NASA SP-7003 (01)

LUNAR SURFACE STUDIES

A CONTINUING BIBLIOGRAPHY

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A Selection of Annotated References to Unclassified Reports and Journal Articles introduced into the NASA Information System during the period April, 1964–January, 1965.

Scientific and Technical Information Division
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. MARCH 1965

INTRODUCTION

With the publication of this first supplement, NASA SP-7003 (01), 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 April, 1964–January, 1965.

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Lunar Surface Studies

a continuing bibliography

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N64-16076 Manchester U., Macclesfield (Gt. Brit.)
RESEARCH INTO METHODS OF DETERMINING THE RELATIVE HEIGHTS OF PHYSIOGRAPHIC FEATURES OF THE MOON Annual Summary Report No. 2
Zdenek Kopal Aug. 1963 20 p
(Contract AF 61(052)-524)
(ASR-2; AFCRL-64-83; AD-430705)

The research summarized in this report has been concerned with the following problems: (1) redetermination of the libration constants of the moon; (2) development of a theory of lunar librations not requiring the moon to behave like a rigid body; (3) evaluation and measurement of the old Paris photographic plates of the moon for determination of the departures of the lunar surface from a sphere; (4) determination of the exact shape of the moon from measurements of its profile during the annular eclipses of the sun on July 31st, 1962, and January 25th, 1963; and (5) an analysis of previous observations of the form of the lunar globe by expansion in tesseral harmonics with the aid of an electronic computer. Author

N64-16443 Army Map Service, Washington, D.C. Corps of Engineers
TOPOGRAPHIC LUNAR MAP [LUNAR NAMES LISTING]
Washington, Govt. Print. Off., 1963 2 p Edition 1-AMS
Available from GPO: $1.00

A 1:5,000,000 topographic lunar map (relief style) is presented along with a listing of all named features occurring in each 1° area. Only the western half of the lunar surface is shown. P.V.E.

N64-16547 California U., Livermore Lawrence Radiation Lab.
FEASIBILITY OF USING NUCLEAR EXPLOSIVES TO EXTRACT WATER FROM LUNAR ROCKS
R. A. Heckman 25 Sep. 1963 18 p refs Presented at the Mining and Process Subgroup of the Working Group of Extraterrest. Resources, Colo. School of Mines Res. Found., Sep. 25, 1963
(Contract W-7405-ENG-48)
(UCRL-7515) OTS: $0.50

The feasibility of a proposal to use nuclear explosives for in situ dehydration of lunar water-bearing deposits is investigated. Nuclear explosives are an obvious economic choice over conventional explosives for such use because of their much greater yield-to-weight ratio. For deep water-bearing deposits, contained explosions would be used. A relationship is worked out giving minimum depths for containment of explosions in the lunar environment. These range from 2,000 to 10,000 ft for the explosive yields of 1 to 100 kilotons that are contemplated. It appears feasible to emplace and detonate nuclear explosives at these great depths on the moon, but a complete evaluation of the technique must await knowledge of the geological nature of water-bearing deposits at these depths. For shallow lunar water-bearing deposits, use of "earth-moving" nuclear explosions coupled with mining techniques appears attractive. Author

N64-17505 Texas Instruments, Inc., Dallas
RADAR ANALYSIS OF THE MOON. PHASE II: SURFACE PROPERTIES Final Report
James D. Shaw and Carl A. Barlow, Jr. 16 Jan 1964 113 p refs
(Contract AF 19(628)-2478)
(AFCRL-64-74; AD-432403)

Careful evaluation of the relevant diffraction theory for describing radar return from an arbitrary terrain clearly shows the inherent ambiguity between geometrical and electromagnetic contributions and the deficiencies of the frequently used Huygens–Kirchoff theorem. A method for factorizing the geometrical and electromagnetic contributions is demonstrated, under the proviso that a separation between surface texture and gross terrain configuration is permissible. A study was made to determine the extent to which the electromagnetic properties of terrestrial materials (having possible lunar surface counterparts) are influenced by physical state (e.g., crystalline structure, density, grain size, and shape), mineral and chemical composition, and testing conditions (e.g., temperature, pressure, and radar frequency). Analyses were made of data obtained from the literature and X-band (3 cm) experiments on several geologic samples, whose mineralogic and chemical composition had been determined. This work demonstrates the limited value of measurements made of materials in a terrestrial environment and the need for a careful study of postulated lunar materials under simulated lunar environmental conditions. Author

N64-17592* Stanford U., Calif. Radioscience Lab.
RESEARCH AT THE STANFORD CENTER FOR RADAR ASTRONOMY Semi-Annual Status Report No. 2, 1 Jul.–31 Dec. 1963

V. R. Eshleman. Feb. 1964. 9 p.
(NASA Grant NsG-377)
(NASA CR-53205) OTS: $1.10 ph, $0.80 mf

Research conducted 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. R.T.K.

N64-17652 Perkin-Elmer Corp., Norwalk, Conn.
RESEARCH IN AUTOMATIC BALLOON INSTRUMENTATION FOR SELENODETIC MAPPING PHOTOGRAPHY Final Report
R. A. Kelley. 20 Feb. 1964. 117 p. refs
(Contract AF 19(628)-2396)
(AFCRL-64-201; AD-430942)

A study was conducted to determine the feasibility of an automatic balloonborne selenodetic plate camera for high-resolution photography of the moon. The areas of investigation include the optical system, system configuration, system stabilization, photographic materials, plate camera arrangement and operation, plate calibration, possibilities for improved resolution, and estimated system performance. Diagrammatic arrangements of the system are provided. Studies indicate that low-contrast lunar details having dimensions exceeding 1,000 ft can be recorded photographically by working at the f/20 focal plane of a 36-in.-telescopic optical system. The optical form will be similar to that employed in Stratoscope II. Study results indicate the desirability of incorporating ground-controlled acquisition and automatic tracking of the lunar surface. It is concluded that an automatic balloonborne selenodetic plate camera system is feasible. Author

N64-18434* Boston U., Mass.
CALCULATION OF LUNAR SURFACE AREA
David Friesen. Feb. 1964. 14 p. refs
(NASA Grant NsG-246-62)
(NASA CR-53588; *Its* Astron. Contrib. Ser. 2 no. 32; Res. Rept. 14) OTS: $1.60 ph

The problem of calculating the actual lunar surface area S, represented by an area A on a photograph of the moon, is discussed. The area A is projected onto the lunar surface and the resulting area S is calculated by integrating the projection of A over the limits of A. A computer program was written that calculates the areas S of the subsection of an area A. The method is one of numerical integration using Simpson's rule. The program has been coded for both the IBM 1620 and the IBM-90-94 series. Coding in both cases is in FORTRAN II. Input is interchangeable between the two programs. R.T.K.

N64-18439* Virginia U., Charlottesville. Research Lab. for the Engineering Sciences
EVALUATION OF THE LUNAR PHOTOMETRIC FUNCTION Final Report
Hermon M. Parker, Thomas T. Mayo, IV, D. Scott Birney, Jr., and George Mc Closkey. Jan. 1964. 71 p. refs
(NASA Grant NsG 468)
(NASA CR-53576, AST-4015-101-64U) OTS: $7.60 ph

A critical study of the available photometric data was conducted for the purpose of determining the accuracy with which lunar surface brightnesses may be predicted. The best published set of data for lunar maria, Fedoretz data, was used to determine the photometric function. These data plotted against brightness longitude for constant phase angle were fitted to (1) the Cornell theoretical photometric function, (2) a theoretical photometric function based on a modification of lunar models used by Bennett and Van Diggelen, and (3) empirical hand-drawn curves through the data points. The next best published set of data for lunar maria, Sytinskaya and Sharonov data, was analyzed in the same fashion. The problem of slope determination from lunar satellite observations is considered. It is shown that, if the photometric function is known, the surface slope can be determined theoretically. I.v.L.

N64-18497* Cornell U., Ithaca, N.Y. Center for Radiophysics and Space Research
PACKING PROPERTIES OF FINE POWDERS AND THE DEPTH OF THE LUNAR DUST LAYER
Bruce Hapke. Repr. from J. Geophys. Res., v. 69, no. 6, 15 Mar. 1964, p. 1147-1151. refs
(NASA Grant NsG-382)

The results of measurements on terrestrial powders show that the packing properties of fine dust are such that a layer of rock powder of considerable depth on the moon could maintain itself in a low-density state. The measurements reported were made with rock dust being sifted in an atmosphere rather than in a vacuum. Fine powders have also been sifted from a low height in a vacuum and have been observed to have similar low-density-packing properties. The data indicate that if processes on the moon operate so as to transport fine dust from higher areas and deposit it gently in depressions, as proposed by Gold (1955, 1962), the resulting sediments could be unconsolidated to considerable depths. The density profiles of actual lunar soils would depend on the history of the soils. Extensive, deep deposits of dust on the lunar surface do not appear to be incompatible with current radiofrequency, infrared, and optical observations of the moon. At present, these observations are felt to be insufficient to permit a decision as to whether the lunar surface consists of rock foam or similar porous materials covered with a thin layer of dust, or whether deep deposits of rock powder are widespread. R.T.K.

N64-19174* Aerojet-General Corp., Azusa, Calif. Von Karman Center
RESEARCH ON PROCESSES FOR UTILIZATION OF LUNAR RESOURCES [Quarterly Progress Report, 16 Nov. 1963-29 Feb. 1964]
S. D. Rosenberg, G. A. Guter, and G. R. Jameson. Mar. 1964. 29 p. refs
(NASA Contract NAS7-225)
(NASA CR-53749; Rept. 0765-02-1) OTS: $2.60 ph

Laboratory apparatus has been designed, fabricated, and operated for studying the reaction of methane and natural silicates to yield hydrogen, carbon monoxide, and slag. Successful runs were performed with the equipment, under varying conditions, with the use of a 450-kc induction heater. Excellent temperature control was achieved up to the operating limits of the apparatus (1,900° C). Several runs are reported that relate to development of the unit. Silicates were reduced with methane to form carbon monoxide, hydrogen, and slag by bubbling the gas through the rock melt. Incomplete reaction of carbon with the silicates was noted. Author

N64-19329 Joint Publications Research Service, Washington, D.C.
HISTORY OF THE ROTATION OF THE MOON AND THE RHEOLOGICAL PROPERTIES OF ITS SUBSTANCE

B. Yu. Levin *In its* Probl. of Cosmogony, Vol. VI 30 Apr. 1964 p 64–70 refs (See N64-19326 12-28) OTS: $6.00

The deviation of the moon from equilibrium shape is not a matter of tidal bulges, but rather of a considerable oblateness. Even so, this means that the material of the moon possesses a creep threshold of the order of 10 kg/cm^2. It is believed that the moon's oblateness indicates that it solidified under conditions of free rotation. Deceleration of the moon's rotation to the point of equalizing the periods of rotation and of revolution must have taken place as the result of significant dissipation of energy accompanying tidal deformations of the moon resulting from the earth's gravitational attraction.

Author

N64-19358 Kyoto U. (Japan)

A THEORY ABOUT THE INTERNAL COMPOSITION AND DEVELOPMENT OF THE MOON

Peter Hevervari *In its* Contrib. from the Inst. of Astrophys. and Kwasan Obs. 1963 16 p refs (See N64-19355 12-29)

(*Its* Contrib. 126)

On the basis of astrophysical considerations, the pressure and density distribution of the moon is calculated. These calculations indicate the following: (1) No significant magnetic field or Van Allen belt exists around the moon. (2) The moon is quasi-homogeneous. (3) The density of the moon is also similar to that of the earth's mantle. (4) The thickness of the moon's crust is of the same order of magnitude as in the case of the earth. (5) The continents represent the original crust of the moon. (6) There are no basins as yet on the moon's surface. (7) The transformation of the metallic core of the moon supplied essentially more energy than that necessary to produce tectonic processes on the moon.

R.T.K.

N64-19452 Joint Publications Research Service, Washington, D.C.

EXPLOSIONS OF METEORS AS A FACTOR IN THE DEVELOPMENT OF THE LUNAR SURFACE

N. N. Sytinskaya *In its* Probl. of Cosmogony, Vol. V 27 Apr. 1964 p 8–15 refs (See N64-19451 12-05) OTS: $4.00

The question as to the role of endogenic and exogenic factors in the formation of the lunar surface is considered. Sun-moon investigations reveal endogenic factors as the probable primary cause, but exogenic factors, such as photon and corpuscular solar radiation and, in particular, the impact of meteoric bodies cannot be ignored. The problem consists of how to evaluate the effectiveness of the exogenic factors upon the moon's substance. This paper offers evidence that exogenic factors were more significant than endogenic factors in lunar-surface development.

A.W.

N64-19499 Kansas U., Lawrence

THEORY OF RADAR SCATTER FROM ROUGH SURFACES, BISTATIC AND MONOSTATIC, WITH APPLICATION TO LUNAR RADAR RETURN

A. K. Fung Repr. from J. Geophys. Res., v. 69, no. 6, 15 Mar. 1964 p 1063–1073 refs

Presented is a theoretical expression for the bistatic radar return without neglecting terms involving partial derivatives of the surface. A better method of evaluating the integrals involved is shown in which no approximation needs to be made of the autocorrelation function. The final results are specialized for backscatter cases to permit comparisons with the lunar radar observations. They appear to fit the lunar observations over a wider range of angles than previous theories. Author

N64-19586* Kansas U., Lawrence Center for Research in Engineering Science

EFFECTS OF STRUCTURE SIZE ON MOON AND EARTH RADAR RETURNS AT VARIOUS ANGLES

A. K. Fung and R. K. Moore Repr. from J. Geophys. Res., v. 69, no. 6, 15 Mar. 1964 p 1075–1081 refs

(NASA Grant NsG-477; NASA Grant NsG-298-62)

Radar scatter from lunar and terrestrial surfaces is compared with theoretical calculations based on a novel autocorrelation function for surface-height deviation from the mean. A very close fit is obtained with the lunar experimental return curves of Evans and Pettengill over the entire range from normal incidence to 85° from normal. The correlation function approaches different exponentials for different lag distances. The autocorrelation differs from the slowly varying exponential only near the origin. Large-scale features determine the return at near-normal incidence and small-scale features determine that from nearer grazing incidence. Author

N64-19790* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

INTERPRETATION OF RESULTS FROM SURVEYOR ALPHA-SCATTERING EXPERIMENT

Alden A. Loomis 30 Apr. 1964 17 p refs

(NASA Contract NAS7-100)

(NASA CR-53876; JPL-TR-32-606) OTS: $1.60 ph

Rocks on the moon's surface may differ from rocks below because of contamination by meteoritic infall, sputtering, and extensive mixing by impact. The broad categories of igneous rocks and meteorites, which are familiar on earth are the best models for rocks on the moon. Anhydrous igneous rocks and meteorites may be categorized based on their atomic percentage of oxygen. The Si/Na ratio is another reliable chemical parameter: terrestrial anhydrous igneous rocks and meteorites occupy well-defined fields in a plot of oxygen percentage vs Si/Na. The best parameter to resolve ambiguities in such a plot is the Mg/Si ratio; chief drawback is accuracy. More sophisticated subdivisions could be made if Ca and K could be separated. Classification should not be based on using iron as an indicator. The concurrence of high Mg/Si and Mg/Na ratios with oxygen contents over 60% indicates water in the sample. The amount of water can be estimated by balancing the cations and anions in the actual analysis. Concomitant measurements of the magnetic susceptibility and bulk density of the sample help chemical interpretation. Television of the analyzed spot and the area surrounding the spacecraft is necessary to supply megascopic rock texture, structure, and field relations data. Author

N64-19850* New Mexico U., Albuquerque Engineering Experiment Station

AN INVESTIGATION OF ELECTRIC CHARACTERISTICS OF THE LUNAR SURFACE Status Report, 1 Nov. 1962–31 Oct. 1963

Nasir Ahmed, James A. Doran, Ahmed Erteza, and Donald H. Lenhert Mar. 1964 34 p refs

(NASA Grant NsG-129-61)

(NASA CR-53880; EE-104) OTS: $3.60 ph

An approach to the study of correlation between pulsed radar and photographic data as a method of supplementing the available statistical information on area-extensive radar scattering surfaces is described. A method of determining an improved estimate of lunar-surface properties is presented. Work has been accomplished on the electronics for the receiving system in the acoustic simulator in preparation for experiments to determine the effect of roughness. Attempts

were made to analyze the data taken in the depolarization experiment reported previously. These attempts failed to obtain a solution because of the complexity of the problem involving spherical waves rather than plane waves incident on the target. R.T.K.

N64-20608* California Inst. of Tech., Pasadena
SURFACE TEMPERATURE VARIATIONS DURING THE LUNAR NIGHTTIME
Bruce C. Murray and Robert L. Wildey Repr. from Astrophys. J., v. 139, no. 2, 15 Feb. 1964 p 734-750 refs
(NASA Grant NsG-56-60, NSF G-25210)

A new photometer incorporating a mercury-doped germanium photoconductor has been used with a 19-in. telescope to measure the 8μ to 14μ brightness temperatures of the shaded lunar surface. Right-ascension scans carried into the lunar nighttime from the terminator show a characteristic pattern of cooling inconsistent with the occurrence of a thick homogeneous dust layer. No difference in nighttime temperature distribution was observed between maria and uplands. However, local areas of higher-than-average brightness temperature were encountered. These indicate extensive exposures of consolidated material. Local temperature anomalies of this type are associated with the bright-rayed craters Tycho and Copernicus, but they are distributed over an area larger than that represented by the respective craters. Two other groups of temperature anomalies were found in otherwise undistinguished mare border areas. Author

N64-20898* Pittsburgh U., Pa.
SOURCE OF EVOLUTION OF GAS FROM THE LUNAR CRATER ALPHONSUS
Alvin J. Cohen Repr. from Nature, v. 201, no. 4923, 7 Mar. 1964 p 1015-1016 refs
(Grant NsG-416)

Plausible mechanisms to account for the gas issuing periodically from Alphonsus are discussed. There is a possibility that the gas was injected into brecciated shock-faulted areas in the craters of Alphonsus during their creation, if produced by impact of cometary matter, and that slow outgassing is taking place. However, it is more probable that Kozyrev observed outgassing from the major fault bisecting Alphonsus, and that the gas has its source deep within the Moon's surface where it is slowly being ejected as a result of radioactive heating. I.v.L.

N64-21813 Grumman Aircraft Engineering Corp., Bethpage, N.Y.
OLD AND NEW LUNAR PHOTOMETRIC MODELS AND WHAT THEY MEAN
J. D. Halajian Apr. 1964 33 p refs Presented at the Meeting of the Environment and Resources Subgroup, Comm. of Extraterrest. Resources, Golden, Colo., Apr. 1964
(ADR-04-04-64-1)

Previous attempts at inferring the nature of the lunar surface from its photometric properties and the limitations of experimental techniques used are assessed in the light of new model-matching experiments performed with an improved photometer. A number of new successful models consisting of powdered or coherent materials are reported. It is concluded that: (1) Any final conclusion regarding the consistency, bearing strength, chemical composition, and absolute roughness of the lunar surface layer on the basis of its photometry alone is unjustified. (2) The surface of the moon, whatever its origin, is covered with a dark, highly porous material having interconnected cavities. (3) An underdense rigid silicate promises to reconcile the photometric and infrared portions of the lunar data better than a loose fluff. Author

N64-22036 Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div.
MAIN STRUCTURAL ELEMENTS OF THE MOON
Yu. A. Khodak *In its* Cosmic Res. 14 Feb. 1964 p 216-227 refs (See N64-22027 15-29)

A description is given of the main structural elements of the near and far sides of the moon, and a series of deep-fracture zones in four directions, which segment the lunar crust into huge blocks, is noted. Author

N64-22063* Cornell U., Ithaca, N.Y. Center for Radiophysics and Space Research
A THEORETICAL PHOTOMETRIC FUNCTION FOR THE LUNAR SURFACE
Bruce W. Hapke Repr. from J. Geophys. Res., v. 68, no. 15, 1 Aug. 1963 p 4571-4586 refs
(Grant NsG-119-61)

A formula describing the observed photometric properties of the lunar surface is derived theoretically. Functions for both the differential and integral brightness are obtained. The model surface on which the derivation is based consists of a semi-infinite, porous layer of randomly placed obscuring objects suspended in depth in such a way that the interstices separating them are interconnected. A layer of fine, loosely compacted dust is in the category of surfaces described by this model, but volcanic foam is not. The shape of the photometric curve depends on the fractional void volume. Bulk densities of the order of one-tenth that of solid rock are implied for the upper layers of the surface of the moon. Author

N64-22461* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
RANGER 1964
[1964] 37 p ref
(NASA-CR-56289) OTS: $3.60 ph

The mission of the Block III Ranger flights is to obtain television pictures of the lunar surface. The pictures are expected to be at least an order of magnitude better in resolution than any earth-based photography. The Ranger spacecraft, mounted atop the Atlas-Agena combination launch vehicle, carries a multiple TV camera subsystem. A series of about 3,000 video pictures, commencing approximately 10 minutes before lunar impact, is expected to be obtained by each mission. Included is a discussion of the moon, launching problems, spacecraft description, space-flight operations, and mission description. P.V.E.

N64-22643 Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div.
SPECTROPHOTOMETRY OF THE LUNAR SURFACE
V. G. Teyfel' 26 Feb. 1963 12 p refs Transl. into ENGLISH from "Spektrofotometriya Poverkhnosti Luny" Leningrad, Akad. Nauk SSSR, 1960 p 3-10
(FTD-TT-63-10/1; AD-299624)

An abstract is presented of a paper concerned with a spectrophotometry study of the lunar surface. The paper is devoted

to spectrophotometric and spectrocolorimetric investigation of individual, relatively small sections, and details of the lunar surface. The purpose of the paper is to study the chromatic properties of a great number of lunar objects, situated in various sections of the lunar disk, and the obtainment of spectral curves of a number of lunar-surface sections, as well as a comparison of obtained data with the other optical and morphological properties of these objects. P.V.E.

N64-23216 Boeing Scientific Research Labs., Seattle, Wash. Geo-Astrophysics Lab.

