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COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE

INFORMATION FURNISHED IN CONFORMITY WITH ARTICLE XI OF THE TREATY ON PRINCIPLES GOVERNING THE ACTIVITIES OF STATES IN THE EXPLORATION AND USE OF OUTER SPACE, INCLUDING THE MOON AND OTHER CELESTIAL BODIES

Letter dated 27 October 1967 from the Representative of the United States of America to the United Nations addressed to the Secretary-General

I have the honour to forward herewith a report on "Preliminary Scientific Results from Surveyor V", the United States spacecraft which made a soft landing on the lunar surface on September 10, 1967 and successfully completed a number of experiments designed to increase man's knowledge of the surface of the Moon. The report is submitted in accordance with article XI of the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," which provides:

> "In order to promote international co-operation in the peaceful exploration and use of outer space, States Parties to the Treaty conducting activities in outer space, including the Moon and other celestial bodies, agree to inform the Secretary-General of the United Nations as well as the public and the international scientific community, to the greatest extent feasible and practicable, of the nature, conduct, locations and results of such activities. On receiving the said information, the Secretary-General of the United Nations should be prepared to disseminate it immediately and effectively."

The attached report contains an introduction by Dr. Homer E. Newell, Associate Administrator for Space Science and Applications, NASA, followed by scientific presentations in the following areas by scientists responsible for the experiments concerned:

Lunar Topography and Geology	Dr. Eugene Shoemaker U.S. Geological Survey

Mechanical Properties of the Lunar Surface	Elmer Christensen Jet Propulsion Laboratory
Magnetic Properties of the Lunar Surface	Mrs. J. Negus de Wys Jet Propulsion Laboratory
Chemical Composition of the Lunar Surface	Dr. Anthony Turkevich University of Chicago
Implications of Surveyor V Data on Lunar Theory	Dr. Donald E. Gault Ames Research Center

Dr. Harold Masursky, U.S. Geological Survey, Dr. James H. Turnock, Deputy for Programmes, Apollo Program, Office of Manned Space Flight and Richard T. Mittauer, Public Affairs Officer, NASA, also assisted in the presentations.

I would appreciate circulation of this letter as a document of the United Nations. Sufficient copies of the report[1/] are enclosed to permit its dissemination to all Member States, with additional copies for the Library of the United Nations Outer Space Affairs Group.

(Signed) Arthur J. GOLDBERG

1/ Copies of the report have been circulated to the Permanent Missions of all Member States. Additional copies are available for consultation in the library of the Outer Space Affairs Group.

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NEWS NASA

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FOR RELEASE: 10:00 a.m.
October 17, 1967

LUNAR ORBITER V

SCIENTIFIC RESULTS BRIEFING

PARTICIPANTS:

DR. HOMER E. NEWELL, Associate Administrator.

MR. CLIFFORD NELSON, Lunar Orbiter Project Manager,
Langley Research Center.

MAJ. GEN. SAMUEL C. PHILLIPS, Director, Apollo Program.

MR. L. HAROLD SPRADLEY, Aeronautical Chart and Information Center,
St. Louis, Missouri.

MR. HAROLD MASURSKY, U.S. Geological Survey,
Menlo Park, California.

DR. JOHN FINDLAY, Assistant Director, National Radio Observatory,
Charlottesville, Virginia.

MR. C. A. GURTLER, Experimenter for Meteoroid Experiments.

DR. J. H. TURNOCK, Deputy Director for Apollo Program.

CAPTAIN LEE R. SCHERER, Program Manager, Lunar Orbiter.

MR. RICHARD T. MITTAUER, Public Affairs Officer, NASA.

MITTAUER: Ladies and gentlemen, welcome to the briefing on the results of Lunar Orbiter V. A few extraneous announcements.

One, the News Center will open at JPL tomorrow morning at 8:00 o'clock Pacific Time for the encounter with Venus by Mariner V. There will be a pre-encounter briefing at the News Center at 2:00 p.m. tomorrow afternoon Pacific Time.

Transcripts will be available of this briefing later this week. Please sign envelopes in the newsroom on the way out. There are glosses available for the news media in Les Gaver's office across the hall. This afternoon when this meeting is concluded and we can move some of the chairs out we will install on the floor of this auditorium the 30-foot square mosaic of the front side of the Moon resulting from Orbiter IV photography.

You all are welcome to come up, and as long as you take your shoes off, walk across the Moon.

To open today's session, Dr. Homer Newell, Associate Administrator of NASA, acting I guess in his capacity as Acting Associate Administrator for Space Science and Applications.

NEWELL: Thank you, Dick.

Let me give you just a little background of the Lunar Orbiter program before we call on the real speakers of today.

Lunar Orbiter, as you know, was designed and put into operation to act as a companion to the Surveyor so that in effect one can have a two-pronged attack on the study of the Moon.

By way of some history, the go-ahead for Lunar Orbiter was given just 42 months ago. The contract called for the design, development, and operation of a block of five of these spacecraft intended to obtain high resolution photography of major areas of the Moon from close-in orbits.

Twenty-eight months after the go-ahead, in August 1966, the first mission was launched. This was a very short time for the development of a spacecraft of this complexity, as I think you will recognize, by comparing the time involved with what it has taken to do some other missions.

One year later all five missions had been launched and all of them were successful, leading the Boeing Company to come out with a button like this which says, "Five for five." I am sure Boeing will be glad to give anyone who wants one of these, one to wear.

By the end of the third mission the initial objective of Lunar Orbiter, that is, the search for smooth areas for Apollo, will be essentially satisfied and as a consequence the last two missions could be devoted to broader goals with more complex missions. So the requirement that the photography be taken only in close-in orbits was relaxed, and as you know the Lunar Orbiter IV mission undertook the mapping of the entire front surface of the Moon.

Today we propose to review the results of the last two missions.

The photography that you see around the walls here, and additional photography that the speakers will show to you, constitute a collection of scientific data and engineering data that will keep scientists and engineers busy for the indefinite future.

Before the first Lunar Orbiter mission this country had never placed spacecraft into orbit about any other celestial body other than the earth. In all five of the Lunar Orbiter missions, the spacecraft were not only placed into initial orbits as desired, but then the orbits were changed in accordance with a plan that had been set up beforehand, in what might be called a precision type of operation. The spacecraft were maneuvered literally thousands of times, in fact about two thousand times, to point the camera, to adjust power, thermal levels, and otherwise to do the housekeeping necessary to keep the spacecraft healthy.

Some of this maneuvering was done out of sight of the earth, on the other side of the Moon.

Lunar Orbiter and its companion, Surveyor, have shown that we can use sophisticated technology in complicated spacecraft for automated missions to other bodies of the solar system. And it is this kind of capability that we will be using again and again as we continue the exploration of our solar system.

NASA wants today to express its thanks to the fine Lunar Orbiter team for a most successful series of missions, for a well managed effort.

I would like to introduce to you some of the key individuals responsible.

From the Office of Space Science and Applications, first, Oran Nicks, Director of the Lunar and Planetary Programs. Oran, will you stand, please.

Secondly, Lee Scherer, Lunar Orbiter Program Manager.

I am very pleased to be able to introduce as a member of OSSA, George Hage, who was formerly Engineering Manager of Lunar Orbiter, and is now OSSA Deputy Associate Administrator for Engineering.

Is George Hage in the room? I don't see him here.

At the Field Center there is Dr. Floyd Thompson, who is Director of the Langley Research Center. Dr. Thompson is on the way from the airport by autocar, which in today's weather turns out to be Richmond.

(Laughter)

So he isn't quite here yet, but we hope he will be here before the meeting is over.

At the prime contractor, Robert Helberg, Lunar Orbiter Program Manager of the Boeing Company. Bob has moved on to another job now, but he was the Manager of the Lunar Orbiter.

And for two major subcontractors, Dr. William Feldman, of Eastman Kodak, and Mark Sasso, of RCA. I understand he is weathered in, too. I am sorry to hear that.

I would also like to acknowledge outstanding support provided to the Lunar Orbiter program by the Atlas-Agena team with five perfect launches. The team consisting of the Lewis Research Center, Kennedy Spacecraft Center, the Air Force, General Dynamics, and Lockheed, among others. And the Jet Propulsion Laboratory and their deep space network and operations facilities.

Now let's get on to the meat of the session.

The first speaker is Mr. Clifford Nelson of the Langley Research Center, who is the Lunar Orbiter Project Manager. I would like to call on him for some introductory remarks.

NELSON: The last photo of the Moon from Lunar Orbiter V was sent to earth 7 weeks ago, 40 months after the spacecraft contract was signed.

The initial objectives have been surpassed. More scientific data has been obtained than had been originally planned. All flights have been judged successful. Lunar Orbiter I was launched last year on August 10, 1966. The remaining four launches were made at the planned three-month intervals. The last launch of the five-mission program occurred just short of one year later on August 1, 1967.

The primary task of the Lunar Orbiter project was to obtain photography of the Moon to aid in the selection of Apollo and Surveyor landing sites and to contribute to the scientific knowledge of the Moon. Secondary tasks were to obtain meteoroid and radiation measurements in the near lunar environment, provide information on the gravitational field and to provide a Moon orbiting spacecraft with radio frequency equipment to support checkout and training for the manned space flight network, communications net and orbit computing programs at Manned Spacecraft Center.

The photo data provided by Lunar Orbiter I, II, III, and Surveyor I resulted in eight candidate Apollo landing sites being selected in the central equatorial belt of the Moon's nearside. The mission plan of Lunar Orbiter IV was completely different from the earlier three and was devoted entirely to providing data to increase our scientific knowledge of the Moon.

The scientific community was near unanimous in asserting that the next step in photographic exploration of the Moon should be to obtain as much coverage of the lunar surface as possible with primary emphasis on the front side.

Following this concept the Lunar Orbiter IV provided coverage of the front side of the Moon and yielded one hundred times the detail that is obtainable from earth-based observations, even of the central areas clearly seen from earth. This represents about 7 million square miles of lunar surface.

After the formal part of the press briefing, as has been mentioned by Dr. Newell, we plan to remove the chairs in the back part of the room and roll out the 30-foot mosaic that had been prepared from the original prints as we received them on the ground. I invite you, as he said, to walk on the face of the Moon and to examine many of its unusual features at close range.

It has been estimated that the detail that you will see is roughly equivalent to your eyes being approximately 400 miles from the Moon itself.

The mission of Lunar Orbiter V was again a new and different type, requiring photography of three times more sites than the earlier missions. The mission V plan was developed with the support of a planning group with representatives from various scientific disciplines, including Apollo, Surveyor, Apollo Applications and Lunar Orbiter. Its primary objective was to photograph scientifically interesting areas on the front side of the Moon, complete the farside coverage, and to provide supplemental photography of potential Apollo landing sites.

Lunar Orbiter V photograghed all of the selected 36 front side science sites, completed the photographic coverage of the entire farside, and the supplemental photograph requested by Apollo. The mission was performed from a near-polar 85° inclined orbit, with three different orbit sizes. Much of the farside was obtained from the initial and intermediate orbits that had the same apolune altitude of 3600 miles and perilune altitudes of 120 and 60 miles, respectively. All of the front-side science sites were photographed from the 900 by 60 mile final orbit. The large mosaics made up of working prints around the room represent a sampling of the 36 sites covered by Lunar

Orbiter V.

The present status of the Lunar Orbiter spacecraft is as follows: Lunar Orbiter I was intentionally crashed on the farside last October, after completion of its mission, to prevent possible R.F. interference because its attitude gas supply was running low and loss of control from the ground was imminent. Last week Lunar Orbiter II and III were crashed on the Eastern and Western limbs of the Moon for the same basic reason. Lunar Orbiter IV stopped transmitting in the middle of July sometime, after its photo mission, and based on previous tracking data of its orbit, Lunar Orbiter IV will crash into the Moon's frontside near the end of this month. Thus, from the original fleet of Orbiters circling the Moon, only Lunar Orbiter V remains in orbit to carry out the important tasks associated with the extended mission. All of its subsystems appear to be healthy and functioning properly. Our next concern for its safety has to do with getting it safely through the deep umbral eclipse of the Moon, which will occur tomorrow morning from 4:26 to 8:05 a.m. This long period of darkness will cause the spacecraft temperature to plunge and the battery to discharge as solar power is cut off.

To prepare for this event, on October 10th we adjusted the orbit of Lunar Orbiter V to minimize these effects and were able to still retain enough rocket fuel to be able to crash the spacecraft, if required at some future time.

The maneuver was successful and exactly as planned and we are looking forward to its survival of the eclipse and its continuing to provide meteorite and radiation data, sending down added information of the gravity figure of the Moon and most importantly, continuing to act as a responding target vehicle for exercising the Manned Space Flight network and the Manned Spacecraft Center's computing programs for orbit determination.

To conclude this summary of the overall program, I will attempt to summarize the status of current investigations concerning selenodesy, meteorite and radiation hazard and MSFN support. Fortunately the experimentors are present and can handle questions you may have later in these areas.

Dr. William Michael of the Langley Research Center is the principal investigator for selenodesy, and he and his co-investigators have already published several papers regarding the selenodesy of the Moon; including the size, shape, and gravity field distribution.

As tracking data have become available from successive Lunar Orbiter flights, these data have been used in continuing analyses at the NASA Langley Research Center to define the components of the gravitational field of the Moon. The results obtained for the gravitational field are being used in applications for determination of various physical properties of the Moon and in applications to predict orbits for lunar satellites. Other data from the Lunar Orbiter spacecraft are being used to determine the radius of the Moon, relative to its center of mass, at various locations corresponding to regions covered by concentrated Lunar Orbiter photography.

With respect to new knowledge of the physical properties of the moon, two preliminary conclusions have been obtained so far. The first result pertains to the density distribution in the moon. The analyses indicate that the interior of the moon is very nearly homogeneous, with nearly constant density throughout. This is considerably different from the earth, where the density increases a great deal toward the center. The result is also considerably more reasonable, than previous and more indirect determinations of the density distribution in the moon, determinations made before establishment of lunar satellites, which indicated that the moon was considerably more dense near the surface than deep in the interior. Therefore, this question of density distribution in the moon now seems to be resolved with use of lunar orbiter data.

Another result is that the radius of the moon, in the direction toward the earth, is one or two kilometers less than what was previously obtained from earth-based photography(1738 KM). This tends to confirm results obtained from some of the Ranger probes. This result may indicate that the center of mass of the moon is displaced toward the earth from the center of its geometrical figure, a situation which would have interesting scientific implications as to the stability of the moon and its origin and history.

Analyses of tracking data from the lunar orbiter will be continuing for many months yet, and will contribute materially to the further definition of the lunar gravitational field and to the applications for determination of physical properties of the moon such as those already obtained.

Mr. Charles Gurtler, Langley's experimentor and developer of the pressurized cell technique, has come to the following conclusions regarding the assessment of the meteoroid hazard at the moon.

The meteoroid experiments on the lunar orbiter spacecraft have provided a direct measurement in the near lunar environment of meteoroid penetration rate in one thousandth inch thick beryllium copper. The experiment on each of the five spacecraft consists of 20 pressurized cell detectors with an exposed area of two square feet.

Data which have been collected continuously over the last 14 months indicate 18 of the 100 detectors have been punctured. These data, also, indicate that the measured rate in the region covered by lunar orbiter spacecraft is less than one-half the rate in the near earth environment as measured by the same type of detectors as used on the Explorers XVI and XXIII.

The lunar orbiter meteoroid experiments were exposed to the lunar environment over altitudes ranging from 24 to 3600 miles, and have been in both equatorial and polar orbits.

Although 18 punctures is statistically a small number, the punctures have been randomly distributed around the spacecraft and have shown no conclusive directionality preference.

Dr. Trutz Foelsche of Langley has examined and interpreted the radiation measurements provided by lunar orbiters to assist in solving pertinent operational problems. The prime function of the radiation sensor was to provide constant monitoring of radiation dosage affecting the on-board film. This was necessary to provide a basis for operational control and management of film usage.

All radiation sensing apparatus worked properly. Throughout the entire mission three significant solar particle events occurred, only one event took place when the film was in a sensitive condition -- prior to development. During this event the film was not measurably darkened, as it had originally been selected to have a low response to high energy particle radiation.

By measuring these three events in lunar orbit, and the low level radiation near the moon during long periods of quiet sun and, also, radiation during five passages through the earth's radiation belt,we have accmulated considerable data concerning radiation dose levels.

Detailed analyses of these measurements will be reported at a later time.

With regard to the status of the manned space flight network use of lunar orbiter spacecraft, all 13 stations have successfully tracked and communicated with lunar orbiter spacecraft and all 13 stations of the network will have completed their certification by the end of this month. The orbit determination programs are in the initial stages of checkout and this work will continue with Lunar Orbiter V.

I would now like to conclude my remarks with a few statistics that are related to overall performance of the lunar orbiter fleet at the moon.

1. In the total program so far, 800 spacecraft days of lunar orbiting experience has been accumulated.

2. The deboost engines have been successfully operated 28 consecutive times. In several cases the engine has performed after inert storage periods of up to four months. The engine of the Lunar Orbiter II spacecraft was successfully operated to perform an impact maneuver after operation of almost one year in space.

3. Over 2,000 single axis maneuvers have been performed in a flawless manner.

4. The photography from the program accomplished total coverage of the moon, at a resolution many times better than can be obtained from earth-based telescopes. This represents 14 million square miles, which is equivalent in area to all of North America and Europe. I cannot disassociate this record of accomplishment with the lunar orbiter team whose dedication and professional effort contributed to overfilling the objectives of Lunar Orbiter.

I would now like to amplify Dr. Newell's remarks and recognize some key members of the team who are here today: Mr. James Martin, Assistant Project Manager; Mr. Israel Taback, who is the Spacecraft Manager at

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Langley; Mr. William Boyer, who was the Mission Director for Lunar Orbiter IV and V. I thank you.

NEWELL: Thank you, Cliff. That is a most impressive list that you have just reviewed. As we mentioned at the start, the Surveyor-Lunar Orbiter team had as a prime objective support to Project Apollo. Everyone is interested in just how the data obtained by the Lunar Orbiter will be used in Project Apollo, and to give you some remarks on that subject I would now like to call on General Sam Phillips, Apollo Program Director. General Phillips.

PHILLIPS: Ladies and gentlemen, it is a distinct pleasure for me to be able to participate in this conference on the most successful Lunar Orbiter program. I am reminded that it was only about three years ago that the Apollo system was being designed to land on a model. In other words, we had developed from the best scientific information available at the time, mostly based on earth-based observations, a specification which described what we believed would be the lunar surface that the Apollo landing vehicle would have to be prepared to land on. That model was based on certain assumptions as well as the best combination of scientific judgment of the data available at the time.

There were several uncertainties. It was necessary for us at that time to build into our planning elements of conservatism, elements of caution, insofar as what we might expect as we got on down to a lunar landing.

I remember more than one session in that time period when we would have given a great deal for just one very high resolution stereograph of the lunar surface.

I think it is significant that today the landing vehicle and the equipment that is necessary to carry out a manned landing on the moon are in the latter stages of manufacturing and testing, that the landing mission and the maneuvers that we expect to carry out in landing on the surface are essentially designed, that crews are presently in training, and that most

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significantly they are studying detailed data which has been made available to us from the Lunar Orbiter program as they study the approach paths and the details of the topography on which they will be expected to carry out the final manual maneuvers in setting down the lunar module. At this point we are proceeding with this, proceeding with competence, based on facts and data that tell us what the topographical features of the lunar surface are in all the areas of interest, down to fine resolution.

We are proceeding also with very accurate data on landing site location. There is therefore today much less need for conservatism and less need for planning performance margins which in earlier states of uncertainty were necessary.

The Apollo site selection process is well along. We expect early this coming year to make the final selection of those three or four specific sites on which, on one of which we expect to accomplish the initial lunar landing.

We started about two years ago with 30 candidate sites, based on the best information available at that time from earth-based photography. We have been looking at Apollo for landing sites essentially along the lunar equator, plus or minus five degrees in latitude and plus or minus 45 degrees in longitude. These constraints are placed on the initial lunar landing. In the case of the latitude constraint to insure that we have what we call a free-return trajectory, such that if we choose, as we approach the moon to not enter lunar orbit, the spacecraft will return to earth without added energy. That latitude band is also defined partly by the performance reserves that we will have available to us in the early vehicles.

