APOLLO 16 MISSION REPORT

"SOMETHING WORTHWHILE FOR OUR FELLOW MAN"

"Captain John Young"

HEARING

BEFORE THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS HOUSE OF REPRESENTATIVES

NINETY-SECOND CONGRESS

SECOND SESSION

MAY 16, 1972

[No. 18]

Printed for the use of the
Committee on Science and Astronautics

U.S. GOVERNMENT PRINTING OFFICE
79-181 O WASHINGTON : 1972

COMMITTEE ON SCIENCE AND ASTRONAUTICS

GEORGE P. MILLER, California, *Chairman*

OLIN E. TEAGUE, Texas
KEN HECHLER, West Virginia
JOHN W. DAVIS, Georgia
THOMAS N. DOWNING, Virginia
DON FUQUA, Florida
EARLE CABELL, Texas
JAMES W. SYMINGTON, Missouri
RICHARD T. HANNA, California
WALTER FLOWERS, Alabama
ROBERT A. ROE, New Jersey
JOHN F. SEIBERLING, JR., Ohio
WILLIAM R. COTTER, Connecticut
CHARLES B. RANGEL, New York
MORGAN F. MURPHY, Illinois
MIKE McCORMACK, Washington
MENDEL J. DAVIS, South Carolina
BOB BERGLAND, Minnesota

CHARLES A. MOSHER, Ohio
ALPHONZO BELL, California
THOMAS M. PELLY, Washington
JOHN W. WYDLER, New York
LARRY WINN, JR., Kansas
ROBERT PRICE, Texas
LOUIS FREY, JR., Florida
BARRY M. GOLDWATER, JR., California
MARVIN L. ESCH, Michigan
R. LAWRENCE COUGHLIN, Pennsylvania
JOHN N. HAPPY CAMP, Oklahoma

CHARLES F. DUCANDER, *Executive Director and Chief Counsel*
JOHN A. CARSTARPHEN, JR., *Chief Clerk and Counsel*
PHILIP B. YEAGER, *Counsel*
FRANK R. HAMMILL, JR., *Counsel*
W. H. BOONE, *Technical Consultant*
JAMES E. WILSON, *Technical Consultant*
RICHARD P. HINES, *Staff Consultant*
HAROLD A. GOULD, *Technical Consultant*
J. THOMAS RATCHFORD, *Science Consultant*
PHILIP P. DICKINSON, *Technical Consultant*
WILLIAM G. WELLS, JR., *Technical Consultant*
JOHN D. HOLMFELD, *Science Policy Consultant*
CARL SWARTZ, *Minority Staff*
JOSEPH DEL RIEGO, *Minority Staff*
ELIZABETH S. KERNAN, *Scientific Research Assistant*
FRANK J. GIROUX, *Clerk*
DENIS C. QUIGLEY, *Publications Clerk*
A. PATRICK NUCCIARONE, *Assistant Publications Clerk*

APOLLO 16 MISSION REPORT

TUESDAY, MAY 16, 1972

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The committee met, pursuant to notice, at 10:30 a.m. in room 2318, Rayburn House Office Building, the Hon. Olin E. Teague, presiding.

Mr. TEAGUE. The committee will come to order.

The committee is very pleased and honored to have the Apollo 16 astronauts with us this morning.

The Chair recognizes Dr. James Fletcher, the Administrator of NASA, to present the astronauts.

Dr. FLETCHER. Mr. Chairman, thank you very much.

I am very pleased to introduce the crew of Apollo 16 to you. We've had really a fantastic expedition to the Descartes highland area of the moon, which is the first time in the history of the program that we have visited the highland area.

I won't attempt to describe what they found there. In the first place, they only can give you a sample this morning of what was found, and in the second place we're still working very hard on the data to find out what new concept of the moon will result from this expedition.

I'm happy to report that the crew members are all in good health, and the scientific community, as a whole, marks this as probably the greatest scientific expedition in history.

At this time I would like to introduce to you Capt. John Young, Col. Charlie Duke and Comdr. Ken Mattingly. Mattingly and Duke have just been promoted, and that's why I used their new titles.

To introduce the program for you this morning will be Capt. John Young.

Captain YOUNG. Thank you very much, Dr. Fletcher.

Let me tell you how pleased we are to be here today, speaking for the three of us.

You don't go on a trip like Apollo 16 half-heartedly. We've been training for it for 2 years, sometimes a hundred hours a week, and been trained by some of the best scientists in the country. They gave of their time and energy to get us the kind of education that a fellow needs to have when he goes to the moon, to operate, to understand, and to activate the scientific equipment. A lot of that time was free. The Government didn't pay for it.

We feel like the education was invaluable to the three of us, and I'm sitting with a couple of guys here that I feel, outside of the principal investigators on the experiments, know more about the systems that we operated than anybody on this earth. I'm mighty pleased to have been operating with such a couple of competent crewmen.

Ken knows more about the scientific instrumentation module than perhaps anyone, and Charlie certainly knows the lunar module systems, and the lunar module systems experiments, that we put out on the moon's surface.

What we have today to show you are some slides, preliminary results to the scientific results of the Apollo mission, and also a short movie clip. I think that probably the best thing to do would be to start, with your permission, and go ahead with the first slide.

APOLLO 16 IN THE PLAN OF LUNAR EXPLORATION

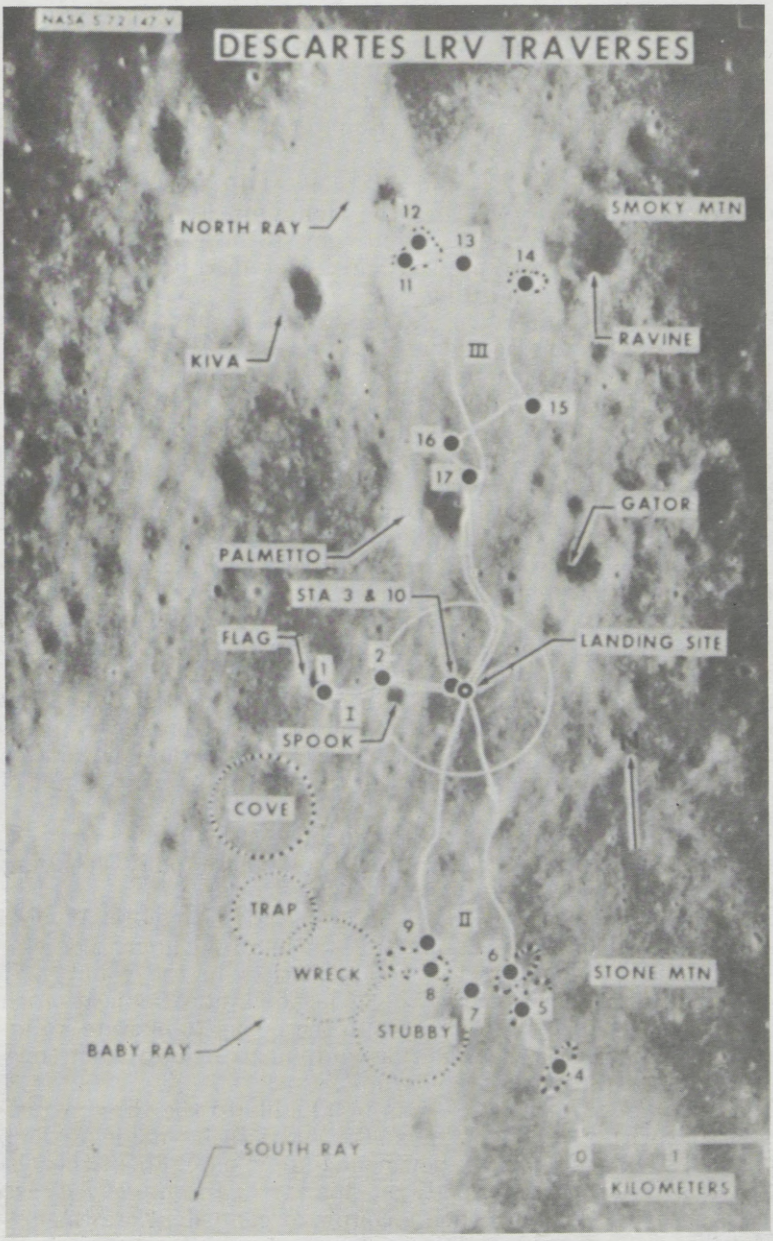

FIGURE 1

Commander MATTINGLY. I would like to start by setting the scene for the mission of Apollo 16, and why it was flown.

One of the questions I'm frequently asked, and I'm sure you probably are too, is why we are returning to the moon successively; the assertion is sometimes heard that surely by now we must have all the information necessary.

I think as we go further and further into our exploration of the moon, we'll find it more and more complex than we suspected it would ever be. In our fondest dreams, I believe we never suspected the hidden treasures that are buried underneath the lunar soil.

