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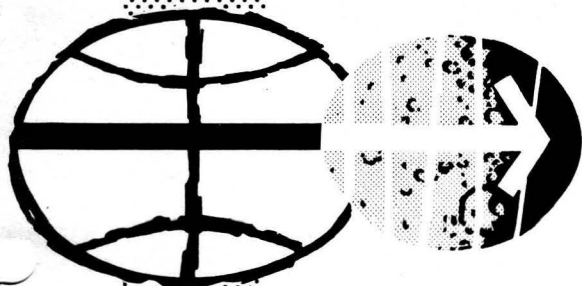
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 11 PHOTOGRAPHIC AND SCIENTIFIC DEBRIEFING

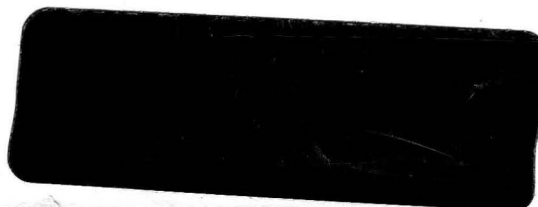
OPERATIONAL PHOTOGRAPHY
LUNAR-SURFACE PHOTOGRAPHY
GENERAL OBSERVATIONS

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PREPARED BY:
LUNAR SURFACE OPERATIONS PLANNING OFFICE
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MANNED SPACECRAFT CENTER
HOUSTON, TEXAS



FOREWORD

This is the transcription of the Apollo 11 photographic and scientific debriefings conducted at the Lunar Receiving Laboratory on August 6, 1969.

Where possible, the last names of those who asked questions were indicated at the extreme left of each page; otherwise, the word Query was used. In the transcribed text, a series of three dots (...) was used to designate garbling caused by multiple speaking or recording problems. Two dashes (- -) were used to indicate an interruption by another speaker. If a word could not be verified as valid, the phonetic equivalent was provided followed by a bracketed question mark [?].

CONTENTS

	Page
OPERATIONAL PHOTOGRAPHY	1
LUNAR-SURFACE PHOTOGRAPHY	7
GENERAL OBSERVATIONS	63

PHOTOGRAPHIC AND SCIENTIFIC DEBRIEFING

CHAIRMAN We have this session organized in three phases. The first phase will cover the operational photography; the second phase will cover the lunar-surface photography; and the third phase will cover general observations.

OPERATIONAL PHOTOGRAPHY

QUERY First, were the decals that we provided useful and valuable? Would you prefer these to a light meter, and did you always use them?

ARMSTRONG Generally, we used the decals for camera settings. Sometimes, we used intermediate settings; on frequent occasions, on pictures that we thought were important, we varied the exposure one stop each way on the theory that it was better to have a few bad pictures than to have no pictures at all.

QUERY Was this usually one stop on either side of the nominal setting on the decal?

ARMSTRONG Well, on the low-light-level photographs, we used every exposure that was available to the camera.

COLLINS

The decals were useful inside the command module as opposed to the light meter. The light meter is inconvenient, although I am sure it is much more accurate. Usually, by the time you have dug the thing out and made use of it, the view that you wanted to take a picture of is gone, so I found the decals quite useful.

ARMSTRONG

It seems as though the latitude of the film is sufficient to provide reasonable pictures that would account for differences between light-meter and decal readings. For example, we took most of the distant-planet photography for the C-EX film at 1/250th at f:11 or less. The light meter indicated that 1/250th at f:8 was a better setting, and we took some at f:8 and some at f:11. Now, it would take a laboratory analysis to tell the difference because you can't really tell the difference by just looking at those positives.

QUERY

Did you ever think it would be useful to have a light meter on the lunar surface or would it be impossible to use one?

ARMSTRONG

A light meter would be useful if it were readily available and conveniently fashioned. The kind that we have available to us now would just be a hindrance. The only practical solution would be to have it built into the camera.

ALDRIN In taking many of the pictures out the windows of the LM, we would set one of the f-stops and then take a sequence all the way around knowing that, in some cases, they would be off as we approached the cross-Sun direction, but then we would make changes. Instead of changing as we went along, we'd cover the spectrum and do the whole thing in about three or sometimes four different f-stops.

QUERY Did you ever use anything other than the 1/250th second? Did you ever cut it down to 1/125th, for example?

ARMSTRONG I did, frequently; particularly on surface photography where I wanted more depth to field, to buy a little f-stop, I went down to 1/125th and occasionally to 1/50th.