The longitude boundaries of plus or minus 45 degrees are defined primarily by the need for earth-based tracking and for support in navigation in lunar orbit and for the rendezvous coming up off the lunar surface; and an important requirement to be able to communicate during the landing phase on the lunar surface and during the take-off phase.

The accuracy with which we expect to be able to land Apollo tells us that we are looking for an ellipse of approximately five miles in width or cross-range, and approximately seven -- these are kilometers -- in down range axis. So we are looking for an ellipse of about five kilometers by seven kilometers, which our target point will be in the center of, and with the accuracy of the navigation and the control that we will be using we will be able to land well inside that ellipse.

We are looking also for an approach path some 30 miles in length over which we know in detail the topography in order to be able to plan on and count on the landing radar performance during that approach pass. In the landing maneuver itself we will expect to be at roughly 25,000 feet of altitude above the lunar surface, approaching on a pretty flat tradjectory at about 30 miles from the landing site. It is this last 30 miles that we are interested in from the details of the topography and the radar return which is coupled into the automatic control and landing system.

At this point in time, based primarily on the Orbiter data, the Apollo site selection has been narrowed down to eight candidate sites. These sites are located in Tranquillitatis in the east, in Sinus Medii in the center, and in Procellarum in the west. The reason for the spacing of these flights is that we expect to schedule our mission for a landing on an eastern site on the opening of the monthly launch window.

We expect to be able to hold or to recycle in the event we have difficulties in preparing a vehicle for launch, such that with a 48 or 72 hour interval from the first day, we would retarget to a landing site in the center in Sinus Medii. And again if we have to hold or recycle due to preparation delays, we would expect to recycle on a 48 or 72 hours interval for a landing on the western site.

These eight sites are currently -- the data pertaining to these sites from the Lunar Orbiter are being evaluated and assessed at the present time by teams from the Manned Spacecraft Center, Langley Research Center, supported by various contractors and other organizations, data being reduced with a view to the final site selection to occur shortly after the first of the year, narrowing down to the specific three or four sites, one in each of the eastern, center, and western locations.

In addition to the supporting of the picking of specific landing sites and the development of the high resolution stereography and the approach path, including oblique photography, for the training and preparation of the mission and the target study that needs to go with it on the part of the crews, we have learned a very great deal from Orbiter about the rather unusual lighting conditions and the effect of light reflections from the lunar surface under various angles from the Orbiter photography, and this is helping us a very great deal in planning the details of the approach maneuver and the final landing maneuvers.

We also have data that validates our design and gives us increased confidence in terms of radiation that we can expect and micrometeoroid fluctuations that we can expect, these data also having been obtained from the most successful Oribter.

And very importantly, as you know we are basing our navigation and our guidance very heavily on earth-based tracking, computation and support, and have in the recent Orbiters obtained a great deal of information from both the deep space network at JPL and from the manned spaceflight network in terms of the tracking information, and our people at the Manned Spacecraft Center and at Goddard are currently working over these data to perfect the gravitational model which is essential for both the earth-based and on-board navigation equipment. This will be particularly critical, in gravitational model, and the navigation support to the rendezvous phase where velocity accuracy and position accuracy in the lunar module coming up off the surface to rendezvous with the command and service module will be especially critical.

Today we are proceeding with facts and knowledge in confidence, in the actual preparation of training information and of landing site topography details which the crews are studying. It has been a very great pleasure

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for me to have participated as an active member in the Orbiter-Surveyor utilization planning which in every case has given priority to the attainment of information to support the Apollo lunar landing. It has been eminently successful. It has been a pleasure to be an interested party to that team. My compliments to the Orbiter team. They have certainly established a project success record that all of us will find hard to beat.

Thank you, Dr. Newell.

NEWELL: Thank you, Sam. We all feel considerably more comfortable now to have hard data to work with, rather than the best guesses that had to be used at the start.

The Army Map Service and the Aeronautical Chart and Information Center have been involved in the photographic handling and mapping and charting support to the Lunar Orbiter right from the beginning. I should like now to call on Harold Spradley of ACIC to discuss the photographic coverage provided by the Orbiter missions.

Mr. Spradley.

SPRADLEY: Thank you, Dr. Newell.

The first three Orbiter missions were directed toward specific information regarding specific target areas that were of prime interest to the Apollo site candidate selection and validation goals. With Orbiters IV and V it became possible to extend the program scope to more general type coverage, providing information over widespread sites and extending the information rate about the surface of the Moon as greatly as possible within the remaining vehicles in the Orbiter program.

The greatest step toward achieving this information expansion was in the use of polar orbits, which gave the gained access for near-vertical photography over any areas on the surface of the Moon. The photography that you will be examining in great detail from Lunar Orbiter IV represents a truly fantastic combination of spacecraft maneuvers and planning to provide detailed high resolution coverage over the entire earth side hemisphere of the Moon, with vertical photography. The photography was taken with the format of the high resolution camera oriented longitudinally along the orbit track, permitting overlap of both the sides and the ends of consecutive frames that give cartographers the ability to join widespread areas of the Moon in networks of triangulation and in continuous mapping-type coverage of the lunar surface.

The outstanding feature of this coverage is not only that there is represented a gain in information level of features that could not be observed from earth, but the earth-based coverage of the Moon hemisphere in this direction was restricted by the synchronous orbit and rotation rates of the Moon so that limb areas could be only observed with a great degree of foreshortening and a large amount of the contribution of the Lunar Orbiter frontside coverage is that it offers vertical perspective, seeing down into craters that had been only viewed at a near-tangential angle of perspective, and seeing these areas with a continuum of information covering the entire frontside of the Moon.

The actual information level in this photography is better than a factor of ten in linear resolution, or more than a factor of 100 in total information rate above the best earth-based photographs even of the central areas of the Moon.

In terms of really expanding the horizons, the amount of information we know about the Moon, the lunar farside coverage is by far the greatest general coverage contribution that has come from the Lunar Orbiter program.

(Slide)

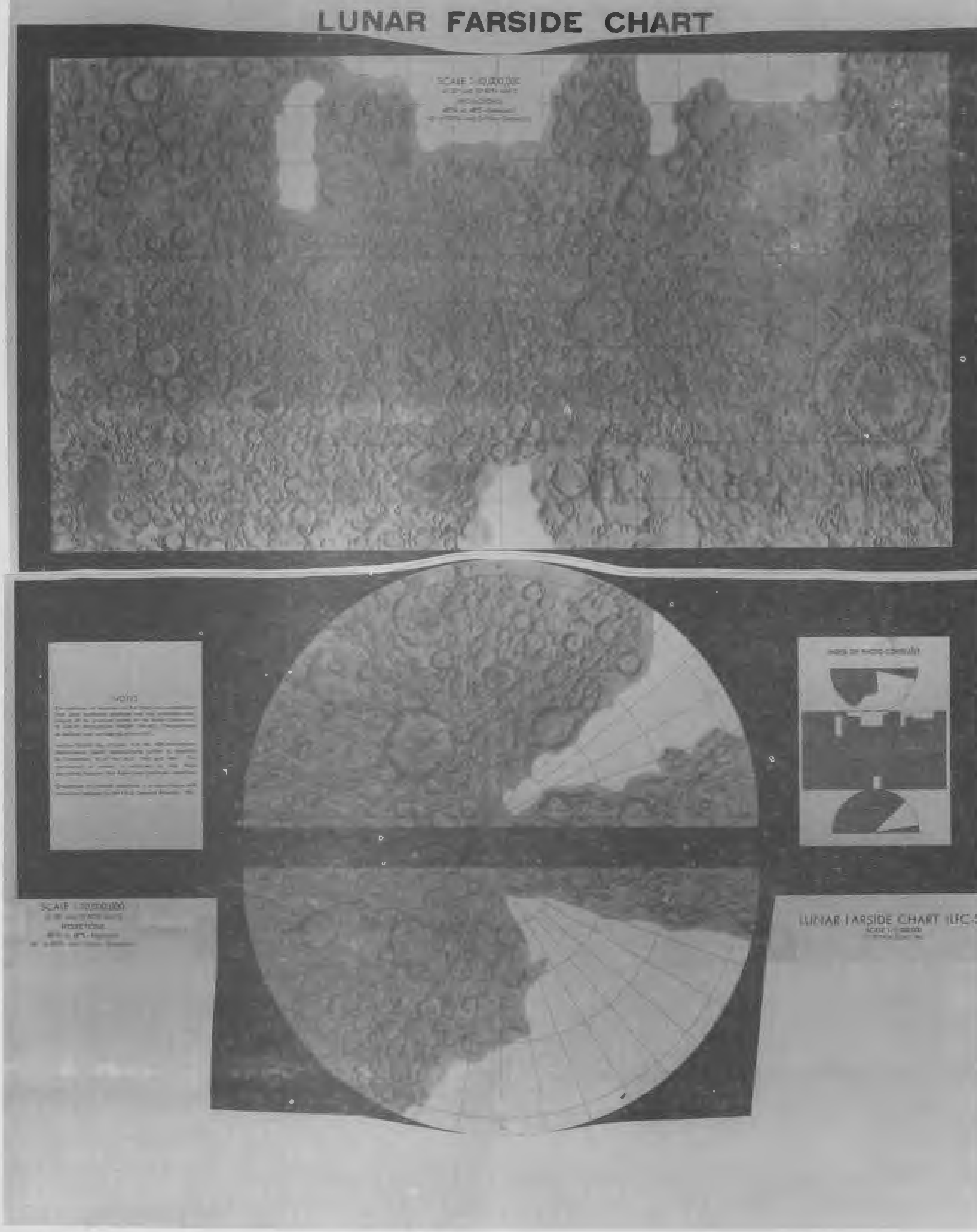
This represents our first attempt in putting photographic material together and forming a map of the far hemisphere of the Moon. This was performed using information from Lunar Orbiters I, II, III, and IV, and it was prepared in August of this year.

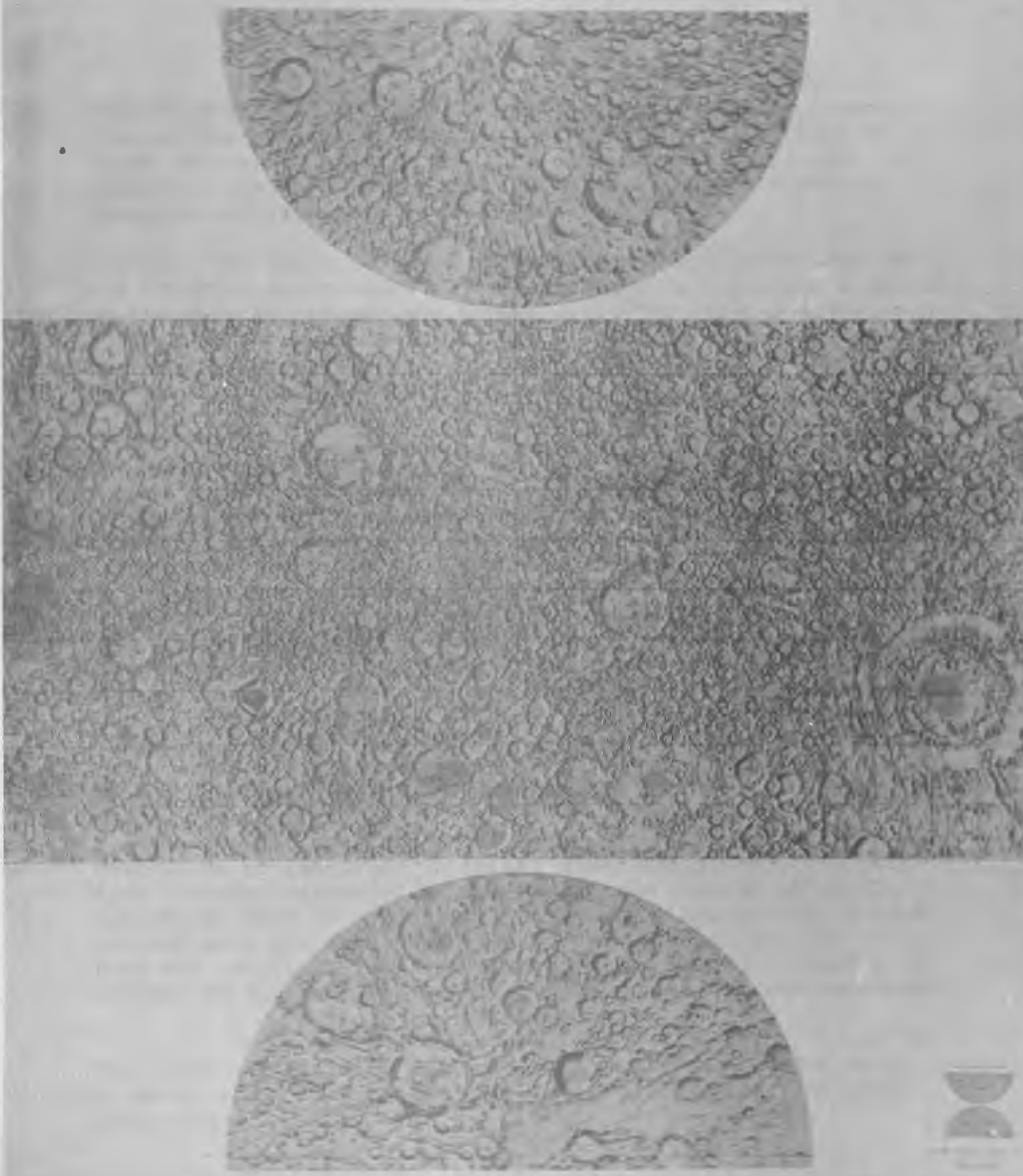
The information band in this area contains a much lower level of resolution of the surface. It was filled in from using the ZOND III material of the Soviet Union. But the outstanding feature that everyone notices are the gaps that remained in this coverage that had not been filled in from the earlier Orbiter missions. These were primarily in the Northern Hemisphere, the Polar area, and in the band across the top of this equatorial projection.

With the Lunar Orbiter V mission came the objective of filling in the remaining gaps and bringing this information level up to a more complete status.

May I have the slides, please.

(Slide)


LUNAR FARSIDE CHART
LUNAR FARSIDE CHART (LFC-2



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This is the new picture. In the terminology of Procter & Gamble, the Moon is now 99.44 percent pure coverage. This is the completed lunar farside chart, made possible by Lunar Orbiter V coverage that not only filled in the gaps but filled in the areas where the ZOND material did not permit adequate resolution of surface features.

At the end of the presentation you will be able to see enlarged photographs of this new farside chart and a mosaic of the farside photographs themselves. The chart was prepared by the Air Force Aeronautical Chart and Information Center. The mosaic prepared, using rectifications of the photography, by the Lunar and Planetary Laboratory, University of Arizona, with mosaicing and compilation by the Army Map Service, Corps of Engineers.

The significant level of data can be appreciated if one recognizes that the worst coverage on the lunar far hemisphere is as good as our level of information about the earth-side hemisphere prior to spacecraft photography. So the information rate about this additional 7 million square miles of lunar surface has been complete in that it has filled in what it took hundreds of years of telescope observation on the earth-side hemisphere, largely through the Lunar Orbiter IV and V missions.

The projections that are used here, the polar areas, are contained on polar stereographic projections. You see before you a part of what is called the cartographers nightmare, that is, the attempt to place a three-dimensional body on a two-dimensional sheet of paper. The polar projections are such that lines of longitude intersect equal angles from the pole with circular portrayal of latitude lines down to 48°. The equatorial belt is contained in a Mercator projection, including not only the far hemisphere of the Moon but information from 80° longitude from the earth's side, you have about a 10° overlap at each end of the chart on the earth's side hemisphere.

The scale of this chart, which will be contained in the press kit, is such that detail is at equal scaling along the match lines between the Mercator projection and the polar projections.

May I have the lights.

If you are artistically inclined or handy with scissors, this will enable the fit of the two projections at the 48 parallel, and give you a little more appreciation of the far hemisphere of the Moon as it is now complete, and can be projected and fitted on to the cylindrical cartographic projection and the polar projections in these regions.

If you would like to later come and examine this, and examine the mosaics and the large scale charts at the back of the room, these will be there at the time you are also able to walk around on the front side.

QUESTION: Do you know if the globe of tne Moon is now being prepared by anybody?

SPRADLEY: I think so.

PHILLIPS: It is not being prepared. We are making plans to try to provide a globe of the Moon.

NEWELL: Thank you, Mr. Spradley.

I have seen a number of cartoons indicating that the other side of the Moon might be a hollow cup or so. But this is the first time it has been suggested it might be a cylinder.

(Laughter)

The U. S. Geological Survey, as you know, has been thoroughly involved in both the Surveyor and Lunar Orbiter programs. I would like now to call on Mr. Harold Masursky of the USGS to discuss some of the preliminary interpretations from the Lunar Orbiter photography.

#4 Mr. Masursky.

MASURSKY: May I have the first slide, please.

(Slide)

It was about one hundred years ago that scientists of the scientific community of that time joined with the Army Engineers and Cavalry in exploring along the 40th parallel between the Mississippi River and the West Coast to determine what natural resources lay in this large area of new country.

Growing out of that survey came a number of government institutions to utilize those natural resources. The Bureau of Reclamation, the Forest Service, the Indian Service, the Geological Survey, all had their growth from this early survey. We are delighted in the Geological Survey to join with the Department of Defense and NASA in a new exploratory program of our sister planet.

I am going to present some very preliminary conclusions as a result of the interpretations of photographs from the Lunar Orbiter. This will be a very mixed bag of tricks. Some of the ideas are very old ones that we have worked on assiduously for many years. Others of them are as young as a week old, when we first got the new mosaics and were able to plan or to plot on this Moon-wide coverage some new features and arrive at some very preliminary and new conclusions.

The ideas I will present to you were put together by a large number of people, some of whom I will mention as I go along. And of this group are ideas contributed by some 35 geologists. Of course I am going to interpret their results for you. I don't believe any of them are here to object, so I can speak freely.

What I am going to do is cover a few of the sites from the missions 1, 2 and 3, the coverage which is shown on the index map, and in the next map, are the sites that were covered on mission 5.

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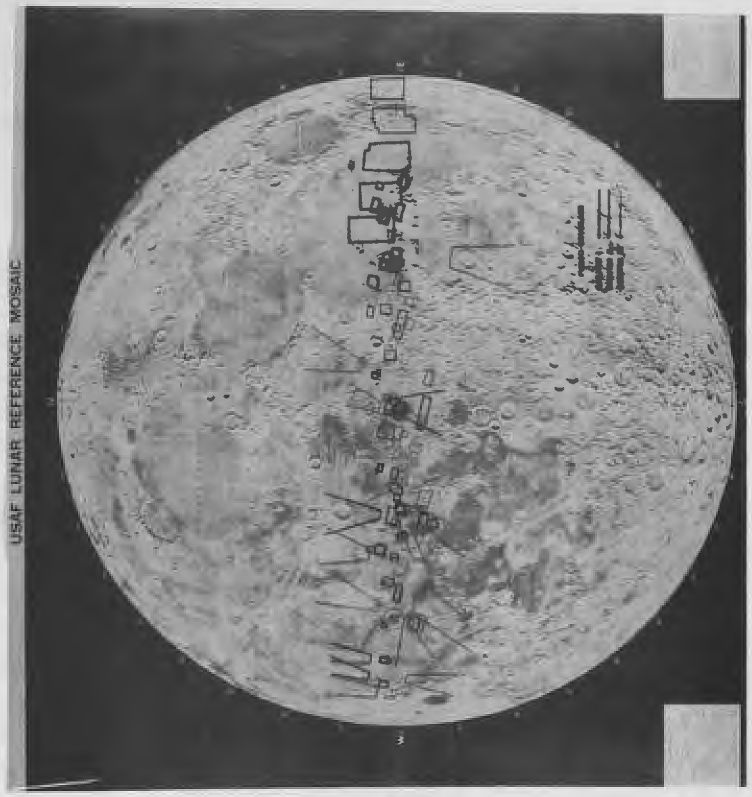
I am going to start by showing a couple of photographs from earth-based experiments. We tried to stay within one step


USAF LUNAR REFERENCE MOSAIC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of interpretations of Orbiter photographs by examining terrestrial features that are as similar as possible to the features that we see on the Moon, and many of these we have succeeded in duplicating in the laboratory, working cooperatively with a number of other organizations.