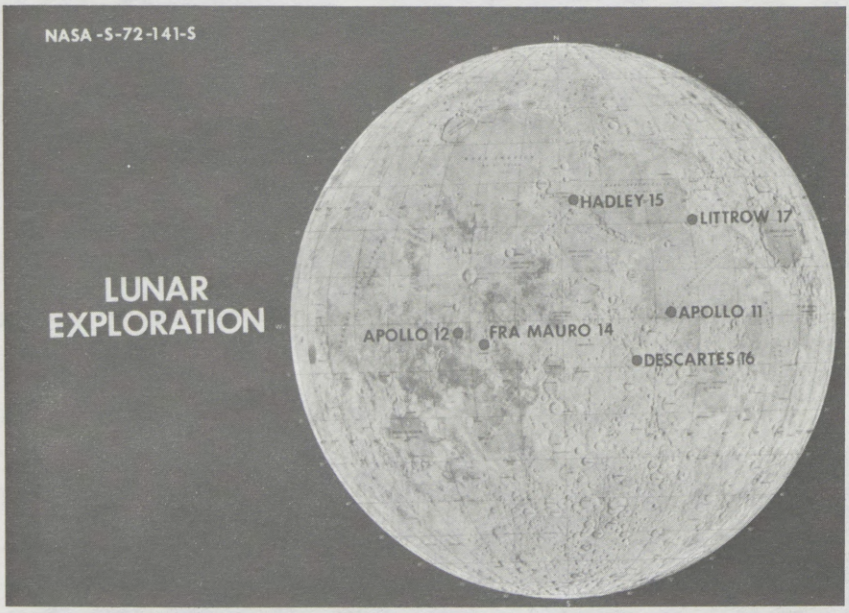

FIGURE 2

We started out making our first landing on Apollo 11 in an area that was selected to be a good place to land, in the Sea of Tranquility.

This gave us mare-type material. Mare, as you know, is the black area that you see as you look up.

The second landing was chosen to sample the western maria to determine if the material there was the same, and it turns out that the maria on the western side of the moon are indeed different in age and in composition from the maria found on the eastern side. We're still tackling the problem of explaining how these differences came to be and what their significance is.

The second thing that Apollo 12 did for us was to demonstrate, and we proceeded with the exploration, that we could land directly on the spot we had chosen. We demonstrated this conclusively by landing next to the Imbrium Basin.

Apollo 13 was intended to, and Apollo 14 did, land at the formation Fra Mauro.

One of the dominant features, when you look at the moon, is the Imbrium Basin to the north. One of the theories about the moon that

is presently a very strong one is that this Imbrium Basin was caused by a large impact. It's rather staggering to the mind to consider what that could have been and how that could affect the moon—how that would express itself on the surface of the moon.

We felt that if this were an impact event, the material would have been excavated from deep below the surface, and we did find this at Fra Maura.

Apollo 15, landed much closer to the Imbrium event, and therefore we were looking much closer into the interior of the moon, and also it gave us a chance to look at one of these strange things which we call "rilles," things that look like a stream bed, except we don't see any water.

With Apollo 16 we had a very unique opportunity to look at the moon on the front side and explore the large portions of it which are light colored. One of the significant things that we found when we'd flown around the moon the first time is that on the back side of the moon it's almost all the lighter material, which we call the "highlands."

The purpose of the Apollo 16 mission was to find out what this material is, to bring home samples, and to do a job of discovering whether the samples we collected at the site known as Descartes are indeed typical of that of the rest of the moon.

Our presentation today will help point out some of the things we have learned and to try to show what we think the area Descartes represents.

EARTH PHOTOGRAPH FROM APOLLO 16

FIGURE 3

Captain YOUNG. This photograph (fig. 3) is probably one of the best pictures ever made of the United States of America. It shows America from coast to coast except for the weather system over the Northeast. It shows as far north as the Great Lakes, Lake Superior—that's the tip of it—Lake Michigan. Florida is all open. You can see Cuba, the Bahamas, as far to the east as Puerto Rico, and the whole Yucatan Peninsula.

One thing that is significant about this type of picture is that it shows the great weather systems that cover the whole earth, our country, and the oceans. We're a long way from understanding those weather systems, but with this kind of information, we have a start. I think that our technology, growing as fast as it does, is going to give us answers to these things sooner than we expect, particularly from the data that we get from our weather satellites.

Colonel DUKE. During the early phases of mission training we received many briefings on the Descartes landing site. Primarily the geologists were interested in obtaining samples of the material at the Cayley Plains, which is the area on our landing site out to the west of the immediate landing site.

We were also interested in obtaining materials on the Descartes Mountains, which are to the west, north of the landing site and also down to the south, and extend down into the old crater, Descartes.

These types of terrain are totally different, when you view them on the photographs that we had of the area, from the other highland landing sites. Descartes was picked because of the accessibility of these two types of terrain, which can be mapped across a total of 11 percent of the front side of the moon, and we had never sampled these two types of material in the Apollo program, not directly that is.

So our traverses during our three EVA's were designed to maximize the return of the samples from these two units.

EVA EXPLORATION ON APOLLO 16

The first EVA was to go out to the west to sample, to get a wide areal distribution of the Cayley material over about 1 to 2 kilometers in radius.

EVA 2 was to traverse down to the Stone Mountain area, to climb this mountain about 500 feet above the landing site, and to sample the Descartes Mountains.

EVA 1 and EVA 2, even though we landed 6 hours late, went on schedule, although not timewise. We covered the objectives of the EVA's and, except for stop No. 7, at the Stubby Crater, we completed our traverse on EVA's 1 and 2.

EVA 3 had two objectives, which were again to sample the Cayley Plains and the ejecta from North Ray Crater, which is about a kilometer across; this crater is 4 kilometers away from the lunar module.

We managed to get to North Ray Crater on our third EVA and spent about an hour up at that crater, not nearly enough time, we felt, to do the whole job, but as much time as we were permitted.

We then returned almost directly to the lunar module, after stopping at stop No. 13.

FIGURE 4

The next slide shows the types of terrain, or types of rocks, that we were expecting to find, which were two types of volcanic rocks, as the geologists had predicted. However, the rocks that we found in our area were not the types that we were expecting. Most of the rocks that were returned are breccias that are formed in two ways: either by a very explosive volcanic eruption, or, in the case of the moon, more likely by an impact by a large meteorite which breaks up the rocks that remelt and then come together.

This scene (fig. 4) shows the Descartes stop No. 4 up in the Descartes Mountains. You can see the Rover in the distance, with myself working it. John is on the back of the Rover. John is taking the picture.

Captain YOUNG. If you have a magnifying glass, you can see the lunar module sitting off in the Cayley Plains about 2½ miles away, and we're about 800 feet above that lunar module right now.

Colonel DUKE. We feel that the rocks that were returned from both the Descartes and the Cayley will show that we do have representative samples of the total lunar highlands, and we can relate these rocks to the whole moon.

The geologists and the scientists are very pleased with the types of rocks that we brought back.

We had some crystalline rock of the type that has never been seen before in any of the Apollo samples. We also had some special sampling techniques to do.

FIGURE 5

This photograph (fig. 5) that was taken on EVA 2 shows a boulder that John was able to turn over, and we sampled the soil. It had been sheltered from the sun's rays and other cosmic ray sources, for however long that boulder had been on the lunar surface in that position. The soil probably dates to the South Ray Crater event; South Ray is a large crater to the south of our landing site.

The soil under that rock will give us a history of the solar influx of cosmic ray particles on the moon for however long that rock has been there, which they will be able to date, due to the effect of the

South Ray Crater. This will be of great value to the scientists who are interested in the radiation output from the sun.

Captain YOUNG. One sample that we took off the bottom side of that particular rille by beating on it with a hammer is very much like earth rocks, and I think the scientists are going to be surprised when they dig into that one.

My personal assessment, which is kind of hard to make in a hand specimen, is that it might have some strange looking earthlike minerals in it that people are going to be surprised to see on the moon.