QUERY Was the RCU bracket difficult to use? Did you find it easier to handhold and point the camera to take a picture, rather than to attach and detach the camera from the RCU bracket?

ARMSTRONG Buzz did some handheld shots. I did almost all mine from the RCU mount, which I thought was a very convenient place to take pictures from.

ALDRIN I think control and consistent pointing of the camera are enhanced by the use of the RCU. One can maintain a more

ALDRIN
(CONT'D)

constant orientation of the camera. I did the first panorama without using it, because it seemed fairly natural to hold the camera with the hand grip. It surprised me a good bit because the camera is so heavy, even the lighter-weight models that we have. As we experienced in the simulations, they always appear to be very cumbersome; but I didn't really find this to be true to the same degree when using it on the lunar surface under one-sixth g. But I still feel that the RCU is an advantageous mount.

QUERY

I would be interested to know whether you remember which pictures were taken with the longer exposure, the 1/50th, and whether those showed any indications of being less sharp. In other words, could we contemplate taking a longer shutter time to have a smaller lens on future equipment?

ARMSTRONG

I'm afraid I can't identify those exposures that were done at slower speeds from memory; perhaps if I thought about it a little bit and reviewed frame by frame, I could think of some occasions where I attempted to get as much depth of field as possible. I'll think about that the next time I review them and see if I can do that.

ARMSTRONG
(CONT'D)

I wouldn't hold much hope that I would be able to do it accurately; I made no record of it at the time.

QUERY

I suppose that one could find out from microscopic examination of the film whether any pictures are alike; this would probably help you in that.

ARMSTRONG

Perhaps. I took several pictures of the plaque that was mounted on the LM skirt, and I think I slowed those down. One of them was as slow as 1/30th. This was handheld, so you might get some indication from that. Most were at 1/60th, and I think one of them was at 1/125th; but I know for certain that one of them was at 1/30th. I think it's the one with the most illumination.

LOBB

I just wanted to ask a question in regard to the use of the 16-mm camera on the crashbar or on any sort of mount on the LM. Is it a difficult thing to operate? For instance, during the ascent phase or during the jettisoning of the LM, was it difficult to have access to the camera at this time? Is this one of the reasons why it was not run at that particular time?

ARMSTRONG

The camera was not mounted on the crashbar. It was mounted on the onboard mount above the window for descent and

ARMSTRONG
(CONT'D)

ascent, and it is a little bit difficult to manipulate the controls in that particular position. I think this was somewhat a crew error in not having the films started and ready at ascent. In reviewing what took place, our checklist called for turning the camera on 2 minutes before ascent. At that time, I decided that, at 12 frames/sec, 2 minutes before ascent was too early to turn it on. I intended to turn it on about when average-g came on, at approximately 30 seconds, but I neglected to do that. So it didn't get turned on for ascent until about 1 minute afterward, shortly after the pitchover.

LOBB

Then it had nothing to do with the operation of the camera? I mean, there's nothing we can do to help you out on that?

ARMSTRONG

No. I think it has to be a different place on the checklist.

LUNAR-SURFACE PHOTOGRAPHY

QUERY Do you make use of the target-of-opportunity chart, first, when collecting photographic targets from orbit?

COLLINS No, I did not. Unfortunately, it is not the sort of situation that you have 45 minutes of interrupted time in which to take photographs. It's usually 3 minutes here and 4 minutes there, and you take whatever is out the window at the particular time when you happen to have the opportunity. So I did not use that chart for that purpose. I did use that chart to help me find out where I was, and it was useful in terms of how much time I had before I would reach the terminator, when I would be above the LM, and so forth, putting it in synchronization with my digital event timer. But I did not use it as a target chart.

QUERY There is talk about increasing the revolutions in lunar orbit after rendezvous to get additional photography on future missions. What would be the best method of indicating where the additional photography is desired?

COLLINS Our primary purpose in carrying that chart was in the event that something went wrong with the LM. For example, if we couldn't activate the LM, we would be spending a

considerable period of time in lunar orbit with nothing to do. In this situation, I think the map would be of great value; that was our primary reason for carrying it, and I suggest that it continue to be carried. I think it is a good portrayal of information; it's just that in the normal flow of events, during the LM descent, and stay on the surface and then during ascent the Command Module Pilot is busy with other things and doesn't really have leisure time to slip through the map and discover where the good craters are and then wait for them to come. As I said, you have several minutes; you can stick the lens out the window and click it several times and you get whatever happens to be down there at that time.