RADIATIVE TRANSPORT OF HEAT IN LUNAR AND PLANETARY INTERIORS

Zdenek Kopal (Manchester U.) Feb. 1964 89 p refs

(D1-82-0328)

The aim of the present investigation was to formulate and solve the problem of the radiative transfer of energy in solid globes of planetary size - both in their interiors as well as surface layers - with the radiative loss into space taken into account. The time-dependent partial differential equation of radiative transfer was formulated in terms of spherical polar coordinates, and a method developed to construct a solution of this equation, to an arbitrary order of accuracy, both for the emissivity or temperature as the dependent variable. In the latter case, the well-known equation of heat conduction is obtained as a limiting case if the mean free path of the energy-carrying photons tends to zero. The problem of the radiative transfer of energy in planetary interiors, with radiative loss at the boundary, is solved analytically for the case of a homogeneous globe characterized by constant absorption coefficient. A suitable substitution can render the problem linear if the emissivity—rather than temperature—is adopted as the dependent variable, and solvable in terms of Fourier series arising by the invasion of a certain finite Fourier sine transform of the emissivity. The same technique is applied to the solution of a plane-parallel problem of radiative energy transfer in surface layers subject to a periodic insolation from above. Author

N64-23526* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

THE INTERIOR OF THE MOON

Stanley Keith Runcorn 15 Dec. 1963 15 p refs

(Contract NAS7-100)

(NASA-CR-56510; JPL-TR-32-529) OTS: $1.60 ph

The differences in the moments of inertia of the moon and its ellipticity toward the earth are between 15 and 40 times those calculated on a hydrostatic theory. Of possible explanations, the most satisfactory explanation is that convection, described by second-degree harmonics, is occurring. Second-order convection implies the existence of a small core, presumably iron, and results in a new discussion of the moon's evolution and thermal history. Author

N64-23528* Bell and Howell Research Center, Pasadena, Calif.

STUDY DIRECTED TOWARD SELECTION OF APPARATUS FOR ANALYSIS OF LUNAR CRUST AND ATMOSPHERE Summary Report

Wilson M. Brubaker Oct. 1963 32 p refs

(Contract NAS8-11013)

(NASA-CR-56545) OTS: $3.60 ph

This study is directed toward the instrumentation problems associated with the analysis of the lunar crust and atmosphere by mass spectrometry. Based on a survey of the present knowledge and theories of the lunar characteristics, a major portion of this study is concerned with the type of mass analyzer that holds the greatest potentialities for this specific application. The lunar environment has been considered, with emphasis being given to its influence on the instrumentation package. The characteristics of various types of ionic mass analyzers have been reviewed, and their potentialities for use in the lunar environment are discussed. The desired improvements in the state-of-the-art in the field of mass spectrometry are considered. N.E.A.

N64-24023* General Mills, Inc., Minneapolis, Minn. Aerospace Research

INVESTIGATION OF SPUTTERING EFFECTS ON THE MOON'S SURFACE Fourth Quarterly Status Report, 25 Jan. 1963–24 Apr. 1964

G. K. Wehner, D. L. Rosenberg, and C. E. KenKnight 27 Apr. 1964 47 p refs

(Contract NASw-751)

(NASA-CR-56292; Rept.-2563) OTS: $4.60 ph

Additional hydrogen sputtering yields on metals and metal oxides were obtained, confirming earlier values for Al, Ti, and Fe and revealing that chemical effects double the sputtering rate on SiO_2 relative to Si, for which yields of $0.018/H_2^+$ and $0.046/H_3^+$ at 7.5 keV were obtained. Helium yields were determined using the same mass-analyzed ion beam hole-drilling technique as with hydrogen. Bombardment of powdered basalt by ions from He and $He\text{-}H_2$ mixture plasmas does not result in accelerated surface darkening or alteration. Surface darkening by hydrogen bombardment of a segment of the Holbrook meteorite were observed and measured. The normal albedo was reduced from 0.30 to 0.12 by the equivalent of 10^4 years of solar-wind bombardment. Reflection curves and normal albedos are given for various oxides and minerals before and after exposure to simulated solar-wind bombardment equivalent to periods of up to 2×10^5 years. Author

N64-24035* Ohio State U. Research Foundation, Columbus Antenna Lab.

INVESTIGATION OF THEORETICAL AND EXPERIMENTAL ANALYSIS OF THE ELECTROMAGNETIC SCATTERING AND RADIATIVE PROPERTIES OF TERRAIN, WITH EMPHASIS ON LUNAR-LIKE SURFACES Semi Annual Report, 1 Nov. 1963–30 Apr. 1964

1 May 1964 15 p refs

(Grant NsG-213-61)

(NASA-CR-56539; Rept.-1388-14) OTS: $1.10 ph

This report reviews work aimed at clarifying the relations between the electromagnetic scattering properties of a surface, in particular, the lunar surface, and its surface structure. Theoretical studies were made of the correlation properties of the scattered signal as a function of frequency separation and surface roughness for the adjacent frequency scattering experiments. A laboratory model of the two-frequency system was constructed to measure the correlation properties of the scattered signals from simple targets. A 10-kw transmitter facility operating at a frequency of 2,270 Mcs was completed and is now in operation. Author

N64-24069 Iowa State U., Iowa City
THREE COLOR PHOTOMETRY OF MARE CRISIUM DURING THE TOTAL ECLIPSE OF DECEMBER 30, 1963
Satoshi Matsushima and John R. Zink (Wisconsin State Coll.) [1964] 19 p refs Submitted for Publication
(SUI-64-19)

A three-color photometry of the eclipsed moon was carried out by a 12-inch reflector during the total eclipse. To examine the intensity and color distribution of refracted light in the umbral region, the observation was centered at Mare Crisium during the course of the eclipse. The decrease in brightness was nearly the same for all the three colors, which amounted to about 16 magnitudes. The colors of the uneclipsed Mare Crisium area were determined to be B-V = + 0.79 ± .077 and U-B = + 0.41 ± .088, whereas the corresponding values at the midtotality were + 0.67 ± .090 and + 0.44 ± .045, respectively. Thus, it was concluded that this particular eclipse did not show any reddening effect. Author

N64-24205 Manchester U. (Gt. Brit.)
DEVELOPMENT OF THE LUNAR TOPOGRAPHY INTO SPHERICAL HARMONICS, II Technical Note No. 2
C. L. Goudas Feb. 1964 60 p refs
(Contract AF 61(052)-524)
(AFCRL-64-428; AD-601137)

On the basis of absolute height measures on the surface of the moon made previously, the lunar figure was analyzed into spherical harmonics, including terms of up to the eighth order. In doing so, it was postulated that the two sides of the moon were symmetrical. Two sets of values were determined for the coefficients of the harmonic expansion based on Schrutka's and Baldwin's sets of points. The results agree with the theoretical conclusion based on a hydrostatic stress and uniform density assumption, that the second surface harmonic of the moon is small. Author

N64-24260 Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div.
NEWS OF THE COMMISSION ON PLANETARY PHYSICS Selected Articles
13 Dec. 1962 21 p refs Transl. into ENGLISH of two articles from Izv. Komis. Po Fiz. Planet (USSR), no. 2, 1960 p 46–54, 65–72
(FTD-TT-62-1514/1+2; AD-295436)

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1. PRACTICE OF DETERMINING THE TEMPERATURE OF INDIVIDUAL PARTS OF LUNAR SURFACE Yu. N. Chistyakov p 1–11 refs (See N64-24261 17-29)

2. INDICATRICES OF REFLECTION OF INDIVIDUAL SECTIONS OF THE LUNAR SURFACE N. P. Barabashov and V. I. Yezerskiy p 12–17a refs (See N64-24262 17-29)

N64-24261 Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div.
PRACTICE OF DETERMINING THE TEMPERATURE OF INDIVIDUAL PARTS OF LUNAR SURFACE
Yu. N. Chistyakov *In its* News of the Comm. on Planetary Phys. 13 Dec. 1962 p 1–11 refs (See N64-24260 17-29)

Preliminary results are reported of temperature measurements of lunar-surface sections with angular size of 1.5-minutes square. Observations were carried out with a vacuum-compensating thermocouple, 0.7-mm square, with a sensitivity of 10 v/w, set in the Newton focus of a 13-inch reflector of 1,600-mm focal length. Analysis was by a modified Menzel method. Radiation-absorbing atmospheric water vapor was calculated by the Hann formula. These results were obtained: temperature of the subsolar point near full moon equals 400° ±30° K; maria temperatures are higher than temperatures of surrounding areas; and the ratios of radiometric to visual albedo for individual sections are equal to the similar ratio of average albedos over the lunar disk. D.E.W.

N64-24262 Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div.
INDICATRICES OF REFLECTION OF INDIVIDUAL SECTIONS OF THE LUNAR SURFACE
N. P. Barabashov and V. I. Yezerskiy *In its* News of the Comm. on Planetary Phys. 13 Dec. 1962 p 12–17a refs (See N64-24260 17-29)

By applying the principle of optical reciprocity to data of a photometric catalog of the lunar surface, reflective indices of individual sections of the lunar surface were obtained and compared. D.E.W.

N64-24490 Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div.
THE MOON—THE NEAREST BODY IN THE UNIVERSE
Josef Sadil *In its* To the Near and Distant Universe 16 Jul. 1963 p 2–21 (See N64-24489 17-05)

Brief discussions of the following are presented: (1) size and mass of the moon; (2) orbit of the moon around the earth; (3) phases of the moon; (4) earthshine; (5) lunar atmosphere; (6) temperature of the moon's surface; (7) composition of the moon's surface; (8) lunar mineralogy; (9) lunar radioactivity; (10) telescopic view of the moon's surface; (11) formation of lunar seas and craters; (12) life on the moon; (13) origin of the moon; and (14) astronomic observations on the moon. P.V.E.

N64-24770 Joint Publications Research Service, Washington, D.C.
THE LUNAR SURFACE AND THE EARLY STAGES OF THE DEVELOPMENT OF THE SOLAR SYSTEM
J. Kuiper (Yerkes Observatory) *In its* Probl. of Cosmogony, Vol. VII 25 May 1964 p 94–95 Presented at Gen. Meeting of the Intern. Astron. Union, 15 and 19 Aug. 1958 (See N64-24759 17-29) OTS: $5.00

Discussed are the peculiarities of lunar relief, and the role of fusion and the impacts of colliding bodies in the formation of the moon. Author

N64-24832* National Aeronautics and Space Administration, Washington, D.C.
LUNAR RADIO EMISSION—THE PHYSICAL STATE AND NATURE OF THE MOON'S SURFACE [RADIOIZLUCHENIYE LUNY, FIZICHESKOYE SOSTOYANIYE I PRIRODA YEYE DOVERKHNOSTI]
V. S. Troitskiy Jul. 1964 32 p refs Transl into ENGLISH from Izv. Komis po Fiz. Planet. Akad. Nauk UKR. SSR, no. 3, 1961 p 16–30
(NASA-TT-F-172) OTS: $0.75

On the basis of investigations of lunar radio emission at wavelengths of 0.4 and 3.2 cm, radio data are not consistent with the widely accepted two-layer model of the lunar surface, which postulates the existence of a thin non-heat-conducting layer covering the dense lunar rock and transparent to radio waves; therefore, this model should be discarded. The nature of the dependence of the lunar radio emission on the wavelength unambiguously indicates that the properties of the outer layer are quasihomogeneous, at least to a depth of the order of 1 m. Author

N64-24873 Grumman Aircraft Engineering Corp., Bethpage, N.Y.

THE CASE FOR A COHESIVE LUNAR SURFACE MODEL

J. D. Halajian Jun. 1964 62 p refs Presented at the Conf. on Geol. Probl. in Lunar Res., Sponsored by the N.Y. Acad. of Sci., N.Y., May 1964

(ADR-04-04-64.2)

The lunar dust controversy is reexamined in the light of new data and experiments. The interpretation of the data shows that cohesionless dust has to be either very fluffy in order to match the lunar photometry or densely packed in order to match the thermal inertia constant, $(k\rho c)^{-1/2}$, of the moon. The likeliest model that could satisfy both aspects of the data at once is a highly porous but cohesive material, such as a rock froth or slag. This conclusion is reached by the following "model-matching" and "environment-simulation" experiments: (1) photometry; (2) thermal measurements; (3) lava and soil behavior in vacuo. Author

N64-25680* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

LUNAR SEISMOLOGY

R. L. Kovach and F. Press 10 Aug. 1962 15 p refs

(Contract NAS7-100)

(NASA-CR-56971; JPL-TR-32-328)

A knowledge of the seismicity of the moon will provide an insight into its thermal and tectonic history. Analyses of lunar seismograms from a simple passive experiment should give an estimate of the composition of the moon and indicate its main internal structural features, such as the presence of a lunar crust and core. Meteor impacts will most probably be recorded by a lunar seismograph, even though the task of distinguishing such impacts from natural moonquakes may prove to be difficult. A single-axis seismometer will be carried aboard Ranger V, and the data from any lunar seismic disturbances will be telemetered to earth for subsequent analyses. More sophisticated active seismic experiments can contribute important information on the regional and location variations in the internal structure of the moon and should rank high in priority for future lunar missions. Author

N64-26312 Grumman Aircraft Engineering Corp., Bethpage, N.Y.

COMPARATIVE PERFORMANCE OF NON-CIRCULAR AND CIRCULAR WHEELS IN A SIMULATED LUNAR SOIL

Joel W. Schachter Jan. 1964 32 p refs

(ADR-04-05-63.2)

An investigation of locomotion on the lunar surface led to the testing of various noncircular and circular wheel forms in a simulated lunar type of soil to gather comparative performance data. The wheels tested were: the metalastic wheels (both spaced link and smooth), the elliptical wheel, and the rigid-circular wheel (having a diameter equal to the unloaded metalastic wheel). The wheels were evaluated by their performance in gross traction, drawbar pull vs. percent slip, rolling resistance, and tandem wheel tests. Author

N64-26404* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

COMMENTS ON EXHAUST FLOW FIELD AND SURFACE IMPINGEMENT

Leonard Roberts and Jerry C. South, Jr. Repr. from AIAA Journal, v. 2, no. 5, May 1964 p 971-973 refs

(NASA-RP-242)

The problem of the impingement of a jet exhaust on simulated lunar surfaces is considered and is discussed both theoretically and experimentally. Included is information on the region of applicability of present theory for conical nozzles, the variation of surface pressure with height, and the surface pressure distribution. R.T.K.

N64-27120* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

APPLICATION OF PENETROMETERS TO THE STUDY OF PHYSICAL PROPERTIES OF LUNAR AND PLANETARY SURFACES

John Locke Mc Carty, Alfred G. Beswick, and George W. Brooks Washington, NASA, Aug. 1964 30 p refs

(NASA-TN-D-2413) OTS: $0.75

A study was made to evaluate the practicality of employing the penetrometer technique as a means for determining physical characteristics of a remote surface such as that of the moon or a planet. The study included a review of the history and fundamentals of the penetrometer concept and an examination of the basic requirements for penetrometers and necessary support apparatus. The applicability of penetrometer concepts and techniques to various present-day manned and unmanned spacecraft is discussed. In addition, details of a specific application of the concept as a payload for the Ranger spacecraft are appended. Author

N64-27303* Arizona U., Tucson Lunar and Planetary Lab.

LUNAR AND PLANETARY LABORATORY SECOND SEMI-ANNUAL STATUS REPORT, 1 DECEMBER 1961-1 JUNE 1962

Gerard P. Kuiper et al [1962] 20 p

(Grant NsG-161-61)

(NASA-CR-56888) OTS: $1.60 ph

The laboratory has been concerned with the preparation and publication of major collections of scientific records as well as with research. Two editions of Part II of the "Orthographic Atlas of the Moon," one carrying the orthographic grid alone and the other having the latitude-longitude grid as well, have been issued, completing the atlas, which combines lunar-coordinate information with high-quality photography. Studies associated with the preparation of the "Rectified Lunar Atlas" and with the globe photography program are described, and a list of communications published by the laboratory on lunar and planetary studies is included. D.S.G.

N64-27304* Nuclide Corp., State College, Pa. Nuclide Analysis Associates

ANALYSIS OF THE LUNAR SURFACE AND ATMOSPHERE BY MASS SPECTROSCOPY Summary Report

B. R. F. Kendall, L. F. Herzog, P. J. Wyllie, D. S. Edmonds, and C. Bauer 11 Jan. 1964 168 p refs
(Contract NAS8-11119)
(NASA-CR-56552) OTS: $12.00 ph

A study has been made of problems associated with the determination of the composition of the lunar atmosphere and lunar crust by mass spectroscopy. Methods for determining the mineralogy and petrology of lunar samples from their chemical compositions are summarized. Consideration is given to the characteristics of the lunar environment and its influence on the general design of the lunar instrumentation package. Various types of ion sources, ion mass-charge analyzers, and ion detectors are evaluated. Instrument calibration and ground-based data processing are also discussed. The conclusion of the study is that the most promising type of equipment for the proposed application appears to be a Monopole mass analyzer with an electron bombardment ion source and electron multiplier detector. Author

N64-27358* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
AN INTERPRETATION OF SCHROTERS VALLEY AND OTHER LUNAR SINUOUS RILLS
Winifred Sawtell Cameron Repr. from J. Geophys. Res., v 69, No. 12, 15 Jun. 1964 p 2423-2430 refs
(NASA-RP-284)

Several theories have been proposed for the origin of lunar sinuous rills, such as Schröter's Valley. This paper presents a new explanation of the formation of these rills, namely, that they are valleys eroded by nuées ardentes. Characteristics of the rills, including form and association, are cited in support of this theory. Supporting evidence is found in the similarity of the rills to furrows eroded by nuées ardentes on the earth. Author

N64-27666* National Aeronautics and Space Administration, Washington, D.C.
RANGER VII PRELIMINARY RESULTS CONFERENCE, JET PROPULSION LABORATORY, PASADENA, CALIFORNIA
Homer E. Newell et al 31 Jul. 1964 26 p Available from th Scientific and Technical Information Division

First reports of lunar pictures taken by Ranger VII are presented and evaluated. The quality of the pictures was considered excellent. The most significant result was stated to be the confirmation afforded by the pictures of previously held scientific theories of the moon's composition. It was also held significant that the dimensions of the region of the moon observed were down a factor of a thousand below what had been observable before, and that this tremendous range of new knowledge presented no totally unforeseen problems. Even though the craters increased in number very rapidly, there came a time that the pictures no longer looked as rough as they had at intermediate scales; they began to get smoother, and this was termed significant although it was considered too early to fully interpret this significance. A.W.

N64-27806* Ohio State U. Research Foundation, Columbus Antenna Lab.
THEORETICAL AND EXPERIMENTAL ANALYSIS OF THE ELECTROMAGNETIC SCATTERING AND RADIATIVE PROPERTIES OF TERRAIN, WITH EMPHASIS ON LUNAR-LIKE SURFACES Semi-Annual Report, 1 Nov. 1962-30 Apr. 1963
1 Jun. 1963 10 p refs
(Grant NsG-213-61)
(NASA-CR-50859; Rept.-1388-10) OTS: $1.10 ph

Theoretical and experimental studies conducted to provide the fundamental data needed to interpret or to design planetary radar experiments are discussed. Back-scattering measurements from moon-like surfaces were made. Theoretical studies included these: an analysis of the specular part of the lunar scattering in terms of a physical optics model which predicted a nongaussian second probability distribution and gave an estimate of the rms slope of the intermediate scale features of the lunar surface; fundamental studies in radar photometry, including the solution of the doppler mapping problem in closed form; and studies of the polarization transforming properties of rough surfaces, with application to the interpretation of lunar radar experiments using linear polarization. Preliminary studies were made of a proposed CW lunar radar experiment to be performed with the "Saucer Field" receiving system. R.T.K.

N64-27884* Berne U. (Switzerland)
STUDIES ON THE RADIOACTIVE DATING OF THE LUNAR SURFACE Status report No. 3, 10 Jan. 1963-10 Jan. 1964
P. Eberhardt and J. Geiss Jan. 1964 9 p
(Grant NsG-157-61)
(NASA-CR-56792) OTS: $1.10 ph

The experimental studies on a system for the determination of rare gas isotope concentrations by remote-controlled operation were continued. Modifications in the rare gas and purification system resulted in smaller dimensions, reduced weight, and greater reliability. The experiments with the extraction system for four rock-samples and the development of valves were continued. In addition to the experimental and technical work, a theoretical study on the possibilities, significance, and limitations of dating lunar surface material is carried out. Author

N64-28405* Virginia Polytechnic Inst., Blacksburg
PROCEEDINGS OF THE CONFERENCE ON LUNAR EXPLORATION, AUGUST 12-AUGUST 17, 1962
James B. Eades, Jr., ed. May 1963 70 p refs *Its Bull.*, v. 56, no. 7, Eng. Expt. Station, Ser. 152, Suppl.
(Sponsored by NASA and NSF)

CONTENTS:

1. TOPOGRAPHY OF THE LUNAR SURFACE Zdenek Kopal (JPL) p 28 refs (See N64-28406 10-29)
2. INSTRUMENTATION FOR A LUNAR SOFT LANDER Karl W. Linnes (JPL) refs (See N64-28407 10-29)

N64-28406* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
TOPOGRAPHY OF THE LUNAR SURFACE
Zdenek Kopal, Manchester U. *In* Va. Polytech. Inst. Proc. of the Conf. on Lunar Exploration, Aug. 12-Aug. 17, 1962 May 1963 28 p refs (See N64-28405 20-29)

The main point of this report is whether the bulk of the mass of the moon behaves as an elastic fluid or as a viscoelastic flow. It is assumed that the bulk of the mass of the moon consists of rocks akin to the silicates, and the results of laboratory measurements of the bulk compression modulus of the moon are employed. These results indicate that, as far as magnitude is concerned, this modulus is of the order of 10^{12} cm^2/dyn. The present estimates of the viscosity of the mantle of

the earth, which are the best guides to lunar viscosity, range from 10^{22} g/cm/sec down to 10^{17} or 10^{18} g/cm/sec, which represents the lower limit. The product of these two quantities is the dimension of time. If the upper limit for the viscosity is adopted, the maximum relaxation time should come out to be of the order of 10^{10} sec, which is just about 300 years. If the lower limit is adopted, this relaxation time can be reduced to 10^{6} sec, which is just about 10 days. Thus, insofar as long-drawn out process are concerned—such as probable convection is the lunar interior—the moon is almost bound to behave as viscoelastic. The superadiabatic temperature gradient would cause the matter to flow. I.v.L.

N64-28407* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
INSTRUMENTATION FOR A LUNAR SOFT LANDER
Karl W. Linnes *In* Va. Polytech. Inst. Proc. of the Conf. on Lunar Exploration, Aug. 12 Aug. 17, 1962 May 1963 38 p refs (See N64-28405 20-29)

Instrumentation design constraints for a lunar soft landing and instrumentation under study are discussed. The design constraints are vibration, shock, and acceleration, thermal control, lunar dust, and vacuum conditions. Instrumentation considered includes a gamma backscattering device for measuring material density, an instrument for measuring thermal diffusivity; moving coil geophones and a six-shot, explosive acoustic source for measuring acoustic velocity; a subsurface goephysical logging sonde for soil mechanics studies; an X-ray spectrograph; an X-ray diffractometer; a petrographic microscope; and a gas chromatograph. I.v.L.