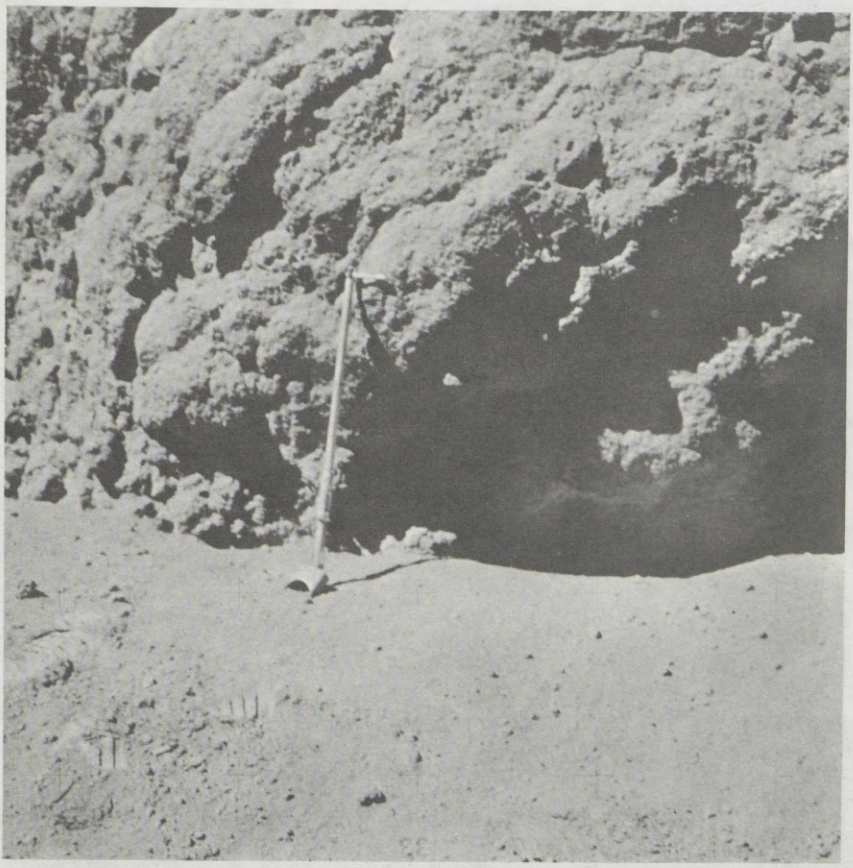

FIGURE 6

Colonel DUKE. The next slide (fig. 6) is a photograph of one of the largest rocks that we sampled during our entire EVA. There was only one larger. This was on EVA No. 3, and it's to the north of the lunar module about 4 kilometers. This rock was named Shadow Rock by the geologists. Here we got a sample of lunar soil that had been shattered from the sun's rays.

Again, to check the cosmic ray input from the sun, this rock is about 15 feet tall by about 15 or 20 feet long, and due to the lack of scale on the lunar surface, we thought it was a very small rock when

we were away from it, but we kept driving, and driving, and driving, and finally we arrived at the rock and it just towered over both of us. These samples will also be unique to the geologists, and to the geochemists and to the geophysicists.

The tube you see there is one of our sampling tubes that we used on the lunar surface. The rock had some very unique, what look like drill holes to us, in the east side of the rock. We had some close-up pictures of those. They look like somebody had been drilling for blasting, but I'm sure that isn't the case.

Ultraviolet Images of the Earth

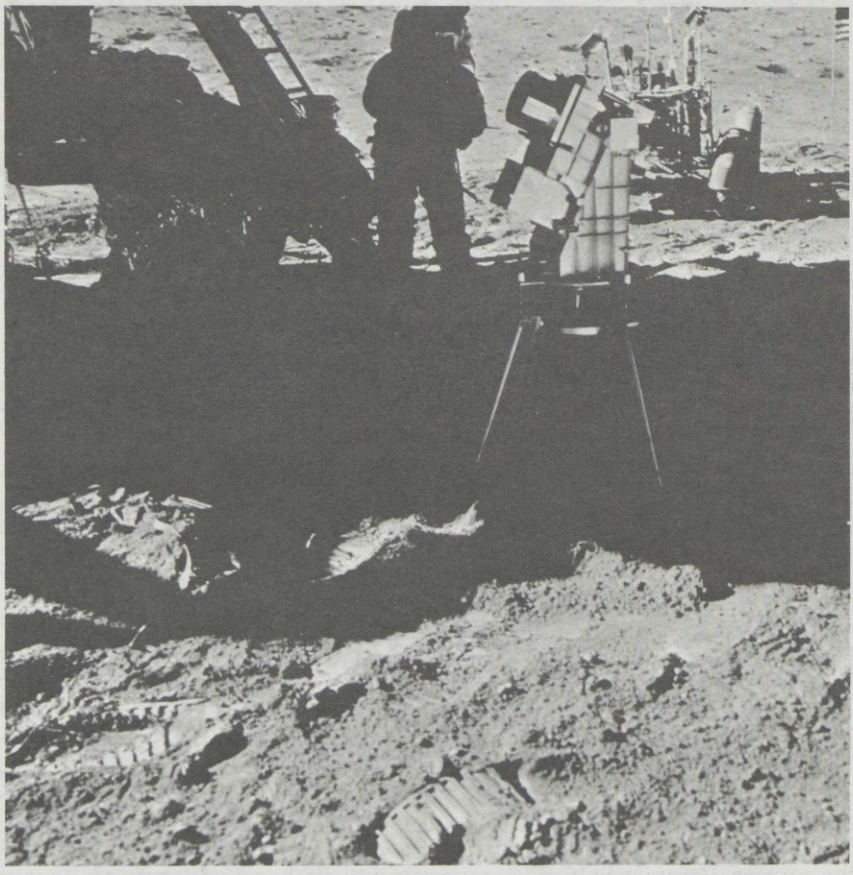

Figure 7

Commander Mattingly. The next slide (fig. 7) shows one of the most spectacularly capable, fascinating instruments that we carried on the moon. It's called a far ultraviolet camera. It weighs 58 pounds, and it is about 2½ feet tall.

The camera is so magnificent that it allows us to get pictures which it takes electronically of ultraviolet light, and the technique—it doesn't do it photographically, it causes it electronically—gives us a capability of being 20 times better than what you would expect to put on a photographic plate.

FIGURE 8

The next viewgraph (fig. 8) shows some of the data that we got from that camera. This is a photograph of our earth, and shows the intensity of ultraviolet light around it. It's been processed electronically. This picture has never before been seen by human beings, of course, and it shows the intensity of ultraviolet light around the earth.

Of real significance are these aurora belts down south. This is the earth here [indicating] and the sun is shining in from this direction, from the right. There's a real bright southern aurora belt. There's the aurora borealis belt. There's another belt here, which is an equatorial belt, and there's another one here, which nobody's ever seen before, nor had they predicted it existed. It's called a magnetosheath. It's inclined at 30° to the Equator, and I confess that neither I nor the scientists thoroughly understand this. This is going to be food for a lot of intensive study in the next 2 or 3 years.

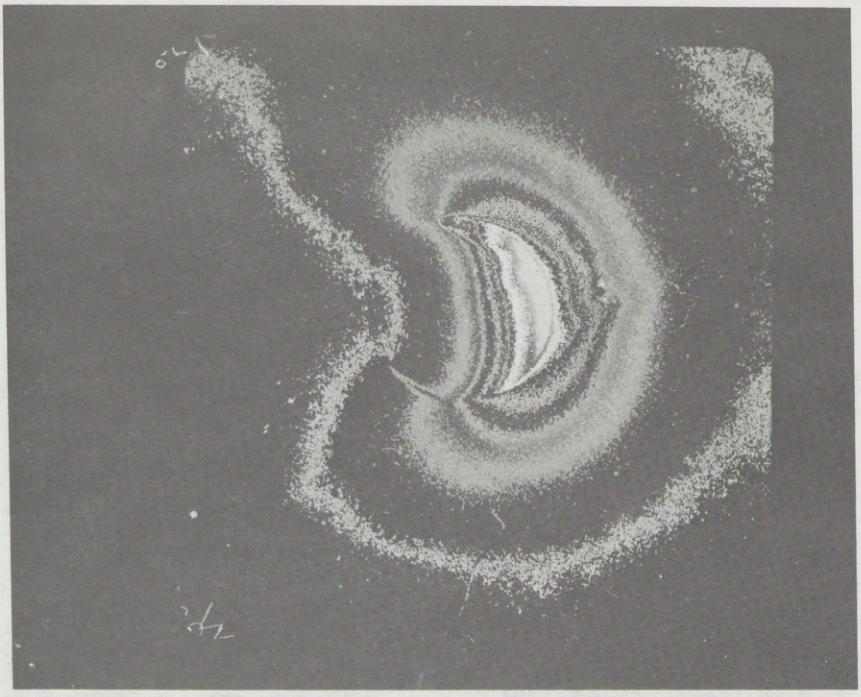

FIGURE 9

Captain YOUNG. The next viewgraph (fig. 9) is the same picture taken for a longer time duration, and it shows in color the intensity of the geocorona that protects us all, made up of that sheath, that shields us all from ultraviolet light coming from the sun and other places.

What this shows us—and it was mapped in spectrography at a distance of 100,000 miles from the earth—is that because of this sheath not much of the bright ultraviolet light of ionized hydrogen ever reaches our earth. Astronomers are quite interested in that sort of thing because it helps them to understand what our cosmos is made of.