QUERY

This is in reference to the solar corona photography. There is a sequence of about 40 frames apparently on the magazine where it appears that you took this. Could you comment on how long after sunset you began the photography? Was the photography, once it was started, taken at any particular intervals; and, if so, what was the interval? I'd also like some comment on the exposure setting that you used.

COLLINS Well, the sunset time was in our flight plan, and I don't recall right now whether a new time was given to us, but I, at least, wasn't aware of the time we went into sunset.

QUERY How long after sunset, regardless of what the time was, did you start taking the photographs?

COLLINS I didn't know when sunset was so I can't tell you how long after sunset we started. We conversed with the ground at the time we started taking photographs, so that time is documented in the air-to-ground tapes. We don't know when sunset occurred. Sunset is not obvious unless sunlight is coming in the window. Now, when one is in PTC (as we were at the time), the Sun goes out the window and it's night. It does not matter whether one is in or out of the shadow as far as the spacecraft is concerned. The next time it's obvious that something is different is when the windows rotate into the field of view of the Sun and the Sun isn't there. The cockpit is not illuminated. So it was a surprise to us, at least to me, to discover we were in a shadow, and I wasn't thinking about being there yet. So, at that time, of course, we looked out the window to see the Moon, and

COLLINS
(CONT'D)

we saw a most spectacular sight, one that I hope we can capture on film on future flights by improving our prediction of what we'll need to get that picture. The solar corona is evident, of course; it's very bright when the horizon is at the point nearest the sun. The picture we saw was something like that, with this being far the brightest part as far as illumination was concerned. But the thing that was so striking to us and the thing we wished to capture on film and completely failed to do was not the dim-light part, which is certainly of interest, but the Moon itself, which is illuminated by earthlight — a striking three-dimensional appearance, a stark contrast to any other view of either the Earth or the planets or the Moon. It is a very spectacular sight; if it isn't of scientific interest, it's certainly of general interest. It was certainly one of the most impressive views of the many we had during the flight.

QUERY

You know where north is on that drawing?

COLLINS

Yes, I think so.

ALDRIN

Down this way.

COLLINS I would have put it about like this, and Buzz says he would have put it down something like that.

ALDRIN Right. Looking north, if this were north, I would have put the corona, with respect to viewing it, mostly down in this region.

COLLINS We were in PTC at — This is ecliptic north. I guess we differ; I would have put this as ecliptic north, but I guess Buzz would have put it down here.

QUERY From the Surveyor pictures of the sunset, one saw, in several cases, not just the corona but also a sharp bright line on the lunar horizon for some hours. For Surveyor, it was some hours but for you, a few minutes; did you ever see such a phenomenon? In addition to seeing the relation of the Sun and the corona, an unresolved sharp narrow bright line on the lunar horizon?

ALDRIN No, I didn't see that.

COLLINS I did not.

QUERY Once you started taking exposures, Neil, was there any sequence to these, like 5 seconds apart or any typical

QUERY
(CONT'D)

interval between exposures? Or were they just at random; how was this done?

ARMSTRONG

The spacecraft was rotating; actually, we got just several pictures out one window, then passed the camera to someone else who took the view as it comes by his window, and then passed it to the next man who took some pictures. It was haphazard at best, but we were really only attempting to cover the possible exposure range. Of course, with the film speed we had, it just didn't work out very well.

ALDRIN

About 2 seconds, I think, was the longest.

COLLINS

Six was the longest.

QUERY

Can you tell us the exposure time within one-half second?

COLLINS

No, I think we started with f:8 or something like that.

QUERY

About the close-up camera, we have about 17-1/2 excellent double frames of very high quality, and our business now is to try to locate them as best we can to determine where they were taken. I have a number of questions on that. First, I want to ask some questions about the operational camera to be sure that we make the correct

QUERY
(CONT'D)

future improvements. Having read what you said in the last few days in the transcripts, I understand that there were several things that you believe should be improved. Would you indicate how you would prefer the handle to be redesigned?

ARMSTRONG [Drew proposed handle using blue chalk]

QUERY That would make it easier to photograph vertically downwards but it would make it harder to lift up to photograph any steeper surfaces. Suppose you wanted to photograph a rockslide facing you; you would find that harder. Would that be a problem?

ARMSTRONG Yes, that's true.

QUERY So what do you think? Should we stick with this or should we go to the blue shape?

