such samples produced color changes resembling those recently observed on the lunar surface (the Aristarchus event). A brief review of the study's results - as compared with published reports defining the nature of the lunar surface - is presented, and it is emphasized that many of these reports are based on material forming under atmospheric pressure, unlike the moon. It is concluded that the results tend to indicate that lava is present on the lunar surface and that earth-moon correlations can be made if the physical properties of the materials are determined in similar environments. M. L.

A65-34234

PALEOVOLCANIC ORIGINS OF THE LUNAR SEAS.

A. Dauvillier (Collège de France, Paris, France).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N.Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 516-523.

Review of some of the theoretical framework and features of the paleovolcanic origins of the maria. Arguments concerning

homogeneity and internal heat, convection currents, and palevolcanism are recapitulated, and some of the chemical reactions that might account for the present structure of the moon are reviewed. The possible relationships between convection currents and the formation of walled plains are considered, and comparisons with the earth's surface are made. The part played by the geothermal flux in these arguments is emphasized. M. L.

A65-34235

CONVECTIVE ORIGIN OF LUNAR CRATERS.

H. Tazieff (Institute of Volcanology, Paris, France).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 526, 527.

Brief summary of the arguments in favor of the convective origin of large lunar craters. It is pointed out that the only acceptable mechanism that simultaneously accounts for (1) the polygonal shape of the large craters, (2) their flat bottom, (3) their juxtaposition, (4) the fact of a non-overlap of a larger crater over a smaller one, and (5) the presence of a single peak in many craters is that convection currents occurred in the outer layer of the moon prior to its solidification. Thus, it is concluded, the craters are in fact convection cells, the size of which had been decreasing with time. M. L.

A65-34236

BALANCE OF ENDOGENIC TO EXOGENIC ENERGY IN THE CRUST OF THE MOON.

Robert Enzmann (Avco Corp., Research and Advanced Development Div., Wilmington, Mass.).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 532-542. 22 refs.

Theoretical investigation of the balance of endogenic to exogenic energy in the moon's crust. Nine orders of geomorphic features are proposed, in parallel, for the earth and moon, and a table listing the features of the proposed geomorphic orders, and suggestions for the energies and forces tending to create, maintain, and destroy them, is given. It is pointed out that on the earth, attrition of objects the size of sand grains is dominated by transport mechanisms, but that on the moon, transport mechanisms are weaker or absent. It is thought conceivable that attractive forces may dominate objects as large as sand grains. M. L.

A65-34237

THE ORIGIN OF LUNAR FEATURES.

Ralph B. Baldwin (Oliver Machinery Co., Grand Rapids, Mich.).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 543-546.

Brief summary of the arguments for a meteoritic-impact theory of the origin of lunar craters. While evidence supporting the presence of igneous activity on the moon is considered strong, it is argued that meteoritic impact must also be a very likely process on the moon. The major evidences cited are statistical analyses of crater dimensions as functions of size; in particular, the relationship between rim-to-rim diameter and rim-to-bottom depth, expressed on a log-log scale as a simple quadratic that is equally valid for tiny, explosive craters on earth, through terrestrial-meteoritic-crater range, and up to the large lunar craters. The diameter-vs-rim-height curve and the rim-width-vs-diameter relationship are also noted. It is concluded that both the volcanic and impact processes are necessary to explain the lunar surface features. M. L.

A65-34238

CRATER FREQUENCY EVIDENCE FOR VOLCANISM IN THE LUNAR HIGHLANDS.

Robert T. Dodd, Jr., Vern G. Smalley, John W. Salisbury, and Joel E. M. Adler (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Bedford, Mass.).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 555-561; Discussion, A. Marcus (California, University, Berkeley, Calif.), p. 561, 562.

Consideration of the possibility that cratering might be interrupted by deposition of a thick blanket of material, as part of a continuing statistical study of the crater frequency in the lunar highlands. The surface area considered lies in the Cratered Plain Province. Details of the crater measurements are presented. Results are obtained by submitting the data to a least-squares fit, using an IBM 7090. The plotted frequency-diameter data are found to suggest two curves of the form $F = AD^{+B}$, intersecting at a diameter in the vicinity of 10 to 20 km. It is concluded that the simple relationship between crater diameter and frequency for the mare surfaces deteriorates in the highlands where, evidently, several processes have been at work. It is noted that there is a complexity in the geologic history of these areas that is not generally appreciated. The criteria by which the boundaries of the Cratered Plain Province were determined are outlined. M. L.

A65-34239

GRAVITATIVE EFFECTS ON LUNAR IMPACT STRUCTURES.

William L. Quaide, Donald E. Gault, and Richard A. Schmidt (NASA, Ames Research Center, Space Sciences Div., Moffett Field, Calif.).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 563-572. 10 refs.

Study of the relationship between crater morphology and dimension. It is considered that any explanation must be based on a probable mode of origin of the craters. It is shown that although the lunar cratering rate is considerable, in view of the moon's age, the rate is not reliable enough to account for all the lunar craters, but it is assumed that most of the craters have had their origins in hypervelocity impacts. The radii of 169 selected young lunar craters are considered, and several cratering mechanisms are discussed: (1) large craters (diameters more than 10 km) are produced mostly by cometary impact, and smaller craters by dense projectiles; (2) all craters produced by dense projectiles; and (3) postcratering events have modified crater shapes, in particular, isostatic rebound, gravitative effects, and impact-triggered volcanism. It is concluded that if large craters are assumed to originate by hypervelocity impact, then one process that can account for most of their observed features is gravity sliding, probably along ring fractures produced during impact. A major implication of this conclusion is noted - namely, that it is not possible to determine the mass of the cratering projectile from diameter-depth relations of large lunar craters. M. L.

A65-34241

LUNAR AND TERRESTRIAL STRUCTURAL MODELS ON A COMMON SPHERE.