N64-28969* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SURVEYOR LANDER MISSION AND CAPABILITY
Milton Bellock 1 Aug. 1964 26 p
(Contract NAS7-100)
(NASA-CR-58247; JPL-TR-32-618) OTS: $2.60 ph

The organization, purpose, and general engineering nature of the Surveyor lunar soft-lander project is reviewed in the context of unmanned lunar exploration and anticipated needs of manned lunar programs. Flight and lunar-surface operations are discussed for both the test missions and the operational missions. An estimate of the nature and capability of the engineering payload and of each experiment of the scientific payload is presented. Finally, a brief discussion of the possibilities of follow-on missions is given. Author

N64-30339* National Aeronautics and Space Administration. Goddard Inst. for Space Studies, New York, N.Y.
DISCOVERIES FROM SPACE EXPLORATION
Robert Jastrow *In* NASA, Washington Proc. of the 4th Natl. Conf. on the Peaceful Uses of Space 1964 p 109-121 (See N64-30326 22-01) GPO: $1.50

Some contributions of space science in astrophysics, geodesy, geology, meteorology, and astronomy are reviewed in considerable detail. R.L.K.

N64-30455 Joint Publications Research Service, Washington, D.C.
RECENT DEVELOPMENTS IN LUNAR ASTRONOMY
18 Sep. 1964 31 p ref. Transl. into ENGLISH of 2 articles from Priroda (Moscow), no. 6, Jun. 1964 p 44-55
(JPRS-26460, TT-64-41718) OTS: $2.00

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1 LUNAR "GEOLOGY" V. V. Kozlov and Ye. D. Sulidi-kondrat'yev p 1-14 ref

2 WHAT WE CAN OBSERVE ON THE MOON K. A. Kulikov p 15-28 ref

N64-30516* Boston U., Mass.
CATALOG OF LUNAR CRATERS
Gerald S. Hawkins, David D. Friesen, Peter W. Mitchell, Frank Hugh Byers, Badri Aghassi et al. May 1964 109 p refs *Its* Astron. Contrib., Ser. II, v. 5, no. 36
(Grant NSG-246-62)
(NASA-CR-58785) OTS: $4.00 fs, $0.75 mf

Several well-defined areas on the lunar surface, representing both maria and highland regions, were selected, and all crater-like formations in these areas were measured and described according to numerical code. The highland region includes a section extending from the center of the lunar disk toward the limb on the southeast edge of the moon. The maria region includes Sinus Aestuum and parts of Mare Nubium. About 3.1% of the lunar surface lies within these boundaries. Measurements of 2659 crater formations are included. The information listed for each crater includes a sequence number, the crater name, the coordinates in the direction-cosine projection and in the latitude longitude system, the diameter, a description of degree of definition and shape, special notes on physical structure, and a notation of the photograph (from the "Photographic Lunar Atlas," edited by G. P. Kuiper) on which the measurements were taken. There is also a section on coordinate transformation, a photographic finding list, an alternate reference list to trace craters to references in the literature, and an alphabetical list of named craters. R.L.K.

N64-30575 Joint Publications Research Service, Washington, D.C.
INFRARED RADIATION COEFFICIENTS AND DIFFERENCES IN THE PARAMETER $\gamma = (k\ \rho\ c)^{-1/2}$ FOR THE SEAS AND CONTINENTS ON THE MOON'S SURFACE
M. N. Markov and V. L. Khokhlova 23 Sep. 1964 9 p refs Transl. into ENGLISH from Dokl. Akad. Nauk SSSR (Moscow), v. CLVII, no. 2, 1 Aug. 1964 p 826-829
(JPRS-26521; TT-64-41779) OTS: $1.00

Color temperature was determined, using the ratio of the values of the radiation flux in two spectral intervals. The windows of atmospheric transparency 8μ to 13μ, and 3.6μ were chosen. Integral equations are given for the fluxes from the lunar surface in both of the above spectral regions, and methods for determining the coefficients of reflection and emission are discussed. The observed difference in fluxes apparently should be attributed to the differences of the value $\gamma = (k\ \rho\ c)^{-1/2}$ for the seas and continents. (Here k is the heat conductivity, ρ is the density, and c is the heat capacity.) According to computations, when the observed value is $\gamma = 600$, the observed difference in the fluxes corresponds to a difference in γ of about 20%. I.v.L.

N64-30730 Cornell U., Ithaca, N.Y.
STRUCTURE OF THE LUNAR SURFACE
Thomas Gold *In* School of Aerospace Med. Lectures in Aerospace Med., 3-7 Feb. 1964 [1964] p 239-271 refs (See N64-30712 22-16)

There are three distinct types of observable properties of lunar-surface structure—the optical scattering law with angle and polarization of the lunar surface; the thermal radiation, both in the infrared and radio-wave band, and its changes over the day and during eclipses; and the reflection of radio waves as observed with radar techniques. It is concluded that the majority of the moon's surface has a low-density and high-porosity structure, as well as a deposit of fine rock dust. A.W.

N64-30857* *Consultants and Designers, Inc., Arlington, Va.*
THE EFFECTIVE LUNAR SURFACE TEMPERATURE DUE TO THE REFLECTION FROM IT OF COSMIC RADIO EMISSION [EFFEKTIVNAYA TEMPERATURA LUNNOY POVERKHNOSTI, OBUSLOVLENNAYA OTRAZHENIYEM OT EYE KOSMICHESKOGO RADIOIZLUCHENIYA]
A. M. Starodubtsev 29 Sep. 1964 11 p refs Transl. into ENGLISH from Izv. Vyssh. Ucheb. Zaved., Radiofiz. (Gor'kiy), v. 7, no. 3, 1964 p 399–405
(Contract NAS5-3760)
(NASA-TT-F-8964; ST-LPS-10212) OTS: $1.00 fs; $0.50 mf

The effective temperature due to the reflection from the moon's surface of cosmic radio emission at 100, 200, and 400 mc/sec is computed for the lunar surface. A dielectric sphere with a perfectly smooth surface, with permittivity equal to 1.5 to 4, has been considered as the model of the moon. It follows from calculations that the average brightness temperature varies little as a function of the moon's elevation angle, some increasing taking place only in the region $\alpha = 280°$; and the radiation polarization ratio depends little on the frequency, not exceeding 12% for $\epsilon = 1.5$, its average value being $\sim$ 2% to 5%. Author

N64-31213* *National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.*
TEKTITES AND IMPACT FRAGMENTS FROM THE MOON
John A. O'Keefe Repr. from Sci. American, Feb. 1964 10 p refs
(NASA-RP-335)

A broad outline of evidence indicating a lunar origin for tektites is presented. The fact that tektites have a lunar origin is shown to indicate the following: (1) The moon has a hot interior and is differentiated into a crust and a mantle (although it has no molten core). (2) The moon is not a small planet "captured" by the earth but is either a chunk of primordial earth or a twin of the earth, formed at the same time from the same batch of materials. P.V.E.

N64-31449* National Aeronautics and Space Administration, Washngton, D.C.
THE PRINCIPLE STRUCTURAL ELEMENTS OF THE MOON [GLAVNEYSHIYE STRUKTURNYYE ELEMENTY LUNY]
Yu. A. Khodak Feb. 1964 15 p refs Transl. into ENGLISH from Kosmich. Issled. (Moscow), v. 1, no. 3, Nov.–Dec. 1963 p 465–471
(NASA-TT-F-8835) OTS: $1.00 fs, $0.50 mf

The characteristics of the principal structural elements of the visible and far sides of the moon are described. It is noted that the lunar crust is divided into large blocks by a series of deep fault zones running in four directions. Author

N64-31718* *Northrop Space Labs., Huntsville, Ala. Space System Section*
APOLLO LOGISTICS SUPPORT SYSTEMS MOLAB STUDIES: GROUND WAVE PROPAGATION ON THE LUNAR SURFACE
J. D. Hughlett, Jr. Huntsville, Ala., NASA Marshall Space Flight Center, Oct. 1964 27 p refs
(Contract NAS8-11096)
(NASA-CR-61014) OTS: $2.00 fs; $0.50 mf

This report presents a digital-computer program for an optimum frequency on the lunar surface. It is based upon mobile operations and limited for antennas resonating at frequencies less than 0.1 wavelength. Also, it is designed for the given parameters as stated in the Section titled "Computer Program." A section follows on direction-finding antennas, discussing the loop antenna and four vertical monopoles with a goniometer. Emphasis was placed upon the loop antenna, with findings indicating that increased efficiency can be gained by introducing low-loss ferrite cores into the windings, the exact percent efficiency depending upon the material chosen. An overall block diagram is shown, illustrating a proposed complete transistorized medium-frequency subsystem operating at 1.5 megacycles for voice communication. Author

N64-31723* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
RANGER VII PHOTOGRAPHS OF THE MOON. PART I: CAMERA "A" SERIES
Gerard P. Kuiper et al Washington, NASA, Sep. 1964 226 p refs Sponsored by NASA
(NASA-SP-61) GPO: $6.50

The Ranger VII mission and trajectory are described. Impact-area selection and camera terminal alignment are discussed. The television system is described, and a table of values for camera *A* is given. The table includes for each photograph the Gmt, the moon-centered coordinates, photograph data, scale, and angular deviation north. A series of 199 photographs is presented that was taken by camera *A* in Ranger VII and telemetered to earth from lunar altitudes between 2096 km and impact. D.E.W.

N64-31740 Manchester Coll. of Science and Tech. (Gt. Brit.)
LABORATORY SIMULATION OF LUNAR LUMINESCENCE Final Report
J. E. Geake Jul. 1964 9 p refs
(Contract AF 61(052)-379)
(AFCRL-64-749; AD-606650)

Equipment is described that was constructed for irradiating, with protons and with uv radiation, samples of materials, that may be like those on the lunar surface. The spectrum of the resulting emission was obtained by a photoelectric spectrophotometer, which is also described. A type of material was found that luminesced strongly under proton bombardment; its main emission was at the far red end of the spectrum. This led astronomers to observe the moon through filters centered on the red peak of emission in order to find parts of the lunar surface luminescing in this way. Preliminary results suggested that at least one such region was found. Most of the samples investigated consisted of dust ground from different types of meteorites. This report chiefly summarizes information appearing in publications and technical notes. R.L.K.

N64-31972 RAND Corp., Santa Monica, Calif.
SHAPE AND INTERNAL STRUCTURE OF THE MOON
Donald L. Lamar and Jeannine Mc Gann Sep. 1964 36 p refs

(Contract AF 49(638)-700; Proj. RAND)
(RM-3964-PR; AD-606027)

Studies of the libration of points on the moon's surface and the occultation of stars on the limb reveal a 10-km range in heights on the moon's surface. These data and the 1-km separation of the center of mass from the center of the moon's disk indicate that the continental areas are approximately 3 km higher than the maria. The values of the differences in the moon's principal moments of inertia require that there be a concentration of material in the equatorial regions and around the axis pointing toward the earth. If continental areas were so concentrated, the density distribution within the moon could be spherically symmetrical. Utilizing charts prepared from Russian photographs of a portion of the moon's far side, it is shown that the actual continental-maria distribution is opposite to that required to explain the moment-of-inertia data. This discrepancy between the differences in moments of inertia and the gross shape, as reflected in the distribution of continents, indicates that density variations exist within the moon. Author

N64-32886* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
LUNAR STORAGE OF SMALL QUANTITIES OF CRYOGENIC FLUIDS
J. R. Olivier and W. M. Mc Combs 21 Jan. 1964 92 p refs
(NASA-TM-X-51918; TR-4-42-2-D) OTS: $3.00 fs; $0.75 mf

This report presents the results of a study of the feasibility of storing small quantities of cryogenic fluids on the lunar surface. Factors taken into consideration were types of fluids, quantity, boiloff, heat-leak, storage time, vented and nonvented concepts, system weight, tank design, and insulation type and thickness. Author

N64-33064* Consultants and Designers, Inc., Arlington, Va.
MOON DROPS (A NEW VIEWPOINT ON THE ORIGIN OF TEKTITES) [SLEZY LUNY]
13 Jul. 1964 5 p Transl. into ENGLISH from Nedelya (Moscow), 21–27 Jun. 1964
(Contract NAS5-2078)
(NASA-TT-F-8944; ST-PR-10168) OTS: $1.00 fs; $0.50 mf

This article covers the hypothesis that tektites are minerals of lunar origin. Several tektite sites are described, with emphasis given to the australites. It was found that the australites came across the melting point twice, and their age was established by uranium tracks as being about 700 000 years. Their contents of 10.2% nickel along with two combinations of schreibersite and troilite, only found in extraterrestrial bodies, do not exclude the fact that the origin of tektites might be located much further in space than the moon. G.G.

N64-33162* Bellcomm, Inc., Washington, D.C.
LUNAR PHOTOGRAPHIC ORBITER: LIGHTING AND VIEWING CONDITIONS
C. J. Byrne 11 Oct. 1963 13 p refs
(Contract NASw-417)
(NASA-CR-59192) OTS: $1.00 fs; $0.50 mf

The photometric function of the moon is used to derive the best lighting and viewing conditions for observation of the lunar surface from orbit. The best pictures are obtained when the sun is about 30° from the horizon and the camera looks away from the sun at an inclination of 30° from the vertical. The discussion and results of this paper are also applicable to the Apollo Command Module, Lunar Excursion Module, and Lunar Reconnaissance Module. Author

N64-33422 Army Missile Command, Huntsville, Ala. Translation Branch
CORRELATION OF STEPS OF A VISUAL BRIGHTNESS SCALE OF LUNAR OBJECTS WITH ABSOLUTE VALUES OF THE BRIGHTNESS FACTOR
N. Sytinskaya 21 Sep. 1964 5 p Transl. into ENGLISH from Astron. Tsirkuliar Akad. Nauk SSSR (Kazan), no. 144, 1953 p 11–12
(RSIC-273; AD-606780)

The problem of conversion from visual evaluations of the brightness of lunar objects on a 10-point Schröter scale to photometric data is considered, using a catalog of absolute visual values of the brightness factor of lunar formations published in 1953. A number of features were measured photometrically, and the data were compared graphically with visual values. An equation of a linear relationship was derived, and a table of correspondences is given. D.E.W.

N64-33679* Aerojet-General Corp., Azusa, Calif.
RESEARCH ON PROCESSES FOR UTILIZATION OF LUNAR RESOURCES Summary Report No. 2895, 16 Nov. 1963–15 Jul. 1964
S. D. Rosenberg, G. A. Guter, and F. E. Miller Aug. 1964 72 p refs
(Contract NAS7-225)
(NASA-CR-59167) OTS: $3.00 fs; $0.75 mf

Laboratory apparatus for studying the reduction of igneous rock with carbon, hydrogen, and methane was designed, fabricated, and operated. Several experiments demonstrated that with the use of specially designed inlet tubes, methane reacts with silicate materials at 1600° C to form carbon monoxide, hydrogen, silicon, carbon, and slag. Quantitative recovery of carbon was achieved. Reactor materials were found that allow the reaction to run at 1600° C for long time periods. Author

N64-33683* Yale U., New Haven, Conn.
CONDUCT RESEARCH ON GAS CHROMATOGRAPHIC SYSTEMS TO ANALYZE CERTAIN CHEMICAL CONSTITUENTS OF THE SURFACE OF THE MOON Progress Report, 1 Feb.–31 Jul. 1964
[1964] 4 p ref
(Grant NsG-192-61)
(NASA-CR-59301) OTS: $1.00 fs; $0.50 mf

Studies of certain ionization phenomena in gases were made to detect the processes responsible for the presence of permanent as well as other gaseous samples in ionization detectors being used in gas chromatography, and for a research program concerning parameters used in the analysis of various gases comprising planetary atmospheres, as well as the presence of organic compounds on planetary surfaces. G.G.

N64-33686* Stanford U., Calif. Radioscience Lab.
RESEARCH AT THE STANFORD CENTER FOR RADAR ASTRONOMY Semi-Annual Report No. 3, 1 Jan.–30 Jun. 1964
V. R. Eshleman Jul. 1964 9 p refs

(Grant NsG-377)
(NASA-CR-59325) OTS: $1.00 fs; $0.50 mf

This research program on radio and radar studies of the lunar and planetary ionospheres, atmospheres, and surfaces, and radar studies of the sun and interplanetary medium contains the following articles: "Planetary Research"—correlation characteristics of the radio-noise storm from Jupiter and from the Sun; "Propagation Characteristics through the Solar Corona"—a doppler shift observation in a radio wave sent from the earth to a solar probe; "Magnetohydrodynamic waves in Interplanetary Space"—the use of radar astronomy techniques for MHD waves in the interplanetary medium; "Solar Radar Program"—a conclusion that no solar echoes were present in the 1963 solar data; and "Cislunar Gas Studies"—automatic data-processing techniques development to edit and to store lunar data, a study of several methods to measure cislunar gas density, and development of a method to measure the total daily electron content in the ionosphere as a function of time and rate of change in electron content over the entire earth–moon path. G.G.

N64-33812* Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div.
EXPERIMENTAL INVESTIGATION OF ULTRA-HIGH VACUUM ADHESION AS RELATED TO THE LUNAR SURFACE
First Quarterly Progress Report, 1 Jul.–30 Sep. 1964
J. A. Ryan 26 Jun. 1964 30 p refs
(Contract NAS7-307)
(NASA-CR-59364) OTS: $2.00 fs; $0.50 mf

The vacuum system was assembled, the experimental apparatus was constructed, and the initial silicate samples were prepared. The main unresolved problem was the inability to obtain the desired vacuum due to flange warping. Systems are described for producing and maintaining a vacuum, for applying loads, for measuring the adhesion, and for heating various parts of the vacuum system. Sample choice criteria and preparation techniques are described. D.E.W.

1965

N65-10275# Army Missile Command, Huntsville, Ala. Redstone Scientific Information Center
INVESTIGATIONS ON THE COLORIMETRY OF THE MOON, PARTS I AND II
V. V. Sharonov 22 Sep. 1964 30 p refs Transl. into ENGLISH from Vestn. Leningr. Univ. (Leningrad), v. 10, no. 11, 1955 p 113–120; v. 11, no. 1, 1956 p 155–167
(RSIC-283; AD-607393)

Observations of the optical features of the outer core of the lunar surface by visual colorimetry of the moon have proved to be highly accurate and effective. The colorimetric parameter values were used to evaluate the differences in the curves of the spectral distributions. A comparison of the color of the sun with the color of the moon was made, and it was concluded that the color of moonlight does not vary as a function of the moon phase. Spectrophotometric observations, in agreement with colorimetric data, made it possible to reject the presence of extensive sedimentary, as well as acidic, magnetic soil mantles on the moon, the coloring of which would be similar to terrestrial rocks of the same composition. On the contrary, it was concluded that the hypothesis of the presence of lava mantles on the moon must be further developed. G.G.

N65-10304*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
LUNAR ENVIRONMENT: AN INTERPRETATION OF THE SURFACE OF THE MOON AND ITS ATMOSPHERE
John R. Rogers and Otha H. Vaughan, Jr. 3 Sep. 1964 126 p refs
(NASA-TM-X-53124) OTS Prices: HC $4.00/MF $1.00

Under the heading of lunar topographic features, comparative analyses have been made of several geological classifications of lunar features based on inferred age relationships. A discussion of the major landforms, continents and maria, is included. The genetic classification, based on inferred geological origin of the various lunar landforms, attempts to compare by analogy certain lunar features with their interpreted terrestrial counterparts. Author

N65-10445# Shock Hydrodynamics, Inc., Sherman Oaks, Calif.
ANALYSIS OF FLARE IMPACT ON LUNAR SURFACE
R. L. Bjork, Nancy B. Brooks, M. Rosenblatt, and L. Zernow Santa Monica, Calif., Douglas Aircraft Co., Jul. 1964 51 p refs Prepared under subcontract for Douglas Aircraft Co. substantiating data to SM-47954
(SM-47954)

A study was made of a triorthogonal disc configuration to be used as a chlorine trifluoride container for a lunar flare. Computations of a theoretical powder, soft lunar surface, and also of a hard-rock surface were made. The simulated container impacts against these two targets were studied by the use of an equation of state, which was based upon the particle-velocity determination at several pressures. It was concluded that the triorthogonal CTF flare configuration will perform satisfactorily against either a hard or a soft lunar surface. G.G.

N65-10774*# Stanford Research Inst., Menlo Park, Calif.
EVALUATION OF INFRARED SPECTROPHOTOMETRY FOR COMPOSITIONAL ANALYSIS OF LUNAR AND PLANETARY SOILS. PART II: ROUGH AND POWDERED SURFACES
R. J. P. Lyon Washington, NASA, Nov. 1964 278 p refs
(Contract NASr-49(04))
(NASA-CR-100) OTS Prices: HC $4.00/MF $1.25

This is a study of the normal emittance, reflectance, and transmittance spectra of roughened and powdered rock and mineral surfaces from 8μ to 25μ wavelength. Tektites and chondrites showed a 2.0μ displacement in the wavelength of their spectral peaks. The definition of rock compositions, by either reflectance or emittance techniques, decreased in proportion to their particle size, and only materials with marked special contrast are distinguishable near the 50μ particle size. The frustrated multiple internal reflectance (FMIR) technique seems to be feasible in the compositional analysis of silicate powders in the 1 to 40 size range. The emittance and reflectance processes of rocks and minerals were found to be determined to a large extent by the "surface skin" on each grain. G.G.

N65-11061# Douglas Aircraft Co., Inc., Santa Monica, Calif
MISSILE AND SPACE DIV. LUNAR MISCELLANY
J. A. Ryan Apr. 1963 41 p refs
(SM-43544; AD-420980)

Brief, nontechnical discussions are presented of the following subjects: (1) facets of the lunar surface temperature problem, particularly those that have given rise to some degree of confusion; (2) demonstration of the fact that the radioactivity of the lunar surface materials, either introduced at the time

of their formation or produced through the action of the incident radiation, is not a hazard to man; and (3) the present state of knowledge concerning lunar soil mechanics. P.V.E.