There's a theory that 90 percent of the mass of the universe is ionized hydrogen, and this is why we can't see it when we're sitting on the earth because of this sheath that protects us from it. It goes out to 100,000 miles away, so the moon is an ideal place to put something, being 220,000 miles away, to view this kind of phenomenon, and to, in fact, explain our cosmos.

Is that important? I think it is, because I believe that the studying of stars and studying of stellar phenomena is exactly what led us down the road to hypothesizing about nuclear power. Those energy processes were there and we studied them, and that's where the ideas that substantiated nuclear power came from.

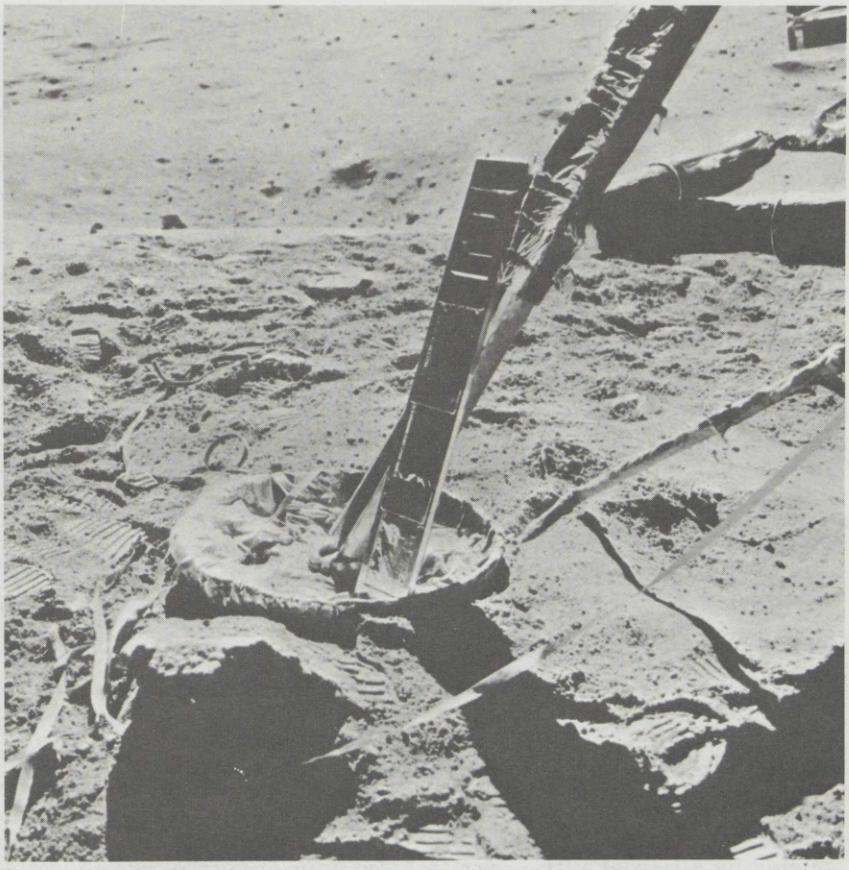

FIGURE 10

The next slide (fig. 10) is a cosmic ray experiment which we mounted on the lunar module. It has the ability to measure high energy particles of cosmic rays, and the results we got are going to receive intensive study in the next 6 months.

It was overheating—it was behind the module and facing directly into the sun—so we put it on the wide foot pad over here [indicating] to keep cool.

The high energy flux is extremely important, and there again is another phenomenon we're shielded from. When we learn to understand it, we'll learn more about the sun, what the solar wind is doing, and what the intergalactic cosmic flux is doing to us.

LUNAR PORTABLE MAGNETOMETER

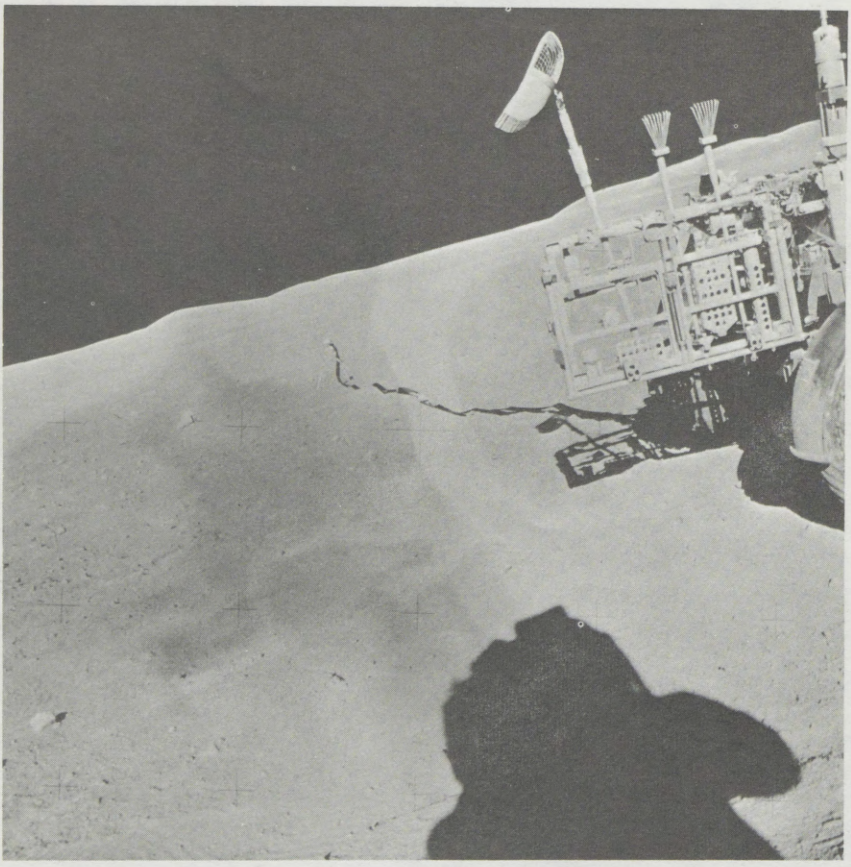

FIGURE 11

In the next slide (fig. 11) this three-legged "critter" that you can barely see out on the end of this 45-foot cable is a lunar portable magnetometer. It gave us the highest magnetic readings ever recorded on the moon, 10 times higher than had ever been recorded before, which was at least 100 times higher than anybody ever predicted in terms of lunar magnetism that the moon actually had.

What that means is that the theories for the original evolution of the moon are in flux right now, and it's a magnetic flux I guess.

FIGURE 12

The next slide (fig. 12) shows our permanently operating ALSEP Station, that should be operating up there for the next 2 years.

This little device over here is the passive seismic experiment, a very sensitive seismometer, which is able to record all the impacts on the moon, plus any internal moonquakes. Here's our central station, and this is a permanently installed lunar surface seismometer. Over in this region here you can see Charlie starting to work the active seismic experiment.

Colonel DUKE. I might add that our flight had placed the last seismic station that will be placed on the Apollo missions, and it completes the triad.

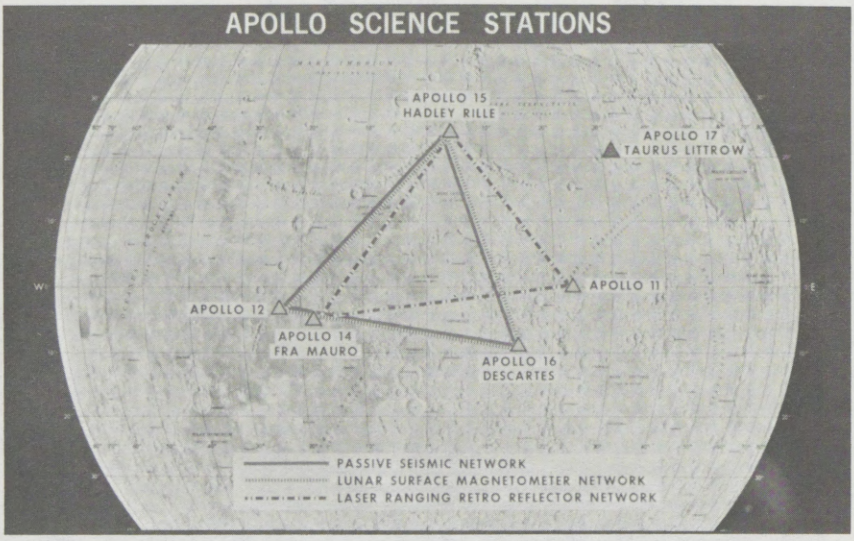

FIGURE 13

This slide (fig. 13) shows the location of the passive seismic experiment. It completed the triad for the investigator. Fortuitously, within a month after we had placed this, we had the largest seismic event ever recorded on the lunar surface, and so the seismologists are now being able to sample and predict the moon down to 600 kilometers from this seismic event.

EXPLORATION FROM LUNAR ORBIT

Commander MATTINGLY. Now we get up from the surface, where we will conduct our lunar exploration on the forest and trees principle. John and Charlie did their sampling on the surface, picked up rocks, and they collected data. This told us a great deal about the unique area of the moon that we call Descartes.