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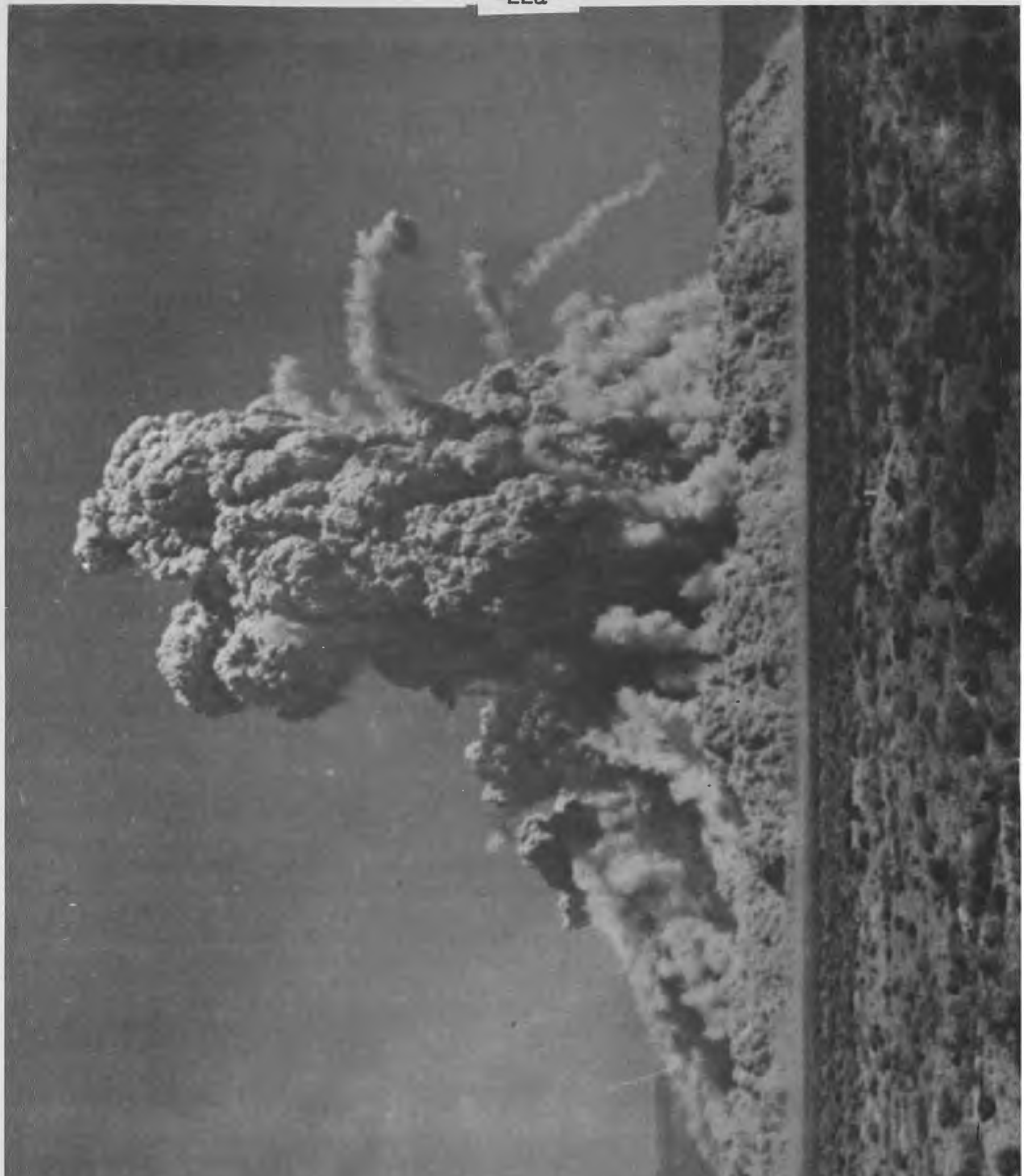
In the first slide is a photograph of the Sedan nuclear event. This was a detonation of a nuclear device buried at the Nevada test site at a depth of 600 feet. This is most intriguing to look at because from the detonation of the device a compressional shockwave expands spherically, followed by a relaxation wave following closely behind it, and this represents very closely the later events in a hypervelocity impact. That is, the projectile enters, and at its farthest point of travel induces the generation of a spherical shockwave in a very similar fashion.

We can see a number of most interesting things here because we can, in high speed films, watch the development of the various features here, and since we could examine the ground shortly thereafter, we could see the very subtle kinds of things that in the mapping we have done on natural impact craters have been long since removed by erosion.

We can see a couple of things that have happened here that we think are most important in the formation of lunar surface feature.

When the device is detonated, a large dome arises which then breaks and the flaps lie over and the rocks are then upside down along the edge of the crater. Then jets of material break out through this and travel. Here they are being ablated in the atmosphere. On the Moon this erosion would not take place. These projectiles land out and make a line of secondary craters.

At the base you can see the fuzzy line. That is the air shockwave, and following this close behind it is the boiling turbulence that represents the air elutriation of fine grain debris. This hides the real process that is taking place on the ground. That is, there is a flow outward along the surface of particulate material that is thrown up and flows down and out.



(Slide)

This is a vertical aerial photograph of the Sedan crater. It is 1300 feet in diameter and 300 feet deep. You can see the hummocky deposits made by the overturned flap and the deposition in this hummocky fashion of this instantaneously ejected material. This was the first time we could see the development of rays, and these were formed by the jets of material that came out, and the clots of alluvium fall along the lines in this fashion, forming a ray and a secondary line of craters. It is even possible in the movies to watch the order formation of these. They land here, then here, and here. This is nicely confirmed in lunar pictures. We can see the successively overlapping secondary craters and see that apparently an exactly similar formation takes place on the Moon.

(Slide)

That photograph was taken several weeks after the event, and even in that very short length of time the wind had redistributed these materials so that we had lost some of the materials that are visible here. This is a vertical aerial photograph taken a few minutes after the event. You can see the cloud that has drifted downwind away from the crater. But displayed here is something we had not seen up until this time. These are dune shapes that circle all the way around the crater.

These are the deposits made by the base surge moving outward and flowing along the ground. Some very minor irregularities on the ground cause the deposition of this fine grain material flowing along the ground.

(Slide)

This shows Taal Volcano in the Philippine Islands. It erupted with great violence two years ago and James Moore, of the Geological Survey, was sent out to look at the results of this eruption and predict what might happen in the future. Incidentally, this volcano has become active again and it is in eruption at the present time.

The interesting thing that happened here, there was a great jet of material that was thrown far into the atmosphere, and then flowed down and out in all directions. There were villages located around the volcano, and these were all destroyed. A number of people were killed and a great many animals were

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killed. But the thing that was new about this, for the first time we appreciated that the destruction was caused not by material ejected in ballistic trajectories or thrown into the air and fall-out as an aerosol subsequently, but rather material flowed out around the ground and moved outward at velocities of about a hundred miles per hour. It was these hurricane force winds, accompanied by the material moving along the ground, that caused the destruction and the formation here of the dunes around the crater in exactly a similar fashion.

In other words both in impact events and in volcanic events, this deposition of material by the base surge is a very important concept and one that has just emerged in the last two years.

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Upon arriving at this idea we looked at our entire file of lunar photographs to see whether we could see signs of these types of deposits on the earth-based photography and we were not successful in finding any example of it. So we were delighted to get this photograph from Lunar Orbiter III of Moesting C, which is a small crater right in the middle of the Moon. And this was our first example of this kind of deposition.

We see here a very, very fresh young impact crater. It is one of the brightest spots on the Moon. It is a very tiny crater, only 3-1/2 kilometers in diameter. But it has both this bright and visual albedo, and it is one of the hottest spots on the Moon in the infrared investigations conducted by Saari and Shorthill, of Boeing Research Laboratory. It was no surprise to us because of its brightness and infrared, that as we looked at it here were the very fresh features and here a beautiful display of the dune forms around this small crater as well as the secondary crater linear -- or the secondary craters lined up linearly and in loops around the crater. This was our first confirmation by Lunar Orbiter of this very fundamental lunar process.

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This is the crater Taruntius, which is on the east

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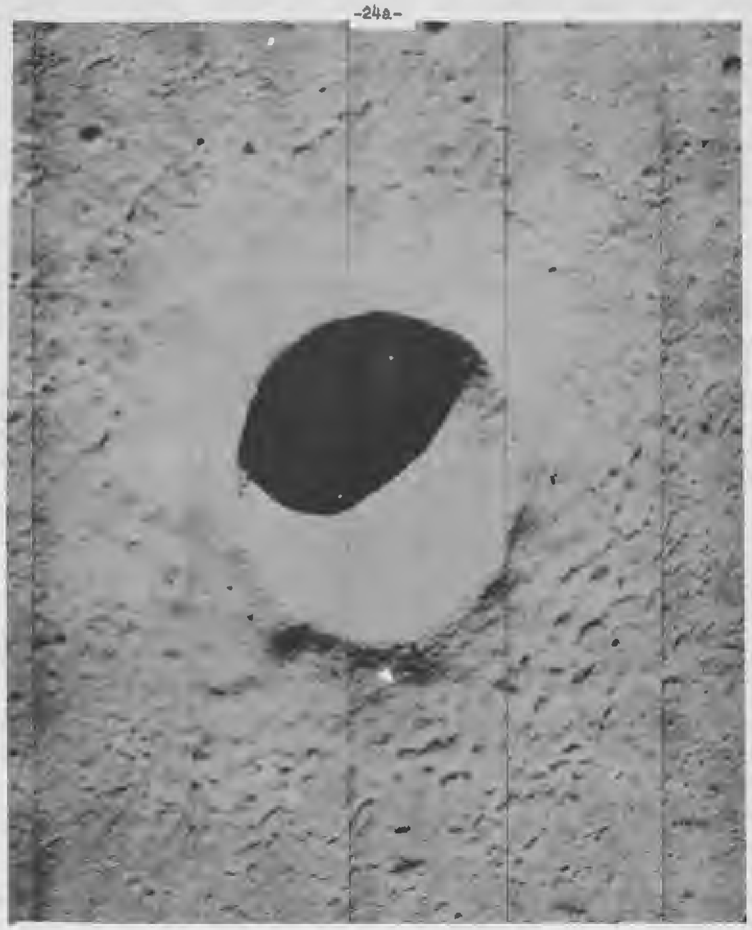

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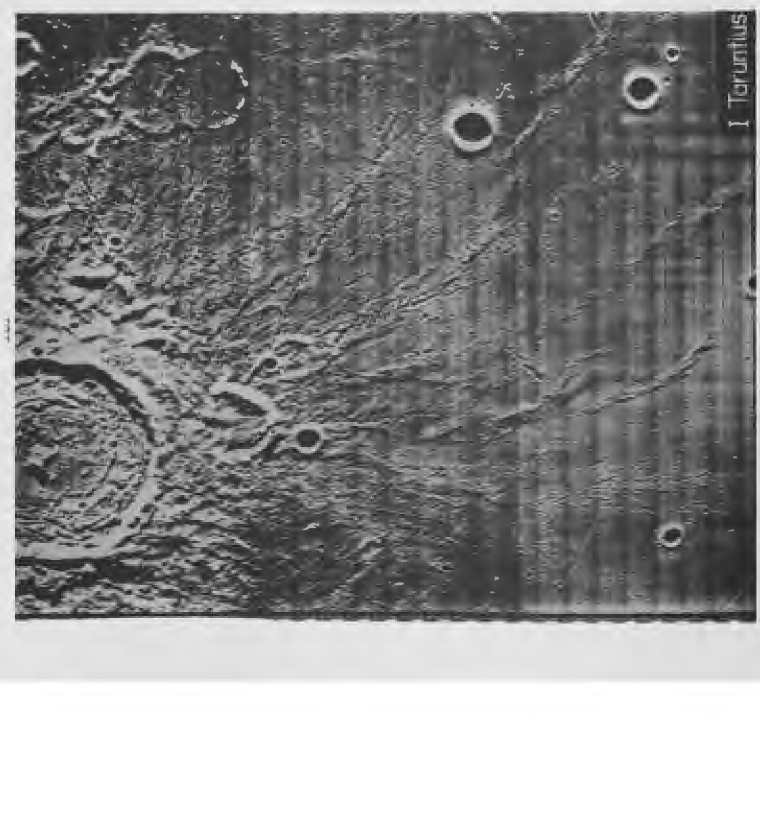

limb of the Moon, and this is a much larger feature, about 40 miles in diameter. Don Wilhelms, of our group, had studied this crater telescopically for three years and tried to see on many, many nights at Kitt Peak and at Lick Observatory whether or not there was a field of secondary craters. The idea was, was this an old impact crater, was this a volcanic feature. We couldn't really see the detail necessary. In this magnificent photograph from Lunar Orbiter I we instantaneously resolved the problem.

Here are the hummocky deposits, the linear rays of secondary craters, dune-like things close to the crater, and here also are radial fractures along which there are many craters aligned. So these are secondarily induced volcanics along radial fractures.

We got another very nice piece of information from this because as well as the secondary crater field around Taruntius, and Taruntius is a fairly old young crater, that is, the rays have gotten quite dim and it looks like it is one of the oldest of our Copernicus age craters. In addition to that here is another line or field of secondary craters. We can project these in this direction and find they are related to the crater Theophilus. Here we can clearly see this group of secondaries lies on top of the secondary craters from Taruntius.

Finally, along this border we can see another group of even larger, fresher secondary pressure impact craters and we can trace these down to the crater Langrenus in this direction. So in this photograph we can see that the oldest ones belong to Taruntius, the next younger are the Theophilus secondaries, and the youngest of all are Langrenus secondaries. We were most happy about this because in our preliminary geologic maps this was the age sequence we had arrived at from the relative brightnesses. That is the Langrenus is the brightest, youngest looking of the sequence of craters, then Theophilus and finally Taruntius.

Here in one photograph we got some very fundamental information, both of our processes and relative age of the lunar features.

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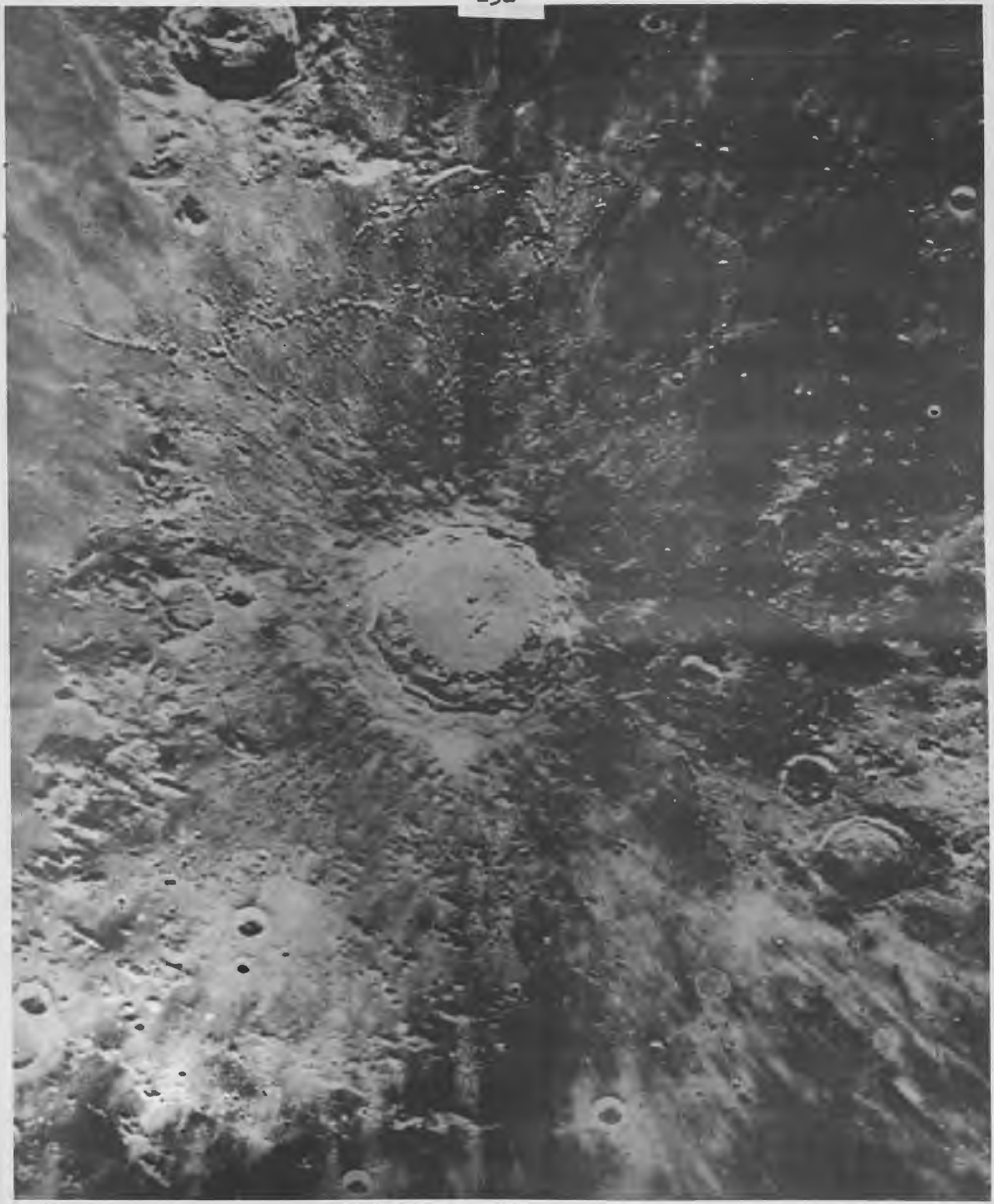

This is an earth-based photograph of the crater Copernicus, taken at Wilson Palomar, at the hundred inch telescope. And this and the Lick Observatory photographs and visual telescopic study resulted in the map on the next slide, prepared by Jack Schmitt, now a scientist-astronaut, and at that time with our organization, and Newell, Trask, and Gene Shoemaker, and a great many other of our group. This is a recently published map that is largely based on the earth-based observations. The question is what can we add to this story from the recent Lunar Orbiter photographs.

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This is a photograph from Lunar Orbiter V that shows the crater in much better detail than we had ever been able to see it before. One thing is immediately apparent. If this crater is to be the site of a manned landing, the obvious place is this much smoother area here.

The second thing is we can see in great detail, the great land slides that have come down from the rim of the crater. The true crater, in the terminology of the people working with experimental craters, the rim was about here, and it retreated back by successive collapse and down sliding and it is almost a third larger than it was at the instant of formation.

We can see a great many details in the central peaks, in the floor and the walls. I will show you some examples of this.

(Slide)

This is the lovely oblique photograph from Lunar Orbiter Mission II. We were able to add a great deal to our knowledge of the crater from this photograph.