B. B. Brock (Anglo American Corporation of South Africa, Ltd., Johannesburg, Republic of South Africa).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 617-630.

Theoretical comparison of lunar and terrestrial surface features, by means of a transparent, plastic dome used to study the repetitive patterns on a geological globe. In addition to the dome, earth and moon globes of identical size are used. The nautical manner of distance measurement, in terms of angle of arc subtended at the center of the sphere, is used because it is applicable to any heavenly body and allows a comparison of those structural patterns which, it is believed, are a function of the body itself. It is tentatively concluded that the coarser tectonic patterns of the earth and moon

are similar because, when compared on a common sphere, the degree of correspondence in size and shape between the larger moon features and earth features is sufficiently impressive. The similar patterns are considered ordered, and not fortuitous, and it is emphasized that the aliquot relationship of the fragmentation patterns to the sphere itself is significant in that the pattern is integrated with the spherical shape in both cases. M. L.

A65-34242

EARTH AND MOON - TECTONICALLY CONTRASTING REALMS.

Robert S. Dietz and John C. Holden (U. S. Coast and Geodetic Survey, Washington, D. C.).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 631-640; Discussion, G. J. H. McCall (Western Australia, University, Perth, Australia), p. 640. 15 refs.

Review of existing evidence supporting the view that, tectonically, the moon is dead and rigid, has either insignificantly little or no convection, and that the terrestrial sea floor does not resemble the lunar surface. Because the water that energizes the explosivity of volcanoes on earth is considered to be recycled water, the occurrence of explosive volcanism on the moon is held to be unlikely, in view of the absence of a hydrosphere. It is concluded that explosive volcanism requires both a hydrosphere and the conveyance of hydrated rock by mantle convection. M. L.

A65-34243

PRINCIPAL STRUCTURAL ELEMENTS OF THE MOON AND THE SIGNIFICANCE OF THE GEOGRAPHIC-GEOLOGICAL APPROACH.

Iu. A. Khodak.

(Akademiia Nauk SSSR, Izvestiia, Seriia Geologicheskaia, no. 8, 1963, p. 11-22; New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 641-655. 76 refs. Translation.

Study of the chief structural elements of both sides of tne moon. The nature and distribution of rock formations, including walled plains, craters, ridges, maria, valleys, and fissures, are analyzed. The sources include Khabakov's map of topographical formations on the visible side, recent photographic atlases, a photographic atlas edited by Kuiper, as well as a map based on the Soviet probe of 1959 of the far side of the moon. Several maps of the important structural features are presented, including one of the reverse side. Several areas of further investigation are indicated, including clarification of the polygonal-annular nature of the structure of the walled plains and craters. The meteoritic-impact explanation of lunar surface features is considered to offer only a one-sided approach to any elucidation. M. L.

A65-34244

THERMAL PROPERTIES OF POSTULATED LUNAR SURFACE MATERIALS.

P. E. Glaser, A. E. Wechsler, and A. E. Germeles (Arthur D. Little, Inc., Cambridge, Mass.).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 656-670. 44 refs.

Contracts No. NAS8-1567; No. AF 19(268)-421.

Review of the computations of the heat balance of the lunar surface layer during a lunation in relation to measurements of thermal properties of postulated lunar surface materials. Micrometeoroid impacts and the lunar photometric and polarization data are discussed. Details of the testing of a variety of foam, powder, and solid materials are presented. It is concluded that the thermal parameters obtained from the heat balance during a lunation differ considerably from those of unconsolidated particles measured in the laboratory and that the discrepancies suggest that the surface is not composed solely of unconsolidated particles. Sintered materials or highly vesiculated rocks appear to be more representative of lunar surface materials, as compared to an agglomeration of unconsolidated particles. It is expected that the combination of theoretical work based on accurate temperature measurements during lunations and eclipses and determinations of photometric and thermal properties of different materials in the laboratory promises to lead to acceptable definitions of the nature of lunar surface materials. M. L.

A65-34245

THE CASE FOR A COHESIVE LUNAR SURFACE MODEL.

J. D. Halajian (Grumman Aircraft Engineering Corp., Bethpage, N. Y.).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 671-710; Discussion, B. W. Hapke (Cornell University, Center for Radiophysics and Space Research, Ithaca, N. Y.), p. 710. 37 refs.

Research sponsored by the Grumman Aircraft Engineering Corp.

Investigation of the nature of the lunar surface material. An experimental approach, consisting of "model-matching" and "environment-simulation," is used. With the first technique, it is found that the photometric and radiothermal signatures of the moon complement one another as they coverge toward an "underdense-hard" material (bulk density < 1 gm/cm^3), such as rock froth or slag. With the latter technique, it is found that the extensive sticking of dust particles in an ultrahigh vacuum provides a genetic clue to the cohesive lunar surface material suggested by the model-matching experiments. Two major conclusions are made: (1) it is not necessary to stipulate the existence of a layer of dust on the moon in order to account for the measured lunar photometric and radiothermal data; and (2) a "homogeneous underdense-cohesive silicate" model (i.e., rock froth or sintered slag) reconciles the high porosity and low $(k\rho c)^{-1/2}$ indicated, respectively, by the latest lunar photometric and radiothermal measurements; cohesionless soils, at whatever density, do not. It is noted that this model is consistent with either a volcanic or meteoritic activity on the moon. M. L.

A65-34246

EFFECTS OF A SIMULATED SOLAR WIND ON THE PHOTOMETRIC PROPERTIES OF ROCKS AND POWDERS.

Bruce Hapke (Cornell University, Center for Radiophysics and Space Research, Ithaca, N. Y.).

(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 711-721. 17 refs.

Grant No. NsG-382.