The next question that we have to answer is a larger question in context: we want to know when we sampled Descartes how much of the moon have we sampled.

Our intent was to find out the characteristics which may be similar or dissimilar to that other part of the moon, the back side, the other highland areas on the front side, and what we see in the Descartes area. We searched it in great detail.

Of course, the first impression we had was that they are indeed dissimilar. The more we searched, and the more in detail we looked at it, the more impressed we became with the idea that indeed these are very similar types of material, and that our samples of Descartes should, indeed, be representative of a large portion of the moon materials.

Several other things that occurred on the moon were in the serendipity category. We had optimized our flight line, our time line, to

try to provide the maximum amount of time for the orbiter to look at the surface of the moon. We provided a set of 10 power binoculars in hopes that by looking through a set of those eyes that had been educated in preflight training that we would see some indication of where we should turn our sensors.

The uniqueness of man's observation is his curiosity, in the fact that his eyes are far better sensors than any camera or spectrometer that we could build. This is primarily due to the dynamic range.

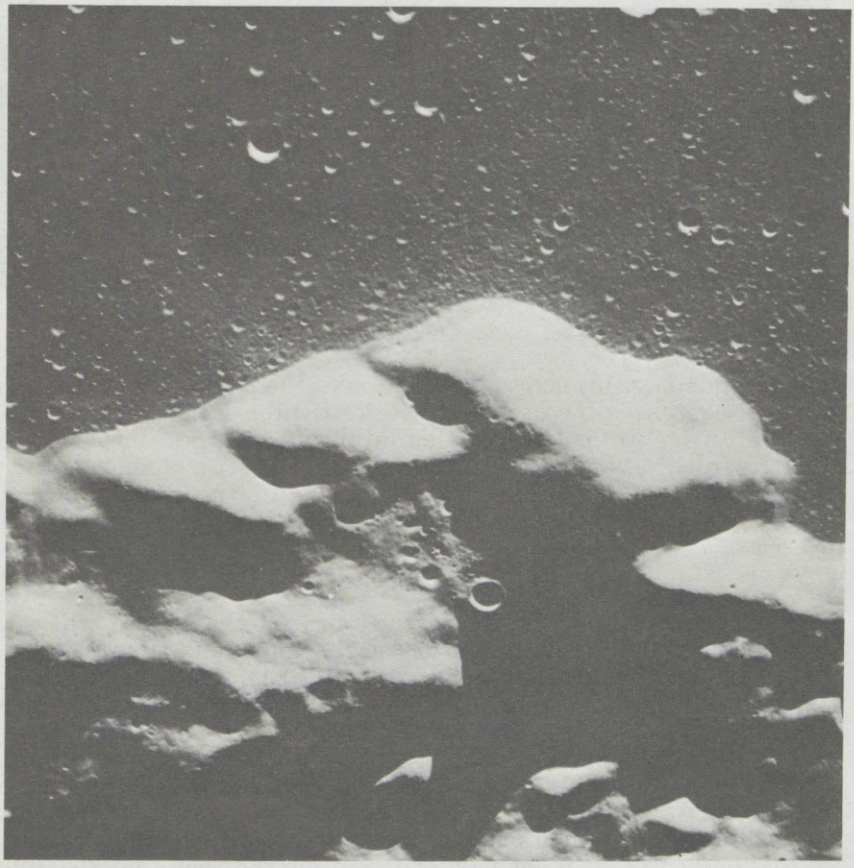

FIGURE 14

One of the things that we saw (fig. 14) that has not been reported before is this formation out in the western Mare region. If you will notice, this is a typical piece of Mare. This is a typical piece of highland material sticking through the Mare, and if you'll notice along the rim of it, you'll see what looks like a high watermark.

The significance of this is that not only is it on this particular slide, which makes a good example of it, but you found this throughout this entire region.

The first and obvious conclusion that you have to think about is the question that perhaps the surface of the Mare at one time was that much higher. It was rather frightening to me that no matter where I looked in his region—and it's a very long, large region bounded by many hundreds of kilometers on the side—I don't know the full extent of it—but, if you'll look at that and look at the height this represents, we're obviously talking about large quantities of materials that have been moving on the moon.

The question that comes up next is: Did this go away by any relation? Was it fluid in the seismic backing of the interior of the moon, or was there some other mechanism involved?

This is our first evidence of an actual movement of large masses of material, and to be able to trace its origin and its record in the walls and other features.

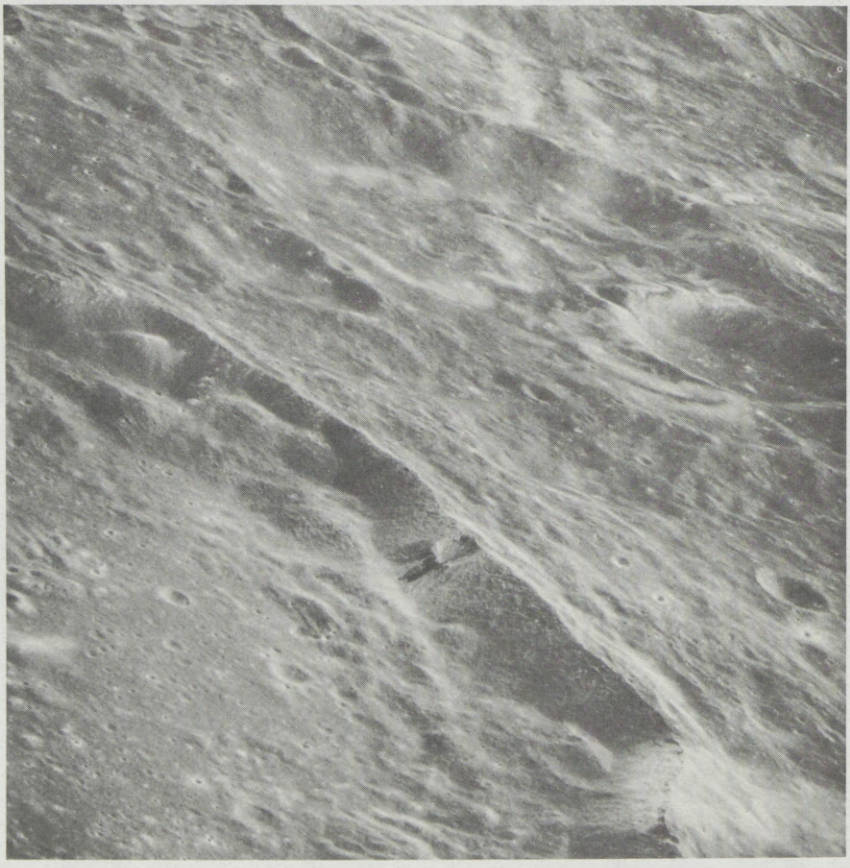

FIGURE 15

In the next viewgraph (fig. 15), another piece of serendipity, appears just on the back side of the moon, just prior to coming around at a point where we established contact with the earth. This is the one

that I find most satisfying. I happened to be looking out to the north of the ground track and saw this blob, or black piece here, which I thought was a shadow. I took a look at it and, instead of finding a shadow, what we found was a large crater.

This crater is probably some 75 kilometers in diameter. Inside of it there's a small crater, and then running out of it we found one string of black material and two strings of a dark brown material. Now, this we saw in one of the earlier rims. It became a subject for study and subsequent passes over this area.

It turns out that with eyeball instead of binoculars we were able to see a great deal more than with a set of binoculars. It shows up in this photograph (fig. 15). This is a little bit too far off in our ground track to allow good coverage with our high resolution hand camera. So that remains for the human observer to record when he sees and documents the specimens as well as possible.

These are a lot of things that do not show in this slide. Even in the enlargements, we find that the eye was able to resolve features that were not able to be recorded.

We can see structure in the walls of the crater that sloped around this sloping hole, and it appears there may be something intrusive underneath there. There's evidence of shock that go around in the patterns of the wall.

To my knowledge, this is the only place on the lunar surface where we can see evidence that material has definitely flown from one place to another, and that we can see the origin. This is unique.

Even, as in lunar geology it's frequently that we can run across lava flows of one type or another, but it's very seldom that you can find evidence of shock. I think it's indeed fortunate that we were able to see this as part of our mission.