N65-11362# Bendix Corp., Ann Arbor, Mich. Systems Div.
APPLICATION OF A PHOTOMETRIC TECHNIQUE FOR MAPPING THE LUNAR SURFACE
M. E. Amdursky Oct. 1964 30 p refs *Presented at the 3d* Symp. on Remote Sensing of Environment, Michigan U., 14–16 Oct. 1964

The program for landing men on the lunar surface requires that suitable and safe sites be defined and verified before the actual landings. This may be accomplished in part by remote sensing from orbiters and from surface stationary or roving platforms. The studies discussed 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 that exhibits the photometric characteristics and an analysis of the accuracies achievable are described. Means by which a computer can be used to analyze the video data are suggested. Author

N65-11401*# Radio Corp. of America, Princeton, N.J. Astro-Electronics Div.
LUNAR IMPACT TV CAMERA (RANGER III, IV, V) Final Engineering Report, Mar. 25, 1960–Nov. 1, 1961
15 Nov. 1963 67 p
(Contract JPL-M-48068)
(NASA-CR-59579; AED-R-2076) OTS Prices: HC $3.00/MF $0.75

The lunar impact TV camera, designed to take and transmit a series of detailed pictures of the surface of the moon during the descent of the spacecraft to the moon, was limited to a read-out time of 10 seconds per picture with horizontal and vertical resolution requirements of 200 lines each, due to the 2-kc bandwidth restriction. Other limitations were imposed upon the design of the camera by the maximum weight and power permitted, the optical systems available, the anticipated light levels, and the environmental requirements. Design of the image sensor was performed within these limitations and necessitated significant advances in the state-of-the-art for slow-scan TV camera systems in three areas: (1) rapid-erase techniques, (2) dark-current compensation, and (3) the use of a subcarrier frequency video signal to improve video amplifier capabilities. The final image sensor configuration comprised an electrostatically deflected and focused vidicon containing a special slow-scan photoconductor storage surface with rapid-erase capabilities. Author

N65-11408*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
THE LUNAR REFLECTIVITY MODEL FOR RANGER BLOCK III ANALYSIS
D. Willingham 2 Nov. 1964 15 p refs
(Contract NAS7-100)
(NASA-CR-59564; JPL-TR-32-664) OTS Prices: HC $1.00/MF $0.50

The methods employed in deriving a revised lunar reflectivity model are described in detail, illustrated by plots showing the data scatter that was encountered. A discussion of the need for the revision to the photometric function developed in 1963 and a comparison of the old and new functions are also included. Author

N65-11476# Aeronautical Chart and Information Center, St. Louis, Mo. Cartography Div.
LUNAR COLOR PHENOMENA
May 1964 15 p refs
(ACIC-TP-2; AD-606412)

Factual recordings of two separate observations of reddish spots near the lunar crater Aristarchus are presented. Included is a record of observations of a violet and purple–blue color form on the west side of Aristarchus at the same time as the other observations. Also given is a brief list of previous observations of color phenomena in the Aristarchus region of the moon. P.V.E.

N65-11780# Army Missile Command, Huntsville, Ala. Redstone Scientific Information Center
ON THE PROBLEM OF PHOTOMETRIC UNIFORMITY OF THE MOON'S SURFACE
N. P. Barabashov, V. A. Yezerskaya, V. I. Yezerskiy, and T. I. Ishutina 9 Oct. 1964 21 p refs Transl. into ENGLISH from Izv. Akad. Nauk SSSR, Komis. po Fizike Planyet (Moscow), no. 1, 1959 p 67–79
(RSIC-304; AD-607724)

On the basis of V. A. Fedorets' catalog of reflectivity of the moon's features and by specially measuring of the photographs of the moon, it was established that the moon's surface is characterized by a high degree of photometric uniformity; i.e., on the average, it has uniform porosity. Author

N65-11972# Army Missile Command, Huntsville, Ala. Redstone Scientific Information Center
COLOR CONTRASTS ON THE LUNAR SURFACE
N. P. Barabascheff 21 Sep. 1964 11 p refs Transl. into ENGLISH from Priroda (Moscow), v. 42, no. 12, 1953 p 88–90
(RSIC-271; AD-607722)

Observations of the lunar surface by various astronomers are reviewed for the study of the distribution of colors and the evolution of lunar-surface features. Although rough conclusions can be made from previous studies, it is concluded that quantitative measurements of colors in many areas of the moon are essential for the determination of the intensity of these colors and their comparison with colors of earthly species. D.S.G.

N65-11973# Army Missile Command, Huntsville, Ala. Redstone Scientific Information Center
DETERMINATION OF THE POLARIZATION OF THE LUNAR AUREOLE
Yu. N. Lipskiy 9 Oct. 1964 23 p refs Transl. into ENGLISH from Tr. Gos. Astron. Inst., Soobshcheniya (USSR), no. 80, 1951 p 3–17
(RSIC-303; AD-607958)

It is said that the aureole surrounding any sufficiently bright heavenly body is a consequence of the diffusion of light in the earth's atmosphere, and that its polarization is not caused by the atmosphere. Repeated studies indicate that

lunar light is partially polarized, and that the degree of polarization changes with the lunar phases. Some propositions relating to partially polarized light are discussed, and measurements are reported of the intensities of lunar light analyzed with a polaroid filter oriented in various directions. D.E.W.

N65-12190# Army Missile Command, Huntsville, Ala. Redstone Scientific Information Center
A COMPARISON OF THE LAW OF LIGHT REFLECTION AS RELATED TO THE MOON AND TO SOME ROCK VARIETIES
N. S. Orlova 9 Oct. 1964 10 p refs Transl. into ENGLISH from Vestn. Leningr. Univ. Ser. Mat., Mekh. i Astron. (Leningrad), no. 1, 1957 p 152–157
(RSIC-301; AD-607959)

This study pertains to the comparisons of indicatrixes of celestial bodies with those of terrestrial materials. A theory is presented that all surfaces having a similar indicatrix under any conditions of illumination will also have a similar photoelectric relief. Indicatrixes of the reflections of the moon's surface were juxtaposed on several indicatrixes for smooth, natural surface fractures of rock specimens, and the light intensities and their relative magnitudes for each rock specimen were plotted in conventional graphs with cartesian coordinates. A close similarity of the scoriae-light indicatrix to the moon's surface indicatrix was observed. G.G.

N65-12409*# Aerojet-General Corp., Azusa, Calif. Chemical Products Div.
RESEARCH ON PROCESSES FOR UTILIZATION OF LUNAR RESOURCES Quarterly Report, 16 Jul.–15 Oct. 1964
S. O. Rosenberg, G. A. Guter, and F. E. Miller Oct. 1964 25 p *Its* Rept.-0765-03-1
(Contract NAS7-225)
(NASA-CR-59633) OTS Prices: HC $1.00/MF $0.50

Laboratory apparatus has been placed in operation for studying two of the important steps in the Carbothermal process. A silicate reduction unit was designed, fabricated, and tested. The unit will handle a charge of 1 lb of silicate material, and utilizes a resistance-heated furnace. An automatically controlled carbon monoxide reduction reactor was put into operation for long-term catalyst life studies. This unit gives quantitative conversion of carbon monoxide with excellent water and methane yields. To date, it has operated for more than 600 hours without any apparent change in catalyst activity. Author

N65-13012# Army Missile Command, Huntsville, Ala. Redstone Scientific Information Center
COLOR EXCESSES IN SIX LUNAR CRATERS ACCORDING TO ELECTROPHOTOMETRIC OBSERVATIONS
K. I. Kozlova and Yu. V. Glagolevskii 23 Oct. 1964 5 p refs Transl. into ENGLISH from Astron. Tsirkuliar (Kazan), no. 198, 1958 p 1–2
(RSIC-313; AD-608538)

Observations were conducted on August 31 and September 1, 26, 27, 28, and 29, 1958. Photometry was performed on the bottoms of six craters through two light filters, yellow and blue. Crater Manillius was used as the base for comparison. All the bottoms of craters observed were compared with it. A color excess CE was determined for each crater in its relation to the base Manillius. The results of measurements on Copernicus, Plato, Plinius, Kepler, Tycho, and Menelaus are presented. P.V.E

N65-13221*# Fairchild Camera and Instrument Corp., Syosset, N.Y. Fairchild Space and Defense Systems Div.
[PHOTOGRAMMETRIC AND PHOTOMETRIC OBJECTIVES AND CAPABILITIES OF THE SURVEYOR LANDER TV EXPERIMENT] Final Report
30 Dec. 1963 162 p refs
(JPL-950665)
(NASA-CR-59879; SME-BA-130) OTS Prices: HC $5.00/MF $1.00

Detailed scientific objectives for the Surveyor Lander TV Experiment are discussed in terms of photogrammetry, photometry, and colorimetry. The mission of the Surveyor Lander S/C is the soft landing of a package of scientific instruments on the lunar surface in an effort to determine some of its basic properties. The local spatial brightness and color characteristics of the lunar surface are to be established by the Surveyor S/C survey television subsystem, whose primary requirements are established for geometric fidelity, photometry and colorimetry. The design features, calibration objectives, and operation considerations of the TV subsystem are discussed. R.L.K.

N65-13273* New Mexico U., Albuquerque. Engineering Experiment Station
[EXTENDING THE CONCEPT OF DIFFERENTIAL REFLECTIVITY TO DETERMINE THE ELECTROMAGNETIC PROPERTIES OF THE LUNAR SURFACE] Semiannual Status Report, 1 May–31 Oct. 1964
Ahmed Erteza, James A. Doran, and Donald H. Lenhert Nov. 1964 10 p ref
(Grant NsG-129-61)
(NASA-CR-59910; EE-117)

The two major areas of extension discussed are the transient solution of electromagnetic scattering, and the effect of the relative velocity between the source and target on the scattered radiation. A short discussion is given in each of the areas of future investigation. Author

N65-13280*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
RANGER VII: MISSION DESCRIPTION AND PERFORMANCE, PART I
H. M. Schurmeier 15 Dec. 1964 98 p refs
(Contract NAS7-100)
(NASA-CR-59904; JPL-TR-32-700) OTS Prices: HC $3.00/MF $0.75

This paper is a technical description and an evaluation of the performance of the various systems and other elements comprising the Ranger project. It constitutes part of the formal report of the Ranger VII mission, the second in the Block III series, whose flight phase lasted from July 28 to July 31, 1964. Sections included cover the launch preparations and operations, the launch vehicle system, the spacecraft system, the deep space network system, the space-flight operations system, the flight path, and preflight calibration and data enhancement. Appendices summarize Ranger VII spacecraft flight events, the redesign following Ranger VI, and Ranger spacecraft configuration and interfaces. D.E.W.

1964

A64-14140
ADHESIVE BEHAVIOR OF SILICATE POWDERS IN ULTRAHIGH VACUUM.
J. W. Salisbury (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Bedford, Mass.), P. E. Glaser, B. A. Stein, and B. Vonnegut (Arthur D. Little, Inc., Cambridge, Mass.).
Journal of Geophysical Research, vol. 69, Jan. 15, 1964, p. 235-242. 12 refs.

Presentation of preliminary results of experiments designed to determine the effects of only ultrahigh vacuum on the mechanical properties of fine silicate powders. Samples of powdered silicates have been sifted in a vacuum chamber at pressures of 10^{-10}, 10^{-9}, and 750 mm Hg. Rocks to be tested in the chamber were picked for probability of their occurrence on lunar surface. Comparison was made of the angle of repose of dust samples sifted at atmospheric pressure and samples sifted at 10^{-9} and 10^{-10} mm Hg. An effort was made to obtain semiquantitative information on the strength of the cohesive bonds. The role of electrostatic forces in the adhesion process was studied experimentally.

A64-14148
EXCITATION OF LUNAR LUMINESCENCE BY SOLAR FLARES.
Zdeněk Kopal and Thomas W. Rackham (Manchester, University, Dept. of Astronomy, Manchester, England).
Nature, vol. 201, Jan. 18, 1964, p. 239-241.
Contracts No. AF 61(052)-378; and AF 61(052)-400.

Review of a systematic program of lunar photography through narrow-passband interference filters centered at λ 6725 Å (that is, the peak of the observed luminescence of achondritic meteorites) and λ 5450 Å, in order to determine whether or not a luminescence akin to that of the meteoritic material may be excited on the lunar surface by the present activity of the Sun. During the night of November 1-2, the photographic work was confined to the northwestern part of the Oceanus Procellarum containing the craters Aristarchus, Copernicus, and Kepler. A temporary enhancement of the Kepler area in the red is found. The consequences of a hypothesis are developed that the temporary enhancement was caused by the luminescence of lunar ground covered by meteoritic debris, similar in composition to the samples which Derham and Geake induced to luminesce under proton bombardment simulating the solar wind.

A64-14463
PHOTOGRAPHIC RESOLUTION ON THE LUNAR SURFACE FROM GROUND-BASED FACILITIES.
Zdeněk Kopal and Thomas W. Rackham (Manchester, University, Dept. of Astronomy, Manchester, England).
Icarus, vol. 2, Nov. 1963, p. 329-333.
Contracts No. AF 61(052)-168; No. AF 61(052)-400; AF 61(052)-524; AF 61(052)-496.

Discussion of the limits of spatial resolution of the lunar surface obtained from existing ground-based astronomical facilities, with particular reference to the performance of the 24-inch f/30 refractor of the Observatoire du Pic-du-Midi. A particular example selected from more than 40 thousand lunar photographs secured in the past 5 years is illustrated, and its interpretation is discussed.

A64-14969
THE ROLE OF UNMANNED SYSTEMS IN LUNAR EXPLORATION.
H. A. Lassen and R. A. Park (Space Technology Laboratories, Inc., Redondo Beach, Calif.).
Astronautics and Aeronautics, vol. 2, Mar. 1964, p. 12-19. 13 refs.

General review of the problems involved in the development of unmanned lunar exploration systems. Present conjecture as to the nature of the lunar surface is outlined, and note is made of the information which can be expected from three precursors now under development. The importance of scientific examination of the Moon after a manned landing is stressed, and a program is proposed for the initial exploration phase following such a landing. Landing guidance systems are briefly noted, followed by description of three concepts for unmanned logistic vehicles, with a discussion of their equipment and the types of missions to be carried out. The importance of exploration of the lunar polar regions by unmanned systems is emphasized in view of the difficulty of manned exploration at present, and because of the possible discovery of ice there in shadowed craters. The elements of cost and risk place a high priority on the development of unmanned elements for lunar exploration.

A64-15467
RADIO-FREQUENCY RADIATION AND THE NATURE OF THE MOON [RADIOIZLUCHENIE I PRIRODA LUNY].
V. D. Krotikov and V. S. Troitskii.
Uspekhi Fizicheskikh Nauk, vol. 81, Dec. 1963, p. 589-639. 84 refs. In Russian.

Discussion of the physical nature and self-radiation of the Moon. A historical review of the methods used in lunar investigations over the last decades is included. Specifically examined are recent results concerning the surface temperature of the Moon, the theory of lunar radio-frequency radiation as compared to experimental data, the structure and thermal properties of the lunar surface, the density and the dielectric constants of lunar surface formations, the thermal flux emitted from the interior of the Moon, and the thermal state of the Moon's interior. The data presented are compiled from a broad survey of Soviet and foreign literature. The study is concluded by a discussion of the major problems involved in lunar investigations based on the radio emission of the Moon.

A64-15525
WATER RECOVERY FROM FUEL CELLS AND LUNAR MINERALS.
Frank J. Hendel (North American Aviation, Inc., Downey, Calif.).
I & EC - Industrial and Engineering Chemistry, vol. 56, Mar. 1964, p. 29-31. 10 refs.

Review of techniques and principles involved in the recovery of water from fuel cells and lunar minerals for long-duration life support of space missions. Two types of fuel cells are considered which are anticipated for space missions. In one fuel cell, an electrolyte is held between two diaphragms, one diaphragm being an anode and the other a cathode. In the other fuel cell, an ion membrane is held between two electrodes. An example of the first cell is the Bacon fuel cell, and an example of the second cell is the ion-membrane fuel cell constructed for the Gemini spacecraft. The operation of these cells is discussed and the electrode equations are presented. To make the recovered water from an ion-membrane fuel cell fully potable, percolation through activated charcoal or ion-exchange resins, and use of permeable membrane are recommended. The occurrence of water in minerals on the lunar surface is considered and theories for the origin of the water are discussed. Also considered is water in the form of subsurface ice, and water derived from meteorites.

A64-15732
PACKING PROPERTIES OF FINE POWDERS AND THE DEPTH OF THE LUNAR DUST LAYER.
Bruce Hapke (Cornell University, Center for Radiophysics and Space Research, Ithaca, N. Y.).
Journal of Geophysical Research, vol. 69, Mar. 15, 1964, p. 1147-1151. 8 refs.
Grant No. NsG-382.

Description of tests on ground dunite made in an endeavor to provide a replica of a hypothetical lunar soil which would reflect radio-frequency, infrared, and light waves in a manner compatible with observations. It is considered possible that lunar soil may be unconsolidated to depths of a meter or more.

A64-16058
THE LUNAR SURFACE.
John W. Salisbury (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Hanscom Field, Bedford, Mass.).
Air University Review, vol. 15, Mar.-Apr. 1964, p. 69-80.

Survey of current knowledge concerning the surface of the Moon. Two main theories for the origin of the lunar craters are discussed, one supporting an internal volcanic origin and the other an external

origin by meteoritic impact. The current theories regarding the origin of the maria and the highlands are explained, and the small-scale roughness of the lunar surface is analyzed for the purpose of obtaining information that will be useful to designers of lunar vehicles.

A64-16113
THE SURFACE OF THE MOON.
Seymour Tilson.
Space/Aeronautics, vol. 41, Mar. 1964, p. 62-69. 7 refs.

Discussion and evaluation of information on the nature of the lunar surface. Recent observation of mists and the emission of hydrogen in Moon craters is noted, and speculation is made as to the existence, origin, and characteristics of lunar dust. The Moon may be considered to have a nonhomogeneous surface in view of its varied reflectivity from one place to another. Lunar material may have come to the Earth in the form of dust ejected as a consequence of hypervelocity meteoritic collisions, or as tektites, which may be lunar fragments dislodged by large meteoritic collisions or possibly may be due to volcanism on the Moon, whose low gravity might permit fragments to reach lunar escape velocity. The relative youth of tektites is cited.

A64-16119
WATER RECOVERY IN LUNAR ENVIRONMENT.
R. N. Rickles (Dorr-Oliver, Inc., Stamford, Conn.).
Space/Aeronautics, vol. 41, Mar. 1964, p. 103, 105.

Presentation of three methods of recovering water from lunar rocks. The first utilizes a solar-heated pot calciner, which would only supply small quantities of water. The second method envisages dehydrating and decarbonizing carbonaceous chondrites at 1300°F - 1800°F in a fluidized bed reactor using solar infrared energy to produce both water and carbon dioxide. Third, by oxide reduction of lunar rock, using atomic power, oxygen, carbon monoxide or water, or combinations of these could be produced.

A64-16312
ORIGIN OF THE MOON. II.
John F. Simpson (Goodyear Aircraft Corp., Akron, Ohio).
Spaceflight, vol. 6, Mar. 1964, p. 55-62. 54 refs.

Consideration of the consequences of a theory, developed in a previous paper, that the Moon originated from the Earth and took with it more than half of the Earth's original crust. The important terrestrial consequences of this hypothesis are analyzed, including the origin and migration of the Earth's continents, and the asymmetric terrestrial magnetic field. Important lunar consequences are the period of crustal melting and volcanism, which explains the origin and material of the lunar surface features. It is noted that the hypothesis may be readily proven or disproven by active seismic work on the Moon during early instrumented landings.

A64-16333
STATISTICAL RADAR ESTIMATE OF THE LUNAR SURFACE ROUGHNESS.
H. S. Hayre (Kansas State University, Dept. of Electrical Engineering, Manhattan, Kan.).
(International Scientific Radio Union and Institute of Radio Engineers, Symposium on Electromagnetic Theory and Antennas, Copenhagen, Denmark, June 25-30, 1962.)
Franklin Institute, Journal, vol. 277, Mar. 1964, p. 197-205. 21 refs.
Grant No. NsG 129-61.

Approximation by the cosine transform of the lunar return power delay spectrum of the spatial height distance autocovariance function for the central portion of the visible side of the lunar surface; this spectrum is shown to have an exponential, rather than the commonly assumed gaussian form. As many commonly occurring rough terrains also have an exponential autocovariance, it is stated that the lunar surface features are in this sense similar to those of the Earth. The experimental lunar echo return is then fitted to the theoretical radar scattering cross section per unit area calculated using the exponential autocovariance function, $\exp(-|r|/B)$. This is shown to result in one possible set of statistical constants B/L and s/L of 1.0 and 0.1, respectively, for 56% of the central lunar area, where s is the standard deviation of heights and L is the wavelength used. The result is statistically interpreted to indicate that the standard deviation, and the average size (along the surface) of the lunar surface irregularities (small scale) may be of the order of 6.82 cm, whereas its average slope may be of the order of one in ten, which correlates well with the results of the acoustic simulation of Moon echoes, and with other results reported so far.

A64-16486
STRESS HISTORY OF THE MOON AND OF TERRESTRIAL PLANETS.
Zdeněk Kopal (Manchester, University, Dept. of Astronomy, Manchester, England; California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
Icarus, vol. 2, Dec. 1963, p. 376-395. 16 refs.

Study of the effects of nonuniform expansion or contraction of elastic globes of planetary size and mass caused by the secular escape of their primordial heat and radiogenic heating. Differential equations are set up which control the mechanical effects of isothermal compression or thermal expansion. The exact coupling of the mechanical and thermal phenomena is formulated, and first approximation solutions of the problem, in the form of series expansions, are given. These, in turn, are used as a basis of numerical computations to reconstruct the thermal and stress history (as well as the future) of the Moon, Mercury, and Mars, to the order of approximation to which their radiogenic heat sources can be regarded as uniformly dispersed throughout their mass, and the coefficients of thermal diffusivity, as well as of volume expansion, can be treated as constants. It is shown that, within the scheme of these approximations, the secular changes in external radii of these three celestial bodies probably did not exceed 0.6% ± 0.1% of their present values throughout their long astronomical past; it is stated that, whether or not such changes as did take place were monotonic or oscillatory, remains as yet impossible to say.

A64-16584
NEW DATA ON THE STRUCTURE OF THE LUNAR SURFACE.
N. F. Kuprevich (Academy of Sciences, Main Astronomical Observatory, Pulkova, USSR).
(Astronomicheskii Zhurnal, vol. 40, Sept.-Oct. 1963, p. 889-896.)
Soviet Astronomy, vol. 7, Mar.-Apr. 1964, p. 677-685. 6 refs.
Translation.

Presentation of results of observations of the Moon in the infrared spectral region 0.9 μ-2.3 μ using a television system. Provided is a brief description of the receiving apparatus. Photographs of the Moon, obtained in the visual and infrared spectral regions, are compared, and the details detected on the infrared photographs are described. The assumption is made that the increase in contrast of the infrared photographs can be explained by a decrease in the luminescence of separate details of the lunar surface in the infrared. It is stated that the dust layer on the lunar surface is likely to be thin or completely absent.

A64-16828
SURFACE TEMPERATURE VARIATIONS DURING THE LUNAR NIGHTTIME.
Bruce C. Murray and Robert L. Wildey (California Institute of Technology, Div. of Geological Sciences, Pasadena, Calif.).
Astrophysical Journal, vol. 139, Feb. 15, 1964, p. 734-750. 30 refs.
Grant No. NsG 56-60; NSF No. G-25210.