Experimental investigation of the effects of prolonged bombardment by 2-kv hydrogen ions of various rock and rock powders, including quartz, granite, basalt, and dunite. The intensity, polarization, and color of the target materials are compared before and after irradiation by means of photometric measurements. It is found that all naturally occurring rocks and powders were affected by the irradiation, and that the effects observed included loss of color and a reduction in albedo. The darkening is believed to be due to three different mechanisms: chemical reduction by atomic hydrogen, differential collection of sputtered material, and differential sputtering of heterogeneous materials. Two major conclusions are drawn: (1) that solar wind bombardment has been demonstrated to drastically affect the color and albedo of rocky materials and that consequently, inferences about lunar surface materials made on the basis of resemblances to terrestrial rocks must be regarded with great suspicion and (2) proton irradiation of fine rock powders changes their photometric characteristics so as to more closely resemble lunar characteristics - thus strongly supporting the hypothesis that the lunar surface is everywhere covered with fine rock dust. M. L.

A65-34248

SOME RESULTS OF PHOTOMETRIC AND COLORIMETRIC COMPARISON OF TERRESTRIAL VOLCANIC CRUSTS WITH THE LUNAR SURFACE.

V. V. Sharonov.
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 740-750. 7 refs.

Summary of the results obtained when albedo, color data, and diffusion diagrams are made for certain types of soil of volcanic origin now existing on earth. The data are compared with those obtained earlier for the lunar surface. It is found that certain of these volcanic terrestrial soils - such as slag, lapilli, and sand - have a notable similarity to those observed on the moon, with respect to their dark color and sharp elongation of their reflection diagrams toward the light source. It is concluded that it is therefore possible that the presence on the moon of such coverings is entirely possible, judging from photometric data. It is noted that if it were possible to discover nonperiodic changes in color in small regions of lunar surface, this would be a strong argument for the existence of currently active volcanoes on the moon. (Author) M.L.

A65-34249
INTERPRETATION OF LUNAR SURFACE FEATURES.
Karl Krejci-Graf (Frankfurt, Universität, Geologisch-Paläontologisches Institut, Frankfurt am Main, West Germany).
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 751-755.

Review of some of the major considerations involved in correctly assessing the lunar surface features. Rays, crater shapes, and meteoritic impacting are briefly considered. Why rays are not thought to be veins or cracks formed by a central impact or explosion is explained. It is noted that dust is the best protection against continued physical weathering, especially when there is vacuum in the pores, and it is therefore considered improbable that there are any thick masses of dust on the moon, with the exception of accumulation on the toes of slopes. M. L.

A65-34250
PHOTOMETRIC DATA FOR AND AGAINST THE PRESENCE OF WIDELY DISTRIBUTED VOLCANIC ACTIVITY ON THE MOON.
N. N. Sytinskaia (Leningrad University, Leningrad, USSR).
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 756-767. 7 refs.

Review of geological data according to color and reflective properties, published by the special laboratory of Planetary Astronomy of Leningrad University, in order to make comparisons with similar lunar data. Reflectivity of samples of terrestrial geological specimens is expressed in the form of a coefficient of brightness (coefficient of diffusion), $\mu = B/B_0$, where B is the brightness of the samples in given direction by illuminating the samples with a beam of parallel rays, which fall normally on a surface, and B_0 the brightness of an absolutely white surface (albedo equal to unity), at the same intensity of illumination. It is found that for the range $0.03 < \mu < 0.22$, the closest correspondence with lunar surface data is given, respectively, by volcanic slag and by lapilli. All data are summarized in three tables, listing the color indices and brightness coefficients for selected lunar features, and the brightness coefficients and color indices for terrestrial and extraterrestrial materials. It is deduced that the rust-colored cover on the moon and other nearby bodies of the solar system originated as the result of exogeneous factors, chiefly the impact of meteorites. M. L.

A65-34251
THE FAINT RAY SYSTEMS.
Dinsmore Alter.
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 768-775.

Photographic study of the dim, fine structure of part of the Mare Imbrium as a start of such a study for lunar areas in general. Some modifications of standard photographic technique are made in order to clarify faint markings. The effects of printing on softer paper and of retouching to increase contrast are illustrated, and the association of craters along the line of some of the rays is discussed. It is concluded that the general resemblance between these faint patterns of spots and lines and the patterns of craters and bright ray systems is strong enough to show that they are of the same genus. It is thought that the existence of these patterns appears to contradict any hypothesis of a deep dust layer (although it possibly favors a shallow layer). The data are also considered to oppose a hypothesis that the craters and craterlets observed so commonly along bright rays are direct results of secondary impacts from the formation of a parent ringed plain or other crater. M. L.

A65-34252
MORPHOLOGICAL FEATURES OF THE LIBRATORY REGION OF THE MOON.
S. Miyamoto (Kyoto University, Kwansan Observatory, Kyoto, Japan).
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 776-796. 6 refs.

Comparison of the morphological features of the craters of the libratory region of the moon with those of the maria and the reverse side. Fourteen photographs of the libratory region, under varying light conditions, are presented. The various kinds of craters found are morphologically classified in a sequence: normal craters with bright and rather rough floors in continental areas, craters with dark and flat floors, and partly ruined craters and ghost craters in maria. It is suggested that the possible controlling parameter of this sequence may be the decreasing thickness of silicic crust. The origins of maria in the libratory region and of circular maria and crater formation processes in continents and maria are considered. M. L.

A65-34253
AN EVALUATION OF THE REPORTED LUNAR CHANGES.
Patrick Moore.
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 797-810. 56 refs.

Review of the evidence supporting the idea that lunar changes have occurred. All reported changes are classified into one of three categories: (1) structural changes, such as craters which vanish (Linné), craters or other features that appear (Hyginus N), alternations over a wider area (Madler's Square), and changes in size or shape (Messier); (2) obscurations and long-term changes in brilliancy; and (3) outbreaks (Alphonsus, 1958) associated with reddish patches that persist after the actual outbreak is over. All events in the first two categories are completely discounted, after a thorough review. Although some doubt remains, it is concluded that some category 3 events have actually occurred and that there is indeed activity on the moon. Possible explanations of the Alphonsus red patches and of the Aristarchus bands are presented. M. L.