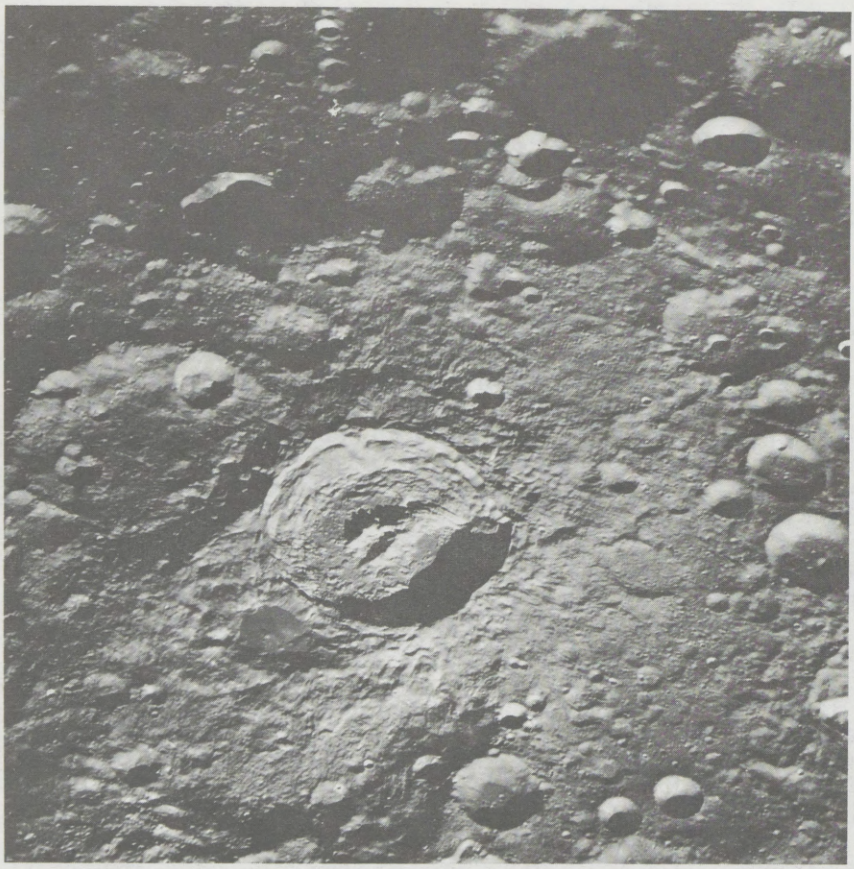

FIGURE 16

The next slide (fig. 16) is a slide that was taken post-TEI, on our way home. It shows the crater that we consider to be one of the most exciting and interesting features on the far side of the moon. It's a crater known as King. It has a unique lobster shaped central feature, and around it, the more we study it, the more we find that this looks like a lava pool. I emphasize that's what it appears to be.

The floor has, as you can see, evidence of motion. You can find dark materials which seem to be the outcrop that stick to the surface, and light materials. Some of this light material runs way out to the north and it may, in fact, be what was reported earlier by the Soviets as the Soviet Mountains. There has been no evidence that can support the size of the Soviet Mountains or their extent. However, it appears that part of the structure may run up to the north and may indeed be a mountain range.

We carried our laser altimeter, which took measurements across this area, and the first shot shows that there may indeed be some dropoff.

The Lunar Rover in Motion

Colonel Duke. We have a short film clip of what we call an experiment, or a design test ejecta for the flybacks to photograph the Rover in motion. I just mounted the Rover, took the 16-millimeter camera, and photographed John over about 2 minutes of an optical course, which was nothing but the lunar surface, and for about 2 minutes of this, we call it the Grand Prix, and this is what we would like to show you and also give you a view of how it is from riding across the lunar surface from our vantage point on the Rover in this short film clip.

There goes Barney Oldfield, the future president of the Dune Buggy Club of America.

We're about 10 kilometers an hour here over some of the roughest terrain that we traversed in the whole stay on the lunar surface.

Captain Young. I think what it's important to point out here is that the vehicle looks like it's bouncing up and down, but that terrain that we landed on is extremely rough, all of it downhill, lots of slots, lots of craters, and that vehicle just went up and down and right over them just as if they didn't exist.

What that vehicle allows us to do was to expand our traverse. We covered about 6 miles north and south, if you take the total distance north and south, of where the lunar module landed. We could never have done that on foot. It would have been physically impossible. And it carried all our tools, and all our rocks, and everything that we needed.

Colonel Duke. This vehicle has completely revolutionized lunar exploration. I think that the investment return in this was outstanding, from our point of view, because it gave us great mobility, and as John said, it allowed us to return a lot more rocks from a lot more different places.

Captain Young. This next is a shot from on board. As you can see, it's a ray from the South Ray Crater, and you can see the extent of it. We're right now about 3 miles away from the South Ray Crater, and these rocks are scattered all up and down. In addition to the rocks, there are numerous secondaries and it makes going very rough, because sometimes your best option is to avoid a big secondary and go into a smaller secondary.

Colonel Duke. The terrain to the south, as you can tell, is extremely rough. To the north it's much smoother than this, and we had quite a nice ride.

The rain that you see coming down into the photograph occasionally is the lunar dust that is spilling on top of us, due to the fact that we had a fender fall off on the left rear. We didn't think much about it at the time, but it really did spray us with dust.

Captain Young. This photograph shows a little later the EVA 3. The other was shot at EVA 2, and it shows us leaving the rim of North Ray Crater.

North Ray Crater is as big as the Meteor Crater in Arizona, fully half a mile across and that rim is probably about 20° steep. Although the rim is very steep, the block field is not nearly as bad, and right in here is where we were able to, by going downhill, pick up the maximum velocity, which was a roaring 11 miles an hour. Now, that

doesn't sound like very much, but in a lunar rover buggy in one-sixth gravity, when you try to turn the wheels you just keep going in a straight line.

Colonel DUKE. We certainly had our seat belts on during the whole time too. It's like riding in a car that's on ice, or on a slippery street. (Film clip completed.)

Captain YOUNG. This next slide repeats what Rene Descartes, the famous French mathematician and philosopher said in 1637, and I think it typifies the scientific results that we were able to bring back from our mission.

"*There is nothing so far removed from us as to be beyond our reach or so hidden that we cannot discover it.*"

As we've said, we've just been able to take a preliminary look. We haven't really started to dig into it, but some of the results are going to be so scientifically spectacular and rewarding that I can imagine that some of the things that we found, from the cameras, the telescopes that we carried for all the scientific data, the rocks that we brought back, the data that we got from the satellites that are still up there—I think it's going to revolutionize our concept of the solar system, of the moon, and quite likely of the earth.

I don't think anybody's going to the moon to find out the origin and the evolution of the moon. We're going to the moon to relate the origin and evolution of the moon to our earth, to our mineral resources here on earth, and one of these days we'll be smart enough to do just that.

I think humanity is selfish enough to realize that what we're doing on the moon is going to benefit us here on earth, or we wouldn't be be doing it.

Thank you very much. [Applause.]

Mr. TEAGUE. Are there any questions by members of the committee? Mr. Davis?

Mr. JOHN DAVIS. No questions.

Mr. TEAGUE. Mr. Mosher?

Mr. MOSHER. Mr. Chairman, I apologize for arriving late. I was over in the Oceanography Subcommittee, down in the depths of the ocean instead of up on the moon, where there also are resources that we are searching for.

I won't ask any questions, but I do want to join the rest in enthusiastically congratulating you gentlemen upon the success of the Apollo 16 venture and upon your safe return.

There were some difficult moments, I know, moments of suspense for all of us and I particularly remember, and maybe you've already mentioned this, Mr. Chairman, but I particularly remember a coincidence that one of your moments of great suspense, when you weren't sure whether the mission could continue, came as the House was approving by an overwhelming vote the authorization bill. I'm glad that we were able to give you that encouragement while you were out there exploring for us.

Mr. JOHN DAVIS. Mr. Chairman, if I may offer one comment.

I would just like to say that I'm deeply impressed by what I think will be discovered, will be found out, in your trip. I was there to see you off, and it's awfully good to see you back.

Captain YOUNG. Thank you, sir.

Mr. TEAGUE. Mr. Fuqua?

Mr. FUQUA. Thank you, Mr. Chairman.

Gentlemen, I would like to join in congratulating the very fine crew of the Apollo 16 on a very successful mission.

As Mr. Mosher mentioned, we were struggling here in the House Chamber trying to get the money for this fiscal year, and we were successful in getting the authorization passed with a rather fine vote, and also for the Space Shuttle.

I think the information that you have given us today is a further indication of the worthwhileness of this fine program. I was particularly impressed with—I don't know all the names—but the electronic photographs that you made of the earth, and the various patterns that we have around the earth, I think will be very interesting work for a number of years.

This, I think, is another indication of not only what we find about the creation of the moon, but how we can use the moon as a vantage point for studying the earth. I think this is a further indication of the tremendous benefits that we have received from space.

I want to again congratulate you for a beautiful liftoff and a great mission, and we're glad to have you back.

Mr. TEAGUE. Mr. Pelly?

Mr. PELLY. Thank you, Mr. Chairman.

I think for those of us who have been fortunate enough to have these reports ever since John Glenn first came to our committee, feel that this is the real highlight, and probably the high point of all of the risks and the efforts of the scientists.