Description of the use of a new photometer incorporating a mercury-doped germanium photoconductor with a 19-inch telescope to measure the 8-14-μ brightness temperatures of the shaded lunar surface. Right-ascension scans carried into the lunar nighttime from the terminator show a characteristic pattern of cooling inconsistent with the occurrence of a thick homogeneous dust layer. It appears that more highly conducting material either is exposed commonly on the surface or constitutes a substratum generally covered by no more than a centimeter or so of the strongly insulating dust. No difference in nighttime temperature distribution was observed between maria and uplands. However, local areas of higher-than-average brightness temperature were encountered. These indicate extensive exposures of consolidated material. Local temperature anomalies of this type are associated with the bright-rayed craters Tycho and Copernicus, but they are distributed over an area larger than that represented by the respective craters. Two other groups of temperature anomalies were found in otherwise undistinguished mare border areas. These observations and others suggest that surface redistribution processes are operative on the lunar surface over at least a 10-meter range, but are not important over distances much in excess of a kilometer.

A64-16892
A LOAD-SINKAGE EQUATION FOR LUNAR SOILS.
Donald L. Dewhirst (Chrysler Corp., Defense Operations Div., Detroit, Mich.).
AIAA Journal, vol. 2, Apr. 1964, p. 761, 762. 9 refs.

Analysis of the fine-dust type of soil models of the lunar surface, as the one hypothesized to present the greatest challenge to vehicle mobility. The load-sinkage equation, now in common use as most suitable to a wide variety of soils, was compared with the data available for presumed lunar-type soil, namely the dry granular type. It is concluded that any polynomial of degree two or higher gives a better fit to the majority of the data considered than the power function now in use. In addition, the anticipation is expressed that a polynomial would give a better fit to data from nonhomogeneous soils, such as soft soil over hardpan. The only practical question is where should the polynomial be truncated. This truncation is stated to be simply a tradeoff between accuracy and complexity. Two or possibly three terms would seem to be the appropriate compromise.

A64-17761
A STAR MAP OF THE CIRCUM-POLAR REGION OF THE NORTHERN HEMISPHERE OF THE MOON.
V. V. Shevchenko (Moscow Institute of Engineers of Geodesy, Aerial Photography, and Cartography, Moscow, USSR).
(Geodeziia i Aerofotos'emka, no. 1, 1963, p. 87-91.)
Geodesy and Aerophotography, Nov. 1963, p. 38-40. Translation.

Discussion of the construction of a stellar map in lunar equatorial coordinates, for orientation of cosmonauts upon the lunar surface. The various considerations involved, such as changes in the chosen system of coordinates under the effects of precession, are outlined and mathematically formulated. A reproduction of the map is presented.

A64-17809
MANNED LUNAR SCIENTIFIC OPERATIONS.
Paul Lowman (NASA, Office of Space Science and Applications, Manned Space Science Div., Washington, D.C.) and Donald A. Beattie (NASA, Office for Manned Space Flight, Manned Lunar Mission Studies, Houston, Tex.).
American Astronautical Society, Annual Meeting, 10th, New York, N.Y., May 4-7, 1964, Preprint 64-18. 27 p. 10 refs.

Outline of the major objectives, methods, and expected results of manned lunar operations with payloads that are transportable by Apollo launch vehicles. The chief scientific benefits expected from manned lunar exploration lie in the areas of comparative planetology and the study of the evolution of the solar system, and stem largely from the absence of an atmosphere and atmosphere-dependent geologic processes. It is stated that manned lunar exploration should include three main phases: (1) detailed orbital surveys, using photography, multispectral sensing, and geophysical methods; (2) surface exploration traverses, during which geological, geochemical, and geophysical investigations would be made; and (3) fixed-site, long-duration studies of the Moon, including geophysical monitoring and deep drilling.

A64-17877
SOME RESULTS OF INVESTIGATIONS OF THE LUNAR SURFACE BY RADIO-PHYSICAL METHODS [NEKOTORYE REZUL'TATY ISSLEDOVANIIA LUNY RADIOFIZICHESKIMI METODAMI].
V. S. Troitskii (Gor'kovskii Gosudarstvennyi Universitet, Radiofizicheskii Institut, Gorky, USSR).
(Space Research III; Proceedings of the Third International Space Science Symposium, 1962.)
Astronomicheskii Zhurnal, vol. 41, Jan.-Feb. 1964, p. 104-109. 20 refs. In Russian.

Determination of the quasi-homogeneity of properties of the upper layer of the Moon by measuring radio emissions in a wide range of wavelengths. On the basis of precise measurements of radio emissions at wavelengths of 1.6, 3.2, and 10 cm by the "artificial Moon" method, the dielectric constant of the upper layer, its density, and its heat parameter (γ) are established. It is shown that γ is a function of only the density and structure. A temperature increase with depth of the order of 1.5 degrees per meter and a thermal flow from the interior of the order of 1.10^{-6} cal $cm^{-2}sec^{-1}$ are found. At centimeter wavelengths, the lunar material is found to have a loss angle per unit of density equal to 5.10^{-3} radian. This corresponds to material of the type of gabbro, diorite, granite, and others. On the basis of these data it is concluded that the upper layer of the lunar surface is in a solid porous state.

A64-17956
NEW EVIDENCE CONCERNING THE LUNAR SURFACE.
Thomas Gold (Cornell University, Center for Radiophysics and Space Research, Ithaca, N.Y.).
American Astronautical Society, Annual Meeting, 10th, New York, N.Y., May 4-7, 1964, Preprint 64-2. 26 p.

Discussion of evidence derived from the Moon's thermal, radio, and optical properties, and used in determination of the composition of the lunar surface. Particular emphasis is placed on evidence obtained through other means than visual observations. Considered in these investigations are: the optical scattering law of the Moon, the thermal behavior of the surface with regard to heating and cooling during the lunar day and night and during eclipses, radiothermal emission, and radar-scattering properties of the Moon. All of these investigations indicate that the surface material is generally much less dense than any solid rock. Radar data suggest that a porous deposit, whose depth is of the order of meters, is generally present. A few percent of the area is anomalous, having solid material close to the surface.

A64-17960
INFERENCES CONCERNING THE LUNAR SURFACE FROM RADAR, RADIO, AND IR MEASUREMENTS.
Duane O. Muhleman (California Institute of Technology, Jet Propulsion Laboratory, Communications System Research, Pasadena, Calif.).
American Astronautical Society, Annual Meeting, 10th, New York, N.Y., May 4-7, 1964, Preprint 64-3. 34 p. 11 refs.
Contract No. NAS 7-100.

Presentation of a unified study of infrared, radio, and radar observations made of the lunar surface for the purpose of determining its structure. Geometric optics are used to develop a radar backscatter probability function. For this probability function, it is assumed that the lunar surface is covered with plane-scattering elements of unspecified size and that the statistics of the surface are described by the probability distribution of the element-normal vectors relative to the normal of the mean spherical surface. Using a ray optic treatment, qualitative results are obtained concerning the depolarization phenomena associated with reflection from the lunar surface. Lunar surface parameters are determined from radar reflectivities. Thermal radiation measurements, which are felt to be the best understood of the various measuring techniques, are also discussed.

A64-18123
DEVELOPMENT OF A LUNAR ROCK DRILL AND SUBSURFACE SAMPLING SYSTEM.
V. A. Peckham and J. P. Dallas (Hughes Aircraft Co., Space Systems Div., El Segundo, Calif.).
(International Conference and Exhibit on Aerospace Electro-Technology, Phoenix, Ariz., Apr. 20-23, 1964.)
IEEE Transactions on Aerospace, vol. AS-2, Apr. 1964, p. 388-395. 5 refs.

The development of a spacecraft electric-powered subsurface sampler for drilling a 1-1/4-in.diam. hole in the lunar surface to a maximum depth of 5 feet is discussed. The unit is designed to deliver lunar soil samples from selected depths to a sample analysis system and positions a geophysical probe in the hole. Automatic operation by command from an Earth control station on the basis of telemetered information is planned. The system includes four electric motor powered drives designed for operation in a very high vacuum. The total weight of this mechanism is 26.9 lb.

A64-19212
NATURE OF THE LUNAR SURFACE LAYER.
B. Iu. Levin (Akademiia Nauk SSSR, Institut Fiziki Zemli, Moscow, USSR).
(Astronomicheskii Zhurnal, vol. 40, Nov.-Dec. 1963, p. 1071-1075.)
Soviet Astronomy, vol. 7, May-June 1964, p. 818-821. 9 refs.
Translation.
[For abstract see Accession no. A64-13230 06-29]

A64-19214
ALBEDO VALUES FOR SEPARATE FEATURES OF THE LUNAR SURFACE.

N. N. Sytinskaia.
(Astronomicheskii Zhurnal, vol. 40, Nov.-Dec. 1963, p. 1083, 1084.)
Soviet Astronomy, vol. 7, May-June 1964, p. 827, 828. Translation.
[For abstract see Accession no. A64-13232 06-29]

A64-19989
AN INTERPRETATION OF SCHROTER'S VALLEY AND OTHER LUNAR SINUOUS RILLS.
Winifred Sawtell Cameron (NASA, Goddard Space Flight Center, Greenbelt, Md.).
Journal of Geophysical Research, vol. 69, June 15, 1964, p. 2423-2430. 35 refs.

Presentation of a theory concerning the formation of the lunar sinuous rills. It is felt that these rills are valleys eroded by nuées ardentes. A nuée ardente is a fluidized mixture of gas and dust or ash at very high temperature and relatively high density which issues from a volcano with explosive force, often horizontally directed. This mixture rushes down the mountainside at velocities of the order of 100 km/hr with an action similar to that of a marine turbidity current excavating a submarine canyon. Supporting evidence is found in the similarity of the rills to furrows eroded by nuées ardentes on the Earth.

A64-20003
RADIO EMISSION AND NATURE OF THE MOON [RADIOIZLUCHENIE I PRIRODA LUNY].
V. S. Troitskii.
Akademiia Nauk SSSR, Vestnik, vol. 34, Feb. 1964, p. 33-38.
In Russian.

Study of the petrology of the lunar surface on the basis of available data on the thermal radio emission of the Moon. Following a review of the radio methods used to investigate the lunar surface, some results are presented concerning the attenuation spectrum of electromagnetic waves in lunar matter, and the intensity of lunar radio emission. It is shown how relations for the determination of thermal parameters can be derived and used to correlate lunar formations with terrestrial formations by taking advantage of the dependence of these relations upon the chemical and mineralogical composition of a formation.

A64-22221
RADIO EMISSION AND NATURE OF THE MOON.
V. D. Krotikov and V. S. Troitskii.
(Uspekhi Fizicheskikh Nauk, vol. 81, Dec. 1963, p. 589-639.)
Soviet Physics - Uspekhi, vol. 6, May-June 1964, p. 841-871.
84 refs. Translation.
[For abstract see Accession no. A64-15467 08-05]

A64-23640
DARKENING OF POWDERED BASALT BY SIMULATED SOLAR-WIND BOMBARDMENT.
D. L. Rosenberg and G. K. Wehner (Litton Industries, Inc., Applied Science Div., Minneapolis, Minn.).
Journal of Geophysical Research, vol. 69, Aug. 1, 1964, p. 3307, 3308.
Contract No. NASw-751.

Analysis of a simulated long-duration solar-wind bombardment of powdered basalt, in order to study possible causes for the observed differences between the reflective properties of the lunar surface and terrestrial materials. After appropriate exposure to a low-pressure hydrogen plasma, powdered basalt is found to develop albedo and reflection characteristics similar to the lunar surface, becoming a darkened, color-deficient surface with strong optical backscatter. It is concluded that many of the unusual properties of the lunar surface can be explained by the action of solar-wind bombardment.

A64-24445
RECTIFIED LUNAR ATLAS - SUPPLEMENT NUMBER TWO TO THE PHOTOGRAPHIC LUNAR ATLAS.
E. A. Whitaker, G. P. Kuiper (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.), W. K. Hartmann, and L. H. Spradley (USAF, Aeronautical Chart and Information Center, St. Louis, Mo.).
Grant No. NsG 161-61; Contract No. AF 19(604)-8064.
Tucson, University of Arizona Press, 1963. 147 p.
$35.

A record of the lunar surface is presented which is based on the best available photographs, which have been projected onto a globe so as to remove the major effects of foreshortening toward the limb. Containing 118 photographs and 30 extra sheets giving coordinates and nomenclature, this atlas shows the Moon to a scale of approximately 1:3.5 million; i.e., each millimeter represents about 3.5 km and each inch represents about 55 miles. In brief review of the process of rectification, it is stated that a 3-ft-diam precision hemisphere, the projection screen, was coated with a fine-grain dull-white paint which gave a surface with diffuse reflection properties without a visible trace of specular reflection. The projector was placed 10 to 18 m from the globe, depending on the scale of the plates, and the camera was positioned at a distance of 4-2/3 globe radii from the globe. The fields of the atlas are $30^{\circ} \times 30^{\circ}$ in lunar coordinates and there is some overlap between adjacent strips. For an adequate display of lunar detail, it was found necessary to present each field under at least three different illuminations: early morning, full illumination, and late afternoon. In some cases, two supplementary plates - sometimes composite - were necessary. The boundaries of the $30^{\circ} \times 30^{\circ}$ fields are shown on a field index sheet with the visible parts of the polar areas divided into three sectors covering 60° of longitude each. In this way, the visible lunar surface is divided into 30 fields. The clearest photographs of each field are reprinted with a superimposed longitude-latitude grid and with the standard nomenclature adopted by the International Astronomical Union (IAU). Amendments and additions adopted by the IAU are described in the introduction. The precision of coordinates within about 10° of the mean limb is said to leave much to be desired, and it is indicated that precise longitudes and latitudes for the limb regions will not be available until suitable records are obtained from spacecraft. Four tables are included covering nomenclature revisions, new names, preliminary plate selection and plate data.

A64-24799
RANGER MOON PICTURES - IMPLICATIONS.
T. Gold (Cornell University, Center for Radiophysics and Space Research, Ithaca, N.Y.).
Science, vol. 145, Sept. 4, 1964, p. 1046-1048.
Grant No. NsG-382.

Discussion of the lunar surface. The features of craters are used to conclude that an active erosion process is continuously degrading the features of the Moon and is the major effect in shaping the surface. The rate of erosion is estimated to be 1 micron/year and could lead to deposits of rock dust 4 km deep, the lower portion being solidified. Erosion and a sedimentary origin for material is implied by craters formed partly on highland and partly in the seas. The photos confirm radar evidence indicating a relatively smooth surface and allow one to have more reliance in the interpretation of radar results. There is no evidence of lava flow, cracks, faults, or rock formations. This, and the presence of small secondary craters, indicate that the material is soft and not rock. The implication is that dust is the main constituent of the lunar lowlands.

A64-24952
CRATER MÖSTING A AS THE FIRST-ORDER POINT OF TRIANGULATION ON THE MOON.
Karol Kozieł (Jagellonian University, Dept. of Theoretical Astronomy, Cracow, Poland).
IN: LIFE SCIENCES AND SPACE RESEARCH II; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 4TH, WARSAW, POLAND, JUNE 3-12, 1963.
Sponsored by the Committee on Space Research (COSPAR).
Edited by M. Florkin and A. Dollfus.
(COSPAR, International Space Science Symposium, 4th, Warsaw, Poland, June 3-12, 1963, Paper.)
Amsterdam, North-Holland Publishing Co.; New York, Interscience Publishers, 1964, p. 141-144.
[For abstract see Accession no. A63-18967 17-05]

A64-24955
ELECTRONIC POLARIMETRIC IMAGES OF THE MOON.
V. P. Dzhapiashvili and L. V. Xanfomaliti.
IN: LIFE SCIENCES AND SPACE RESEARCH II; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 4TH, WARSAW, POLAND, JUNE 3-12, 1963.
Sponsored by the Committee on Space Research (COSPAR).
Edited by M. Florkin and A. Dollfus.
Amsterdam, North-Holland Publishing Co.; New York, Interscience Publishers, 1964, p. 161-165. 7 refs.

Presentation of results of polarimetric observations of the Moon and planets, performed at the Abastumani Astrophysical Observatory. It is stated that, since 1962, observations of polarimetric images of the Moon have been carried out with an electron polarovisor, which is a scanning polarimeter. Observations of the Moon in different phases permitted the recognition of a class of objects on the lunar surface similar in shape to circles and craters, but not always spatially identified with them, which can be distinguished on polarimetric images. As early as 1960 the authors found that the polarimetry of the lunar surface near full Moon with the small polarimeter aperture (~1.5 in.) shows the existence of small objects (<2.5 km) with very different physical properties. At the beginning of 1963, the second model of polarovisor was put in operation. It is noted that the effect of inversion of the polarization of seas and continents near full Moon was found with this device.

A64-24956
SOME RESULTS OF THE INVESTIGATION OF THE MICRORELIEF OF THE LUNAR SURFACE BY MEANS OF A PHOTOMETRIC METHOD.
N. P. Barabashov and V. I. Ezerski.
IN: LIFE SCIENCES AND SPACE RESEARCH II; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 4TH, WARSAW, POLAND, JUNE 3-12, 1963.
Sponsored by the Committee on Space Research (COSPAR).
Edited by M. Florkin and A. Dollfus.
Amsterdam, North-Holland Publishing Co.; New York, Interscience Publishers, 1964, p. 167-170.

Demonstration of the possibility of revealing the microrelief through comparison of the brightness of individual details of the lunar surface with the law representing the photometric properties of the Moon. It is stated that the details that are systematically brighter, perhaps caused by a smaller value of the porosity of the microrelief, include some craters and continental regions. The details that are systematically fainter, perhaps caused by a greater value of the porosity of the microrelief, include mainly some maria regions. It is noted that the photometric properties of the lunar surface can be interpreted by models with two reference surfaces.

A64-25208
THE MOON.
Ralph B. Baldwin.
IN: ANNUAL REVIEW OF ASTRONOMY AND ASTROPHYSICS. VOLUME 2.
Edited by Leo Goldberg, Armin J. Deutsch, and David Layzer.
Palo Alto, Annual Reviews, Inc., 1964, p. 73-94. 89 refs.

Appraisal of the improved understanding of the nature of the Moon afforded by the recent research on lunar studies. It is now considered worthwhile to ask how the Moon was formed. The 18th-century nebular hypotheses of Kant and Laplace have now reappeared in modern garb. The work of Hoyle, Cameron, and Urey is examined in this connection. Problems associated with the figure of the Moon and its internal temperature and the chemical and physical nature of the Moon's surface are isolated and identified. Questions of the origin of the craters, the circular maria, and the dark areas, and the possibility of a lunar grid system are explored. It is noted that the reverse side of the Moon has proved to be of more continental nature than the front but that, of all the formations reported, only the Soviet Range is of a type differing from those on the Earth side.

A64-25624
CERTAIN RESULTS OF LUNAR INVESTIGATION BY RADIOPHYSICAL METHODS.
V. S. Troitskii (Gor'kovskii Gosudarstvennyi Universitet, Radiofizicheskii Institut, Gorki, USSR).
(Astronomicheskii Zhurnal, vol. 41, Jan.-Feb. 1964, p. 104-109)
Soviet Astronomy, vol. 8, July-Aug. 1964, p. 76-79. 20 refs.
Translation.
[For abstract see Accession no. A64-17877 12-05]

A64-26008
LUNAR-SURFACE COMPOSITION.
OAR Research Review, vol. 3, Aug. 1964, p. 8-11.

Report of an investigation. The equipment consisted of a specially constructed spectrometer coupled to a 42-in. telescope. The mid-IR spectral emission of lunar features was observed. This was facilitated by the presence of two atmospheric windows which largely coincide with the region of interest. These are the 8-14-μ and 16-24-μ windows. The spectra obtained through these windows are presented in graphical form and cover an area of approximately 50 by 300 miles. The difference in spectral response is related to a difference in composition of the features compared. Work in progress is mentioned.

A64-26059
THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Hanscom Field, Bedford, Mass.) and Peter E. Glaser (Arthur D. Little, Inc., Cambridge, Mass.).
New York, Academic Press, Inc., 1964. 532 p.
$12.

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Corp., Santa Barbara, Calif.), p. 215-263. 15 refs. [See A64-26069 22-05]

CORPUSCULAR RADIATION PRODUCED CRYSTALLINE DAMAGE AT THE LUNAR SURFACE. J. A. Ryan (Douglas Aircraft Co., Inc., Santa Monica, Calif.), p. 265-312. 50 refs. [See A64-26070 22-05]

SPUTTERING EFFECTS ON THE LUNAR SURFACE. G. K. Wehner (General Mills, Inc., Minneapolis, Minn.), p. 313-322. 13 refs. [See A64-26071 22-05]

PHOTOMETRIC AND OTHER LABORATORY STUDIES RELATING TO THE LUNAR SURFACE. Bruce Hapke (Cornell University, Ithaca, N.Y.), p. 323-344. 14 refs. [See A64-26072 22-05]

STRUCTURE OF THE MOON'S SURFACE. Thomas Gold (Cornell University, Ithaca, N.Y.), p. 345-353. [See A64-26073 22-05]

MECHANICAL AND THERMAL MEASUREMENTS ON SIMULATED LUNAR SURFACE MATERIALS. L. D. Jaffe (California Institute of Technology, Pasadena, Calif.), p. 355-380. 12 refs. [See A64-26074 22-05]

THE NATURE OF THE LUNAR SURFACE - THE THERMAL CONDUCTIVITY OF DUST AND PUMICE. Nora C. Liu and W. I. Dobar (Bendix Corp., Ann Arbor, Mich.), p. 381-387. 20 refs. [See A64-26075 22-05]

THERMAL PROPERTIES OF POSTULATED LUNAR SURFACE MATERIALS. Alfred E. Wechsler and Peter E. Glaser (Arthur D. Little, Inc., Cambridge, Mass.), p. 389-410. 41 refs. [See A64-26076 22-05]

THE LUNAR SURFACE LAYER. John W. Salisbury and Vern G. Smalley (USAF, Office of Aerospace Research, Hanscom Field, Bedford, Mass.), p. 411-443. 36 refs. [See A64-26077 22-05]

THERMAL EMISSION CHARACTERISTICS OF MINERAL DUSTS. Roger A. Van Tassel (USAF, Office of Aerospace Research, Hanscom Field, Bedford, Mass.) and Ivan Simon (Arthur D. Little, Inc., Cambridge, Mass.), p. 445-468. 13 refs. [See A64-26078 22-05]

FEASIBILITY OF REMOTE COMPOSITIONAL MAPPING OF THE LUNAR SURFACE - EFFECTS OF SURFACE ROUGHNESS. Eugene A. Burns (Space Technology Laboratories, Inc., Redondo Beach, Calif.) and R. J. P. Lyon (Stanford Research Institute, Menlo Park, Calif.), p. 469-490. 17 refs. [See A64-26079 22-05]

CONSIDERATION OF PROPERTIES OF SIMULATED LUNAR SOIL WITH POSSIBLE STABILIZATION TECHNIQUES. Hans F. Winterkorn (Princeton University, Princeton, N.J.) and Rodney W. Johnson (General Electric Co., Valley Forge, Pa.), p. 491-530. 17 refs. [See A64-26080 22-05]

SUBJECT INDEX, p. 531, 532.