A65-34255
RHYOLITE ASH-FLOW PLATEAUS, RING-DIKE COMPLEXES, CALDERAS, LOPOLITHS, AND MOON CRATERS.
Wolfgang E. Elston (New Mexico, University, Dept. of Geology, Albuquerque, N. Mex.).
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.) New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 817-842. 84 refs.
Grant No. NGR-32-004-011.

Examination of the data in support of the idea that terrestrial volcano-tectonic depressions the size and approximate shape of large moon craters possibly exist and may in fact be quite common. These depressions are the ring-dike complexes, whose roots, exposed in deeply eroded terrains, are better known than their surface features, which, it is noted, must be sought in the great rhyolite ash-flow plateaus. An example of such a plateau, the Mogollon plateau, of southwestern New Mexico, is presented. The rocks, geological structure and history, and petrogenesis are analyzed. The significance of the Mogollon plateau lies in the possibility that it represents a type of ring-dike structure common throughout the earth, but in an unusually good state of preservation. When restored to its probable pre-erosion appearance, it bears a striking resemblance to some of the larger lunar craters. M. L.

A65-34256
THE CALDERA ANALOGY IN SELENOLOGY.
G. J. H. McCall (Western Australia, University, Perth, Australia).
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.)
New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 843-875. 47 refs.

Reconsideration of the analogy between lunar surface patterns and patterns of volcano-tectonic origin, drawn by Spurr and reiterated by Green, Poldervaart, and McCall. It is suggested that lunar crater patterns are quite easy to understand if the physical disparity between terrestrial and lunar surface conditions and internal conditions is fully taken into consideration. This leads to the conclusion that, in respect to the eruptive products, an analogy should be drawn between terrestrial volcanic gas emission (and associated fumarolic deposits) and lunar volcanism, rather than the familiar analogy involving common types of silicate-melt effusion, such as basalts. The nature of the volcano-tectonic patterns is believed to provide a far better basis for meaningful comparison than any consideration of the volcano products, and such comparison reveals similarities and systematic relationships which are compatible with a form of volcanism but not with any hypothesis of large-scale cratering by the agency of random meteorite impact and explosion. The large lunar craters are interpreted as surface cauldrons, genetically closely related to terrestrial calderas. It is concluded that such cauldrons cannot be divorced from systems of intersecting fracture lines (mostly pan-lunar) which traverse the lunar surface; craters and lineaments are considered to comprise an integrated volcano-tectonic pattern. (Author) M. L.

A65-34257
ASTROBLEMES, LUNAR CRATERS, AND MARIA.
Robert S. Dietz (U. S. Coast and Geodetic Survey, Washington, D. C.).
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.)
New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 895, 896.

Short description of some terrestrial structures of impact-explosive origin as part of an attempt to relate them to lunar structures of similar appearance. Particular stress is laid on shatter-coned structures as presumed astroblemes, including the Steinheim Basin structure in Germany and the Wells Creek Basin structure in Tennessee. It is suggested that, although much work remains to be done, there may be astroblemes on earth that are analogous to both lunar craters and maria. M. L.

A65-34259
ANALOGUES OF LUNAR CRATERS ON THE CANADIAN SHIELD.
K. L. Currie (Geological Survey of Canada, Ottawa, Canada).
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.)
New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 915-940. 33 refs.

Description of 13 craterlike objects and 7 "basins" recently discovered in the area of the Canadian Precambrian Shield, which appear to have some obscure genetic connection with craters. For the purposes of the study, a crater is defined as a roughly circular feature combining distinct areas of positive and negative relief, e.g., a rimmed pit or a pit with a central peak. The characteristics of the structures are examined and compared. It is noted that Canadian craters occur along a great welt on the craton raised since late Palaeozoic time and that the site of the craters is determined by local structural features, usually faults. Such craters are considered to form by uparching from below followed by collapse. The continental distribution of craters, it is concluded, shows that their root cause must be deep seated, possibly related to an upwelling of volatile-rich material from the mantle. It is thought that if the moon is a terrestrial-type planet, a similar evolution with a similar result is a strong possibility, but proof waits on detailed structural and petrographic examination on the lunar ground. M. L.

A65-34262
INTERPRETATION OF RANGER VII PHOTOGRAPHS.
Jack Green (North American Aviation, Inc., Space and Information Systems Div., Space Sciences Laboratory, Downey, Calif.).
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.)
New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 999-1002.

Comparison of some Ranger VII photographs with photographs of volcanic bomb craters in Kaneakakoi, Hawaii. One or a combination of four processes are considered to explain the formation of lunar craters: (1) impacts of primary meteorites, (2) secondary impact of ejecta blocks thrown out from primary meteoritic impact, (3) secondary impact from volcanic bombs or pyroelastics, and (4) maar or gas explosion cratering. Two maps, one traced from a Ranger photograph and the other from a volcanic bomb field, are presented for comparison. Secondary impact is considered to be one of the dominant mechanisms for the formation of small lunar craterlets. It is pointed out that volcanic bombs could be thrown at least 20 times farther on the moon than on the earth. M. L.

A65-34267
THE LUNAR ORIGIN OF TEKTITES.
J. J. Gilvarry (General Dynamics Corp., General Dynamics/Astronautics, Space Science Laboratory, San Diego, Calif.).
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.)
New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 1061-1081. 71 refs.

Review of the evidence on the origin of tektites in the light of Gilvarry's theory of the formation of the lunar surface features. An effort is made to assess the possible objections to the theory, particularly those tending to imply a terrestrial origin of tektites. The nature of the lunar surface and the evidence for lunar origin of tektites are considered. It is noted that demonstration of a lunar origin for tektites would imply the very significant corollary that, because the specific gravity of the tektites (2.3 to 2.5) is considerably less than that for the moon's average (3.3), the lunar interior could not be homogeneous, and that the crust must be lighter than the core. It follows from this that sometime in its past the moon would have had to become a chemically differentiated body; it would therefore be ineluctable that the selenology of the moon differ only in degree from the geology of the earth, and not in kind. Although the origin of tektites is considered a contentious subject, it is concluded that the weight of the evidence favors a lunar origin. M. L.