First we can see ledges of rock exposed in the crater walls. The crater is almost three miles deep. So here is a chance to look at not only the present surface of the Moon but by examining the successive layers of rock to lookat events in the past, and we can decide what happened for a great length of time back into lunar history by examination of this three miles of strata. This is like examining the

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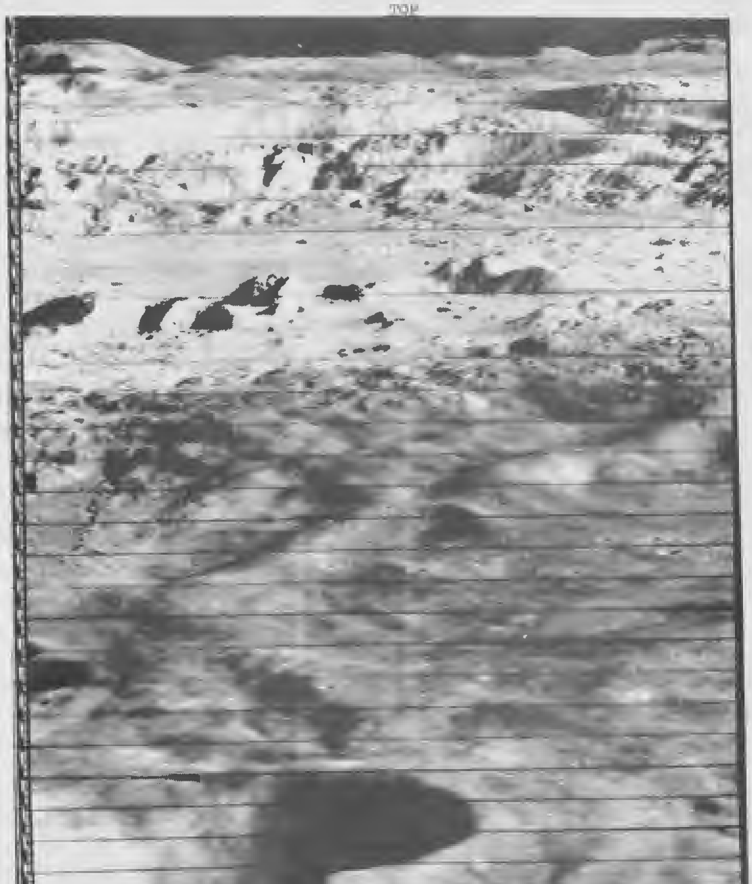

walls of Grand Canyon so we can go back into the very early days of earth history.

A second feature visible here are the ledges exposed in the central peaks. We have completed studies at the Flynn Creek structure in Tennessee, at Sierra Madera in Texas, at Gosses Bluff in Central Australia, and in various experimental impact craters, and I will show you one of these subsequently, that indicate that in the impact process the central peaks rebound immediately after the impact and bring up materials from about one-tenth the crater diameter.

Since Copernicus is 60 miles in diameter, we anticipate that these rocks represent things that have been brought up from about a six mile depth. So we can see the first three miles in the walls of the crater, and hopefully we can see down to a six mile depth in the central peak.

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This is an Orbiter V photograph of the floor of Copernicus. This was very useful for two reasons. First, we had seen on this side of the central peak the ledges exposed in the oblique. But our best manned landing site is in the northwest part of the crater. The question was, if we landed here we would be able to see the rock ledges on the north side of the peak. Lo and behold, here they are beautifully exposed. So we know if we make a landing in this area we will have close at hand the outcropping ledges of these very deep layers from the interior of the Moon.

The second thing is the bewildering array of textures visible on the floor. There are a variety of cracks, things that look like very viscous flow lines, there are little domes with summit craters. These have all the appearance of very viscous lavas.

I will show you another sequence from another one of the craters photographed in Mission V, and this is Tycho, located here.

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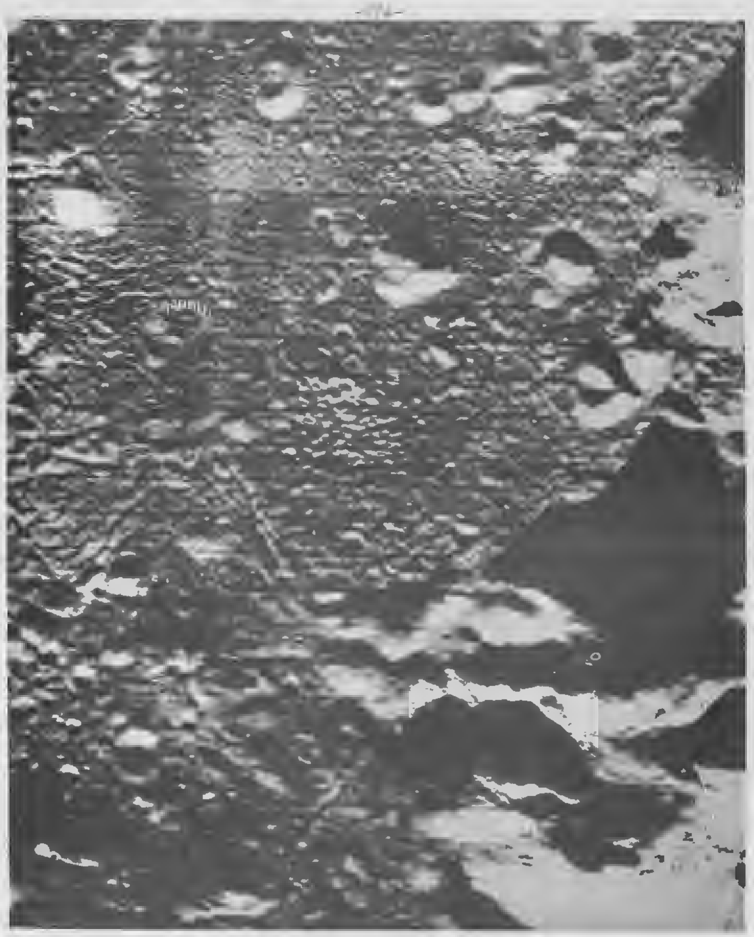
This is Tycho. And it is even younger and fresher



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than Copernicus. In the next slide we will look at this part of the crater floor.

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Copernicus, although it is young, has had a considerable amount of erosion and later deposition that concealed some of the details of the floor. Here they are shown in all their pristine glory. This is what it looks like. Here you can see the lovely flow lines of what looked exactly like terrestrial lava flows. Here is an onion skin structure. You can see the upper layers that have flowed off in a great many places. These look like viscous rhyolite domes and for our interpretation of this, we go to our nearest neighbor to the north.

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Here a number of organizations have investigated large impact craters that are liberally scattered all over Canada. We don't think Canada was particularly host to incoming objects, it is just that they are aware of the problem, and C. S. Bealls, who was head of the Dominion Observatory for many years, started during World War II to look at aerial photographs of the entire country. They have discovered a great many impact structures and are finding them at a rate of about two a year. Two that are pertinent to our discussion here are Clear Water Lake, two adjacent lakes, in Northern Quebec, about 20 miles in diameter, and an even prettier example, Lake Manicougan, and a circle of lakes, Manicougan on the east and Mushalagan on the west, that represent an enormous impact structure that is 40 miles in diameter.

In the next slide the Ring Lake lies here, and here we are looking at the central cliff. There is a great plateau that looks as though it is capped by 200 feet of volcanic rocks. If you look at the tops of these cliffs, they look for all the world like conventional volcanics.

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But if you look at the very base of the cliff in the next slide, you can see an exposure. This is a geologic hammer and this is 12 inches. You can see here the fragments

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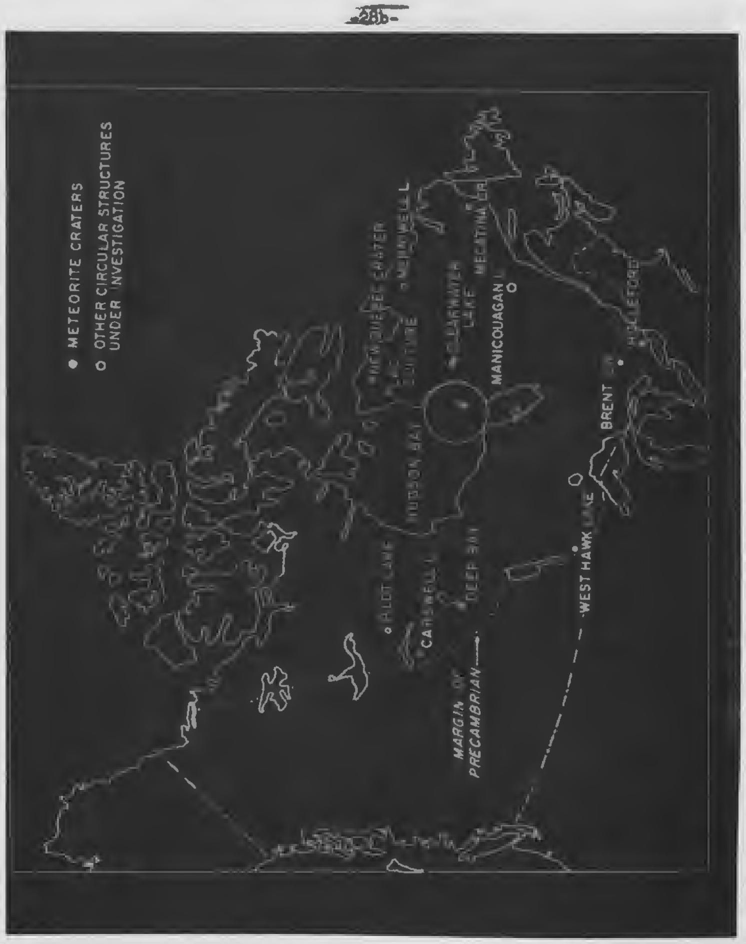
METEORITE CRATERS
OTHER CIRCULAR STRUCTURES UNDER INVESTIGATION
NEW QUEBEC CRATER
MERRIWELL L
CLEARWATER LAKE
MECATINA CR.
MANICOUAGAN L.
HUDSON BAY
HOLLEFORD
BRENT
PILOT LAKE
CARSWELL L.
DEEP BAY
WEST HAWK LAKE
MARGIN OF PRECAMBRIAN

of material that were thrown up into the air and were heated to a very high temperature and partly melted, so that these layers of glass are exposed. This has all the characteristics of shock melted materials. It looks as though this material was thrown into the air, fell back to earth and flowed together because it was still hot. The upper part of the fragmented layer, which was almost 300 feet thick, was so warm that it was secondarily reactivated and actually flowed as conventional lava flows. The rocks themselves don't realize they didn't come out of a volcano. They know they are hot, so they recrystallize and look for all the world like conventional volcanic rocks. Except if you look at the critical area near the base you can see nicely displayed the shock metamorphic effects.

We think that the central filling of the large impact structures on the Moon are made of this kind of shock melted materials.

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Another area of a long standing controversy was just north of the crater there are secondary craters, but there was one line that looked like a graben, along which there were a number of volcanic craters. When Shoemaker first studied this about eight years ago he seesawed back and forth as to whether to call them volcanic or impact, and the controversy raged right up to the time that we went to press on the map.

This photograph from Lunar Orbiter V resolves the question instantly.

Here are the secondary craters, and you can see as each clump lands, it scatters out a little tail of material that is ejected away from the crater. Here is our questionable line. You can see that each one of them is a little secondary impact crater with its accompanying little plume of material that is thrown out away from the crater. So in fact this is a line of secondary craters. And here is the indubitable evidence from the Orbiter photograph.

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A third of our large impact craters is Aristarchus,

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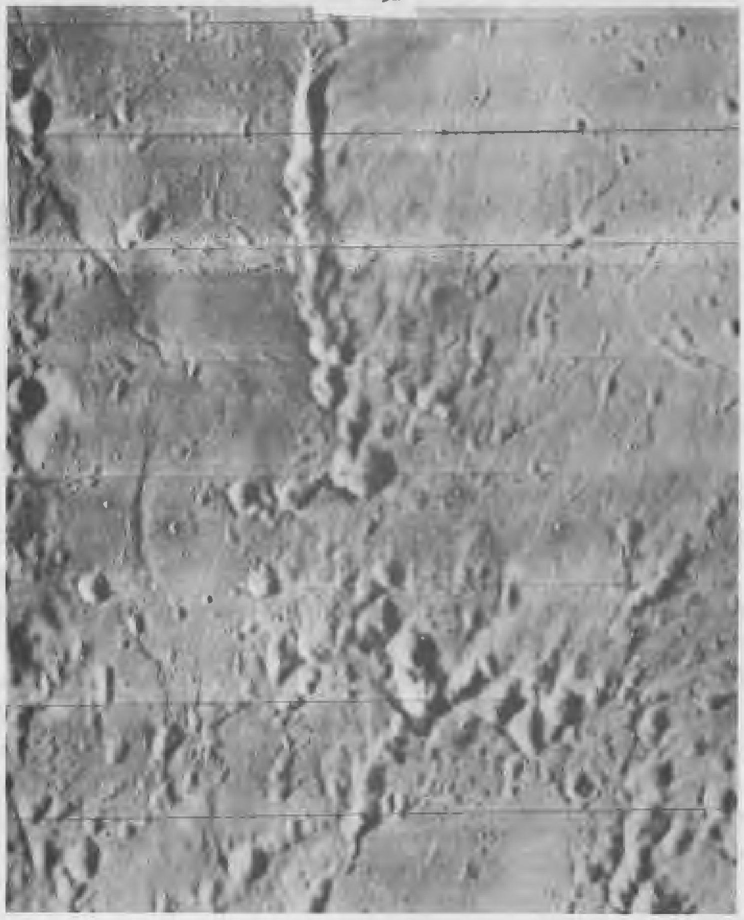

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and it shows even better examples of a couple of features that we thought theoretically could be seen but we had not actually seen them.

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There was an analysis by the Navy of the Bikini atom bomb test where they said in addition to the flap turning up and over when the shockwave made the big dome, that low angle continued travel of material would take place after the flap was turned over. And in this crater we see for the first time one that is fresh enough, so that in the next slide we can see the wall of the crater and material which kept traveling up the wall after the flap turned over. This material is the layers of rock here, upside down, and continued ejection of material is shown by the lines that come up the wall of the crater and erode channels on the outside. So in the late phases of the evisceration of the crater by the rarefaction wave, this continued movement of material up and out forms these flow lines on the surface of the present crater.

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In the next slide I have shifted ground on you. This is a scene in the Uintas that cross between Utah and Wyoming. Here is a high cliff. There is great debris flow which takes place at the foot of the cliff. You can see the low banked areas that are shaped in this fashion piling up at the foot of the cliff. We see this kind of feature in all the lunar positive features. Wherever there is a positive feature, the material migrates down the slopes and forms these patterns.

Even more interesting are the little runs that are made by fine grain material and boulders that travel down the slope and form little natural levees of material piling up on the sides. Here is a big clot of material at the bottom of this avalanche slope.

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This is a photograph of the wall of Aristarchus. Here is a very similar avalanche trail which is natural levees and a little pile of boulders at the foot of this trench. Here

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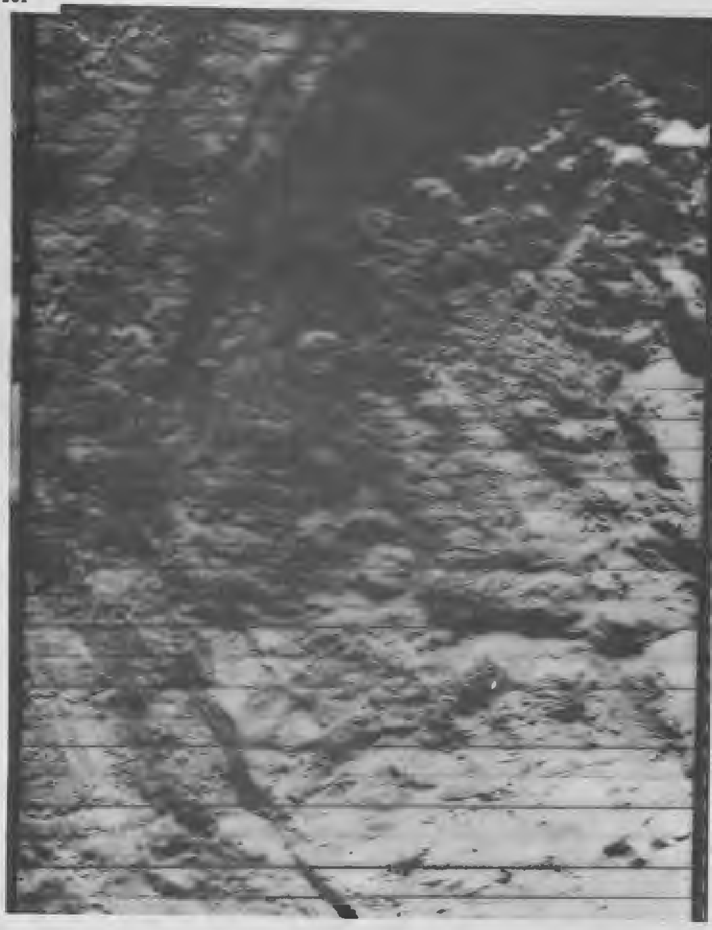

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again it demonstrates the gravitational movement, down slope of materials. And here is a very, very young avalanche indeed.

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The Canadians have also obliged us by running a number of explosive experiments. These are done at the Suffield experiment station in Alberta. Here they have managed for the first time to correctly adjust the velocity of their shockwave. This was made by 500 tons of TNT, laid out in a hemispherical array and exploded over water saturated sediments. The combination of things worked out just right so that they caused not only a crater with its hummocky deposits and its dune-like material made by the flowage of the base surge and the secondary craters and the radial arrays of faults, but in addition they managed to construct for us some beautiful circular fractures around the central crater, and they managed to make central peaks for us for the first time. So they duplicated in this experiment many of the features that we see in the very, very large impact craters.

(Slide)

This is one of the radial cracks, and because the ground water is activated it flows up and out, carrying sand with it, and made a line of mud volcanos along this radial fracture. These look like many of the radial fractures with accompanying volcanic action that I showed you first in Taruntius, and which you can see also in the next slide, which is our friend Mare Orientale.

(Slide)

This is an equivalent structure on the Moon's surface, and by common consent it is the most spectacular photographed in the Lunar Orbiter series.

This crater lies on the west limb of the Moon and in astronomical convention this is the east side, so this is the Sea of the East. Don't let it worry you that it lies on the west limb of the Moon.

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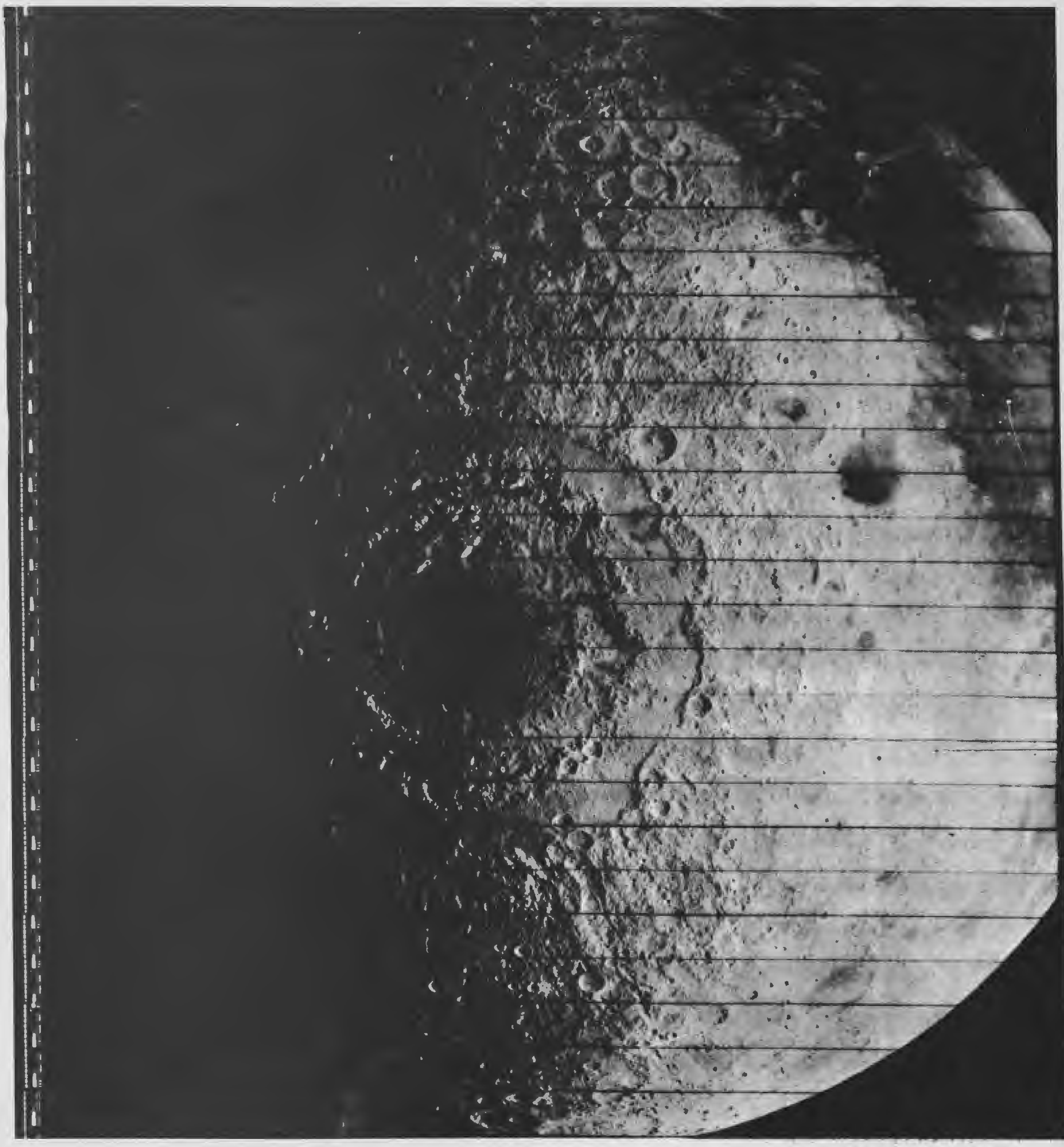

Not only is this a spectacular picture but this was a source of great comfort to us because our interpretations of the front side of the Moon, we studied most intensively the Imbrium Basin here. This is almost exactly the same size as Mare Orientale. But this basin is somewhat older, and we interpreted the deposits around that basin, but they had been enough modified by this down slope gravitational movement of material, by the micrometeorite impact that gradually smooths over all the features, so that a lot of the delicate textures that we looked for in making such interpretations have disappeared in the Imbrium Basin. We called this an impact feature but always said it with a questioning note.