We are most happy to have you here, and I would say that one thing that makes it a little sad for me is that our chairman has a little election out in California and apparently felt that he must be there, but his enthusiasm and inspiration through all these years of this program have meant a great deal to us, and I know if he were here he would probably feel more deeply than any of us our appreciation for what you have done.

Mr. TEAGUE. Mr. Hechler?

Mr. HECHLER. Thank you, Mr. Chairman.

I enter in the sentiments of my colleagues in the happiness and the pride we feel in these men and their work.

I think that what we've seen just in the last few minutes ought to be quite thoroughly broadcast, not only in our country but around the world, because I think especially the spectrograph pictures of the earth, which Mr. Fuqua referred to, reveal elements of the space program which relate to the sustenance and preservation, and understanding of our space relationship to earth.

I realize that we're being asked by the American taxpayers today tough questions about a lot of programs. I think once they've seen, and I hope they will see, a demonstration one way or another, they will reduce the intensity of those questions concerning the space program and they will begin to understand what I think was said quite beautifully by Frank Borman when he came back from the moon without touching, but told us what the earth looked like from that point, a tiny white ball in the middle of space with nothing holding it up, and we had to get to work down here to see that they could live together in the universe with the realities and the mistakes that we've been

making. So I thank these gentlemen for their courage, intelligence, and their commitment.

Thank you.

Mr. TEAGUE. Mr. Winn?

Mr. WINN. Thank you, Mr. Chairman.

I can only say thank you to these gentlemen because I had the pleasure of being at the blastoff, and also on the recovery ship, *Ticonderoga*, and it really sort of brought the whole thing together for me.

I've been on this committee 6 years, and I've watched every blastoff and sat in on all meetings, and have fought this thing through for that period of time. I don't believe I really realized the entire teamwork, and I know all of us have heard the teamwork talked about in practically every one of the missions.

I think, and Mr. Teague will probably agree, because he was out on the recovery ship on Apollo 15, that when you get the entire briefing the night before of the splashdown, in this case which was 9:44 in the morning, out in the middle of the Pacific, that when you see each of these young men——

I want to apologize for my voice. I told, I think it was Ken, that we were catapulted off the *Ticonderoga* and I had a very bad cold, and I don't believe my head, my ears, and my throat were ready for it, for the 4½ G's that they said that we built up there in that 200 feet. At least I haven't gotten rid of this cold yet. I think John said he caught cold out there too.

The teamwork that goes into this, all of these young men aboard the ship, on the airplanes, the pilots and the crew, the rescue ship, the photographers, the NASA officials, and everyone, really it's quite impressive to see them ready to go to work and ready to do their job.

At 6 o'clock in the morning the broadcast came over the PA system. Everybody was awake by that time. It said, "All the green shirts, the blue shirts, the yellow shirts and the red shirts," and they started naming all the different colored shirts to report for their duties. Congressman Esch from Michigan was with me, and Gerry Mossinghoff from NASA. We didn't know what color shirts to wear because we didn't really have anything to do. But we were observers.

I want to congratulate all of you for this great team effort, and I would like to point out that Captain Boyd, now Admiral Boyd—and this was quite a thrill—10 minutes before the sonic boom, gentlemen—I think you know this now—Captain Boyd was notified that he was now an admiral, up on the bridge, and you could see the enthusiasm, the man who had worked so hard to do a perfect job of catching you and then to be notified after all these years in the Navy that he'd been elevated to admiral, just added to our enthusiasm.

I would only say two things to the crew. I appreciate your offer for me to take your physical exams when you were headed for the doctor's quarters, but I'm sorry I have to bow out on that; and next time I think I can get a razor fixed up so that you can use it before you go in.

Thank you.

Mr. TEAGUE. Mr. Seiberling?

Mr. SEIBERLING. Gentlemen, I think your performance under tremendous duress was really remarkable. Perhaps it was unwarranted, but a lot of us were really very concerned when you had that trouble

with the craft, and I just wondered if you at any time felt that you were in serious danger, or if, from your vantage point, you thought it was something you could get under control.

Captain YOUNG. I don't think we were particularly concerned about being able to make the burn. We have mission rules, and we always want to keep the vehicle one failure away from not being able to come home. We were down to a case where we had a problem with the engine that we didn't understand. As it turned out, after a couple of hours investigation by the ground, it was a stable condition and operable condition, and I don't think we were concerned about the mission from then on.

Mr. SEIBERLING. Could you give us some idea as to the temperature on the surface of the moon at the time you were conducting these excursions?

Colonel DUKE. Yes, sir. The hottest, of course, was on EVA 3. As the sun climbs in the sky 1 degree every 2 hours, the temperature increases. We had temperature labels that turned black at various temperatures, and we had temperatures of over 160°.

Our gloves are designed to hold a 250° object for 10 minutes without failure, and at one point during the closeout of EVA 3 we were having a problem with a sticky experiment not coming out of its holder, and I had the holder in my hand. At that point that was the only time in the entire flight that I felt the heat through the gloves.

So we have a lot of margin in our suits, and it got quite hot out there, but you really don't feel it from inside your suit.

Captain YOUNG. The maximum elevation of the sun angle around the moon, the temperatures on the surface run between 180 and 190, and you can postulate regions, for example, in the vicinity of Counts Rock, where you're catching the sun directly on, it sort of forms a parabola where the suit would be the same temperature in excess of 200°. We were as comfortable as you ever want to be in that kind of situation, and didn't even know about it most of the time.

Mr. SEIBERLING. That's remarkable.

Gentlemen, here's your chance to educate this committee on what you think this program needs. If there is any one thing that you have learned from this trip, or have any one recommendation that you would like to make, what would that be?

IMPORTANCE OF LUNAR EXPLORATION

Colonel DUKE. Personally, I'd like to see us continue. I think that we have not even scratched the surface of understanding our moon and solar system in which we live. The history of the early solar system is all preserved on the moon. The rocks that we picked up were different from the rocks of Apollo 15, were different from the materials of all the other landing sites.

I think that with Apollo 17 that will prove to be the case also, as we have barely scratched the surface of the moon on each one of those missions. We learn more and more on each mission, and each mission builds on its own, and it's culminating in Apollo 17. I think personally that we will have an achievement in Apollo 17 that doubles ours, even though ours is said now to be the greatest.

I think with each mission we build on the experience. The redundancy of the hardware, the capability we have in the hardware is

there. Our maturity and confidence in the hardware is such that you can devote your entire effort and training almost to the scientific objectives.

Captain YOUNG. We slept like babies in the lunar module and in the command service module and, regardless of what kind of things they put in there to make you sleep, unless you have confidence that you're going to be alive when you wake up, at this point you aren't going to sleep too good, and I think our sleep record is evidence that we had great confidence in our equipment.

Mr. SEIBERLING. Do you have any recommendations?

Commander MATTINGLY. Yes, sir. I was thinking about your question.

It seems to me that we hear a lot about the technology and the contribution of technology, and we talk a great deal about the management tools that we have perfected.

Apollo is only one facet of a very large endeavor. It seems to me that probably the most important thing that Apollo or NASA has to offer this country is a body of people that are unique. I think the nucleus of their attitude, the preservation of esteem in some form, to continue doing these things has got to be one of the most significant legacies of the Apollo program.

I've watched spacecraft designed, built, tested. I've watched the training program. And throughout it all, I'm amazed at the complexity and the sophistication, and I'm impressed with the foresightedness that the engineering talent had, but by far the most significant impression I'm left with is the fact that every one of those vehicles works, and I know it's going to work because it's put together and checked out with tender loving care.

We had thousands of people who understand that although there is no one in this program that could make it go, any one of them can make it stop.

That's something that I think comes with technology and complications of our modern world, and I think that we've learned to live in this environment, and I think the Apollo program is a good demonstration of just how effectively we've done this.

Mr. SEIBERLING. What you have said I think probably has more or less obfuscations sometimes.

Thank you. I think your performance is very inspiring.

Mr. TEAGUE. Mr. Goldwater?

Mr. GOLDWATER. Thank you, Mr. Chairman.

I just want to join my colleagues in congratulating the three of you for a job well done.

You represent the results of a united effort in a very fine program, a program that's backed by thousands and thousands of people working together; you represent our final achievement, all those hours, all that teamwork, of a job well done.

I'm sort of envious myself, because you gentlemen had the opportunity to travel that great distance to the moon and look back and see what a great place the earth is, while I had to sit here with all these heavy figures which flow at us year after year. It must have been a thrill.

I can only say that you've done a fine job, and I personally am very proud to be associated with you.

Mr. TEAGUE. Mr. Bergland?

Mr. BERGLAND. Thank you very much, Mr. Chairman.

I admire your nerves of steel as I watched you the day the enormous power of the Saturn V was unleashed, and I often wondered at that instance what kind of things crossed your mind.