A65-34270
SELECTION OF ROCK STANDARDS FOR LUNAR RESEARCH.
Jack Green (North American Aviation, Inc., Space and Information Systems Div., Downey, Calif.).
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N. Y., May 16-19, 1964, Paper.)
New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 1123-1147. 9 refs.
Contract No. AF 19(628)-3292.

Study of the petrography, reflectance, electrolytic hygrometry, and differential thermal analysis of a variety of igneous rocks in an effort to set up rock standards for research on lunar surface materials. Meteoritic standards are not included because there is not enough material for bulk quantity experiments. Selection is made on the basis of what might be the span of research to be performed on them, convenience of collection within a geographical area, uniformity with respect to chemistry and texture, abundance for truly bulk quantity research, and what might be termed a lunar rationale. It is noted that the choice of the standards has been dictated by the need for a mineralogically, chemically, and texturally variable set of rocks. With one exception, all the samples have been collected within a 160-km radius of Bend, Oregon. Data are included in an appendix for six rocks: basalt, tholeiitic, semiwelded tuff, obsidian, altered rhyolite, serpentine, and granodiorite.
M. L.

A65-34271
INVESTIGATION OF WATER EXTRACTION PROCESSES FOR USE ON THE MOON.
A. E. Wechsler, P. E. Glaser, and A. E. Germeles (Arthur D. Little, Inc., Cambridge, Mass.).
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N.Y., May 16-19, 1964, Paper.)
New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 1148-1159. 19 refs.
Contract No. AF 19(628)-3279.

Theoretical study of possible lunar water extraction processes. The types of water deposits expected on the moon are briefly discussed, and two types of water extraction processes for these deposits are considered - in situ processes and processes using mined deposits. Energy requirements and water production rates for several processes are presented, and the engineering problems imposed by the lunar environment are discussed. M. L.

A65-34272
USE OF GEOPHYSICAL MEASUREMENTS IN LUNAR SURFACE ANALYSIS.
Richard A. Geyer and Jack R. Van Lopik (Texas Instruments, Inc., Dallas, Tex.).
(New York Academy of Sciences, Conference on Geological Problems in Lunar Research, New York, N.Y., May 16-19, 1964, Paper.)
New York Academy of Sciences, Annals, vol. 123, July 15, 1965, p. 1160-1174. 9 refs.

Survey of geophysical measurements to demonstrate their use in solving major lunar problems by direct measurements and by using specific lunar geologic models. A brief discussion of operational problems caused by lunar environmental or logistic constraints is included, as well as the results of a few geophysical surveys of terrestrial features having possible lunar analogs. Although the geophysical methods are summarized, emphasis is placed on gravity, seismic, magnetic, and electric methods. It is noted that the usefulness of this approach depends on the ability to determine early in the lunar exploration program the origin of specific lunar surface features. M. L.

A65-34814
THE FAR SIDE OF THE MOON.
Y. N. Lipsky (Moscow State University, Institute of Astronomy, Dept. for Lunar and Planetary Physics, Moscow, USSR).
Flight International, vol. 88, Sept. 23, 1965, p. 554-556.

Analysis of the data and photographs available of the far side of the moon. During lunar eclipses a sharp short change in the temperature only takes place on the side of the moon turned toward earth. The surface of the hidden side, however, is not subjected to such sharp variations. The Lunik 3 photographs of Oct. 1959 were taken in such a manner that they included the Eastern marginal zone as seen from the earth and consequently made it possible to place the 500 objects revealed on the hidden side in a single selenographic system of coordinates. The identified formations on the marginal side, moreover, served as specimens for analyzing new details. In July 1965 the Zond 3 automatic space station was launched and photographed practically all of the previously unknown part of the moon's surface, which appears to be brighter and more mountainous than the visible side. D. P. F.

A65-35359
PRESSURE EFFECTS ON POSTULATED LUNAR MATERIALS.
A. E. Wechsler and P. E. Glaser (Arthur D. Little, Inc., Div. 500, Cambridge, Mass.).
Icarus, vol. 4, Sept. 1965, p. 335-352. 61 refs.
Contracts No. AF 19(628)-421; No. AF 19(628)-3279; No. NAS 8-1567.

Review of literature data on the thermal conductivity of solid, porous, and powder rocks and minerals. The line heat source and thermal conductivity probe methods for measurement of thermal conductivity of these materials are described. Experimental data on the effects of pressure from 10^{-10} torr to atmospheric and temperatures from 100 to 400°K on the thermal conductivity of solid, porous, and powder rocks are reported. The results are discussed in terms of possible lunar surface materials. (Author) M. F.

A65-35362
RILLES, RIDGES, AND DOMES - CLUES TO MARIA HISTORY.
William Quaide (NASA, Ames Research Center, Space Sciences Div., Moffett Field, Calif.).
Icarus, vol. 4, Sept. 1965, p. 374-389. 8 refs.

Study of the lunar rilles, maria ridges, and maria domes which are spatially associated with low areas of the lunar surface, the maria, and immediately adjacent terrae. The spatial association implies a genetic relationship. The morphology and structural setting of most of the rilles suggest that they are tectonic features of tensional origin produced by downward bending of maria borders during a stage of maria foundering. The domes and ridges were most likely produced by small central eruptions or by laccolithic intrusions. Most of the ridges appear to be volcanic structures which grew above dike feeders during the last stages of maria filling. Age relationships and structural settings of the rilles and ridges further suggest that the formation of these features took place in sequence, ridges and domes followed by rilles. It is suggested here that this sequence of events occurred repeatedly during a long history of maria growth and that the maria grew to their present sizes by successive stages of volcanic inundation and collapse. Circular maria probably resulted from a simple enlargement of initially circular depressions whereas the irregularly shaped maria resulted from a coalescence of two or more growing basins or depressions.
(Author) M. F.