A64-26060

INTRODUCTION.

Zdenek Kopal (Manchester, University, Manchester, England).

IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.

Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.

Edited by John W. Salisbury and Peter E. Glaser.

New York, Academic Press, Inc., 1964, p. xi-xxiv.

Survey of the direct and indirect methods used in the study of the lunar surface. The information gathered so far is summarized. Special attention is paid to the principal results of the measurements of the properties of moonlight and of its variation with the phase. Finally, conclusions are presented concerning the nature and the relief of the lunar surface.

A64-26061

SOIL MECHANICS CONSIDERATIONS IN THE TESTING OF LUNAR SOIL MODELS.

Ronald F. Scott (California Institute of Technology, Pasadena, Calif.).

IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.

Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.

Edited by John W. Salisbury and Peter E. Glaser.

New York, Academic Press, Inc., 1964, p. 1-21. 7 refs.

Review of the established principles governing the mechanical behavior of soil, with special consideration for the application in the fields of space research. The study covers the formation and grain-size considerations and the structure and contact characteristics relations. Two soil models of limiting characteristics are then discussed. The first is a relatively densely packed granular material whose deformational and yield properties may be varied by a change in the surface frictional properties of the individual grains. The second material exists in a state of extremely loose packing, and the grains are held together by forces of interparticle attraction. Finally, the statics and dynamics of the soil structure are considered.

A64-26062

AN EXPERIMENTAL STUDY IN LUNAR SOIL MECHANICS.

Gerald D. Sjaastad (USAF, Systems Command, Research and Technology Div., Weapons Laboratory, Kirtland AFB, N. Mex.).

IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.

Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.

Edited by John W. Salisbury and Peter E. Glaser.

New York, Academic Press, Inc., 1964, p. 23-65. 48 refs.

Discussion of the Princeton research program in lunar soil mechanics. The project concentrates on the atmospheric effects on the shear strength of a granular mass. Such phenomena as meteoroid impact, sputtering, dust bombardment, and others are recognized as probably greatly modifying the results obtained in the study, but they are not of primary concern in the investigation presented. Earlier experimental lunar-soil studies are surveyed, and a basic approach to lunar-soil research is outlined. The Princeton program is then discussed. The specific objectives include the study of the effect of the atmosphere on the shear strength of a granular material; the investigation of any analytical relationship between interparticle friction and shearing resistance which may be verified in idealized granular materials; the determination of the presence or absence of any change in the frictional coefficient at low pressure for possible lunar surface materials; and the development of apparatus and techniques for the application to further experimental work in this and related areas. Data and conclusions obtained to date are presented.

A64-26063

GRAVITY EFFECTS ON SOIL BEHAVIOR.

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

IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.

Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.

Edited by John W. Salisbury and Peter E. Glaser.

New York, Academic Press, Inc., 1964, p. 67-91. 14 refs.

Discussion covering the gravity effect on the angle of repose of soils, cohesion in lunar soils, gravity effect on dynamic shear strength of soil, gravity effect on soil porosity, gravity effect on soil bearing strength, and a comparison of soil volume with buoyancy of the medium. It is shown that the angle of repose, porosity, dynamic shear strength, and bearing strength of soils depend, among other factors, on interparticle cohesion, degree of soil compaction, and gravity. It is noted that dry soils are subject to van der Waals forces of attraction. The lower the force of gravity, the larger the size of particles subject to this force. In a lower gravity field, cohesive soils have a steeper angle of repose and possibly a higher porosity. In cohesionless soils, gravity has no effect on the angle of repose or its porosity. The effect of lunar gravity on the performance of landing and roving vehicles is considered.

A64-26064
INVESTIGATION OF SOIL ADHESION UNDER HIGH VACUUM.
B. A. Stein and P. C. Johnson (Arthur D. Little, Inc., Cambridge, Mass.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 93-110.
USAF-supported research.

Discussion of the preliminary work in a program designed to measure the adhesive strength of presumed lunar materials under high-vacuum conditions which are intended to simulate, so far as atmospheric pressure is concerned, the lunar environment. The discussion covers the experimental apparatus, its operation and calibration, and the results obtained. It is shown that particles of silicate materials in a high-vacuum environment do exhibit adhesion. In the experiments, 125-μ particles require an average acceleration of 12 g's to remove them from the substrate. The measured adhesion is expected to be a function of particle size, but there are not enough data to decide on a model. It is also not as yet possible to state the nature of the adhesion, although the data suggest that primary bonds may be involved. Also, since bulk materials were used for the substrates, it should be assumed that outgassing was still occurring during the tests.

A64-26066
SONIC VELOCITY AND SHEAR STRENGTH OF POSSIBLE LUNAR SURFACE MATERIALS.
Jack Green and J. H. Osgood (North American Aviation, Inc., Space and Information Systems Div., Space Sciences Laboratory, Downey, Calif.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 135-150. 8 refs.
Contract No. NASw-457.

Presentation of results of sonic-velocity and shear-strength experiments on possible lunar-surface equivalents. Volcanic rocks and dusts are studied, and the effect of vibration on dusts of various grain sizes is partially evaluated. Physical parameters affecting the mechanical strength of possible lunar soils are studied, including bulk density, grain size, and grain shape. An equation for bulk density is presented. It is found that shear strength varies with grain size for constant porosity, and it is qualitatively observed that grain-size effects are reversible in vacuum. For the same soil composition, shear strength is shown to vary with grain shape.

A64-26068
DUST BOMBARDMENT ON THE LUNAR SURFACE.
Curtis W. McCracken (NASA, Goddard Space Flight Center, Greenbelt, Md.) and Maurice Dubin (NASA Headquarters, Washington, D. C.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 179-214. 46 refs.

Review of observational data for the vicinity of the Earth and for interplanetary space in order to establish a good estimate of the flux of small planetary dust particles impacting on the Moon. Data are evaluated for fluxes of dust particles, probable nature of the lunar surface, and possible effects of dust bombardment on the lunar surface. Available data on fluxes of interplanetary dust particles with masses less than 10^4 gm show that the material accreted by the Moon during the past 4.5 billion years amounts to about 1 gm/cm^2 if the flux has remained fairly constant. This value is lower than previous estimates. Hypervelocity impacts of small dust particles are shown to constitute an effective mechanism for developing and maintaining a dendroid layer consistent with observational data for the lunar surface. The dendroid surface is thought to be of the same scale as the dimensions of the particles which dominate the accretion process. It is concluded that ejecta from hypervelocity impacts on such a low-density, porous structure would be largely retained by the surface layer, thereby leading to positive accretion (net gain of mass). The lunar surface thus formed, therefore, would consist of lunar and interplanetary material from 10 cm to 1 m thick.

A64-26069
METEOROID IMPACT ON THE LUNAR SURFACE.
J. W. Gehring, A. C. Charters, and R. L. Warnica (General Motors Corp., Defense Research Laboratories, Aerospace Operations Dept., Santa Barbara, Calif.).
(TECHNOLOGY OF LUNAR EXPLORATION, PROGRESS IN ASTRONAUTICS AND AERONAUTICS. VOL. 10. Edited by Clifford I. Cummings and Harold R. Lawrence. New York, Academic Press, Inc., 1963, p. 97-136.)
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 215-263. 15 refs.
Jet Propulsion Laboratory Contract No. 950299.
[For abstract see Accession no. A63-23421 22-29]

A64-26070
CORPUSCULAR RADIATION PRODUCED CRYSTALLINE DAMAGE AT THE LUNAR SURFACE.
J. A. Ryan (Douglas Aircraft Co., Inc., Missile and Space Systems Div., Santa Monica, Calif.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 265-312. 50 refs.

Study of the effect which corpuscular radiation flux incident on the lunar surface has on the formation of the lunar soil. In the study it is assumed that the lunar surface has been formed mostly from silicate materials; that the lunar surface material is or has been crystalline; and that an essentially static condition exists at the lunar surface. Five groups of incident radiation are considered: high-energy solar flare particles, low-energy solar particles, galactic particles, terrestrial albedo particles, and natural radioactivity. It is concluded that no significant radiation-produced crystalline damage has occurred below a depth of about 2 g cm^{-2}. In the depth range 1-2 g cm^{-2}, significant damage could occur, but it appears that this could not be great enough to completely, or even nearly completely, disrupt the crystalline structure. In the depth range 0-1 g cm^{-2}, particularly in the upper parts of this layer, it is possible that metametization could occur.

A64-26071
SPUTTERING EFFECTS ON THE LUNAR SURFACE.
G. K. Wehner (General Mills, Inc., Electronics Div., Minneapolis, Minn.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 313-322. 13 refs.
Contract No. NASw-424.

Investigation of the rates and effects of sputtering on the Moon under solar-wind bombardment. From space-probe data the solar wind flux is estimated to be 2×10^8 protons/cm^2 sec with 600 km/sec average velocity at one astronomic unit from the Sun. Mass-separated H^+, H_2^+, and H_3^+ beams are used to bombard thin target foils, and the sputtering yield is determined by the length of time to sputter holes through the foil. In the sputtering and breaking up of molecules, oxygen atoms are more likely to escape (or be incorporated in volatile hydrogen compounds) than metal atoms. The surface of such a sputtered powder target acquires a fibrous structure with an opaque appearance with photometric properties which seem to match closely those of the lunar surface. It is concluded that heavy metal atoms are probably favored for being retained, while light atoms have a higher probability for escaping. It is predicted, therefore, that the lunar surface is somewhat enriched in heavy metals.

A64-26072
PHOTOMETRIC AND OTHER LABORATORY STUDIES RELATING TO THE LUNAR SURFACE.
Bruce Hapke (Cornell University, Center for Radiophysics and Space Research, Ithaca, N. Y.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 323-344. 14 refs.
Research sponsored by General Motors Corp.; Grant No. NsG-382.

Investigation of the reflecting characteristics of different surfaces in order to determine the properties which are essential for lunar-type scattering. It is shown that in order to match the lunar photometric law a surface must consist of extremely small, rough, nearly opaque objects, arranged into a complex surface of low compaction. For instance, to backscatter light as strongly as the Moon does, a material must not only have an extremely porous and open structure but the cavities in the surface must also be interconnected. It is concluded that the lunar surface is everywhere covered by a layer of rock dust whose particles have an average size of the order of 10 μ. It is thought that the grains of rock are darkened by exposure to solar radiation or some other agent and arranged by micrometeorite bombardment into a porous material with a bulk density only 1/10 that of solid rock. The depth of the dust layer is unknown but is considered to be at least a few mm.

A64-26074
MECHANICAL AND THERMAL MEASUREMENTS ON SIMULATED LUNAR SURFACE MATERIALS.
L. D. Jaffe (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 355-380. 12 refs.
Contract No. NASw-6; Grant No. NsG 56-60.

Description of the mechanical and thermal properties of rock powders as lunar surface simulators. Olivine basalt is the test material, and the known behavior of terrestrial soils is used as a basis for comparison. Static bearing capacity, dynamic penetration, and thermal diffusivity and conductivity studies are carried out. It is found that the static bearing capacity is the same in vacuum and in air and that it depends on the state of packing of the powder. The dynamic penetration of a probe into dry basalt powder in vacuum is less than in air for loosely packed powder and more than in air for densely packed powder. The dynamic penetration depth strongly depends on the packing of the powder. Thermal diffusivity and conductivity are one hundred times lower in vacuum than in air. It is concluded that the values are in good agreement with accepted values of the lunar surface.

A64-26075
THE NATURE OF THE LUNAR SURFACE - THE THERMAL CONDUCTIVITY OF DUST AND PUMICE.
Nora C. Liu and W. I. Dobar (Bendix Corp., Bendix Systems Div., Ann Arbor, Mich.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 381-387. 20 refs.

Report of correlation of the thermal conductivity and the possible physical nature of the lunar surface. Since pumice is considered a likely lunar material, its thermal conductivity is measured. It is found that the photometric properties of pumice and scoria do not match those of the Moon and therefore cannot be regarded as suitable lunar-surface materials. However, from the viewpoint of thermal conductivity, it is concluded that a pumice type of material is a possible candidate for a subsurface material on the Moon.

A64-26076
THERMAL PROPERTIES OF POSTULATED LUNAR SURFACE MATERIALS.
Alfred E. Wechsler and Peter E. Glaser (Arthur D. Little, Inc., Div. 500, Cambridge, Mass.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 389-410. 41 refs.
Contracts No. AF 19(628)-421; No. NAS 8-1567.

Results of study of postulated lunar-surface materials. The investigation is performed under conditions of pressure, gravity, and radiation which more closely approach the lunar environment. Review of previous work establishes the principle of heat flow through particulate materials. The test data confirm that the laboratory results on the thermal conductivity of postulated lunar-surface materials are in accordance with the estimates made on the basis of the observational data of lunar-surface temperature changes. The effect of gas pressures of 10^{-6} torr is not found to be appreciable under the existing test conditions. The range of thermal property data for different powdered rocks is narrow. This indicates that a dust surface layer would exhibit very similar thermal properties regardless of its mineralogical composition. It is further confirmed as conceivable that a very-low-density porous, fibrous, or whisker-type structure such as has been postulated to exist on the lunar surface could exhibit a thermal conductivity similar to that of powders. The line-heat-source apparatus is shown to be a valuable technique for studying thermal properties of postulated lunar-surface materials under the condition encountered in the lunar-environment simulation chamber.

A64-26077
THE LUNAR SURFACE LAYER.
John W. Salisbury and Vern G. Smalley (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Hanscom Field, Bedford, Mass.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 411-443. 36 refs.

Review of the evidence for the nature of the lunar surface layer and comparison with predictions based on theoretical understanding of the processes operating on the lunar surface. Among the sources of data evaluated are IR and radio emissions, radar reflection, light polarization, and light reflection. It is concluded that the lunar surface is covered with a layer of rubble of highly variable thickness and block size. The rubble in turn is mantled with a

layer of highly porous dust which is thin over topographic highs, but thick in depressions. The dust has a complex surface and significant, but not strong, coherence.

A64-26078
THERMAL EMISSION CHARACTERISTICS OF MINERAL DUSTS.
Roger A. Van Tassel (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Hanscom Field, Bedford, Mass.) and Ivan Simon (Arthur D. Little, Inc., Cambridge, Mass.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 445-468. 13 refs.

Study of the thermal emission of μ-size mineral powders. Powders of andesite, basalt, augite, olivine, serpentine, granodiorite, obsidian, quartz, and a chrondritic meteorite are measured in the 7-14-μ wavelength region at a temperature of 250°C. The emission spectra of these materials, when ground to a particle size comparable with the best estimates of the particle size of the lunar-surface material, are shown to have no unique spectral characteristics which could be used to identify the mineral. Only at larger particle sizes does significant structure appear in the spectra emission curve. These results suggest that, if the particle size of the lunar surface material is as small as present estimates indicate, compositional mapping of the Moon by remote IR sensing is not feasible. A theoretical treatment shows that the structure of the surface material - i.e., particle size and shape, and density of the medium, as well as its composition - determines the IR emission characteristics.

A64-26079
FEASIBILITY OF REMOTE COMPOSITIONAL MAPPING OF THE LUNAR SURFACE - EFFECTS OF SURFACE ROUGHNESS.
Eugene A. Burns (Space Technology Laboratories, Inc., Redondo Beach, Calif.) and R. J. P. Lyon (Stanford Research Institute, Menlo Park, Calif.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 469-490. 17 refs.
NASA-supported research.

Analysis of the feasibility of IR spectral measurement of the lunar surface from orbiting satellites or high-altitude balloons for purposes of gross mineralogical compositional mapping. If the average particle size of the maria is less than 10 μ, IR spectral emission sensing is shown to be an excellent technique for accurate temperature mapping. Furthermore, if areas of the Moon consist of a surface having a coarse structure (bare rocks free of dust, such as those recently broken by meteorite impacts, or cliffs too steep to hold a dust layer), it is concluded that composition studies of these areas can be conducted. The information obtained from these remote measurements is best when acquired from an orbiting satellite, because complete lunar mapping is possible at maximum areal resolution. Some highly meaningful results can also be obtained by measurements from a high-altitude balloon.

A64-26080
CONSIDERATION OF PROPERTIES OF SIMULATED LUNAR SOIL WITH POSSIBLE STABILIZATION TECHNIQUES.
Hans F. Winterkorn (Princeton University, Dept. of Civil Engineering, Princeton, N. J.) and Rodney W. Johnson (General Electric Co., Missile and Space Div., Valley Forge, Pa.).
IN: THE LUNAR SURFACE LAYER; PROCEEDINGS OF THE LUNAR SURFACE MATERIALS CONFERENCE, BOSTON, MASS., MAY 1963.
Conference sponsored by the USAF Cambridge Research Laboratories and Arthur D. Little, Inc.
Edited by John W. Salisbury and Peter E. Glaser.
New York, Academic Press, Inc., 1964, p. 491-530. 17 refs.

Summary of theoretical and experimental studies concerning lunar dust and its possible stabilization. Results of the experimental work on stabilization of simulated lunar dust in varying vacuums indicate that chemical bonding agents offer a feasible solution to the problem when combined with densification. The cementing agent must be capable of reacting in a lunar environment, and the resultant reaction product must be capable of withstanding considerably higher temperatures than those encountered in terrestrial environments. Agents composed of water solutions do not perform satisfactorily in a vacuum and hence are difficult to employ on the Moon. Wetting action of the soil by liquids appears to be retarded when the ambient pressure falls below the vapor pressure of the liquid. It is concluded that stabilization techniques for lunar application must be considered in terms of the particle size of the soil or dust involved. It is emphasized that any stabilization method considered for application to lunar soils must be based on prior knowledge of the granulometry and chemical composition of the soil grains.

A64-26097 •
ERRORS IN THE MEASUREMENT OF THE LUNAR TEMPERATURE.
Eugene A. Burns and R. J. P. Lyon (Stanford Research Institute, Propulsion Sciences and Space Sciences Div., Menlo Park, Calif.).
(Annual Pacific Meeting of Applied Spectroscopy and Analytical Chemistry, 1st, Pasadena, Calif., Oct. 19, 1962.)
Journal of Geophysical Research, vol. 69, Sept. 15, 1964, p. 3771-3778. 22 refs.
Contract No. NASr-49(04).

Presentation of calculations. A detailed criticism of the Pettit-Nicholson work is presented. Emission spectra of mineral suspected to exist in the lunar crust are calculated by using reflective spectra and the Planck-Wien law. Due to the ozone present in the Earth's atmosphere, meaningful emission-spectra measurements of the lunar surface cannot be made. The effect of composition of several materials suspected to exist in the lunar crust on the emissivity vs wavelength curve is investigated, and calculation of the emittance is made in anticipation of measurements taken from above the atmosphere using high-altitude balloons or orbiting spacecraft. These results of the investigation are presented in graphical form.

A64-26098 •
BACKSCATTERING FROM AN UNDULATING SURFACE WITH APPLICATIONS TO RADAR RETURNS FROM THE MOON.
T. Hagfors (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).
Journal of Geophysical Research, vol. 69, Sept. 15, 1964, p. 3779-3784. 14 refs.

Discussion of properties. It is shown that only those regions which are oriented so as to be normal to the incident radiation are effective in the backscattering. This involves taking into account the statistical relationship of surface slopes and height deviation. A modification of the previously accepted scattering formulas is necessitated. In addition, the difference between the scattering properties of the two principal linear polarizations with respect to the mean surface is shown to be exceedingly small for this kind of surface model.

A64-26364 •
THE IMPORTANCE OF GEOGRAPHICO-GEOLOGICAL METHODS IN STUDIES OF THE MOON [ZNACHENIE GEOGRAFO-GEOLOGICHESKIKH METODOV IZUCHENIIA LUNY].
Iu. A. Khodak, V. V. Kozlov, I. N. Tomson, and L. V. Khoroshilov.
Kosmicheskie Issledovaniia, vol. 1, Nov.-Dec. 1963, p. 460-464. 58 refs. In Russian.

Discussion of the importance of geographico-geological methods in lunar studies, with particular emphasis on structural-geomorphologic, structural-geological, and historico-geological methods.

Presentation of a program which is suitable for mapping observations of the nighttime surface of the Moon. The basic data used in the program are the universal times, right ascensions, and declinations of points of interest on the Moon which are recorded from the telescope's coordinate circles and a Greenwich clock. Focal plane precision screw coordinates may be substituted if desired. In addition, for part of these points, selenographic coordinates are input. This subset, necessarily contained on the sunlit portion of the Moon, is used as a set of standards from which to derive a function describing the translation of the center of the Moon on the celestial sphere relative to the vernal equinox. The balance of input data are limiting conditions which may be read directly without interpolation from the ephemeris. Results are presented from test data which show an average geodesic residual of 0.5° fairly independently of which of several versions of the computer program are used. The error is thus random gear train error in the telescope, which can be expected to decrease in future applications. (Author) F. R. L.

A64-28019

ON THE INTERPRETATION OF RADAR RELFECTIONS FROM THE MOON.

J. V. Evans and T. Hagfors (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).

Icarus, vol. 3, July 1964, p. 151-160. 32 refs.

USAF-supported research.

Discussion of lunar radar reflections. Available radar observations have been interpreted as indicating that the surface of the Moon is covered with a very porous material to a very considerable depth. It is considered, however, that this is not a necessary interpretation of the results. The results could be explained by a surface composed of a mixture of sand, rubble, or broken rock occupying about 50% of the volume. The uppermost layer (perhaps 1 cm) of the surface is responsible for the optical and infrared properties of this surface and may not significantly influence the 68-cm or 3.6-cm radar observations. (Author) F. R. L.

A64-28020

THE SURFACE TEMPERATURE OF THE ANTISOLAR POINT OF THE MOON.

J. M. Saari (Boeing Co., Scientific Research Laboratories, Seattle, Wash.).

Icarus, vol. 3, July 1964, p. 161-163. 6 refs.

Presentation of evidence from recent work indicating that the antisolar point temperature is less than the 120 to 122°K ± 5°, previously obtained by Pettit and Nicholson, and by Sinton. A value of 104°K, the average of The Boeing Co., California Institute of Technology, and corrected Pettit and Nicholson data, is suggested as being more accurate. F. R. L.

A64-28200

THERMAL RADIO RADIATION FROM THE MOON AND PLANETS.

Cornell H. Mayer (U.S. Naval Research Laboratory, E. O. Hulburt Center for Space Research, Washington, D.C.).

IEEE Transactions on Military Electronics, vol. MIL-8, July-Oct. 1964, p. 236-247. 45 refs.

Discussion of the thermal radio radiation observed from the Moon, Mercury, Venus, Mars, Jupiter, and Saturn. Particularly emphasized among the results is the important discovery of a surface temperature of Venus, below the clouds, greater than 600°K. The thermal radio radiation from beneath the surface of the Moon is examined with respect to the information that it contains about the temperature distribution and variation, which may be interpreted in terms of the physical characteristics of the subsurface material. This is seen to apply also to planets with thin atmospheres. No complicating nonthermal radiation has been found for most of the planets; however, the nonthermal synchrotron radiation from the Jupiter belts has confused the accurate specification of thermal-radiation intensity over the centimeter wavelength range, and there is some evidence for nonthermal radiation from Saturn. V. P.