ARMSTRONG If we leave it the way it is, we're in danger of having someone throw it over a nearby crater.

QUERY Then you prefer a handle such as you've drawn there?

ARMSTRONG Yes.

QUERY Were you able to observe the cycling light on the handle under all conditions?

ARMSTRONG I think so.

QUERY Did you use the counter on the camera at all?

ARMSTRONG Yes, only to observe that we were, in fact, advancing the film.

QUERY You apparently made some verbal estimate of the number of pictures taken, which was much greater than that of the film used. Is that because the estimate was wrong or because something went wrong with the camera?

ARMSTRONG I suspect that we were poor estimators.

QUERY At the end of the photography, one has to recycle three times to be sure that the exposed film is all wound on the reel so it does not get exposed or cut off. Perhaps you did not have time to do that and that might account for loss of three. Could that be so?

ALDRIN Yes, I think that's possible. We were quite rushed at the time of recovering that magazine.

QUERY So, the thing to do would be to recycle while you're walking back or something like that; but, if the recycling was not done, of course, you wouldn't want to waste 30 seconds standing there waiting for the thing to

QUERY
(CONT'D)

wind up. Now, would you comment on the positions? The first few pictures show a slightly darker type of ground which, I suppose, is the material that I see on the Hasselblad pictures, as thrown out from your feet when you were walking (which makes a big band around the region which you have walked over). On the pictures, I think I recognize that material for being that slightly darker shade. Would it be true that the first few pictures that you took were indeed in such material and that later you somehow contrived to take pictures without having spoiled the ground by footprints?

ARMSTRONG

That is correct. Probably, the first four or five frames were in the area adjacent to the LM where we had disturbed the surface. After that, there were several frames that were taken in an effort to get the camera outside the disturbed area, which was rather difficult to do. Wherever you walk, you're kicking some dust ahead of you, and it's fairly awkward to try to walk one way and then bring the camera out to the side somewhere and catch a place that hasn't been disturbed. It's also quite difficult to see downward very close to your feet. It's a little bit difficult to estimate where the right area might be; but such an attempt was made. Several

ARMSTRONG
(CONT'D)

pictures were taken of the floors of small craters, one or two of which were efforts to capture this peculiar deposit (which I'm sure you've noticed by now) on certain small pieces of material; I won't call them rocks because they didn't appear to be rocks. You may want to discuss those later. At the end, several frames were taken of rock faces. These rock faces were much too large to bring samples back, and we didn't have the opportunity to chip samples from them; they were essentially large surfaces — 1- by 3-foot rocks where we attempted to get two things: first, the nature of the surface as affected by impacts or some other phenomenon and second, the textural mineralogy of the surface.

QUERY

Yes, I saw the pictures of the rocks where you took just the face. Were these taken vertically downward on the faces in each case or was there some substantial side angle involved?

ARMSTRONG

They're essentially vertical. After that, there was one frame where there was an agglomerate of material, and we attempted to get a picture of it.

QUERY

Then we come to the very important matter of how much rocket disturbance, or the amount of spray, there may have been in the whole region. The spray is the kind of rocket disturbance that you saw as you were landing; that would have almost covered the entire region that you were over. Have you any estimate of the affected region in which this spray landed, and how much of a cover would likely be left? I observed no cover before, for example, on this rock; therefore, I'm inclined to think that you were in some regions that received only limited amounts of this debris.

ARMSTRONG

The amount of material that was moved during the terminal phase of landing appeared to be a large amount based on the visibility degradation and on the amount of material that seemed to be going out. However, after touchdown, I think we were both surprised at how little the apparent topography had changed. As you could, no doubt, see from the photographs taken underneath the LM, there was no crater. The surface immediately underneath the engine bell had a singed appearance. There was some erosion of the surface, indicated by a sculpturing effect, radially outward from the engine. This could be observed from the cockpit. It was immediately close to the surface,

ARMSTRONG
(CONT'D)

but not beyond the landing gear. Within the ability of the eye to discern, there was no visual evidence that material was deposited anywhere on top of the surrounding surface.

QUERY

My next question concerns the splashes which you photographed very well and evidently must have seen because you made a particular effort to photograph them. These were the splashes that look like droplets of liquid having congealed as little bumps on the ground.

ARMSTRONG

These are very interesting — somethings.

QUERY

Did you see many more of those? Did you photograph just a few, or did you photograph all that you saw? What was the distribution of these objects?