A65-35363
A GEOLOGICAL MODEL OF MARE HUMORUM.
Luciano B. Ronca (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Bedford, Mass.).
Icarus, vol. 4, Sept. 1965, p. 390-395. 11 refs.

Study of a model of Mare Humorum presented as a working hypothesis. The model was deduced by combining theories and observations of the origin of the vittae (rays), rilles, wrinkle ridges, and faults. In this model, Mare Humorum consists of a basin which subsided by tilting and normal faulting. The tilting is deduced from the observation of the partial flooding of Gassendi and Dopplemeyer, on the north and south shores of the Mare, respectively. The faulting is deduced from the location of several linear features and the vittae, which are interpreted as being loci of sublimate deposition along inframare faults. The basin is filled with volcanic material which behaves incompetently with respect to the basement. Wrinkle ridges are features of the volcanic cover due to compression resulting from the subsidence. Rilles are features of the competent basement material, due to tension stresses occurring at the hinge areas of the subsiding basin and may be grabens and/or superficial dikes. The crustal weakness responsible for Mare Humorum could have originated by impact, but endogenous tectonism is the primary factor responsible for the present structure.
(Author) M. F.

A65-35364
DENSITY OF MATTER ASSEMBLED FROM RANDOMLY INCIDENT PARTICLES.

A. G. W. Cameron and Paul B. Schneck (NASA, Goddard Space Flight Center, Goddard Institute for Space Studies, New York, N.Y.).
Icarus, vol. 4, Sept. 1965, p. 396-398.

Review of the discovery by Hapke and Van Horn that the remarkable photometric properties of the moon can be reproduced from surfaces composed of small dark grains which have been able to fall together individually. Such grains halt upon contact and the resulting structures are underdense by factors of 7 to 10. An investigation has been carried out to find the effects on the structure density of variations, in the grain sizes and shapes, of their angles of incidence. Geometrical shapes representing grains were assembled into structures using Monte Carlo techniques and a computer. The ratios of bulk density to grain density were found to be: uniform radius spheres, isotropic incidence, 0.1136; uniform radius spheres, vertical incidence, 0.1380; spheroids, vertical incidence, 0.1476; variable radius spheres, vertical incidence, 0.1706. These numbers agree with the observed bulk densities of the structures prepared by Hapke and Van Horn. (Author) M.F.

A65-35367
OBSERVATIONS OF THE MOON AND OF THE TERRESTRIAL ROCKS IN THE INFRARED.
A. B. Binder, D. P. Cruikshank, and W. K. Hartmann (Arizona, University, Lunar and Planetary Laboratory and Dept. of Geology, Tucson, Ariz.).
Icarus, vol. 4, Sept. 1965, p. 415-420. 8 refs.

Detection of distinguishing colorimetric properties of the various surface types of the moon in the IR from 1.0 to 2.2 μ and a correlation of these differences with variations in terrestrial rocks. The color of the moon was found to be very uniform in the IR (1.0 to 2.2 μ). Intensity ratios relative to the sun varied by less than 5% over most of the ten points studied. These points included maria, uplands, and recent craters. One point, a bright area near the crater Kant, was found to be bluer than the others by more than 5%. The Aristarchus plateau was the reddest point observed. Terrestrial rock samples generally were found much less red than the moon at these wavelengths. The IR intensity ratios of volcanic rock samples irradiated by Hapke with a beam of 2.0-kev H^+ ions for the lunar equivalent of about 2.5×10^5 yr approached the lunar IR intensity ratios. This supports Hapke's hypothesis that solar irradiation is the principal agent producing the unusual spectral curve and low albedo of the lunar surface. (Author) M.F.

A65-35368
MORPHOLOGICAL ASPECTS OF THE LUNAR CRUST. II.
S. Miyamoto (Kyoto, University, Kwasan Observatory, Kyoto, Japan).
Icarus, vol. 4, Sept. 1965, p. 421-424.

Study of the morphological features of the crater floors of Ritter, Alphonsus, and others which suggest the basaltic magmatism on the moon. These craters are located in maria or near the coastal line, and crater floors are gray or dark. There are no detailed photographs of craters with bright floors in terra, but their profiles suggest that lunar terra may not be so silicic as terrestrial continents. The ultrabasic nature of lunar maria seems obvious by their unique morphological aspect that the surface is extremely flat and covered with soft depressions. Provided that lunar terra is basaltic and maria are ultrabasic, it can be inferred that magmatic differentiation at the time of crustal formation remained at its earliest stage. (Author) M.F.

A65-35371
THE LUNAR CRATER DIONYSIUS.
Vern G. Smalley (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Bedford, Mass.).
Icarus, vol. 4, Sept. 1965, p. 433-436.

Description and discussion of Dionysius, a lunar crater with a white halo and dark rays. The description is illustrated by a contact print of a photographic negative from the 61-in. reflector at the US Naval Observatory. R.A.F.

A65-35809 #
PHYSICAL PROPERTIES OF THE LUNAR SURFACE [FIZICHESKIE SVOISTVA LUNNOI POVERKHNOSTI].
E. L. Ruskol.
Kosmicheskie Issledovaniia, vol. 3, May-June 1965, p. 395-407. 51 refs. In Russian.

Review of papers on the lunar surface published in the USSR and abroad in the last three years, mentioning Ranger 7 and 8 photographic information. The outermost thin surface layer, the parametric inhomogeneities over the lunar disk, the factors shaping the lunar surface, the behavior of volatile substances, the history of the lunar atmosphere, the current manifestations of degassing, and the subsurface thermal gradient are discussed at length in the light of the latest data. V.Z.