A64-28415

LUNAR SURFACE FEATURES- MID-INFRARED SPECTRAL OBSERVATIONS.

Graham R. Hunt and John W. Salisbury (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Bedford, Mass.).

Science, vol. 146, Oct. 30, 1964, p. 641, 642. 6 refs.

Report of observation and spectral scanning of the Moon at mid-infrared wavelengths, in particular, through the 16- to 24-μ atmospheric window. The data indicate that there are differences in mineral composition among several features of the lunar surface. (Author) F. R. L.

A64-28432

FREE OSCILLATIONS OF THE MOON AND OBSERVATIONS BY A LONG-PERIOD SEISMOGRAPH SYSTEM.

Robert L. Kovach and Russell E. Carr (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

IN: INTERNATIONAL ASTRONAUTICAL CONGRESS, 13TH, VARNA, BULGARIA, SEPTEMBER 1962, PROCEEDINGS. VOLUME I.

Edited by Nicolas Boneff and Irwin Hersey.

Vienna, Springer-Verlag, 1964, p. 1-10. 21 refs.

Discussion of the exploration of the Moon by passive seismic observations. The theory of such observations is that, if excited, the free oscillations of the Moon can be recorded by a long-period seismograph (gravimeter or tiltmeter) placed on the lunar surface, and the gross aspects of the Moon's internal structure can be deduced by comparing the frequencies of vibration observed with those predicted theoretically for various lunar models. Low-order oscillations involve the body as a whole, while the higher-order oscillations depend primarily on the physical properties of the body at successively shallower depths. Numerical calculations for the spherical and torsional oscillations are discussed for several assumed lunar models, and the sensitivity of the periods of vibration to variations in assumed internal structure is demonstrated. Torsional vibrations involve shear-type motions only, while spheroidal vibrations involve radial vibrations as well and disturb the gravitational field. The rate at which the amplitudes of oscillation decay with time enables important inferences to be made concerning the elastic or inelastic behavior of the lunar material. The higher-order free oscillations may be regarded as dispersive surface waves, so that observations of surface wave trains with a long-period seismograph will permit discrimination between plausible internal lunar structures. V. P.

A64-28434

EXHAUST JET-DUST LAYER INTERACTION DURING A LUNAR LANDING.

Leonard Roberts (NASA, Langley Research Center, Hampton, Va.).

IN: INTERNATIONAL ASTRONAUTICAL CONGRESS, 13TH, VARNA, BULGARIA, SEPTEMBER 1962, PROCEEDINGS. VOLUME I.

Edited by Nicolas Boneff and Irwin Hersey.

Vienna, Springer-Verlag, 1964, p. 21-37. 22 refs.

Development of a theoretical model to describe the erosion and subsequent transport of dust in the vicinity of a vehicle using retrorockets for a soft landing on the Moon. Available experimental information is examined to provide an improved description of the exhaust-jet/dust-layer interaction. Particular attention is given to the following three phases of the problem: (1) the gasdynamics of the exhaust, (2) the mechanics of surface erosion, and (3) visibility through the dust cloud. It is shown that the Mach number and Reynolds number of the exhaust flow, together with certain dust parameters, define the character of the erosion. The erosion-induced shape of the crater is calculated, and found to correlate qualitatively with the experiment. The extent of the dust cloud and visibility are shown to be functions of particle size, depth of dust layer, and vehicle location above the surface. V. P.

A64-28443

PETROGRAPHIC STUDIES IN EXTRATERRESTRIAL EXPLORATIONS.

W. H. Baier, J. A. Campbell (Illinois Institute of Technology, Research Institute, Div. of Mechanics Research, Space Systems Section, Chicago, Ill.), and P. N. Slater (Illinois Institute of Technology, Research Institute, Div. of Physics Research, Optics Section, Chicago, Ill.).

IN: INTERNATIONAL ASTRONAUTICAL CONGRESS, 13TH, VARNA, BULGARIA, SEPTEMBER 1962, PROCEEDINGS. VOLUME I.

A close combination of geographico-geological (taking into account the comparable material on the Earth) and astronomical methods is proposed for lunar studies. The geographico-geological studies already conducted in the USSR and other countries and a meteoritic approach to the explanation of the development of lunar structure and relief are evaluated.

A64-26365 •
THE MAIN STRUCTURAL ELEMENTS OF THE MOON [GLAVNEISHIE STRUKTURNYE ELEMENTY LUNY].
Iu. A. Khodak.
Kosmicheskie Issledovaniia, vol. 1, Nov.-Dec. 1963, p. 465-471. 26 refs. In Russian.

Description of the characteristics of the main structural elements of the visible and far sides of the Moon. A series of regions of deep fractures in four directions is indicated which separates the lunar crust into large blocks.

A64-26731
REACHING FOR THE MOON.
Vectors, vol. 6, 3rd Quarter, 1964, p. 6-11.

Discussion of the role of the Surveyor soft-landing vehicle in selenographic exploration, with a description of the vehicle and its operation. The Surveyor is a "basic bus" capable of carrying engineering instruments to evaluate spacecraft performance and landing characteristics as well as a television camera to secure detailed pictures of the immediate area. Later missions will carry scientific instruments to determine lunar-surface properties. The surveyor may also carry a secondary vehicle with lunar surface mobility at a still later date. The spacecraft weighs approximately 2150 lbs and has a triangular frame with a landing leg on each corner. Its various instrumentation packages are distributed around the frame. Control is from the Earth, with certain landing operations being preprogrammed. A complete Surveyor vehicle is now receiving system, environmental, and mission-simulation tests, including drop tests with a full-scale model. The sequence of events from launch to landing is described. Upon ejection of the enclosing shroud outside the atmosphere, the spacecraft's legs and antennas are extended, and it coasts along its trajectory. A fixed attitude is maintained in space, using the Sun and Canopus as references, with control supplied by nitrogen jets. After rotation on command from the Earth, the main retro-engine and three variable-thrust vernier engines are actuated so as to permit a lunar landing, cushioned by shock absorbers on each leg. The craft is expected to collect information for 30 Earth days (1 lunar day) or longer. F. R. L.

A64-26947 •
ROCKET PROPELLANTS FROM THE MOON.
Dandridge M. Cole and Ronald Segal (General Electric Co., Missile and Space Div., Valley Forge, Pa.).
Astronautics and Aeronautics, vol. 2, Oct. 1964, p. 56-60, 63. 21 refs.

Discussion of the possibility of using made-on-the-Moon propellants to supplement or replace supplies carried from the Earth to improve the cost feasibility of supplying and maintaining a lunar base. A criterion is presented for measuring the effectiveness of the lunar plant as a function of its manufacturing efficiency. "Break-even" points are found which must be exceeded for refueling to be competitive with or superior to direct flight. These points are determined for a typical manned Mars mission using chemical-fuel rockets, nuclear-thermal rockets, and for chemical rockets with refueling vs nuclear rockets on direct flight. An estimate is made of the ability of some commonly proposed lunar propellant-manufacturing systems to meet the criteria established. Consideration is given also to the possibilities for reducing transportation costs for lunar-base logistics, with the measures of effectiveness being applied to various types of missions. A listing is made of some of the implications of propellant production in the lunar environment as regards space exploration. M. M.

A64-27072 •
STUDIES OF THE MOON AND PLANETS IN KAZAKHSTAN [ISSLEDOVANIIA LUNY I PLANET V KAZAKHSTANE].
V. G. Teifel'.
Akademiia Nauk Kazakhskoi SSR, Vestnik, vol. 20, Aug. 1964, p. 9-17. In Russian.

Review of the physical studies of the planets and satellites of the solar system conducted since 1956 at the Astrophysical Institute and the Department of Astrobotany of the Academy of Sciences of the Kazakh SSR. The studies include spectrophotometric and spectrocolorimetric investigations of the lunar surface, photometric and spectral observations of Mars and Venus, spectral measurements of molecular light absorption in the atmospheres of Jupiter, Saturn, and Uranus, and the optical properties of the Red Spot, an elliptical configuration in the cloud layer of Jupiter. Future studies are outlined. V. Z.

A64-27350 •
EFFECTIVE TEMPERATURE OF THE LUNAR SURFACE DUE TO THE REFLECTION OF COSMIC RADIATION [EFFEKTIVNAIA TEMPERATURA LUNNOI POVERKHNOSTI, OBUSLOVLENNAIA OTRAZHENIEM OT NEE KOSMICHESKOGO RADIOIZLUCHENIIA].
A. M. Starodubtsev (Gor'kovskii Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).
Radiofizika, vol. 7, no. 3, 1964, p. 399-405. 7 refs. In Russian.

Calculation of the effective temperature of the lunar surface dependent upon the reflection of cosmic radiation at frequencies of 100, 200, and 400 Mc. A sphere with an ideally smooth surface, consisting of material whose dielectric permeability is from 1.5 to 4, is used as a lunar model. It is found that: (1) the average brightness temperature varies slightly as a function of the lunar elevation angle, and only in the region of angles $\alpha = 280^{\circ}$ a certain rise in temperature is noted; and (2) the degree of polarization of radiation reflected from the lunar surface slightly depends on the frequency, and for the dielectric permeability $\varepsilon = 1.5$ does not exceed 12%, the average value being about 2% to 5%. J. R.

A64-27457 •
ON THE NONUNIFORMITY OF PROPERTIES OF THE UPPER LUNAR LAYER WITHIN AND ON THE SURFACE [K VOPROSU O NEODNORODNOSTI SVOISTV VERKHNEGO POKROVA LUNY V GLUBINU I PO POVERKHNOSTI].
V. S. Troitskii (Gor'kovskii Gosudarstvennyi Universitet, Radiofizicheskii Institut, Gorki, USSR).
Astronomicheskii Zhurnal, vol. 41, July-Aug. 1964, p. 724-732. 24 refs. In Russian.

Investigation of variations in the nature and structure of lunar surface material characterized by $\gamma = (kpc)^{-1/2}$ and a specific loss angle. It is shown that the space variations of temperature at the subsolar point are caused basically by variations in the albedo and constitute $\pm(1\text{-}1.5^{\circ})$K for surfaces of the same morphology. A high radiometric homogeneity of the Moon is detected, which consists in the absence of any appreciable deviations in the amplitude and phase of emission intensity variations for a given area of the disk from average values for a homogeneous surface. It is shown that a two-layer model of the upper lunar layer structure, which assumes a discontinuity in thermal conductivity at a constant density of material, is theoretically incorrect. It is noted that a decrease in both the density of the material and the thermal conductivity can be expected on the surface. J. R.

A64-28018
A COMPUTER PROGRAM FOR THE TRANSFORMATION OF LUNAR OBSERVATIONS FROM CELESTIAL TO SELENOGRAPHIC COORDINATES.
Robert L. Wildey (California Institute of Technology and Carnegie Institution of Washington, Div. of Geological Sciences and Mount Wilson and Palomar Observatories, Pasadena, Calif.).
Icarus, vol. 3, July 1964, p. 136-150. 8 refs.

Edited by Nicolas Boneff and Irwin Hersey.
Vienna, Springer-Verlag, 1964, p. 88-118. 18 refs.

Discussion of the aspects of petrology that are used in extraterrestrial exploration. Lunar petrological considerations in the light of both the volcanic and the impact theories of the formation of lunar-surface features are summarized. The significance of the physical, crystallographic, and other properties which provide useful data to the petrographer are outlined, and the advisability of including a petrographic microscope system to the equipment of a soft-landing unmanned vehicle is indicated. The effects of environmental conditions upon the operation of the mechanical, electrical, and optical components of the instrument are examined, as are material considerations with emphasis on specimen-immersing plastics. An automatic petrographic microscope system is examined in detail, including the sample introduction subsystem, the sample immersion-movement subsystem, and the optical subsystem. The performance requirements of the subsystems are outlined. Techniques for sample acquisition from the surface of an extraterrestrial body, for studying the physical properties of surface and subsurface rocks, and television techniques suitable to provide a link between optical petrographic instrumentation and an observer on the Earth are discussed. V. P.

1965

A65-10242 #
RADIO-EMISSION TEMPERATURE OF THE MOON AND JUPITER ON A 70.16-CM WAVE [TEMPERATURA RADIOIZLUCHENIIA LUNY I IUPITERA NA VOLNE 70.16 CM].
V. D. Krotikov, V. S. Troitskii, and N. M. Tseitlin (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).
Astronomicheskii Zhurnal, vol. 41, Sept.-Oct. 1964, p. 951-954. 16 refs. In Russian.

Presentation of a method for measuring the effective temperature of the Moon and Jupiter by comparing the intensity of radio emission from these bodies with that of Cassiopeia-A as the reference standard. The results of measurements conducted in September 1963 are tabulated. V. Z.

A65-10368
A CASE FOR CONVECTION IN THE MOON.
Gilbert Fielder (London, University, Observatory, London, England).
Nature, vol. 204, Oct. 10, 1964, p. 171. 12 refs.

Discussion of the cause of the small bulge of the Moon, measured with reference to the mean radius of the limb, pointing in the direction of the Earth. It is stated that Runcorn's convection theory accounts for the bulge, inasmuch as the latter's general form would be similar in the continents and in the maria if they were uplifted uniformly by rising convection currents. There are additional reasons for advocating a convection theory. First, convection currents provide a means of carrying heat to the surface, and they would assist the mare melting and the Moon's differentiation that many authors advocate. Secondly, it is important to find an explanation for the remarkably uniform system of strike-slip faults that traverse the Moon's face. A triaxial Moon adjusting to the equipotential shape is inadequate to explain this lunar grid system. It is stated that specially oriented, low-order convection cells would exert a drag on the crustal layers of the Moon, and the drag at any point would be fixed in direction for a very long period of time and, specifically, during the recent era of lunar history. In principle, this mechanism is said to be capable of providing an explanation of the grid system. M.M.

A65-10452
THE CASE FOR GOING TO THE MOON. III - THE CASE FOR MINING THE MOON.
Neil P. Ruzic (Industrial Research, Inc., Beverly Shores, Ind.).
Industrial Research, vol. 6, Nov. 1964, p. 86-92, 94, 96, 98-100, 102-104, 106, 108-110.

Speculations on the possibility of mining the lunar surface for materials of value and for extending knowledge of the origin of the Earth, the solar system, and the stars. It is believed that numerous different materials potentially useful to man may exist on the Moon in great quantities. Some of these materials are: water (in the form of subselenian ice); oxygen (in combination with iron and aluminum); sulfur; platinum; diamonds; and the noble metals - gold and silver. If volcanism exists on the Moon, it may be possible to obtain electricity from selenothermal heat. It is expected that when lunar landings are made, answers may be found regarding the origin of the lunar craters, the origin of tektites, and possibly even the origin of the solar system. D.H.

A65-10860 ≠
ENVIRONMENTAL TEST CRITERIA FOR LUNAR AND PLANETARY SOILS.
Rodney W. Johnson (General Electric Co., Missile and Space Div., Philadelphia, Pa.).
IN: AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, SPACE SIMULATION TESTING CONFERENCE, PASADENA, CALIF., NOVEMBER 16-18, 1964, TECHNICAL PAPERS (AIAA Publication CP-11).
New York, American Institute of Aeronautics and Astronautics, 1964, p. 267-274. 32 refs.

Review of the experimental results of space environmental testing of simulated lunar soils. The effect of a simulated lunar environment of several soil models is analyzed. The particle size and the chemical composition of the soil grain are shown to exert an interdependent effect on the soil properties. The importance of soil moisture and particle size is stressed in postulating a simulated soil model. Claysize fractions are shown to have a significant effect on the behavior of the soil and are considered a factor which may control the properties of the lunar dust. The effects of temperature, gravity, vacuum, and radiation on the test results are evaluated. Criteria for the testing of simulated lunar and planetary soils are suggested. Results of multiple-parameter environmental tests demonstrating synergistic effects are presented. A conclusion is drawn that a soil-testing program should include simulation of the soil model and multiple-parameter simulation of the environment. V.Z.

A65-11182
INSTRUMENTATION REQUIREMENTS FOR LUNAR EXPLORATION.
Maurice A. Broner (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Sunnyvale, Calif.).
IN: INSTRUMENT SOCIETY OF AMERICA, ANNUAL CONFERENCE, 19TH, NEW YORK, N.Y., OCTOBER 12-15, 1964, PROCEEDINGS. VOLUME 19. PART II - PHYSICAL AND MECHANICAL MEASUREMENT INSTRUMENTATION.
Pittsburgh, Instrument Society of America, 1964. 5 p. 7 refs. (Preprint 16.1-1-64).

Discussion of some of the scientific and technical measurements that are required for successful manned lunar exploration. These measurements are designed to investigate the dynamic and physical properties of the Moon. Investigations of the selenographic history of the Moon, its atmosphere, the nature and magnitudes of its fields, and the content of its surface material are considered to be of particular significance. The measurements fall into biomedical, astrophysical, and engineering categories, and are expected to contribute directly to the success of manned lunar exploration, to define the lunar environment, and to add to man's fundamental knowledge. (Author) F.R.L.

A65-11183
A HYPOTHETICAL MODEL OF THE LUNAR ENVIRONMENT FOR INSTRUMENTATION RESEARCH AND DEVELOPMENT.
George A. Lander, Jr. (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Sunnyvale, Calif.).
IN: INSTRUMENT SOCIETY OF AMERICA, ANNUAL CONFERENCE, 19TH, NEW YORK, N.Y., OCTOBER 12-15, 1964, PROCEEDINGS. VOLUME 19. PART II - PHYSICAL AND MECHANICAL MEASUREMENT INSTRUMENTATION.
Pittsburgh, Instrument Society of America, 1964. 7 p. 9 refs. (Preprint 16.1-2-64).

An assessment of lunar environmental parameters that influence the development of instruments for lunar exploration. The lunar atmosphere is discussed in terms of recent experimental results. Daytime surface-temperature variations are presented as a function of both phase angle and latitude. Large-scale surface features are briefly discussed, and small-scale relief is inferred based on evaluation of current knowledge. Proposed models of lunar-surface structure and composition are reviewed based on interpretation of measurements obtained by indirect methods of observation. It is considered that present knowledge is speculative and that it must be reviewed and revised as new data become available. (Author) F.R.L.

A65-11379

LUNAR EROSION AND BROWNIAN MOTION.

Charles A. Berg (Massachusetts Institute of Technology, Dept. of Mechanical Engineering, Cambridge, Mass.).

Nature, vol. 204, Oct. 31, 1964, p. 461.

Speculation as to the source of the erosion indicated by Ranger-7 photographs of the Moon. Two mechanisms are proposed. Mechanism I: from optical microscope observations of rocks fractured by high-velocity projectiles (bullets), it is assumed that the Moon is covered by particles about 0.1 μ in size. The mean specific gravity of the Moon is about 3.3, and its gravity is 0.16 that of the Earth, which gives a particle weight (mg) of 0.53×10^{-12} dynes. The temperature on the sunny side is of the order of 10^3 °K, and, thus, kT (where k is Boltzmann's constant) becomes 1.5×10^{-13} dyne-cm. The typical scale height of the dust cloud over the surface is then kT/mg = 0.3 cm. As the Moon turns and each portion of the surface is alternately heated by the Sun for about two weeks and then cooled by radiation into space, the dust cloud rises and falls, and the accompanying redistribution of the particle cover gradually obscures the sharper features. Mechanism II: in the extremely cold shadow of a lunar crater, dust particles are drawn over from the hot side to condense locally. Assuming a mean kinetic energy of 3/2 kT, the continuous flow of these fine abrasive particles (average velocity, 10 cm/sec) is deemed sufficient to wear down the sharp ridges and further contribute to the erosion observed in the Ranger photographs. W.M.R.

A65-11815

TEXTBOOK OF ASTROPHYSICS AND STELLAR ASTRONOMY. VOLUME III [KURS ASTROFIZIKI I ZVEZDNOI ASTRONOMII. TOM III].

V. P. Viazanitsyn, M. N. Gnevyshev, O. V. Dobrovol'skii, V. A. Krat, A. V. Markov, A. P. Molchanov, V. M. Sobolev, and V. V. Sharonov.

Moscow, Izdatel'stvo Nauka, 1964. 375 p. In Russian.

The volume, on the results of astrophysical observations and their interpretation, is meant to fill a gap that exists in the Russian-language literature. It is intended for younger astronomers, university students and postgraduates, familiar with the theoretical fundamentals of astrophysics, and is designed to serve as a supplement to theoretical textbooks. Grouped into two sections, (a) The Sun and (b) The Planetary System, the fourteen chapters of the book discuss, inter alia, the following topics: (1) solar spectrum; (2) the structure of the photosphere and related phenomena such as granulations, spots and faculae; (3) the chromosphere; (4) prominences; (5) the solar corona; (6) flares; (7) solar radiation; (8) the Moon; (9) the physics of the planets; (10) individual planets; and (11) comets, meteors, and the zodiacal light. Astronomical observations made by foreign observatories, notably, by those of Zürich, Greenwich, Medon, and Freiburg are utilized and referred to on many occasions throughout the book. Measuring and observation technique, and pertinent instrumentation are discussed at length. Much attention is given, particularly, to planet disk measuring by means of a thread micrometer, heliometer, double image micrometer, and disk micrometer. Literature sources, predominantly foreign, are listed after each chapter. V.Z.

A65-11972

A LUNAR ISOTHERMAL MAP.

Robert J. Hackman (U.S. Geological Survey, Washington, D.C.).

Photogrammetric Engineering, vol. 30, Nov. 1964, p. 1011-1016. 5 refs.

Description of an isotonal map of the Lansberg region of the Moon prepared at a scale of 1 : 2,000,000 as part of a program of geologic investigations of the lunar surface. Tone values were determined by Mac-Beth Ansco densitometer measurements on a high-contrast positive transparency of a full-Moon photograph. The relative densities obtained from 12 traverses and 600 spot measurements were reduced to standard density units. Lines connecting points of equal film density were drawn on the photograph and then transferred to a base map. Comparison of the isotonal map with the photograph shows that the unaided eye cannot unambiguously recognize the same tones at different places, particularly dark tones surrounded by varying darker backgrounds. Tone values measured on the lunar maria are not correlated with recognizable topography and presumably indicate changes in texture or composition. The measurements made could be correlated only approximately with normal albedo measurements. (Author) D.H.

A65-11977

THE GEOLOGY OF THE MOON.

Eugene M. Shoemaker.

Scientific American, vol. 211, Dec. 1964, p. 38-47.