Looking at Orientale, it is a much younger feature. It shows all of the delicate features that we could not see in the older Imbrium Basin.

The other thing, we also said in the Imbrium Basin the basin formed first and then there were craters formed on the floor of the basin and it was later flooded by mare material. The same kind of sequence of events have taken place here, on this since this is younger the basin filling has not proceeded nearly as far so we can still see the detailed structure of the basin floor, and it is only flooded here in the middle and here at the foot of the Rook Mountains and here at the foot of the Cordillera Mountains.

These are very large mountains, over 20,000 feet high. This is an enormous mountain range that stands higher than Himalaya, above the plains of northern India. We can see here the great array of base surge deposits that I will show you, and a great field of secondary craters that can be seen better on the Mission V photography of the back side. So we see the base surge deposits and the great field of secondary craters. So we are prepared to say unequivocally that Mare Orientale is a large impact feature, and by extension, the big basins on the front side are also modified impact features.

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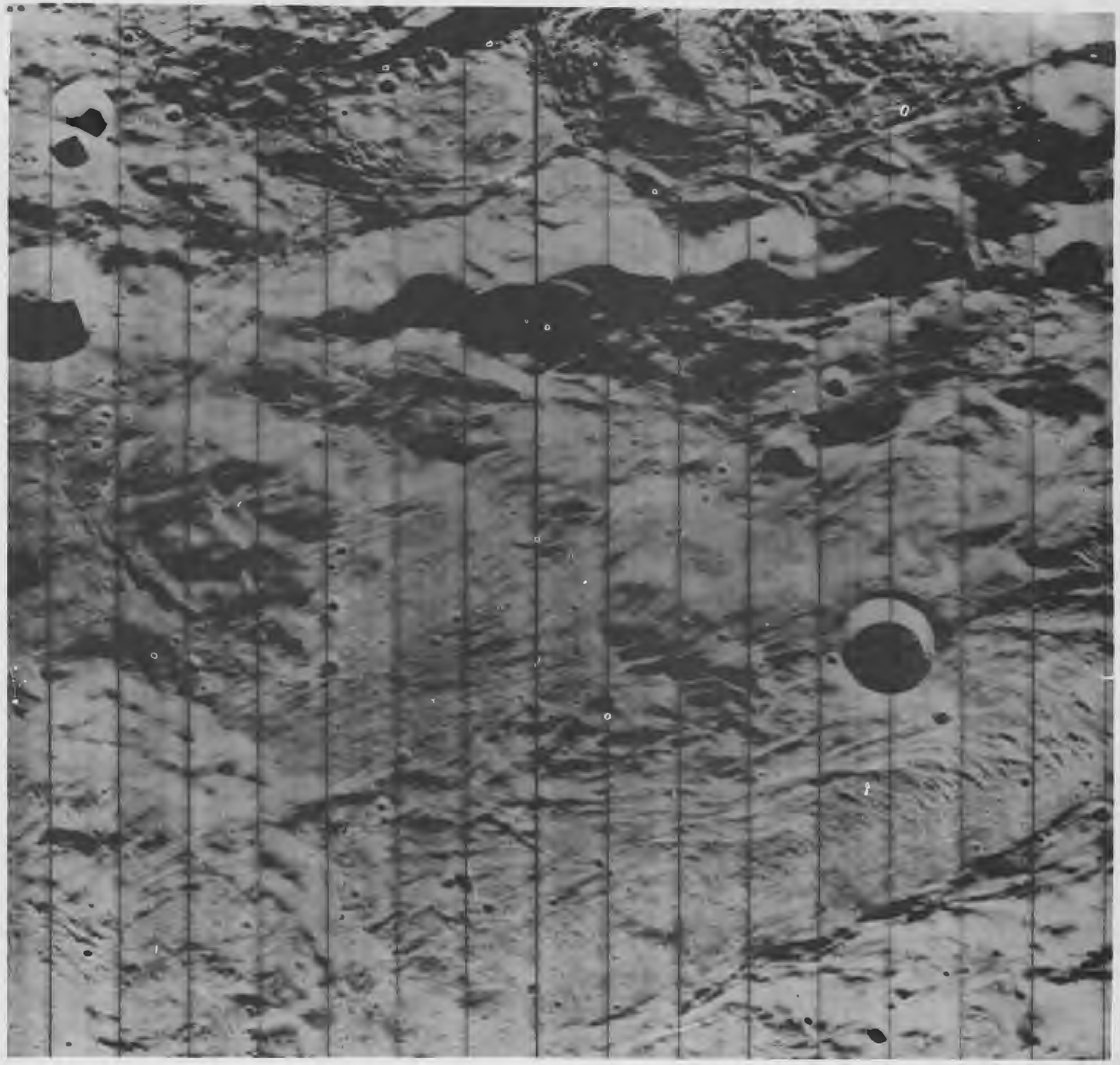
This is a close-up photography of the base surge



deposits lying southeast of the Mare Orientale Basin. Here you see the lineated deposits, and here a preexisting valley down which material has flowed. We can see the flow lines that look very much like glacier flow lines.

We say here that the influence of the topography shows that this material was not emplaced ballistically, but rather came out in this base surge and flowed along the surface. In summary, for the impact type features, I think we can say we understand much of the mechanics from terrestrial experiments, from terrestrial mapping, and from seeing exactly analogous features here on the Moon. That is the large basin shape, the hummocky deposits directly adjacent to the crater, the great field of base surge deposits that have flowed along the surface, and finally the great ray systems and fields of secondary craters that lie around the craters.

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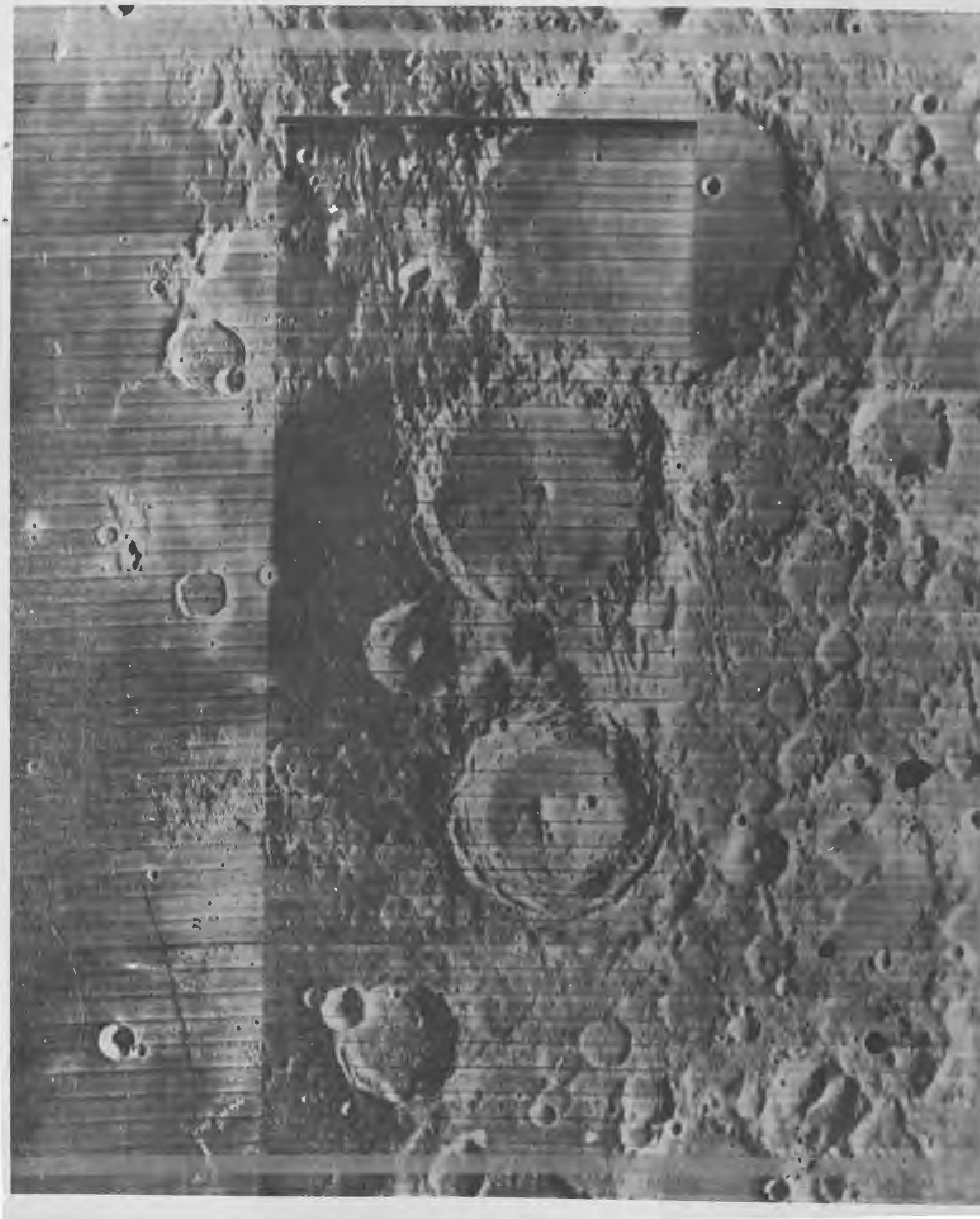
In the next slide we turn to another type of feature, and these are great fault systems or, a better word, tectonic system. This is in the central part of the Moon. Here is the crater Ptolemaus and here is Alphonsus. They lie here in the center of the Moon. The interesting thing here is that we have a number of fault systems, and by examination of the deposits and their relationship to the fault we can show a history. Ptolemaus is a very old crater and it has a rectangular form. By examination of earth-based craters we can see that the fractures influence the crater shape. So that these fractures were there at the time that the crater Ptolemaus was made. Then the Imbrium Basin was formed and this whole area was both fractured by what is called Imbrium sculpture by Gilbert in 1893. The whole country is covered by this array of radial fractures that go out from the Imbrium Basin in all directions. And then the later base surge deposits came through and covered up this area with what we call the Fra Mauro formation. And later the crater was filled by upland basin filling material that we are now calling the Cayley formation, and then the Cayley formation was broken by this fracture which is the same fracture along which the great volcanic deposits down the center of the crater Alphonsus were formed. These cut the second generation of deposits.



Finally the mare material was emplaced and it, Mare Nubium comes right up against the highland here. And finally along the same line, this is the great fault, the straight wall that is over a thousand feet high, and it cuts the youngest mare deposits.

So we have a sequence of four episodes of great faults running out radially from the Imbrium Basin, and what we say is that these faults were here before the Imbrium Basin formed, and that in this area, although they are radially arrayed, here they coincide with the old fault direction so they are the most prominently displayed of any fracture system on the Moon.

But this fracture system moved before the Imbrium Basin was formed by impact, and moved at least on three occasions afterward, the latest time a very, very young fault that cuts these deposits.

So we can say from an examination of this area and many other areas that we can see a tectonic history of the Moon that has been active in many separate episodes, and these cut deposits of many different ages. This again is exactly like similar features on the earth where we can examine ancient faults in the Western United States that have moved as far back in geologic history as we can go, and that are still moving at the present time.

Now to go on to volcanic features in the next slide.

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This is the oblique photograph of the Marius Hills area that lie here. And these have been mapped from earth-based observations. This is the crater Marius and this is the volcanic field that Jack McCauley of our group mapped from the earth-based observations. This photograph shows very beautifully the different kinds of volcanic domes that he had mapped in this area. He said there were two kinds of features: Broad low domes, and you can see these, and sharp peak domes, and you can see these here.

Conventionally on the earth you can almost determine the composition of the lava by the shape of the deposits that

it makes. There are three things involved. One is the chemistry of the volcanic rocks. Secondly is the gas content. And third is the mode of eruption. But these usually seem to run together so that basaltic magmas very commonly come out in very quiet eruptions that spread broadly, and more silicic things make sharp top domes, and these are just about the same height and shape as the intermediate composition lavas that form the great volcanos of the Pacific Northwest. This is something that is very similar in size and shape to Mount Rainier, for example.

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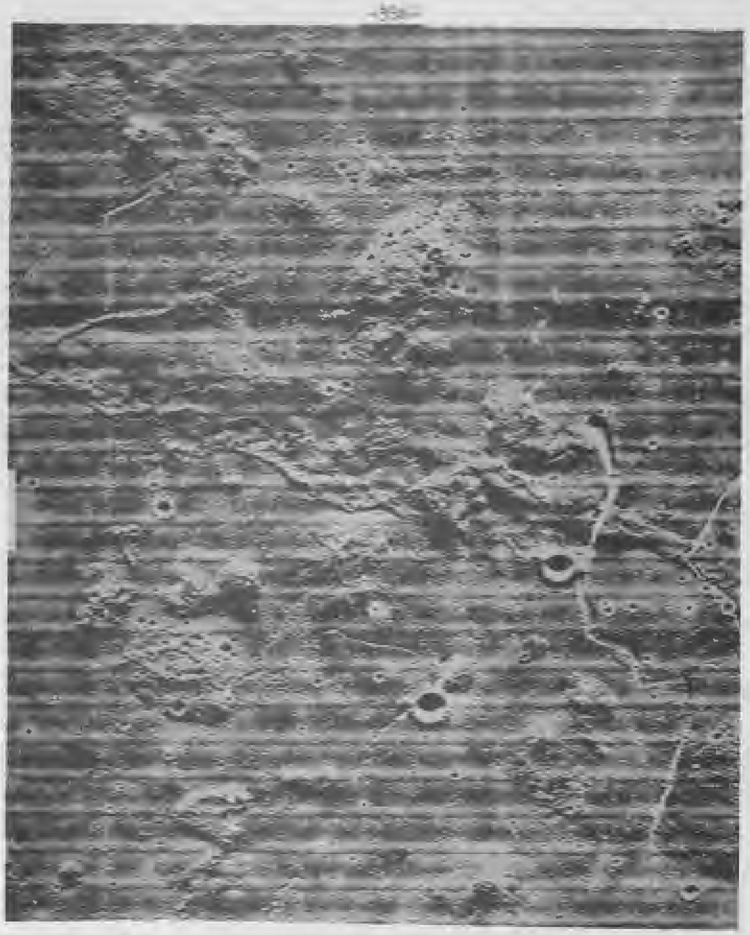
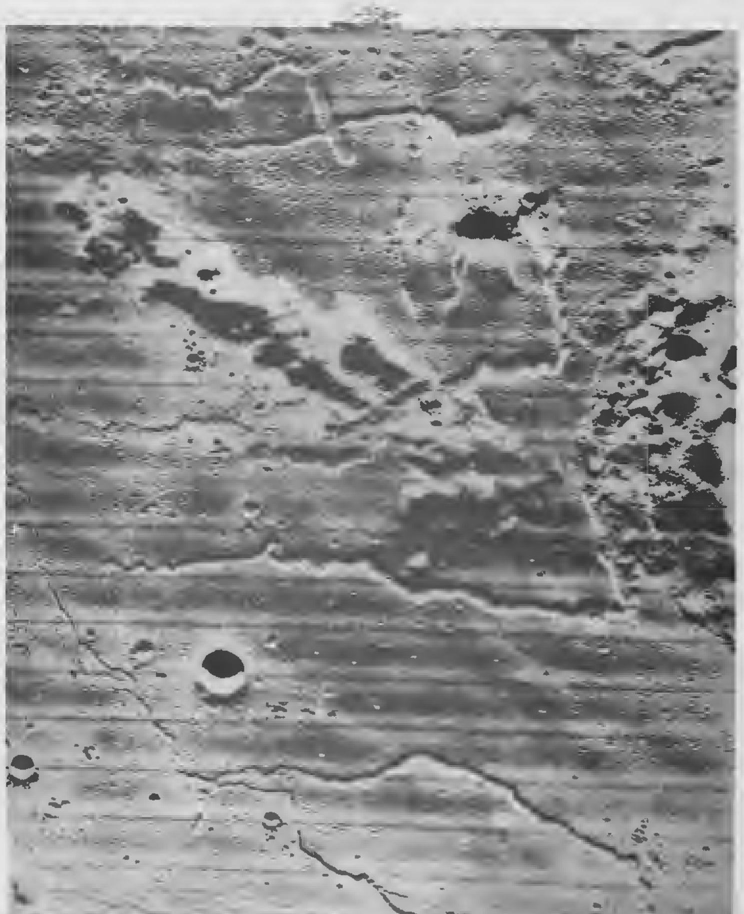
This shows a vertical photograph from Mission V in even greater detail of this area. Here we see the sharp top domes I was speaking of, and here the broad lowlands. They are surrounded by not only single vents but by a whole forest of vents on the tops of these craters. Jack was able to see in many of these on particularly good nights on the telescope, a single crater in the top. Now we can see that the whole volcanic apparatus is perforated by the craters on top of them. This is an area high on the list of things that later manned flights might visit because here is a nice smooth area of mare material that one can land in, and close at hand are a whole variety of tectonic and volcanic forms that can be investigated.

(Slide)

This is the area of the Harbinger Mountains. Here is a whole display of volcanic features that Henry Moore, of our group, mapped from earth-based observations. Here we can see in tremendous details many of the features that he had to guess at by looking at them through the telescope.

This is the crater Prinz and extending north from this on the flank of the crater and running down into the mare basin, Mare Frigoris, a sinuous channel that had long been called sinuous rilles. What stands out here is first there is a crater at the head, then it runs down hill for something like over 1500 meters out into the basin. The strange thing is that the stream grows smaller as it goes out into the basin.





Secondly we can see two stages in the development. There is a big crater with a broad stream that flows down, and a smaller crater inside that with a very highly meandering inner valley. These are called conventionally in terrestrial geomorphology "under-fit streams." This means that in many earth-based cases during the Pleistocene there was a much larger flow in river valleys that carved the broad valley, and the modern river valleys, with a much smaller flow of liquid, incise much fresher, smaller streams in the center. We can see a similar history here.

(Slide)

This shows in detail the broad channel and the meandering course of the under stream.

When we first looked at these photographs we were astounded by the fact that the outside rims of the meanderers are these big, broad, smooth slopes, and projecting into them are the much sharper slopes, and these are called slip-off slopes or point bars. These have received an enormous amount of study because they are of great importance in flood control. And a great amount of attention has been devoted by engineers and hydrologists in understanding this mechanism so that they can appropriately control the cutting and filling of flooding streams.

(Slide)

Here is another beautiful example of a similar feature. This is the famous "Cobra Head." This is the Crater Aristarchus, so we are still in this area. And this is Schroter's Valley which flows for over a hundred miles. Here we see the same kind of thing, a broad valley and inside a much smaller meandering stream, and we will look in detail at the next slide at that course.