A65-36258 #
THE SPECTRAL DEPENDENCE OF LUNAR EMISSIVITY.
Frank H. Murcray (Denver, University, Dept. of Physics, Denver, Colo.).
Journal of Geophysical Research, vol. 70, Oct. 1, 1965, p. 4959-4962. 8 refs.
Grant No. NsG-518.

Measurement of the radiance of the lunar surface in the 8.0 to 10.4 μ region of the IR spectrum as a function of wavelength with a resolution better than 0.2 μ. Measurements were taken from a high-altitude station (elevation 11,500 feet) to minimize the corrections required for atmospheric absorption. The radiance values obtained after correction are not compatible with gray- or blackbody radiation at any temperature. Emissivities calculated on the basis of a 120°C lunar surface temperature vary from near unity at 8.5 μ to 0.90-0.93 in the region from 10.0 to 10.4 μ.
(Author) M.F.

A65-36555 #
CONSIDERATION OF THE AVERAGING EFFECT OF AN ANTENNA RADIATION PATTERN IN MEASURING LUNAR RADIO EMISSION [UCHET USREDNIAIUSHCHEGO DEISTVIIA DIAGRAMMY NAPRAVLENNOSTI ANTENNY PRI IZMERENIIAKH RADIOIZLUCHENIIA LUNY].
V. D. Krotikov (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).
Radiofizika, vol. 8, no. 3, 1965, p. 453-460. 24 refs. In Russian.

Discussion of the characteristics of lunar radio emission, considering the averaging effect of the antenna radiation pattern. The function of surface temperature distribution is determined on the basis of the author's previous calculations of the thermal regime of the lunar surface layer. Using the function, theoretical expressions are set up that relate radio emission from the disk center to the averaged radio emission obtained when the antenna radiation pattern is taken into account. It is shown that the lunar radio emission received with an antenna radiation pattern wider than 40' is virtually integral emission. Using the method, the parameter δ_1 can be determined more accurately than usually from measurements with any antenna radiation pattern. V.Z.

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A66-10274 #
DENSITY VARIATIONS OF THE SURFACE LAYER OF LUNITE WITH DEPTH [OB IZMENENII PLOTNOSTI LUNITA V GLUBINE V PRIPOVERKHNOSTNOM SLOE].
Iu. G. Matveev, G. L. Suchkin, and V. S. Troitskii.
Astronomicheskii Zhurnal, vol. 42, July-Aug. 1965, p. 810-816. 17 refs. In Russian.

Preliminary results of a study of a microstructural model of lunite constructed on the basis of available astronomical and radar

data on radio wave reflectance from the lunar surface. The dependence of the reflection factor on the wavelength, revealed by a comparison of radio astronomical and radar observations, is interpreted as indication of a possible lunite-density increase by a factor of 1.5 to 2.0 within the surface layer. From theoretical considerations and reflection-factor spectral data obtained with a digital computer, it is suggested that the lunite density may increase about 1.5 times to a depth of about 4 cm, remaining then stable to a considerably greater depth. V.Z.

A66-10312

A LUNAR X-RAY DIFFRACTION EXPERIMENT.
Robert C. Speed, Douglas B. Nash, and Neil L. Nickle (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
IN: ADVANCES IN X-RAY ANALYSIS. VOLUME 8.
New York, Plenum Press, 1965, p. 400-419. 14 refs.

An X-ray diffraction system is under development for remote analysis of lunar rocks from an unmanned, soft-landed spacecraft. The objective of this experiment is the identification of rock-forming phases and estimation of their abundances, compositions, and other data which are indicative of the nature of genetic processes on the moon. A 2:1 scanning parafocusing geometry was successfully miniaturized for this purpose by Parrish, and a complete diffraction system based on the design is in preparation. The diffractometer including high-voltage power supply weighs 18 lb, occupies 0.9 ft^3, and requires 56 W of continuous power. A sample acquisition and preparation system will be an integral part of the diffractometer. Diffraction analyses of a rhyolite, basalt, and chondritic meteorite are given as examples of the capabilities and limitations of rock analysis by this method. (Author)

A66-11465 #

THE SYSTEM OF LUNAR CRATERS, QUADRANT III.
D. W. G. Arthur, Alice P. Agnieray, Ruth H. Pellicori, C. A. Wood, and T. Weller.
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 3 (Number 50).
Tucson, University of Arizona Press, 1965. 161 p.
Grant No. NsG-161-61.

Catalog of all craters in the third lunar quadrant recognizable with reasonable certainty on photographs and having a diameter greater than 3.5 km. The designation, diameter, position, central peak information, and state of completeness are listed for each of these craters. A total of 5200 items are to be found in the catalog, which is illustrated by a map in eleven sections. A.B.K.

A66-11493

COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 3 (Numbers 41-49).
Tucson, University of Arizona Press, 1965. 61 p.

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A66-11500 #

VOLCANIC SUBLIMATES ON EARTH AND MOON.
Gerard P. Kuiper.
IN: COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 3 (Numbers 41-49).
Tucson, University of Arizona Press, 1965, p. 33-60.
Contract No. JPL-95077.

Analysis of two groups of photographs of Liamana Volcano, Hawaii, for their relevance to lunar studies. One group consists of eleven black and white and two color illustrations of the 1960 eruption, showing among other factors the resulting cover of sublimates on much of the mountain; the other group is composed of aerial photographs which show many secondary impact craters that formed on Laimana's slopes, as well as remaining sublimates on the crater rims and other hot spots. The two sets of pictures are thought to well illustrate the process of secondary crater formation, and also the production of a sublimate cover as an accompanying feature of the volcano-building process. B.B.

A66-12186

THE CRATER DIAMETER-DEPTH RELATIONSHIP FROM RANGER VII PHOTOGRAPHS.
Ralph B. Baldwin (Oliver Machinery Co., Grand Rapids, Mich.).
Astronomical Journal, vol. 70, Oct. 1965, p. 545-547.