ARMSTRONG

I observed this phenomenon in six or eight places. It was always in the same type of places; namely, the very bottom of small craters. They were collected together; they were not, in general, single pieces. They were combinations of three, five, or maybe ten of these type objects in the bottoms of craters. In larger craters, I never observed them. When I saw the picture, it was a great surprise to me because that isn't what

ARMSTRONG
(CONT'D)

I would have guessed based on visual observation. They looked like pieces from the size of a dime up to something 2 or 3 inches in size. They looked like solder — a big ball of solder that had hit the ground in an semimolten state and splattered out flat on the bottom, then rounded up at the corners with irregular surfaces and frozen. These had a metallic luster. I think the picture shows that there is, in fact, a golden color. I didn't observe that at the time; they were metallic and had some multicolored reflections. I looked at a number of other craters of the same size where these were not in evidence. Not every crater of the 3-foot-diameter size had these. Most of the craters we looked at had raised rims. In every case where these objects were observed, they were in small raised-rim craters.

QUERY

Is there any question of the objects being related to the flame of the rocket? There's some thought that these are very young features because they would not survive in as glossy a state in the case of micro-meteoroid impact. Therefore, because these are so recent, the question has been raised as to whether these may be something that the rocket exhaust caused. Is it conceivable to you that this is material liquefied by

the flame and deposited in the craters or does the position of the objects completely deny that possibility?

ARMSTRONG I can't answer that question, but I can - -

QUERY How far from the LM were those pictures taken?

ARMSTRONG The track of the LM as we approached the landing was actually lateral. We had some lateral velocity before touchdown, so the path over the ground was probably something like this where the exhaust swept the surface. I observed these particular types of craters — something like that. This particular picture was taken at this location.

QUERY Are there any splash marks of liquefied drops or rocks near the rocket bell?

ARMSTRONG No, there was nothing close to the LM.

QUERY So that would tend to argue against the splashes being anything produced by the rocket?

ARMSTRONG It is not impossible, but it seems unlikely based on this distribution.

QUERY In that case, it is a very fascinating observation. The splash marks cover, I think you saw personally in

QUERY
(CONT'D)

this case, perhaps a quarter or half an inch. You said you saw some appreciably bigger ones in other places?

ARMSTRONG

Yes. In some cases, it looked like a handful of these whatever they are.

QUERY

Were any collected?

ARMSTRONG

No, I really meant to. I really meant to get back over there. As you see, none was noted in this area out here; and, at the time, I was rushing around at the end trying to get some samples. I looked in this area, but I didn't see any. The documented sample collection was all done out in this area, away from the rocket exhaust, purposely. I didn't have the opportunity to come back into this area and search for one.

QUERY

I'm sure that there may be some such object in the samples. It is interesting now that we know what they looked like on the surface from the cameras. Now that you've drawn this map, can you indicate the path used while you were doing the close-up photography? You were on a sort of circuit, weren't you?

ARMSTRONG

Yes, I was. The first photographs were taken in the disturbed area; then, I attempted to take several in

ARMSTRONG
(CONT'D)

this undisturbed area. I carried the camera to several places out in here, left it there, and then returned to it. I took it all the way back to the crater, which is several hundred feet away. I don't recall taking any photographs in the vicinity of the 80-foot-diameter crater. The photographs of the rock surfaces were in this area. There were two different rocks in close proximity here, both with a weathered appearance. The big one, 1 by 3 feet, was immersed in the surface, but the top was exposed on a level with the surrounding area.

QUERY

Can you judge how hard that rock was?

ARMSTRONG

It was like hard basalt.

QUERY

You took several pictures of small craters in which the bottoms of the craters were visible, some of which had these splashes in them and others of which were characterized by having a few larger fragments lying centrifugally in the bottom. Can we be sure that those fragments were lying there initially or were they objects that you kicked down there while walking?

ARMSTRONG

No, we did not kick them there. Definitely not; there is no question about that. I could see them, for

ARMSTRONG
(CONT'D)

example, 15 to 20 feet away before I got them in some instances.

QUERY

I see; that's very good. I just wanted to be sure that I don't explain something in terms of erosion, if it was possibly a manned erosion.

ARMSTRONG

These lighter-colored spots that we're talking about did not seem to be much of a surface feature; they seemed to penetrate into the rock or material.

QUERY

Yes, the light-colored spots certainly look like enclosures in the materials. It's interesting to note that they didn't crater-impact into them; they look just the same when they are in the light as when they are on the dark side.