(Slide)

This is a particularly nice one because here we can see that the meander came like this, and that the neck of the meander -- and this looks like the goose necks of the San Juan River -- is starting to be eroded and perhaps in the next eruption we would anticipate that it would cut off here as it

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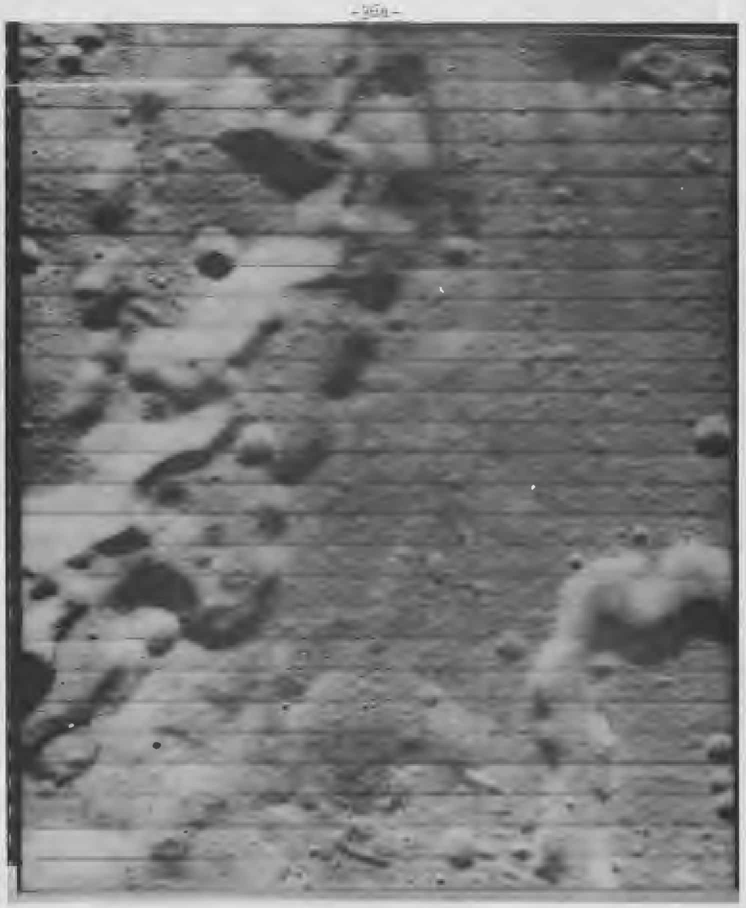

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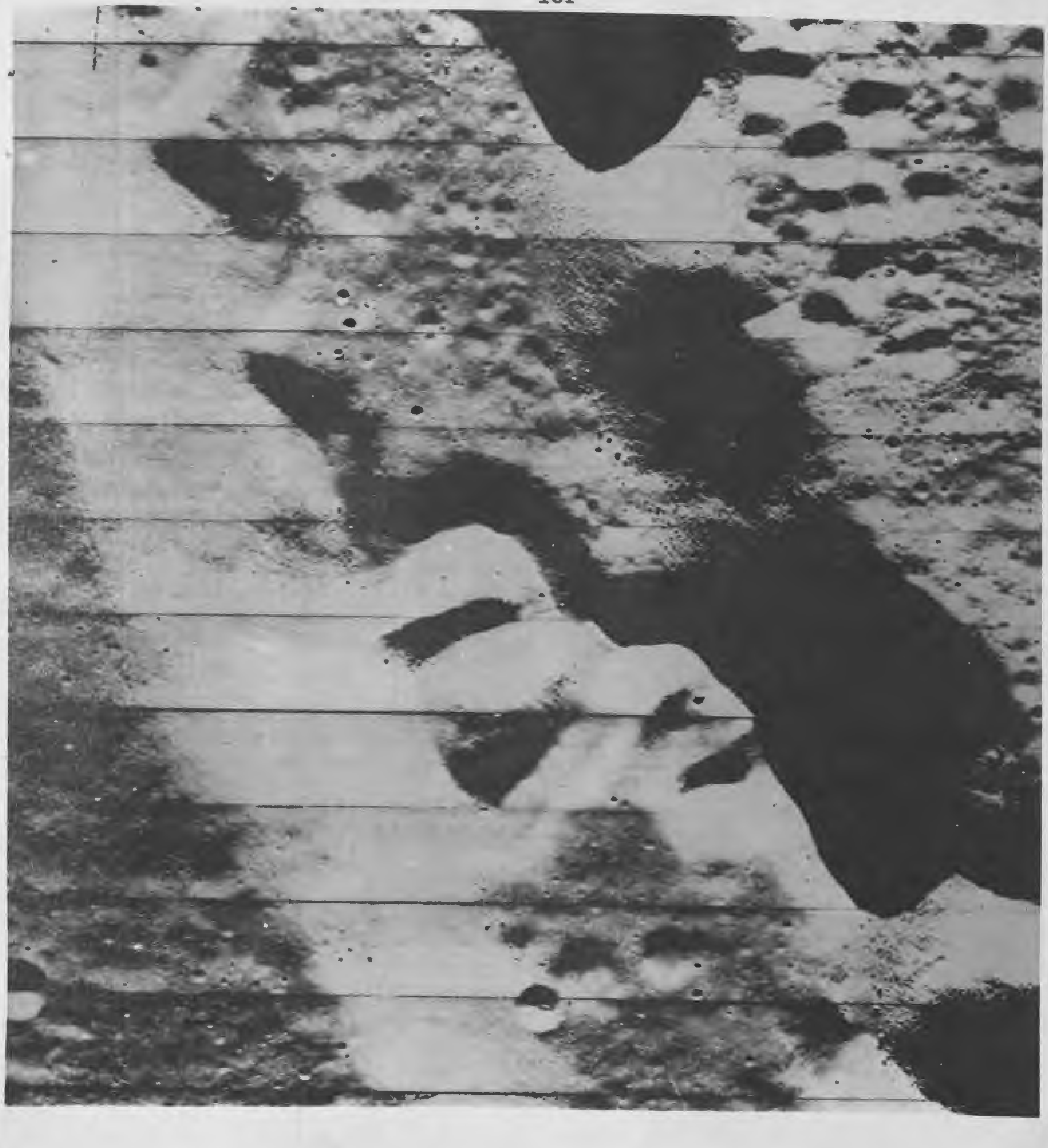

has cut off this meander. The stream used to flow here and now it has cut this off.

Another feature is the migration of material down slope so that it has filled in this part of the channel. Again this is very common in terrestrial streams where the banks slump in and push the channel over against the far bank.

We have had hydrologists from the Foothills Laboratory and from the engineering department and geology departments at Colorado State University looking at these now. They have done a great deal of both methodology and river studies. And they say that they think they can, by knowing the slope, knowing the channel cross section, knowing the meander length, give us information on the kind of material that flowed down these channels. They exhibit all the subtle features that look as though these are fluidal materials. We don't know whether these are solid particles carried by gases, or whether they are solid particles carried by liquids. But they think they can, in the next short period of time, if we can give them the appropriate measurements, come up with estimates of what this material is like.

(Slide)

This is Hadley's Rill in the Apennine Mts. here on the east side of the Imbrium Basin. Here you can see a similar crater at the head and then a beautiful meandering channel that runs down into what is called the "stinking swamp", (Palus Putredinis). They were very imaginative in those days. The hydrologists were particularly interested in this because you can see here that a later flow came down this steep slope and missed the first meander. It just rode right up out of the channel and flowed down the slope. Hydrologists say this exceeds super critical flow, and when this happens the fluid will ignore its channel and just climb right up out of the walls.

Another interesting feature, this is a small volcanic crater because it lacks all of the characteristic impact features that we see here. It is a very young one. You can see here that it is recent enough that it has partly filled in the channel of the Hadley Rill.

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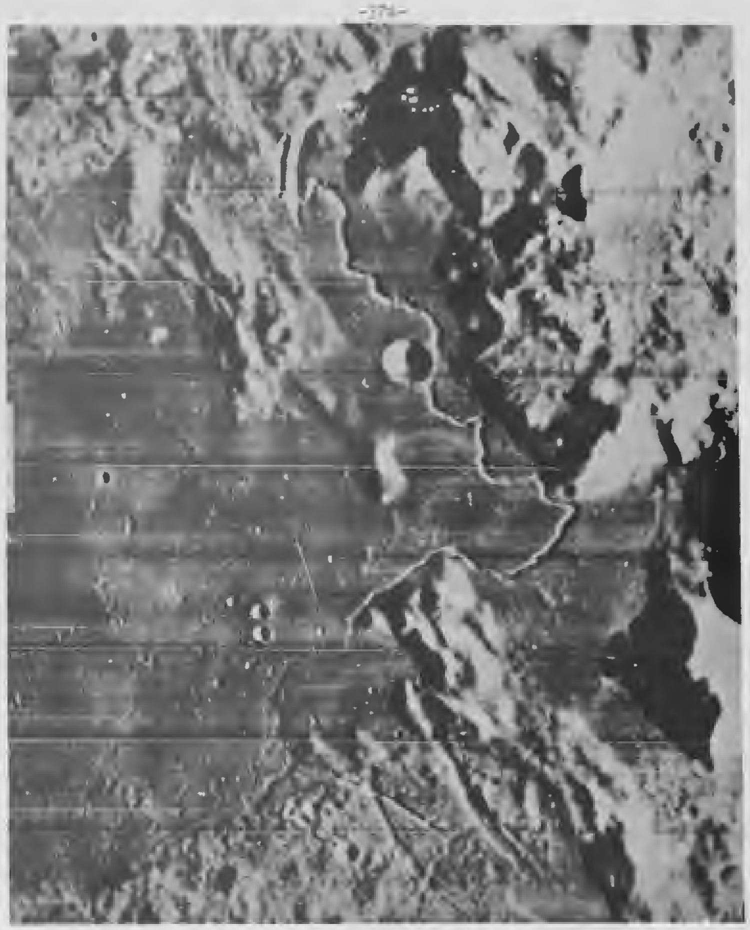

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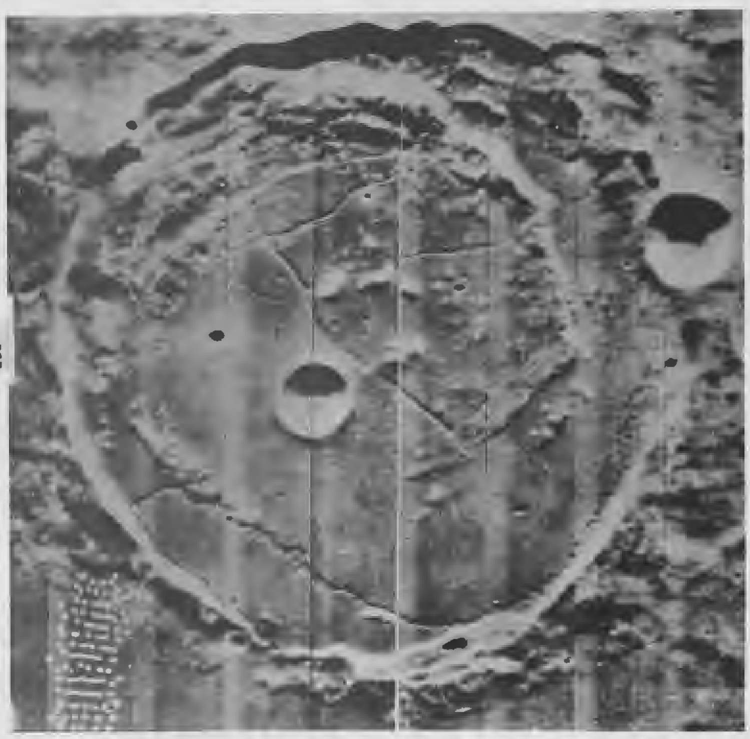

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This is the crater Posidonius which lies here. There are two most interesting features here. First a beautiful example of a sinuous rill that rises here, and follows this wonderfully meandering course, and comes down here, turns back on itself in a hairpin turn, and flows out through a little gap in the wall of the crater.

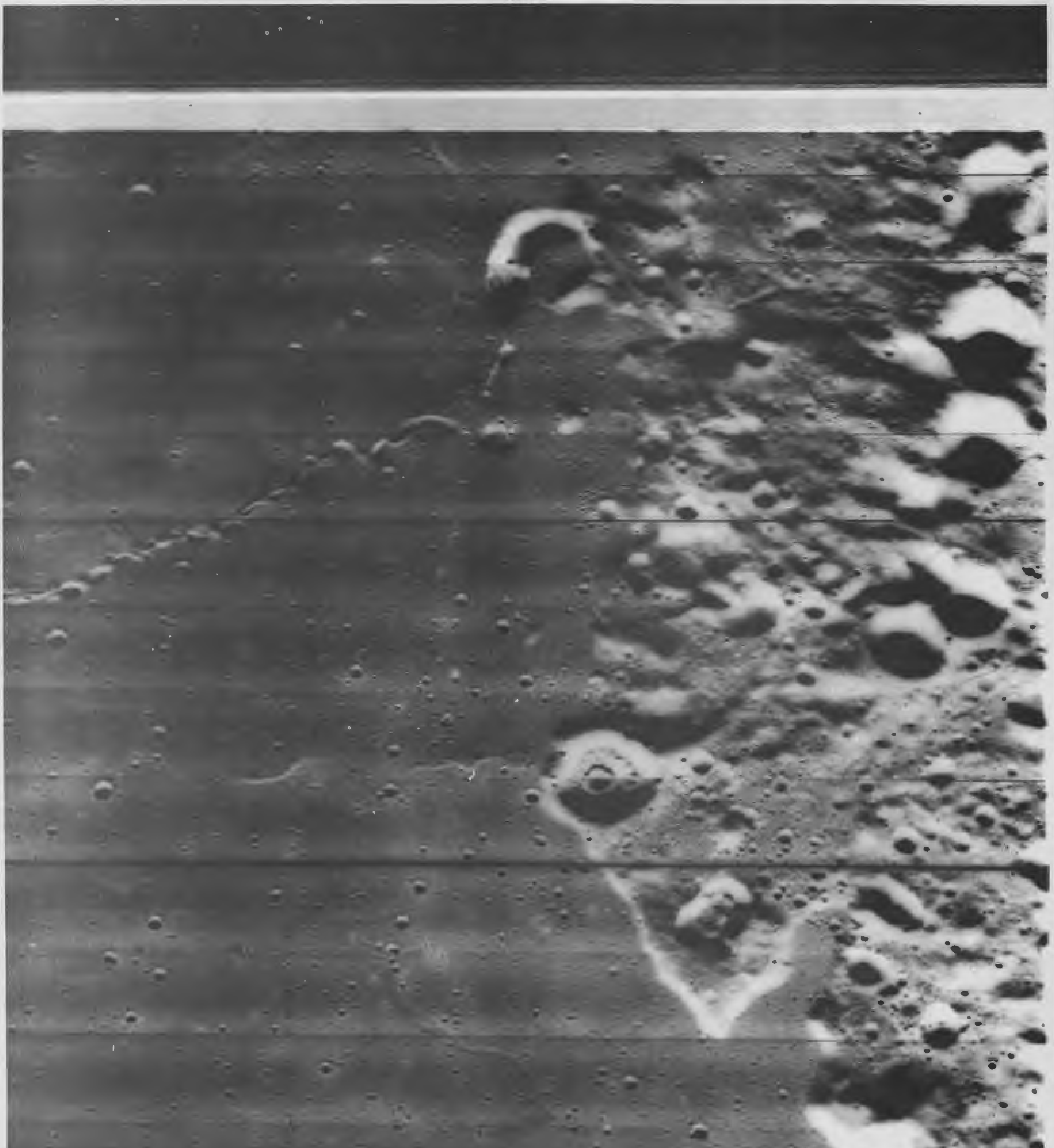
Secondly another kind of tectonic feature is visible here. This crater is 60 miles in diameter. In other words it is the same size as the crater Copernicus. We think that at the time this crater was formed it had the same cross sectional profile as Copernicus. In other words, it must have been about three miles deep. Now you can see it is almost level. Here are the central peaks that still lie on the floor. If this had been filled in by material brought up in these volcanic eruptions, then the central peaks would have been long since buried. But since they have been risen along with the floor, the only analysis that we can come up with is that the whole floor has risen like an elevator, carrying the central peaks with it, and left this marginal gap which is filled in by the later volcanics. This looks very much like the highly distorted crater forms that we see in the large Canadian impact structures.

So we say that this floor has risen by isostatic rebound, and this is now in equilibrium.

(Slide)

Lest you think that we can explain everything, as a final picture this is a small unnamed rill that lies north of Mare Humorum, in this area. Here is our little crater at the head. Instead of running nicely down the hill the way it ought to, it looks as though it runs through a series of craters, and here are positive features. This looks like a sort of cross breed between a false scarp and a sinuous rill and a line of volcanos, and everything in the book seems to have happened here. We would be delighted in any interpretation that you can come up with.

I have shown you a variety of volcanic features. We would say from this variety of forms that we think that they represent a strongly differentiating magmatic sequence,



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and the forms indicate that we have things that range from a variety of compositions.

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This is an oblique of the Hyginus Rill that lies in the central part of the Moon, and we are looking north across it. We can see here in much greater detail than we could see from the earth-based observations, that not only is there graben, that is a fault trough, but that along the fault are a whole series of craters.

(Slide)

In the next photograph, from our Mission V, the vertical aerial photographs show beautifully the line of craters that lie along the fault graben. The fault is much more extensive. This is well over a hundred miles long and about 15 miles wide. And the volcanic craters lie along that graben. We see the build-up of deposits here in the craters. These are not collapsed but they have actually built up the crater walls around the volcanic events.

(Slide)

This is the high resolution Orbiter photograph. We can actually see the outcropping ledges of rock at the margins of the crater. So again this would be a prime area to investigate by later manned landings because it is this kind of volcanic feature that typically, terrestrially, brings up very deep seated materials. And a number of such craters that we have investigated in the Colorado plateau and lakes bring up rocks from deposits of about a hundred kilometers. This is a lunar drill that is far beyond our present technology. All we have to do is land here adjacent to the crater, walk over and get nice fresh rocks along the margin of that crater.

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We are looking south away from the crater Kepler at a field of domes called the Hortensius Domes.