The shapes of the craters shown in the Ranger VII photographs are in excellent accord with the shapes of small terrestrial impact craters, even though some of the lunar craters considered are diffuse and of secondary impact origin. Data from RLC 1-5 charts produced by Aeronautical Chart and Information Center have been compared with the logarithmic diameter-vs-depth curve from The Measure of the Moon which best fitted the terrestrial meteoritic craters and lunar craters from 1 to 20 miles in diameter. (Author)

A66-12455

MARIA SURFACE OF THE MOON.
S. Miyamoto (Kyoto University, Institute of Astrophysics, Kwasan Observatory, Kyoto, Japan).
International Lunar Society, Journal, vol. 2, Dec. 1964, p. 132-136.

The nature and formation of the surface of the lunar maria are treated with regard to the new features revealed by the Ranger VII photographs. It is seen that the surface of the maria is covered with soft depressions and that the smallest pits are distributed at random. It seems to suggest that the surface rock of the lunar mare is ultrabasic and that the original magma contained abundant gaseous components. This leads to the conclusion that magmatic differentiation took place at the time of crustal formation and hence the first separation of lunar terra from maria. (Author)

A66-12756 #

INCIDENT LUNAR EMISSION ON ORBITING SURFACES.
Lloyd M. Candell (Aerojet-General Corp., Astrionics Div., Azusa, Calif.).
(American Institute of Aeronautics and Astronautics, Annual Meeting, 1st, Washington, D.C., June 29-July 2, 1964, Paper 64-336.)
Journal of Spacecraft and Rockets, vol. 2, Nov.-Dec. 1965, p. 964, 965.
[For abstract see Accession no. A64-20176 16-28]

A66-13338

RADIATION SINTERING OF LUNAR DUST.
R. Smoluchowski (Princeton University, Princeton, N.J.).
Science, vol. 150, Nov. 19, 1965, p. 1025, 1026. 18 refs.

Study of the problem of the lunar dust layer. It has been variously suggested that nearly all the moon's surface is covered by a layer of fine dust. Optical evidence seems to indicate that this layer is exceedingly porous and that the micron-size particles cast shadows whenever the angle of the incident light is not normal. Protons in the solar wind displace atoms in the grains of lunar dust. These atoms may, through diffusion, sinter the dust layer into a partly coherent but still highly porous structure. The exact composition of the lunar surface is not known, but the presence of various hard oxides such as quartz and magnesium oxide is suspected. M.F.

A66-13895
TENUOUS SURFACE LAYER ON THE MOON - EVIDENCE DERIVED FROM RADAR OBSERVATIONS.
Tor Hagfors, Richard A. Brockelman, Haines H. Danforth, Leonard B. Hanson, and Gerald M. Hyde (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).
Science, vol. 150, Nov. 26, 1965, p. 1153-1156. 17 refs.
Description of a polarization technique in radar astronomy used in moon investigations and indicating that the lunar surface is covered by a tenuous layer. Observations of the moon were made by radar backscattering. They showed a systematic difference between the backscattering coefficient of waves polarized in, and perpendicular to, the local plane of incidence. The results are stated to be in agreement with a model consisting of a tenuous top layer at least 10 cm thick, supported by a denser underlying layer. M.M.

A66-15332 #
INAPPLICABILITY OF BALDWIN'S RELATION FOR DETERMINING THE CAUSES OF THE FORMATION OF LUNAR CRATERS [O NEPRIMENIMOSTI SOOTNOSHENIIA BOLDUINA DLIA OPREDELENIIA PRICHIN VOZNIKNOVENIIA LUNNYKH KRATEROV].
G. S. Shteinberg (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Institut Vulkanologii, Kamchatka, USSR).
Akademiia Nauk SSSR, Doklady, vol. 165, Nov. 1, 1965, p. 55-57. 14 refs. In Russian.
Consideration of the applicability of Baldwin's relation between lunar craters and terrestrial meteoritic craters. On the basis of a comparison of calderas and lunar craters, it is shown that, although lunar craters satisfy the relations established for explosion craters, it does not follow that they are of meteoritic origin, since these relations are also valid for volcanic objects. A.B.K.

A66-15758
THE MOON.
John A. O'Keefe (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: INTRODUCTION TO SPACE SCIENCE (Professional Edition) Edited by W. N. Hess.
New York, Gordon and Breach Science Publishers, Inc., 1965, p. 631-667. 23 refs.
Account of the present understanding of the structure and origin of the moon. A study of the known geometrical facts relating to the moon is made, and the moon's morphology is outlined. It is assumed that the moon's surface consists of a very fibrous structure. The surface properties discussed include optical properties, radio, radar and polarization. The geophysical problems and the chemistry of the moon are also considered. Present concepts of the origin of the moon are discussed at length. M.F.

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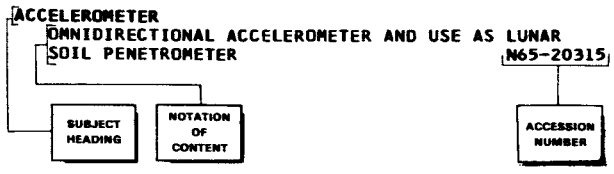

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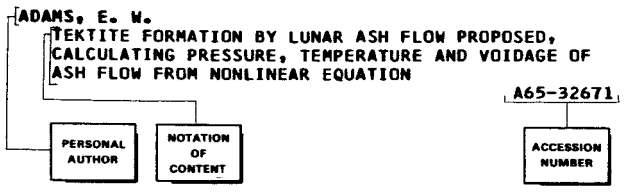

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BHALLA, L. M.
LUNAR DUST/DEBRIS HAZARDS ASSOCIATED WITH MANNED FLYING SYSTEM
NASA-CR-61106 N66-10703

BINDER, A. B.
COLORIMETRIC PROPERTIES OF LUNAR SURFACE FEATURES

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