ARMSTRONG

It could be the same type of material, sort of a weathering phenomenon.

ALDRIN

An even distribution.

QUERY

That's a very good judgment; that's exactly what they exhibit. Did you notice any distribution of this splash material in the little crater? In other words, was it directed to one side or the other?

ARMSTRONG It's all in the dead bottom. If you have a very round crater with a very round bottom, the distribution was right in the middle.

QUERY I think you have already covered the point that they did not appear on the surface or on any positive feature; they were only in the bottom of the crater.

ARMSTRONG The only place we saw it was in the bottom of the crater.

QUERY Were you standing on the rim of that large crater that you went back to when you took the picture of the LM?

ARMSTRONG No.

QUERY You were down from the edge of the rim?

ARMSTRONG It's far back here.

QUERY Neil, we calculate the crater to be about 217 feet.

ARMSTRONG I was going to say approximately 200 feet. This will have to change scale here. As I remember, it's a crater something like this, with this dimension being 80 feet; this dimension appears to be 10 or 12 feet. The rim of this crater would be perhaps 4 feet above

ARMSTRONG
(CONT'D)

the surrounding area. The crater rim was high enough to obscure the interior as I approached. The rim was about eye level, and I couldn't see what was in the crater until I climbed the rim and looked down. From the rim, I took those four or five photographs that showed the rocks and the bog. I haven't looked at the photographs carefully, but the rock in the photograph didn't seem to be large. My impression was that the rocks were 2, 3, or 4 feet. I put the stereo camera on the rim and took photographs across the crater. However, it was not practical to shoot back from some locations to photograph something for scale and position. The trip was too long and I needed to return.

QUERY

Do you think that was the last crater you flew over on the way down?

ARMSTRONG

In the descent-camera 16-mm footage, you can see this crater. If you study the crater, you will see it has a saddleback-type rim; it's not a perfectly symmetrical rim. In the 16-mm footage, you can also see the spot where I stood when I took the photographs.

QUERY

Between sextant sightings while looking for the LM, do you think it would have been possible to do long focal-length photography?

COLLINS I don't know. Sighting the LM could take only one pass if you knew where to look or it could take many passes if you didn't know where to look. Do you mean to hook the camera onto the sextant?

QUERY No. When you couldn't find them by looking through the sextant, could you have taken a 250-mm photograph of the area?

COLLINS The two are incompatible. The attitude required to point the optics at the ground does not offer a window view of the ground through which you could take photographs. Therefore, you must decide, before passing over the LM, whether you will devote that particular pass to viewing through the optics, to photographing through the optics if you have the necessary equipment, or to using the 250-mm lens.

ARMSTRONG I think probably that our views before the flight were like many of your views; if you want to do something, you do it. However, it's a great cost of time and fuel to point the windows the way you'd like to have them pointed. You're playing with your fuel budget with which you must be very cautious at that phase. It's

ARMSTRONG
(CONT'D)

frustrating, you can't do all the things you'd like to do or look all the ways you'd like to look.

COLLINS

I think that the time to do photography is after the LM has returned and has been jettisoned from the command module. The main reason for retaining all the fuel is to assure adequate fuel for contingency situations where the command module must rescue the LM during the rendezvous sequence. However, after the rendezvous has taken place, you have a great amount of fuel; in addition, the inertia of the command module is reduced by the LM removal. Then, you are willing and able to expend the fuel required to do photography.

QUERY

It looks like there's a strip of 70-mm photography taken with the intervalometer that was high oblique looking at the forward horizon. Was that taken for a specific purpose or was that taken in lieu of the vertical stereo photography?

COLLINS

No. My plan was to carry as much film as I could and to expose it on a noninterference basis. Whenever I had the time, set the bracket up and let the camera shoot out the right-hand window. Then I realized it might photograph black sky vertically down, obliquely,

COLLINS
(CONT'D)

or anything. It just happened that those intervalometer pictures were exposed during the time when I had reason to be going around in a local-horizontal attitude-hold mode. It was not my intent to get a sequence of the horizon, nor was it my intent to go through the formality, at that time, of stereo overlapping vertically or obliquely. It was just that I had time to turn the intervalometer on and let it run, and I was just going to take pictures every 20 seconds regardless of which way the camera was pointed. It actually takes less time to expose a thousand pictures than to expose a hundred.

QUERY

How difficult was the use of the 250-mm lens, and is there room, in that situation, for the 500 lens?