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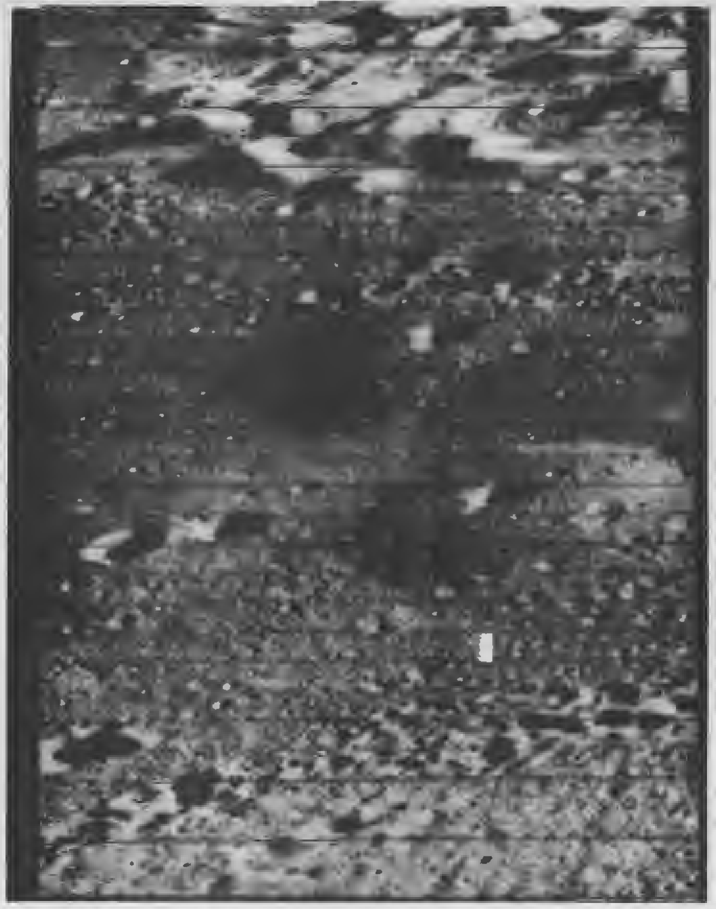

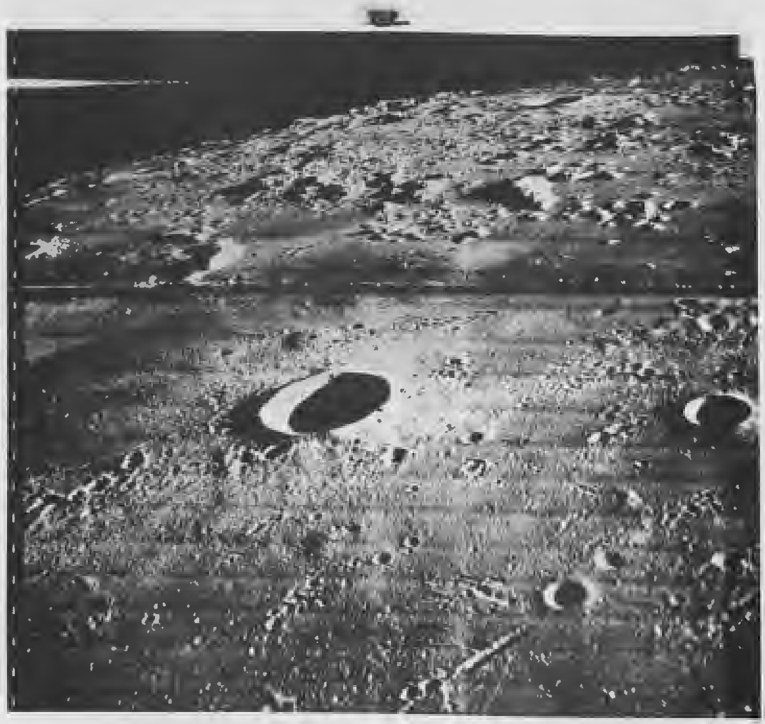

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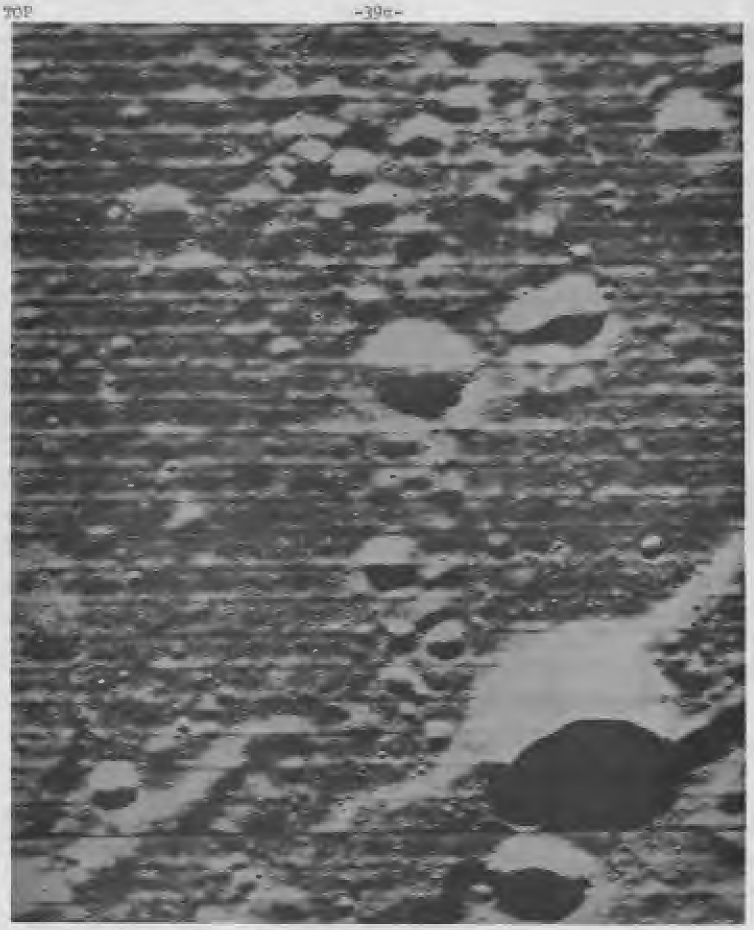

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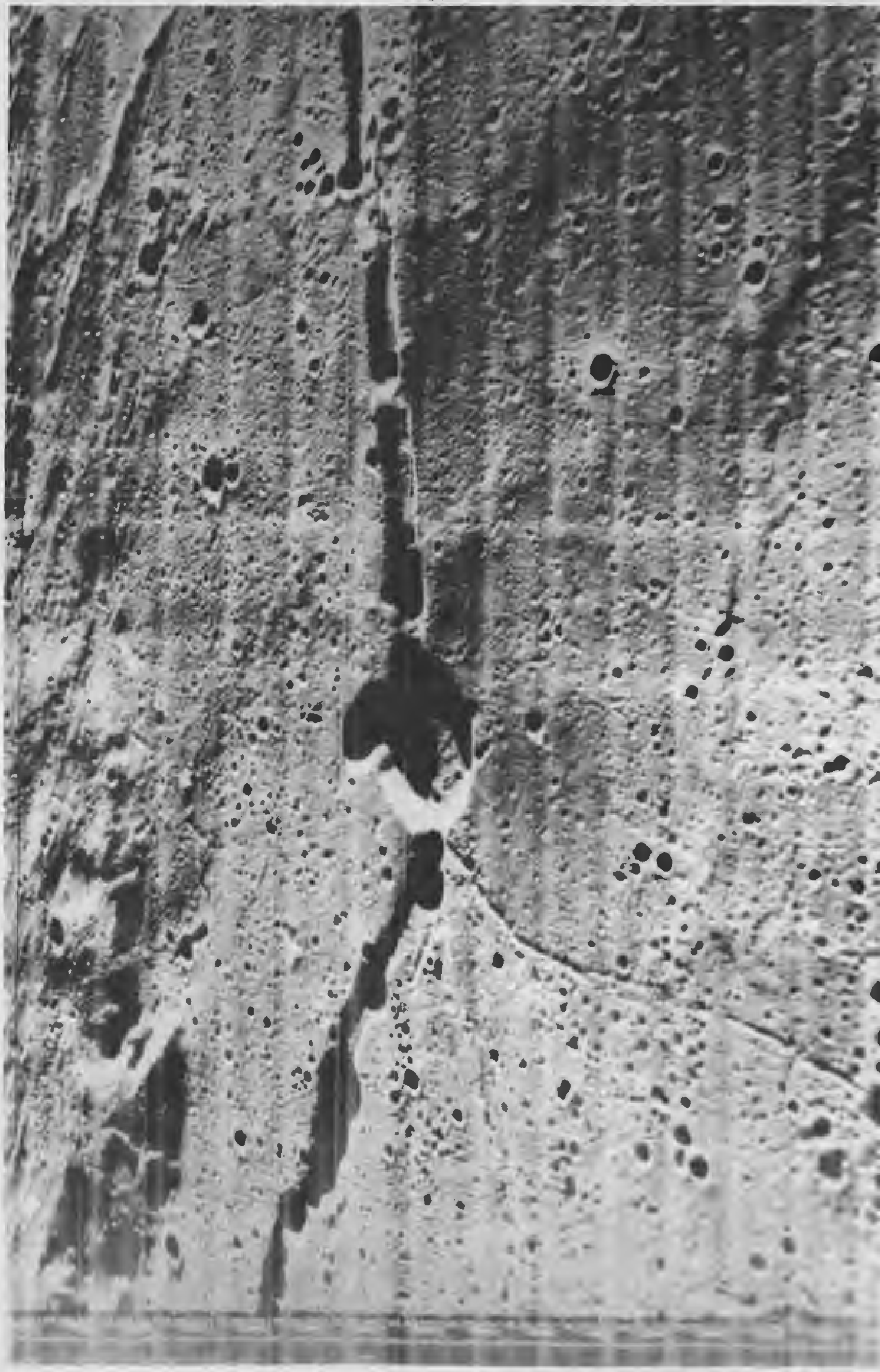

In the next photograph is a close-up of these broad, low, volcanic domes with beautiful summit pits. This is the kind of feature that is typical terrestrially of basaltic shield volcanos.

(Slide)

This is the area of Surveyor V, and it looks just west of a broad field of such volcanic domes, and there are a group of them here. So it comes as no surprise to us that the analysis here indicates that we have a basaltic composition because this lava field is characterized by these broad, low domes that terrestrially are characteristic of basaltic volcanism.

(Slide)

This indicates that the analysis taken here and the broad, low domes indicating that this whole field is underlain by basalt, is probably true over a much more extensive area. That is, all the great mare basins -- Crisium, Tranquillitatis, Serenitatis, Imbrium, Oceanus Procellarum, Mare Humorum -- they all seem to be filled by similar materials. So from this one analysis at Surveyor V we can say that about 20 percent of the visible face of the Moon is covered by basaltic volcanism.

(Slide)

Those are shown by the compilation of the geology of the lunar equatorial belt in the gray color. We would anticipate that hopefully subsequent Surveyors will try to analyze materials that can be similarly extrapolated over large areas. For example, the blue here are the deposits that are ejected from the Imbrium Basin and probably come from great depths. So we would anticipate, if the basalt is derived by differentiation of ultra-basic materials, that very possibly if we land a Surveyor on this blue area that we would have from the Fra Mauro formation, an ultra-basic analysis. In a similar fashion if we land in one of the pink areas, one of the upland basin fillings, we might have quite a chemically distinct type of volcanic materials.

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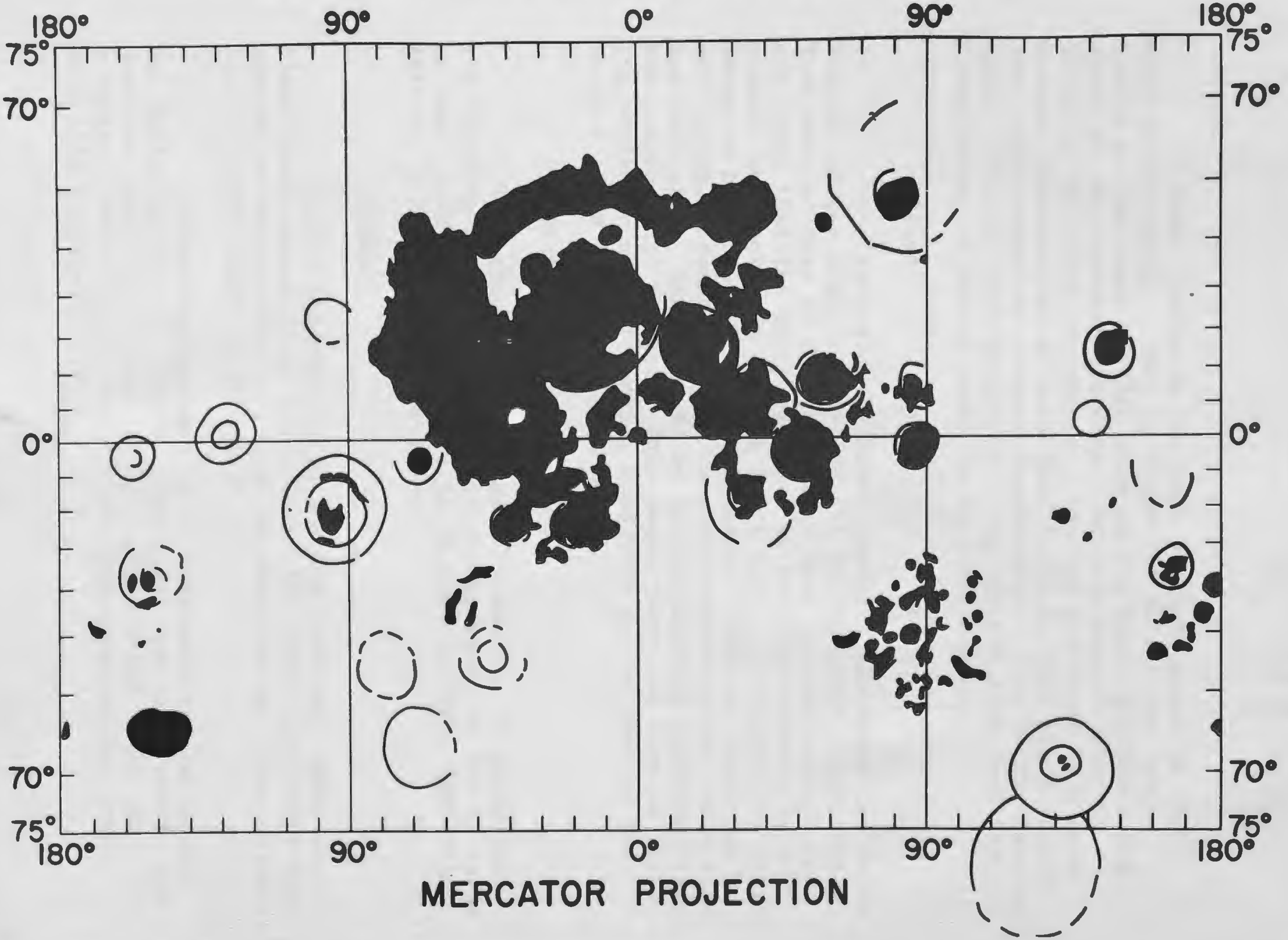
RANGER VIII
SURVEYOR V
MARE MATERIAL

LUNAR MARIA AND CIRCULAR BASINS



MERCATOR PROJECTION

Here I go on to the last subject, based on the Moon-wide coverage. This is a plot of all of the large basins on the front and far side of the Moon, and these are shown by the circular patterns. And the mare filling is shown by the black convention. You can see there is a very unequal distribution of mare that falls in this big H shaped area that centers on Oceanus Procellarum. This is the Imbrium Basin. This is Mare Orientale. You can see also that the distribution of basins seems to be quite random.

(Slide)

This is a plot by Baer, Stewart, Alexander and Keith Howard, of our organization, of all of the large lunar basins. They counted some 27 of them. They show in this plot, by age and size, that the coverage seems to be about equally split between the back side and the front side. Additionally, there seems to be a complete spread in ages. That is, there are both young, intermediate and very old basins on the front side and back side. They seem to be fairly randomly scattered over the entire lunar surface. This means there has been no focusing action or no preferential encounter of the Moon by the various large basin-forming impacts.

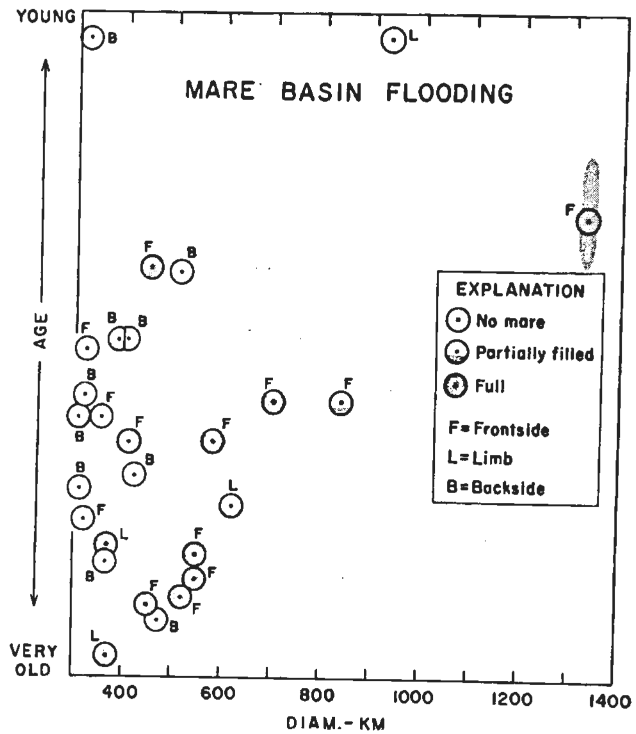
(Slide)

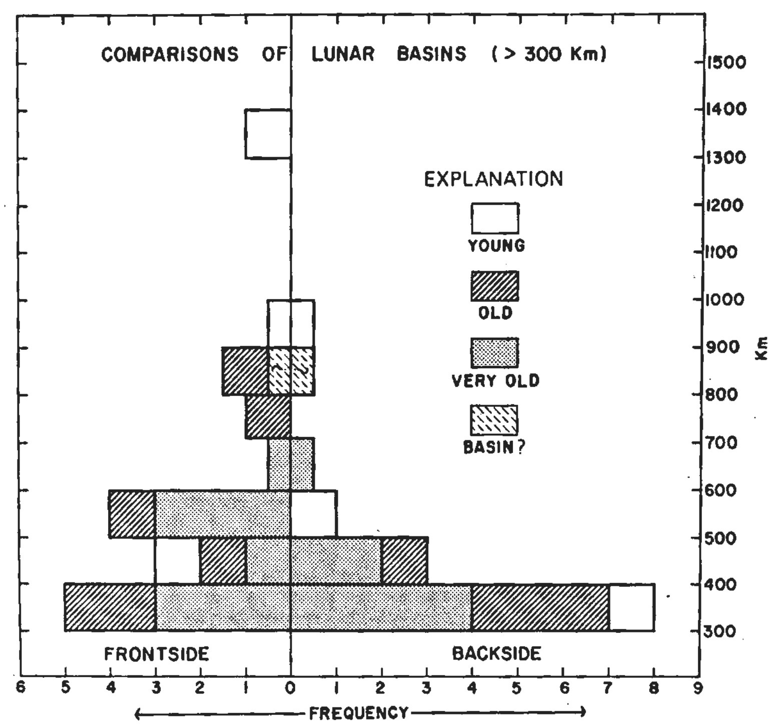
This shows the mare basin flooding. It shows that the flooding is not restricted to either young or old or large or small craters, but it seems to be more aerially controlled than it is either by age or size.

(Slide)

And in the next slide and the last one, these are lines drawn around first the area on the front side where the basins are either full or filled to overflowing. They actually lap up on the sides of the basin.

In the dark pattern is an intermediate area where the basins are partly filled. There are two large areas, one near the back side, northern part, where there is no mare material. And here in the southern highlands on the front side lies in mare material.