Discussion of the use of the geologists' stratigraphic technique to establish lunar time periods. To determine the sequence of major events on the solid surface of the Earth, geologists have long employed the principle of superposition: in most cases, the overlying feature is the younger. Applying this same principle to the geology of the Moon, geologists have hypothesized that craters such as Copernicus which have easily visible rays (bright streaks radiating outward and overlying other features) are of more recent origin than craters such as Eratosthenes which have no visible rays. On the basis of this kind of reasoning, it is possible to divide the Moon's history into chronological periods, designated Copernican, Eratosthenian, Imbrian, and Pre-Imbrian. The Imbrian period is itself divided into Archimedian epoch (during which extensive deposition of mare material of the Procellarum Group and the formation of Post-Appenninian craters older than at least part of the Procellarum Group are thought to have occurred) and the Apenninian epoch (during which events related to the formation of the Mare Imbrium basin took place). Other topics discussed are: the utility of photographs obtined by spacecraft, such as Ranger 7, an attempt to correlate lunar and terrestrial geologic time. It is anticipated that, before the end of this decade, the hypotheses presented may be tested directly by astronauts who have accomplished a lunar landing. D.H.

A65-12537

METEOROID ENVIRONMENT.

Paige B. Burbank and Burton G. Cour-Palais (NASA, Manned Spacecraft Center, Houston, Tex.).

IN: MANNED SPACECRAFT - ENGINEERING DESIGN AND OPERATION.
Edited by Paul E. Purser, Maxime A. Faget, and Norman F. Smith. New York, Fairchild Publications, Inc., 1964, p. 53-61. 18 refs.

Analysis of the effects of the space-meteoroid environment on design criteria for spacecraft. The physical and dynamic characteristics of individual particles in space and the flux of both sporadic and stream meteoroids are examined. A model meteoroid environment is presented which is applicable for interplanetary space near Earth (for altitudes above 70 km), in the cislunar region, and near the lunar surface. The density and orbit velocity of the particles are defined for a range of meteoroid sizes from a minimum, defined by the Poynting-Robertson effect, to a maximum weight of one gm. The reliabilities of a spacecraft structure and of a space suit in this environment are calculated. Examples of penetration probabilities are presented for a given spacecraft structure. P.K.

A65-12742 *

THE LUNAR PROSPECT.

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

IN: APOLLO - A PROGRAM REVIEW; SOCIETY OF AUTOMOTIVE ENGINEERS, NATIONAL AERONAUTIC AND SPACE ENGINEERING AND MANUFACTURING MEETING, LOS ANGELES, CALIF., OCTOBER 5-9, 1964, PROCEEDINGS (SP-257).
New York, Society of Automotive Engineers, Inc., 1964, p. 113-124.

Discussion of the lunar prospect, with reference to its degree of roughness, the thickness of dust at the impact site, the availability of shelter, mineralization, subsurface warmth, radiation dosages, and temperature range. A critique of the validity of a volcanic vs an impact theory of origin of lunar surface features is presented in tabular form, as well as a table of assumed lunar surface structures to be expected if one theory or the other is correct. Of the two theories, the volcanic one is considered to offer the greater possibilities for lunar support, and a table lists potential lunar resources in the categories of shelter, unconsolidated surface material, rocks, minerals, gases, heat, and vacuum, as far as current information makes it possible to estimate the possibility of their occurrence if either theory should be proved valid.
F. R. L.

A65-13079 #
TEST PROGRAM FOR DETERMINATION OF SOIL CONSTANTS IN VACUUM.
Richard E. Wong and Calvin Kern (Bendix Corp., Bendix Systems Div., Ann Arbor, Mich.).
American Society of Mechanical Engineers, Winter Annual Meeting, New York, N. Y., Nov. 29-Dec. 4, 1964, Paper 64 - WA/AV-11.
22 p. 6 refs.
Members, $0.50; nonmembers, $1.00.
Contract No. NASw-642.

Summary of the results of an experimental program to determine soil constants under atmospheric and vacuum conditions. The specific objectives of the experimental program were to obtain and analyze experimental data from the bearing and shear tests involving three variations of grain size for quartz sand, each with typical sharp edge shape, and three variations of density for pumice. From the bearing and shear tests, the soil constants, c, ϕ, k_c, k_ϕ, and n, necessary for analysis of the traction performance of a roving vehicle, were determined and are presented. (Author) F. R. L.

A65-13089
LUNAR MISSIONS AND EXPLORATION.
Edited by C. T. Leondes (California, University, Los Angeles, Calif.) and R. W. Vance (Aerospace Corp., Technical Development Program Office, Los Angeles, Calif.).
New York, John Wiley and Sons, Inc., 1964. 669 p.
$17.50.

CONTENTS:

FOREWORD. P. H. Sheats, G. J. Maslach, and L. M. K. Boelter (California, University, Los Angeles, Calif.), p. vii, viii.

PREFACE. C. T. Leondes (California, University, Los Angeles, Calif.) and R. W. Vance (Aerospace Corp., Los Angeles, Calif.), p. ix-xiv.

THE CHARACTERISTICS OF LUNAR MISSIONS. W. R. Laidlaw (North American Aviation, Inc., Downey, Calif.), p. 1-59. [See A65-13090 04-31]

LUNAR ENVIRONMENT. M. Eimer (Space General Corp., Azusa, Calif.), p. 60-85. 94 refs. [See A65-13091 04-30]

PROPULSION SYSTEMS. George P. Sutton (North American Aviation, Inc., Canoga Park, Calif.), p. 86-121. [See A65-13092 04-28]

LAUNCH-VEHICLE SYSTEMS. George H. Stoner (Boeing Co., New Orleans, La.), p. 122-233. [See A65-13093 04-31]

EARTH-BASED LAUNCH FACILITIES. M. S. Agbabian (Agbabian-Jacobsen Associates, Los Angeles, Calif.), p. 234-275. 18 refs. [See A65-13094 04-11]

GUIDANCE ANALYSIS. Carl Pfeiffer (California Institute of Technology, Pasadena, Calif.), p. 276-307. 15 refs. [See A65-13095 04-21]

LUNAR TERMINAL GUIDANCE. Richard K. Cheng (Hughes Aircraft Co., Culver City, Calif.), p. 308-355. 8 refs. [See A65-13096 04-21]

SPACE POWER SYSTEMS. G. C. Szego (Institute for Defense Analyses, Washington, D. C.), p. 356-424. [See A65-13097 04-03]

LUNAR COMMUNICATIONS. Eberhardt Rechtin (California Institute of Technology, Pasadena, Calif.), p. 425-451. [See A65-13098 04-07]

LIFE SUPPORT SYSTEMS FOR LUNAR BASE OPERATIONS. R. A. Fischer (Garrett Corp., Los Angeles, Calif.), p. 452-497. 15 refs. [See A65-13099 04-05]

LUNAR EXPLORATION. H. M. Schurmeier (California Institute of Technology, Pasadena, Calif.), p. 498-531. [See A65-13100 04-31]

SOME CONSIDERATIONS OF THE LUNAR EXCURSION. Charles W. Frick (NASA, Manned Spacecraft Center, Tex.; General Dynamics Corp., San Diego, Calif.), p. 532-547. [See A65-13101 04-30]

ENTRY GUIDANCE AND CONTROL. E. G. Cole (North American Aviation, Inc., Downey, Calif.), p. 548-587. [See A65-13102 04-21]

RETURN LAUNCH AND RE-ENTRY VEHICLES. Harold Hornby (NASA, Ames Research Center, Calif.), p. 588-664. 16 refs. [See A65-13103 04-31]

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A65-13091
LUNAR ENVIRONMENT.
M. Eimer (Space General Corp., Azusa, Calif.).
IN: LUNAR MISSIONS AND EXPLORATION.
Edited by C. T. Leondes and R. W. Vance.
New York, John Wiley and Sons, Inc., 1964, p. 60-85. 94 refs.

Review of our present understanding of the major processes which formed the features of the lunar surface and of the methods and results of recent lunar observations. The topics considered are evolution of the lunar surface, meteoroid erosion and dust transport, and measurements of surface properties by visible light photometry, visible light polarimetry, infrared radiometry, microwave radiometry, and radar. It is stated that, within the community of knowledgeable lunar scientists, differences in the interpretation of observational data have obscured the fact that substantial understanding and agreement do exist in a number of disciplines, and that substantial agreement and little understanding exist in others. Many of the presently unanswered questions are irresolvable by Earth-bound methods. M. M.

A65-13159
SIMULATED EXTRUSIVE MAGMA SOLIDIFICATION IN VACUUM.
Walter I. Dobar, O. Lyle Tiffany (Bendix Corp., Bendix Systems Div., Ann Arbor, Mich.), and John P. Gnaedinger (Soil Testing Services, Inc., Northbrook, Ill.).
Icarus, vol. 3, Nov. 1964, p. 323-331. 10 refs.

Discussion of the physical properties of Simolivac, a porous material not found in nature, which has been produced by the upwelling and solidification of a simulated magma in vacuum. Bearing strength measurements show that this material can accommodate static loads up to 4 tons/ft^2. Samples of Simolivac were irradiated with a cobalt-60 source, and photometric curves were obtained of nonirradiated and irradiated samples. Good correlation is shown between the photometric curves of Simolivac and the lunar surface.
(Author) M. M.

A65-13162
NOTES ON THE IMPORTANCE OF SHOCK CRATER LIPS TO LUNAR EXPLORATION.
Wayne A. Roberts (Boeing Co., Seattle, Wash.).
Icarus, vol. 3, Nov. 1964, p. 342-347. 7 refs.

Observations on the structure and topographic character of the Sedan crater lip. The Sedan crater lip was formed by the subsurface detonation of a 100-kt thermonuclear device. The nature of this shock crater lip is tentatively extrapolated to the lunar shock craters, and the relationship of these shock crater lips to the early exploration effort on the surface of the Moon is discussed.
(Author) M. M.

A65-13163
SECONDARY CRATERS.
Wayne A. Roberts (Boeing Co., Seattle, Wash.).
Icarus, vol. 3, Nov. 1964, p. 348-364. 6 refs.

Discussion of secondary craters formed by the impact of ejecta missiles, which generally occur outside the lip crest of explosion-induced shock craters. It is stated that numerous shallow depressions occurring in the region adjacent to the lunar crater Copernicus have also been interpreted as secondary craters. Missiles which produce secondary craters are: (1) comminuted

and shock-compacted material, (2) single rock or soil fragments, (3) fragments of structural material, and (4) unconsolidated but discrete masses of crater ejecta. Superposition of ejecta layers, exposed by excavation of the large secondary craters near Sedan, indicates that unwinnowed material arrives first followed by the large masses of unconsolidated alluvium. The impact of these masses forms secondary craters that are essentially compressional features. It is stated that the secondary craters observed on Earth have all been formed by missile impact velocities lower than the acoustic velocity of the medium; however, on the Moon, primary as well as secondary impact craters can be produced at both subsonic and hypersonic velocities. This indicates that the use of shock crater frequency to infer flux of larger meteorites may not be valid. (Author) M. M.

A65-13201 #

CHEMICAL ENGINEERING IN THE LUNAR ENVIRONMENT.

R. T. McCutchan (Thiokol Chemical Corp., Marshall, Tex.).

American Institute of Chemical Engineers, Symposium on Chemical Processing in Extraterrestrial Environments, Annual Meeting, 57th, Boston, Mass., Dec. 6-10, 1964, Preprint 46a. 6 p. $0.50.

Problems to be faced in carrying out industrial chemical processes on the Moon. Besides the conventional logistics problems of a sufficient supply of water and oxygen, the possible extraction of the latter from rocks, and general protection against micrometeorites, other difficult areas include power source: the obvious solution of utilizing solar energy, which, in the absence of a protective atmosphere, is assumed superior to that on Earth, encounters problems in the two-week alternation of night and day on the Moon and thus, involves questions of energy storage or part-time operation. Heat exchange: the heat generated in any process will have to be radiated into space and conservation of heat by exchanging it in the process will only leave energy to be dissipated at a lower temperature, compelling the use of larger radiators. Thus, high-temperature processes are favored, which in turn put increasingly stringent demands on the materials of construction. Weight payout: this is the time required for the process to produce useful material of weight equal to the weight of the equipment used to produce it. If the stay or operating time of the process is less than the weight payout time, it is found better to ship the material from Earth rather than process it on the Moon. The absence of atmosphere means there will be no convective heat transfer. The conductivity of the rock is too low to allow much energy to be dissipated by conduction, even though there is a steady temperature of about $-60^{\circ}F$ somewhat less than 75 ft below the surface. Some of the major problems to be solved appear to be mechanical in nature. Any bearing that must function on the surface of the Moon must face a temperature possibly as high as $245^{\circ}F$ without the aid of air cooling; or possibly a temperature as low as $-310^{\circ}F$. If it is lubricated, it must be sealed against a vacuum of 10^{-13} atm. At such a pressure, the films of gases absorbed on metals have been stripped below the monomolecular layer level and cold welding or vacuum welding takes place as the solid surfaces come together. This leads to seizure of metal bearings. Such low pressures will also cause dust particles to adhere to each other with some strength. However, Moon sites are seen to be of possibly great advantage in that processes requiring extremely low vacuum -e. g., vacuum metallurgy, may be profitably carried out, and construction will, in general, be facilitated as a result of the reduced gravitational and vibrational loading. W.M.R.

A65-13202 #

WATER AND CHEMICAL RECOVERY IN A LUNAR ENVIRONMENT.

R. N. Rickles (Dorr-Oliver, Inc., Stamford, Conn.).

American Institute of Chemical Engineers, Symposium on Chemical Processing in Extraterrestrial Environments, Annual Meeting, 57th, Boston, Mass., Dec. 6-10, 1964, Preprint 46b. 13 p. $0.50.

Two approaches to the recovery of water, oxygen, and various chemicals from the lunar soil. One would use solar energy to thermally produce water and CO_2 from lunar rock at 1300 to $1500^{\circ}F$ and would envision simple reaction steps such as $MOSiO_3CO_3 \cdot H_2O \rightarrow MO_2SiO_3 + CO + H_2O$, where M is a cation. The other would employ electrical or nuclear power to the reduction of the rocks at temperatures in excess of $5000^{\circ}F$ according to a reaction of the type $MO_2SiO_3 + C_xH_y \rightarrow H_y + CO + MO_2 + Si$. From the engineering standpoint, the production of oxygen and water for a long-lived lunar colony is seen to be technically quite feasible. W.M.R.

A65-13203 #

THE ON-SITE MANUFACTURE OF PROPELLANT OXYGEN UTILIZING LUNAR RESOURCES.

S. D. Rosenberg, G. A. Guter, and F. E. Miller (Aerojet-General Corp., Azusa, Calif.).

American Institute of Chemical Engineers, Symposium on Chemical Processing in Extraterrestrial Environments, Annual Meeting 57th, Boston, Mass., Dec. 6-10, 1964, Preprint 46c. 13 p. $0.50.

Development and experience in operation of a reactor for producing oxygen from silicates, regardless of their precise compositions and fine structures. The process does not depend on the presence of water or water precursors in the metallic silicates assumed to be widely distributed over the surface of the Moon. It is cyclic in nature and is exemplified by the reactions (1) $MgSiO_3 \rightarrow 2CH_4 \xrightarrow{1625^{\circ}C} 2CO + 4H_2 + Si + MgO$; (2) $2CO + 6H_2 \xrightarrow{250^{\circ}C} 2CH_4 + 2H_2O$; (3) $2H_2O \xrightarrow{750^{\circ}C} 2H_2 + O_2$. The results are presented of a series of reactions of basalt and granite with carbon and silicon carbide carried out to determine the temperature profile for the reactions which may occur during the reduction of igneous rock with methane. Schematic flow diagrams of the silicate reduction furnace and of the hydrogen-carbon monoxide reactor are given. The effects of temperature, pressure, mole ratio, space velocity, material and heat balance, pressure drop, catalyst (nickel-kieselguhr) life, and bed depth are discussed. W.M.R.

A65-13335

PHOTOMETRY OF THE EARTH-SHINE ON THE MOON TO DETERMINE THE EARTH ALBEDO [PHOTOMETRIE DE LA LUMIERE CENDREE EN VUE DE LA DETERMINATION DE L'ALBEDO DE LA TERRE].

J. Rösch (Toulouse, Université, Observatoire du Pic du Midi, Bagnères de Bigorre, Hautes-Pyrénées, France).

Annals of the International Geophysical Year, vol. 32, 1964, p. 97-100. In French.

Description of photometric experiments to determine the amount of Earth light incident on the Moon. Observations were made at Pic du Midi, France; Ondrejov, Czechoslovakia; and Kodaikanal, India. The difference in the magnitudes of the Earth and the Sun as seen from the Moon is determined as a function of the geocentric phase of the Moon, and the results are compared with those of Danjon. The results are found to vary strongly from station to station, indicating that the Earth albedo varies greatly from region to region on the Earth. P. K.

A65-13344

INTERACTION BETWEEN THE SOLAR WIND AND THE LUNAR ATMOSPHERE.

F. C. Michel (William Marsh Rice University, Space Science Dept., Houston, Tex.).

Planetary and Space Science, vol. 12, Nov. 1964, p. 1075-1091. 16 refs.

Analysis of the flow of the solar wind plasma about the Moon, and of its interaction with the lunar atmosphere. The accretion and attenuation actions of the solar wind on the lunar atmosphere are examined for two limiting models of the flow about the lunar surface. The effects of other accretion mechanisms, such as volcanism, and attenuation mechanisms, such as gravitational escape, are considered. The expected composition and mass of the lunar atmosphere are discussed. P. K.

A65-13412 #

SOIL BEHAVIOR IN A LOW AND ULTRAHIGH VACUUM.

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

American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 29-Dec. 4, 1964, Paper 64 - WA/AV-14.
19 p. 27 refs.
Members, $0.50; nonmembers, $1.00.
Research supported by the Grumman Aircraft Engineering Corp.

Investigation of the behavior of simulated lunar soils. Weights were dropped into a high-porosity (90%) colloidal silica in air and in a vacuum of 10^{-3} torr, and the bearing strength of the system was found to increase for the vacuum. For basalt, glass-bead, and aluminum-powder systems at 10^{-10} torr, extensive adhesion of dust particles was found, also increasing the hardness of the soils. A "clean-surface" rather than an electrostatic mechanism of adhesion is indicated, but the results are inconclusive. Implications of the results, particularly the effects of extensive dust adhesion, on various aspects of lunar surface missions are discussed. P.K.

A65-13417 #
TEMPERATURE CONTROL ON THE LUNAR SURFACE.
Graham Walker (Illinois Institute of Technology, Research Institute, Fluid Dynamics Div., Heat and Mass Transfer Section, Chicago, Ill.).
American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 29-Dec. 4, 1964, Paper 64 - WA/HT-32.
12 p. 10 refs.
Members, $0.50; nonmembers, $1.00.
Jet Propulsion Laboratory Contract No. 950315.

Analysis of requirements and methods for the passive temperature protection of an alpha-particle scattering experiment to be placed on the lunar surface. The equilibrium temperatures of the sensor head of the device are determined for various combinations of polished aluminum and white-coated enclosure surfaces. The lunar surface position is chosen to represent that most likely to give extreme operating temperature conditions. A combination of painted top surface and polished sides appears most suitable, and should provide an environment sufficiently stable to allow continuous operation throughout the entire daylight period. The results demonstrate the order of magnitude of temperature control which can be achieved merely by effecting a change in the radiation characteristics of an enclosure surface. P.K.

A65-13418 #
MOBILITY CONSIDERATIONS OF LUNAR ROVING VEHICLES.
W. B. Sponsler (Northrop Corp., Northrop Space Laboratories, Hawthorne, Calif.).
American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 29-Dec. 4, 1964, Paper 64 - WA/AV-10.
13 p. 15 refs.
Members, $0.50; nonmembers, $1.00.

Analysis of the mobility of various wheel- and track-vehicles for locomotion on the lunar surface. The effects of lunar surface characteristics, vehicle weight, tread configuration, rolling resistance, range, obstacle capability, and acceleration considerations are discussed. Examples for typical vehicles are compared for various lunar surface parameters. The necessity for low speeds, and the effects of lunar environment on energy requirements, locomotion capabilities, and stability and braking considerations are discussed. P.K.

A65-13420 #
A STUDY OF HEAT REJECTION SYSTEMS FOR LUNAR BASED MERCURY RANKINE POWER PLANTS.
L. K. Petersen and Milo Price (Aerojet-General Corp., SNAP-8 Div., Advanced Power Systems Dept., Azusa, Calif.).
American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 29-Dec. 4, 1964, Paper 64 - WA/AV-12.
14 p. 9 refs.
Members, $0.50; nonmembers, $1.00.

Analysis of lunar environmental effects on, requirements for, and the characteristics of, a heat rejection system for the power plant of a manned lunar base. The effects of lunar geography and materials, meteoroids, and radiation on mercury Rankine cycle power systems are considered, for both direct-condensing radiators and indirect signal-phase fluid radiators. Weight optimization and radiator configuration are treated from the standpoints both of vehicle integration and lunar surface erection. The possibility of utilizing waste power-plant thermal energy to perform useful life-support and processing functions is studied. P.K.

A65-13509 #
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. 69, Dec. 15, 1964, p. 5217-5223. 13 refs.
Grant No. NsG 101-61.

Interpretation of the 68-cm radar echoes from the Moon, with the approximate description of the scattering by the laws of geometric optics. The treatment relates the observed angular power spectrum directly to the distribution of surface normals, and no assumed functional dependence of the surface correlation function is required. A simple calculation gives a dielectric constant of 2.6 to 2.8, an average slope of 11 to 14°, and an rms slope of 15 to 23°. The depolarization data and the contour of the angular power spectrum are used in selecting these values from the different possible sets. The reduction technique has the added feature that the derived formulas can be used directly to calculate the microwave emissivity as a function of both angle and polarization. (Author) W.M.R.

A65-13535
LUNAR LUMINESCENCE.
J. E. Geake (Manchester College of Science and Technology, Dept. of Physics, Manchester, England).
Nature, vol. 204, Nov. 28, 1964, p. 866, 867. 7 refs.

Explanation of the red lunar luminescence observed by Kopal and Rackham around the crater Kepler and by Greenacre and Barr on the rim of Aristarchus. Kopal and Rackham have concluded that Kepler was produced by a large enstatite achondrite meteorite because enstatite is known to exhibit a characteristic red luminescence when excited by intense proton irradiation. A difficulty of this interpretation is that all but about one part in a thousand of the material spread out by the impact would be lunar material rather than meteoritic material. If the Moon were to consist of a thin layer of deactivated or nonluminescent material which covers minerals capable of luminescence, any disturbance to the surface (as by a meteorite or volcanic activity) would result in luminescence when the new surface is exposed to proton excitation. Cameron has suggested that such irradiation occurs around the time of full Moon because of an anti-solar tail of charged particles trapped by the Earth's magnetic field. Urey and Cameron have independently suggested that enstatite is probably a constituent of the lunar surface. D.H.

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