COLLINS

I think you can use a 500 lens. I think the 500 lens is going to require more planning, because the limit of acceptable pointing angles is reduced. You have to do more planning to align the window normal to the target, so you can maneuver around behind it and get everything aligned. You could do it in PTC or by sticking it out the window and clicking it while whizzing by the target. As to the image-motion-compensation aspects, I don't know. My impression is that, with

COLLINS
(CONT'D)

the 250-mm lens, you can compensate for image motion by tracking the target by hand. I don't know how satisfactory this solution is. The resolution that you get by using that system is acceptable. Whether that's true for the 500, I don't know. If it were not satisfactory to handhold it, then you introduce problems. Anytime you get a focal-length lens that requires a system other than handholding, you have problems because you have to go into fancy control modes. You are also a victim of the design of the spacecraft stabilization system with its certain deadbands and its limit cycles back and forth across these deadbands at various rates, depending on how the switches are configured. If you can handhold it, the 500 would be acceptable.

QUERY

You could see well enough around the margin of the camera to locate a target on the ground to swing to?

COLLINS

The little ring sight that we attached to the top of the camera is very useful with the 250-mm lens; it would be even more useful with the 500. I think it would be an acceptable pointing device. The geometry works against you. You'd have to be sure that there was enough clear area to manipulate the camera behind

COLLINS
(CONT'D)

the window; you'd probably have to do extra attitude preplanning; therefore, you had better be configured in this attitude in advance.

QUERY

If you had had some high-speed film onboard, do you think you would have had the time and ability on the spacecraft to get photographs of the moonshine and earthshine? Would it have been interesting pictures?

COLLINS

Yes, I think that would be worthwhile. If you had high-speed film, you might also take some good pictures of the solar corona, although that is a function of the individual trajectory. Some trajectories going to the Moon will follow the shadows and others will not, depending on inclination. You would have to look at that individually, but I think, in general, it would be worthwhile to carry high-speed film and to take earthshine or other available things.

ALDRIN

In these missions, you always have two ways to go. One is the completely nominal mission, and certain restrictions apply; then, there are various alternate missions where the name of the game is changed considerably. As I said previously, we carried that map and extra film partially in case we couldn't separate the LM, for example, and we

ALDRIN
(CONT'D)

would be going around for a couple of days in lunar orbit with no surface activities to do. In that case, we wanted to have a little extra equipment on board for taking photographs.

QUERY

Then, for the nominal mission, when you're in the command module - while they're on the surface, there probably would be time to do astronomical tasks such as trying to photograph the gegenschein or zodiacal light?

COLLINS

Yes, I think that's true.

ALDRIN

We've found that a lot of these experiments or additional photographic tasks which are of a specialized nature, require a tremendous amount of preplanning. There is the opportunity to do this, and, in many cases, there is the time, but it does take a lot of preplanning; thus, we feel that many of these activities have to be treated almost like a separate experiment.

QUERY

In that case, would you prefer to have a camera loaded in advance with high-speed film, rather than having to reload a camera for a specific case?

COLLINS

I don't think changing the film is so large a task that it would require that. Maybe you're suggesting an

COLLINS
(CONT'D)

additional camera; I wouldn't think that that would be necessary either.

QUERY

Were you dark-adapted at any time so that you could see the gegenschein or zodiacal light?

COLLINS

I think it's best we be dark-adaptable.

QUERY

Did you have a number of cockpit lights on all the time so that probably you were not very dark-adapted, is that it?

COLLINS

We had to have enough lights on to see the camera setting for operation.

QUERY

But did you consciously observe the gegenschein?

COLLINS

No, I didn't see the gegenschein.

ALDRIN

Neither did I.

HOLT

I did not observe the gnomon in any of the pictures; did you ever unstow the gnomon and use it?

ARMSTRONG

We had operational problems.

ALDRIN

No, that was to be part of the more complete documented sample, and we didn't get to that.

QUERY Anders suggested that a way to get time hacks on your photography is to lean against the camera so that the intervalometer picks up when the camera shutter clicks; it picks up on your heart sensor. Were you aware of this, and did you try it?

COLLINS No, I didn't have an occasion to time-correlated those exposures in that fashion. The intervalometer pictures taken were absolutely on a noninterference basis, and I thought that it was better to be shooting out the window even if it were only taking pictures of black sky than to not be trying at all.

HOLT Could you compare the color that you observed with your eye to the color that shows on the pictures? Any subtle color differences?

COLLINS Are you referring to the pictures taken from orbit?