MARE BASIN FLOODING
YOUNG
AGE
VERY OLD
DIAM.- KM
400
600
800
1000
1200
1400
EXPLANATION
No mare
Partially filled
Full
F= Frontside
L= Limb
B= Backside


COMPARISONS OF LUNAR BASINS (> 300 Km)
EXPLANATION
YOUNG
OLD
VERY OLD
BASIN?
FRONTSIDE
BACKSIDE
FREQUENCY
Km
1500
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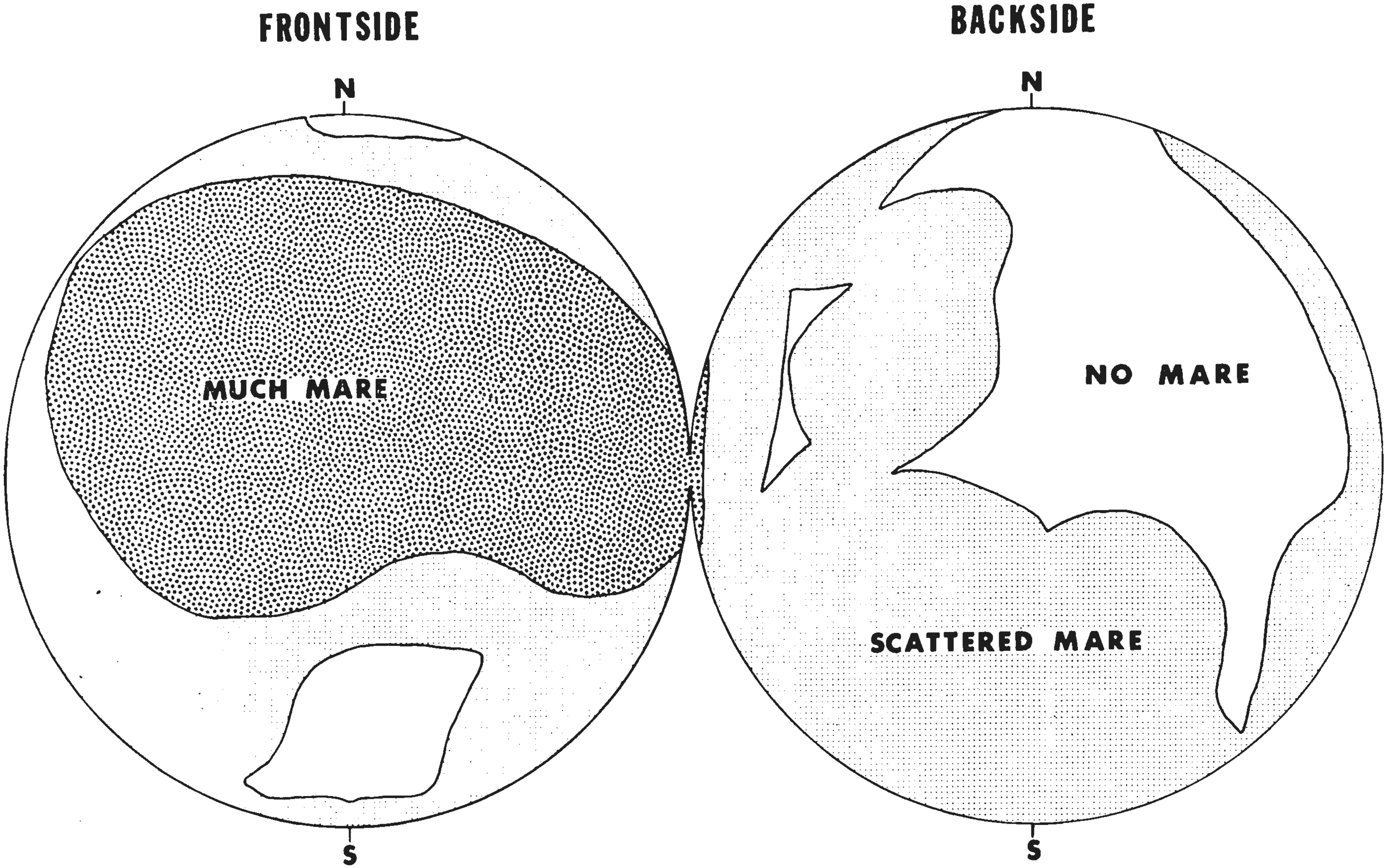

EQUAL-AREA PROJECTION

Our conclusion from this is that the basins themselves are randomly scattered over the Moon's surface, but that the flooding seems to be strongly aereal controlled. You can see that the Oceanus Procellarum basin seems to be the center of this extreme flooding of mare material. There have been two ideas proposed for this great abundance. First, that this is the site of a very large, very old impact, so that this is a very low part of the Moon and gets subsequently flooded. A more popular one is that this is the site of a convection current, that is, there are two convection cells or a single convection cell with two components, and that this is a low area.

If you recall a map of the earth, we have a water hemisphere and a land hemisphere. If you look at the Pacific Ocean basin, it is a much lower area than the opposite hemisphere. One of the very early ideas was that the Moon had been pulled from the Pacific Ocean basin and had made this large hole. I guess that if we extended this idea to account for the big basin around Oceanus Procellarum, we would have to pull the earth out of it. But I think we would get tangled up very quickly.

I guess more pertinent is the idea that apparently the earth and the Moon are very similar in their distribution of high and low ground. And that hopefully, by examination and comparison of this kind of geologic plot with the selenodetic information that will come out of the Orbiter series, we will be able to plot the geopotential field, that is the center of mass and the shape of the Moon, and tie it in with the geology, and perhaps arrive at a better understanding of what makes the major features of the Moon and therefore to compare them with the major features of the earth.

One can ask at this stage of the game whether the ideas that I have been proposing to you, although they are interesting and academic and esoteric, is this the end of this kind of information. Are they interesting facts that can be conveniently filed away. I would like to point out several recent events that indicate that there might be other things that we can do with this kind of information.

For example, on June 30, 1908, there was a great fire ball that struck the ground in the Soviet Union north of Irkutsk, and this was the Tunguska meteorite, or as it is now called, the comet. This knocked down trees in a 50 mile circle, and a man sitting on his front porch some 60 miles away was picked up and thrown 20 feet and knocked unconscious. It doesn't require too much imagination to think what would happen if such an object landed in our East or West Coast areas. It would seem to us that the study of such incoming objects, and monitoring them, is something worthy of considerable attention and thought.

Secondly, there was an earthquake two years ago that affected most of the Alaskan Coast and wrecked large parts of Anchorage, Fairbanks and many other coastal cities.

In 1906 there was a similar occurrence in San Francisco that considerably worries Bay Area residents now.

In 1923 there was an enormous earthquake in Tokyo, that although it made Frank Lloyd Wright's reputation for having put up a building that stands, was tough on the rest of the inhabitants of Tokyo.

The understanding of the energy that leads to mountain-building and to earthquakes is a subject very worthy of our attention.

Finally, there have been a number of volcanic eruptions as at Taal in the Philippines, that I showed you pictures of, in the Hawaiian Islands where Mauna Loa and Mauna Kea are frequently erupting.

In the 1890's there was an enormous eruption in the Dutch East Indies where the volcano Krakatoa blew its top, and the resulting tidal waves killed literally hundreds of thousands of people throughout the entire Pacific basin area. The Dutch have since monitored volcanos to attempt to predict when they might erupt.

We have had a volcano observatory for many years at Hawaii, and the Japanese are very, very closely studying earthquakes and their prediction and volcanos and their prediction.

I would like to point out that in all of these aspects this very fundamental understanding of the causes of phenomena that can vitally affect us all have only been able to be done up to now on the earth. In many of these cases we arrive at ad hoc solutions, that is, we have a single example and we construct a theory that fits that example.

By studying the Moon we know that it has a long, complex geologic history, that many of the same kinds of things that happen on the earth happen on the Moon. We can now play these two against each other, compare their similarities, contrast their differences, and perhaps be able to arrive at a greater understanding of the fundamental processes that affect the earth.

NEWELL: Thank you for a superb and fascinating review of the interpretations of the Lunar Orbiter results.

As you may recall, years ago when we began the program of lunar and planetary exploration we pointed out that one of the results that we hoped for and expected was a better understanding of the earth. I think you can see from Mr. Masursky's review that some of these results are indeed coming to the fore.

It is in this perspective that we see the most importance of these programs. And it is to talk about such perspective that I would like to call on the next speaker, Dr. John Findlay.

Recently we formed a Lunar and Planetary Missions Board, the purpose of which was to provide NASA with advice and guidance on the strategy of our solar system exploration. Dr. Findlay is Chairman of this Board, which is composed of 18 scientists and engineers of top quality, and of the diverse disciplines that are involved in the study of the Moon and the planets.

To give us some comments on perspective, Dr. John Findlay.

FINDLAY: Thank you, Dr. Newell. I shouldn't take more than about five minutes of your time. What I would like to say really derives from the Lunar Orbiter program which we are in a sense, truly in a sense, standing around here and saying very good, very well done.

I am not going to try to summarize what other people have said. It is clear the Lunar Orbiter frame was first of all absolutely essential to the Apollo program. As you have seen from what Mr. Masursky has told you, it has produced scientific results of its own already of very great value. But as Dr. Newell said, it is a thing that I am trying to do with a group of people, to look to the future, to look beyond what we have already done so successfully on the Moon, with Ranger-Surveyor and Lunar Orbiter.

And so, just consider at the moment, although we have these beautiful photographs of the surface, for example, and although Masursky has given you such a wonderful and careful analysis of what those surface features mean, how they can be compared with things on the surface of the earth, consider also it is good for us to do so.

He has been talking about the surface. There is the whole of the inside. It is our task perhaps to think of what kind of lunar exploration program one should go on doing which will continue the geological surveys of the surface, which will solve the problems of the features that we see, which will lead us to an understanding down into the depths of the Moon, which will tell us about heat inflow and outflow through the surface, which will tell us by geophysical exploration what goes on down deep below, and in the end we hope will lead us to one of the basic answers to one of the basic questions which Masursky touched on, how did the Moon get there.

As you know, it is a question to which we do not have a good answer even now, although there are two or three answers which are acceptable. All this you can see spreading out in front of you as a result of the present remarkable progress in lunar exploration.

I am not going to try to tell you what I think the lunar exploration program is going to look like over the next few years, but it will certainly of course be a mix of -- has to be a mixture of manned and unmanned efforts, and it will be, I hope, a mixture which contains continual work from orbiting vehicles, from manned and unmanned landing vehicles, sample runs, geophysical experiments, and the rest.

Also let me say, based on Lunar Orbiter, let me go one stage further and move you away very briefly from the Moon to the planets. The techniques of course as we all know are now available to us to orbit the Moon, to make soft landings on the Moon. Certainly we shall see soon a man placed on the Moon. Let me remind you, as you all know, that so far no spacecraft has orbited a planet as opposed to the Moon. No spacecraft has entered and landed on a planet except in essentially a catastrophic way and sending back no data. And of course no spacecraft yet has made a soft landing on a planet. Yet the field of planetary exploration is open before us and again you can see from the progress made on the Moon essentially the techniques are now in our hands. Particularly the Orbiter technique has so much to give in results for planetary exploration.

I won't go through them all, but time changes alone on the surface of the planet. From an Orbiter we could study with a variety of sensors the changes which are taking place on the surface of Mars. We could look for warm spots, wet spots. Many people don't believe them, wet spots. We could look for changes in color. We could look to see what those changes in color and temperature and the rest are due to. We could do a variety of other experiments. All these are available to us, one now believes, because of the success of the Lunar Orbiter program.

It seems rather funny at the moment -- funny is not a word one should use in NASA on this subject -- although it seems rather curious at the moment to be looking ahead to programs of exploration on the Moon and the planets, when we know we are in a state of financial stringency, nevertheless that is what I and my group are trying to do. We feel ourselves a very great support from the technological and scientific results which have come out of the lunar programs and particularly out of Lunar Orbiter.

NEWELL: Thank you John. Dr. Findlay is Assistant

Director of the National Radio Astronomy Observatory at Green Bank, West Virginia.

It is quite natural to think of the Chairman of the Lunar and Planetary Missions Board as being an astronomer. What I think is especially interesting is that most of the discussion that you heard this morning is really the geosciences. So we see here that astronomy and the geosciences have found an area of very common interest which will continue to develop as the solar system is explored in the years ahead.

I hope that you have gotten a feeling for some of the subdued but nonetheless real excitement that some of us feel with having this data with which to work, and the excitement which will grow as the theories that Masursky and the others have talked about are probed further and developed further, and as additional data come from other missions, as, for example, the Venus encounter which is in the offing.

Now I invite you to ask questions of the members of the panel of speakers this morning, plus a few others.

May I ask those who are here -- you see their names up here -- to come forward and take seats at the table for the question period. I am sure all of you know Dr. Thompson. He has arrived from the airport during the session and he will join us in the discussion period.

Also as Sam Phillips had to leave to get back to some pressing duties that he is involved in at the moment, Dr. Turnock is here in the audience and he is available for questioning in that area should there be questions.

MITTAUER: We have some eavesdroppers at Langley, Lewis and elsewhere, so gentlemen, wait for the mike for your questions.

That is the quietest I have ever seen this press corps.

VOICE: Masursky brainwashed us.

QUESTION: I want to know what the implication is of having hydrologists study the Moon now, whether you are interested in flow that you think might have been lava or whether you are raising the possibility that there might have been some other fluid, water, for example.

MASURSKY: This is the answer that we hope that they can give us. What we can say is that the channel form is such that it looks as though there was surface flow. There have been other ideas that have been presented. For example, saying that there is a permafrost layer, that is, the water that has evolved from the volcanos would freeze, subsurface, and would sublimate so there would be none present at the surface, and when a volcanic eruption took place it would melt the ice and it would flow along this top contact of the permafrost with this surface layer, and that the fluid would have to be flowing underground in an underground channel which collapses to form the sinuous rill. If this is what happens, we think that there has to have been continued flow to give the channel shapes that we see. I think these are incompatible with what hydrologists already know about channel morphology. I think something flowed down those channels.

QUESTION: I think it may have been Mr. Nelson who explained to us the impacts. Was it the micrometeoroid impacts?

NELSON: Yes.

QUESTION: I wonder if there is any way of judging from those, from the information that you have, the size in any way to give us an idea of how serious this might be with regard to astronauts either on the surface or nearing the surface, or in orbit.

NELSON: I would like to refer that question to Mr. Charles Gurtler, who is the experimenter. I believe he is here today.

MITTAUER: Mr. Gurtler, do you want to come here, please.

GURTLER: The meteoroid experiment on Lunar Orbiter could only measure the number of particles that had energy enough to penetrate one mil beryllium copper. So we cannot determine any information concerning size. We can compare this measurement with the earth measurements. That is about as far as we can go.

QUESTION: Did any of them knock out the equipment?

GURTLER: Not so far as we can determine.

QUESTION: Sam Phillips isn't here to answer this, but maybe we can get an answer anyhow. He said that three years ago the Apollo system was being designed to land on a model and that model was based on certain assumptions and scientific data available at that time, and consequently the design of Apollo was done with a very great deal of conservatism. Now you have a lot of solid information about the Moon. I am wondering, with hindsight, if you were designing the Apollo spacecraft lunar lander today rather than three years ago, based on what you know today, how much less conservatism would be used in the design and how this would translate out in terms of weight saving.

SCHERER: I think we should refer that to Dr. Turnock.

TURNOCK: That is a tough one. I don't know of any changes we would have made. The landing gear looks like it is about right. I think the word "conservative" is wrong. It is safe. We have the margins in, and we want to do without those margins. So I don't know of any changes we would make in the LEM.

QUESTION: To follow that up, what is the real value of Lunar Orbiter?

TURNOCK: The great value of Lunar Orbiter is that it bore out our assumptions, that things look like we expected them to look.

NEWELL: May I explore that a bit further. There were questions as to the angles that one might have to accommodate in the LEM landing. There were questions as to the sizes of obstacles, as to the sizes of patches that one might have available during the landing maneuver that one could use to select so as not to land on a rock or in a crater and so on.

On the other hand, as Masursky brought out today, one could not see on the earth-based photographs these features. You had to get the Lunar Orbiter and Surveyor measurements to see whether you were right or not. And if it turned out that you were not right you would have to redesign, you would have to redesign the maneuvering capability, the leg spread, the ability to accommodate the slopes and so on. We have now found, through the Surveyor landings and the Lunar Orbiter, that the parameters used were adequate.

TURNOCK: It also gives us additional information to base our landing strategy and landing maneuvers on.

QUESTION: Mr. Masursky's description of much of the topography around Orientale seemed to me to indicate that it was one whale of an impact when it occurred. I wonder if this was indeed a single impact, and if it was so powerful it could have an effect on the orbit of the Moon itself, or its rotation around its axis, or the angle of its axis?

MASURSKY: A number of people have played with the effect on the orbit of large collisions. And I think all the numbers that have been come up with, although their spectacular effect locally on the topography, the mass of the planet, is so much larger than the mass of the incoming object, it has an imperceptible effect on the planetary movement.

QUESTION: Dr. Findlay, what is your group recommending be done with the last Surveyor?

FINDLAY: I am happy to be able to say we haven't been asked that question so we haven't made a recommendation on it.

NEWELL: The Board of course is invited to make comments on any missions that we undertake.

QUESTION: Would you like to comment?

NEWELL: On the other hand, in the case of Surveyor, and in the case of the Venus mission and so forth, these were all underway. So the Board chose to look at things farther down the road.

In the case of the last Surveyor we are, as we mentioned during the Surveyor conference, very seriously considering making this a scientific type mission rather than a direct support to Apollo landing certification mission, if the next Surveyor has completed meeting all the needs of Apollo.

As Sam Phillips indicated in his discussion this morning, the intent is to have a selection of sites across the equatorial belt of the Moon spaced so that if the one chosen for the early part of the window can't be used because of delays, we can move on to one toward the middle of the belt and if that can't be used we can move on toward the western edge of the belt. This means, now that Surveyor has given us a look at the eastern and western edges, we want to get something in the middle of the belt. That is where the next Surveyor very likely will go. We are reviewing the decision on that right now. That would leave the last Surveyor then for some scientific mission.

QUESTION: In view of what has happened to Voyager this year, does the Board see a future for Lunar Orbiter in a planetary role?

NEWELL: We have no more Lunar Orbiters scheduled in our program. If it is decided in exploring the question of further investigation of the Moon that a mixture of manned landings and automated spacecraft is desirable, we can review that question and go to the Bureau of the Budget with appropriate requests and to the Congress with a program to use automated missions.

QUESTION: I mean as a short term, as a substitute for Voyager.

NEWELL: As I am saying we have none at the moment. We have none at the moment.

QUESTION: Can I follow that up please with a

Homer, isn't it true that you do have the spare parts that would constitute one more Lunar Orbiter lying around, ready to be put together and flown? This is I think probably what Rudy has in mind, and what I would like to know about too.

NEWELL: Yes, there are spare parts that could be put together. If we had followed right through with a continuation of the contract when it was underway, we could have put this together for somewhere between twelve and $15 million dollars. Of course having decided that we wouldn't do that, there is a question as to how much it will cost if you try to pick up later with those spare parts. Nevertheless we are undertaking to preserve them for possible future use.

QUESTION: I would like to ask Dr. Masursky to elaborate on his idea that it might be good to monitor incoming objects that might do something to the East or West Coast.

MASURSKY: There are already a large number of people who are interested in incoming objects, and they very closely monitor them now.

(Laughter)

QUESTION: I would like to ask Mr. Spradley a question. He mentioned, I believe it was he, that in the course of the lunar map making project that some of the work of the Russians with ZOND III was used. I would like someone to compare the photography of the two countries and also perhaps take a flyer on why we haven't seen or heard of more of this type of Russian experimentation. Is it perhaps that they are just waiting for us to put out what you people are in the process of doing, and using that for themselves?

SPRADLEY: The resolution level of the two far side reconnaissance missions is roughly five to one. That is, the Lunar Orbiter has at least five times more information gathering capability than photographs that we have seen from the ZOND material.

With respect to the other question, this is one of the areas of fairly free exchange of information -- or not quite free. These charts come out at 50-cents each through the Government Printing Office. The information from the Lunar Orbiter has not been restricted. It seems that there may be a tacit cooperative program in this because the information is there, we are preparing it on these charts. From what we know of the Soviet publication of Luna 9, in their publication they had it located on an Air Force one to a million scale chart. So I guess this is being used in that fashion.

QUESTION: How much photography have the Russians done in this area, besides ZOND III?

SCHERER: Peter, I can review that in a general sense at least. Luna 3 was first launched in '59. This was a flyby and gave the first coarse pictures of the back of the Moon. ZOND III was a flyby also and went by in July of '65, and it provided some considerably better photographs of the Moon. And some of these were used in the back side chart that Mr. Spradley showed as it stood after Orbiter IV.

They have placed two orbiters around the Moon. Luna 10, in April of '66, and as far as we know this did not contain a camera. This is the one that did the gamma ray spectrometer survey and field and particle survey.

The next one was Luna 12, which orbited in October 1966. It had a camera on board. I personally have seen I think just two photographs that they released, that were fairly coarse. There may have been a camera malfunction. I don't believe that they ever announced what happened on that one.

As to why they have not done more I don't think any of us can really answer that.

QUESTION: I am sure you have answered this before but I will ask it again.

What was the cost of the Lunar Orbiter program, and in view of its outstanding success, how much money did Boeing make?

SCHERER: I guess I have those numbers, too. In round numbers $162.4 million represents the cost of the spacecraft and operations. Boeing is on an incentive contract and there is an incentive for the results of these missions. The missions IV and V have not been reviewed as yet by the Incentive Board which consists of Dr. Dorman, Dr. Thompson, and Dr. Newell. This will be done shortly. Thus far for Missions I, II, and III, Boeing has been awarded a bonus of about $5 million. I think a little less than $5 million.

QUESTION: Does that $162.4 million include launch vehicles and launching services?

SCHERER: No, sir, it does not. There were five Atlas-Agena launched. These total slightly over $40 million. So the total cost was slightly over $200 million.

MITTAUER: Any further questions?

No hands?

Thank you.

(Whereupon, at 12:18 p.m., the press conference was concluded.)