Colonel DUKE. I'll start again since it was my first ride.

There was no question in my mind that that beauty was on its way. At the liftoff I was saying to myself, "Well, finally we're on our way, and that all of that training is finally culminating in a liftoff."

I think that once you liftoff you can no longer be called back, and the fear of not making the flight is greater than any intrepidation about going. We want to all go so much.

So I guess those things flashed through my mind.

I'm a great one for looking out the window, once we got the window to look out of. I'm glad we didn't have one, since John always makes me look back inside when we do have a window to look out of.

But it was quite a thrill. It was, to me, like a runaway freight train. It lifted off in the first stage. It's that kind of an experience, a wonderful experience.

Mr. TEAGUE. Ken, did you think about measles when you took off?

Commander MATTINGLY. Yes, sir; and the lack of them.

The biggest fear that you have in approaching the flight is you feel they might go without you, and I have no doubt how intense that feeling can be, and just how relieved you are when the flight's up and away you go.

Captain YOUNG. I guess that was mighty kind of you to say so, but I really don't have nerves of steel. I'm basically a very cowardly human being. I don't drive down the freeway if I can avoid it because that's a dangerous way to work. As a matter of fact, there is nobody who could get me in a Saturn V unless I felt that I was doing something worthwhile for our fellow man, because I really believe in the space program, and I believe that that's what we're trying to do is something worthwhile for our fellow man, and when you can strap a basic coward like myself to one of those machines and get away with it, I reckon maybe that's what we're doing. I believe that.

Thank you.

Mr. BERGLAND. Mr. Chairman, I think this is a tremendous testimony to mortal men who will admit that they're not men without nerves, and a tribute to the scientific technology that has been accumulated in these United States, and I'm proud of them, and of this program.

Thank you.

Mr. TEAGUE. Mr. Frey?

Mr. FREY. Thank you, Mr. Chairman.

You have not only created a scientific revolution, but I think a revolution in the citrus industry, John.

First, let me say that Dr. Fletcher, George Low, Dale Myers, Rocco Petrone, and the whole NASA team, deserve special credit.

I think we can see your commitment in my district where there are a great many people working on the space program who know they may not be working in it tomorrow or by the next launch. Yet these people have increasingly done a better job, if possible, under these circumstances, and it's a tremendous credit to the entire program.

I think too, John, as you stated it, that man doesn't live by tangibles, he lives by the intangibles. You've obviously been doing this throughout the space program, and I don't think unless you've been involved with the people in the program that you can really understand what I'm talking about.

One thing I was interested in about your EVA's and the vehicle, I wonder if we have stretched it to the limit as far as both your time out in terms of distance and in terms of your physical endurance. Can we go further, can we do more on Apollo 17?

Colonel DUKE. My feeling is that we have probably a vehicle limitation. If we get the proper plan to rest and before liftoff for instance, and such as that, we're hoping for four EVA's, but our vehicles can just really not support the time, for that length of time. I personally do not feel like our schedule was overtaxing to me personally.

Mr. FREY. There's always been a limitation point, hasn't there, as to how far you can go out and walk back? Did we hit that? Did we go out as far as we possibly could?

Captain YOUNG. I think that's a good question. I've been thinking about the question considerably. We've gone out there. We've got two out of three vehicles right now, 17 being the third one, that worked like champs. I'm sort of convinced in my own mind that we were out, at least as far as our walk back capability on the mission we were just on, because of the roughness of the terrain. You can't walk up those very good in a full pressure suit.

Now, the 17 terrain is a lot flatter, until they get right up to the hill, and they don't plan to go up any of them.

It seems to me if all systems are working when you start and that vehicle has redundant power systems in it, they go to both wheels, they go to all four drives, they have double steering, and that you might be able to count on that vehicle to get you back as opposed to walking back, and therefore you might give up a walk back capability. What I mean is we've got kind of a liability, where you might not be able to go very far.

Mr. FREY. John, I was wondering about that, with the risk involved in it. I know we're just talking in ballpark figures, but were there many things, for instance, you wanted to get to that you felt would have added a great deal if you had had this capability?

Captain YOUNG. Not on our particular mission, but on the 17 mission I think there's a couple of areas where they might have on that traverses where they might consider such a thing.

Mr. FREY. Thank you, and obviously, like everybody else, I think the whole country is proud of you and what you have done, and on certain days around here it's nice to have things you can be proud of.

Captain YOUNG. On their mission, of course, they only had three EVA's and there's really a limit on how far you can go and what you can do in that time, and three EVA's back to back, in my way of thinking, unless a crewman gets plenty of rest every night, he's right up against it. That's a pretty big job.

Mr. FREY. Thank you.

Mr. TEAGUE. Gentlemen, I'd like to announce that we must break up this meeting at 11:30 as the astronauts must go over to the Speaker's office.

Mrs. John Young, would you stand?

[Applause].

Mr. TEAGUE. And Mrs. Charlie Duke?

[Applause].

Mr. TEAGUE. Commander, do you want to tell us where your wife is, or do you want me to?

Mrs. Mattingly is very busy elsewhere taking care of a young son, less than a week old.

Mr. Coughlin?

Mr. COUGHLIN. Thank you, Mr. Chairman.

I join in expressing the pride that I know all of you have in these men and this accomplishment.

I know when just having to think of your going to the top of that bird myself, my palms get sweaty, and I just marvel that you can be up there in that thing and alive. It's amazing to me what human beings working together can do, and I guess the phrase "Only in America" expresses some of the pride I feel in what you've done, and what all the people in this program have done.

Thank you.

Mr. TEAGUE. Mr. Camp?

Mr. CAMP. Thank you, Mr. Chairman.

I'm quite interested in what you might predict, or what your thinking might be, as to what you might gain next year with the Space Lab, and then following that in 2 years with the Shuttle?

Captain YOUNG. That's a very good question, and I think the things that we're going to expect to find we probably won't find. We're going to find something different than that that's going to benefit us even more.

That sounds like I'm weaving away from it a bit, but you never go on discovery missions where you don't find out something different from what you expect to find. Columbus was looking for gold when he came to America. He didn't find gold, but we got something a lot better than that.

I think the same thing can be said in space technology. It's my opinion that continued study of the moon and understanding of the processes that make up the moon, and particularly in the field of geophysics and geology, should help us to some extent in some day to know where better to look for mineral resources here on the earth.

I think that's important because we're going to need some more if we keep going like we're going and keep expanding the population, and keep increasing our energy requirements.

The data that you get from studying the stars, we don't understand those energy processes. When we understand them, we can do like we have with nuclear power and convert it to our own use. I think that day is coming. I can't guess when any of these things are going to happen, but I think we need to apply ourselves and make them happen a little sooner than they would, particularly if we're going to have these population growths like we've been having, and the technology growth.

I saw in the paper the other day that some predicted that one of these days when we run out of all our oil and gas that we use hydrogen for fuel, and they told how you could put it in a car and make it safe

for everybody. I don't today recommend hydrogen for a fuel. Of course, I wouldn't have recommended 10 years ago that anybody would make a rocketship using it either. That's what we've done.

Our program has come through the technology that allows you to keep hydrogen safely, but it's going to take some other kind of technology to figure how to keep it from getting banged up in an automobile.

The ideas are limitless as to what you can do with the technology in the things that we've been looking for.

Commander MATTINGLY. I would like to add one thought to that.

When you look back historically at our foremost aviation, I happened to be fortunate enough to have some old copies of Aero Digest magazines, and they predicted what we would be doing 25 years from the time these articles were written, and they were written by leaders in the field to try to answer the same questions. They're almost comical. We've gone so much further in so much less time. That seems to be typical of technology and the way we learn things.

I think that whatever predictions we make, or projections we try to draw, we're going to fall far short of that. Our capabilities are far greater than any of us ever expected.

Captain YOUNG. There was a fellow in 1954 who said we only need 50 airlines across the Atlantic. Today that wouldn't even handle the highjackers.

Mr. TEAGUE. Mr. Davis, do you have any questions?

Mr. MENDEL DAVIS. I want to join with the other members of the committee and congratulate and express our deep pride in these gentlemen, and also join in saying this is another first for South Carolina.

Mr. Duke, you've made us extremely proud, and of course we'll show you how proud we are the 26th of May.

Mr. Chairman, it's just been really great to be associated with a committee that has worked to see these men put America first where it should be.

Thank you, gentlemen.

Mr. TEAGUE. I would like to introduce to the audience Mr. Dorn and Mr. Gettys, who are guests of the committee this morning, and are interested in Mr. Duke.

We have to adjourn our committee, and I hope the audience will understand that we have to rush them over to the Capitol and not delay them.

Thank you very much, gentlemen.

[Applause].

(Whereupon, the committee was adjourned at 11:30 o'clock a.m.)

○