HOLT Both orbit and surface.

COLLINS On viewing the lunar surface from orbit, it was my impression that color depended upon which window you were looking through as to the exact tint that you would see. Even out window number 5, when looking at different angles through it, I would get a different colored

COLLINS
(CONT'D)

texture; and, I believe, upon later examining this window there seemed to be a reddish or brownish tinge to the outer portion of the window. I'm not sure how much reentry degradation occurred. I think it's very difficult to separate the effects that might be seen because of window interference from the true color indications. I think we all agreed that there was some brownish tinge to the surface, viewing the surface through a combination of all the different windows. In comparing the film colors, I think the 16-mm color is closer to the color we actually saw with the naked eye; the 70-mm color is next.

UNDERWOOD

Did you use those series of photographs that we gave you that ran from Borman "slate" to Young "brown"? Did you check any of them as to what you thought you saw?

COLLINS

Yes. It looked somewhere in between the two.

ALDRIN

The print is fouled up.

ARMSTRONG

Yes, we thought you'd given us two extremes. The color is a function of the Sun angle. At the higher Sun angles, the color is toward the brown end of the spectrum; at the shallow Sun angles, it's more towards the slate-gray end; and somewhere in between, you can toss a coin and find

ARMSTRONG
(CONT'D)

yourself absolutely in the middle of the two extremes
that you provided us with.

O'BRYANT

Could you tell us why the view of the lunar surface during
earthshine was so spectacular?

ALDRIN

I don't know that we used the word "spectacular". We were
asked to comment on the impressions that we got in the
region of Aristarchus on the second revolution. I think
we all agreed that there was a considerably lighter region
in the vicinity where we calculated that the crater was.
I think Neil mentioned, at one time, a phosphorescence.
We had the impression that there could have been some
luminescence from that area.

O'BRYANT

But no color change?

ALDRIN

Spectacular earthshine.

QUERY

Was there just a difference in brightness or a difference
in color?

ALDRIN

It was very difficult to discern any color in earthshine.
There was a difference in intensity, perhaps in brightness,
also.

QUERY Now that Neil is back, he's the one that made the statement earlier this morning that the view of the surface in the earthshine was very spectacular; maybe he can comment on that now.

ARMSTRONG Well, I think you're referring to when the surface was illuminated by the Sun from behind, and the earthshine was on it; this was before we reached lunar orbit.

QUERY Yes.

ARMSTRONG We all commented on the accentuated three-dimensional aspects of that particular view, as opposed to, probably, any other views that we had seen. I think the only other accentuated three-dimensional scenes that we observed were those oblique views in the terminator area during lunar orbit, where you have marked contrast in addition to the irregular topography that you see in an oblique in the highlands area of the Moon. But this particular view, where we saw the front side of the Moon illuminated by earthlight with a solar corona in the background, was one in which a lot of detail could be seen — a good bit more detail from that view than later views when we were in lunar orbit. I think the reason we could see such detail

ARMSTRONG
(CONT'D)

is that we had all the lights out in the cockpit in an attempt to have some photographic success, therefore, we had a long time to adapt our eyes to the situation. So, we had good night adaption or adaption to the illumination level that we were observing, and that was a situation that we never really enjoyed in lunar orbit.

COLLINS

Also, remember that this was the first time we had seen the Moon in anything less than 200 and some thousand miles, and now we were probably 5 percent of that distance away. It was spectacular because it was so close, and it was our first glimpse of it.

ARMSTRONG

We could see the full Moon, and it was roughly the size of the circular hatch window when your eye was approximately 18 inches from it; so, as you got a little bit closer, 90 percent of your view was full Moon, or 95 percent. That's pretty impressive.

WEERY

In Aristarchus, with the vision that you had, did you think that there was some extra light other than what might be accounted for by ray patterns on the surface?

ARMSTRONG

Let me finish this other picture with the bad sketch.

QUERY The rays show particularly bright when the illumination source is just behind you. That was the situation I believe you were in; the Earth was just behind you.

ARMSTRONG Yes. Now, I don't recall the altitude, 100 miles or 120 miles or some altitude. You're looking to the far north horizon, something like this, at 300 or 400 miles away. My impression was that, in earthlight, on other areas of the Moon we could only see crater rims and a few other things. But in this general area, there was a generally higher level of illumination. Now we're looking north. The illumination level was not sufficient for me to be able to identify just exactly where I was looking. There was an area with a generally higher level of illumination than other areas. I said on the tape that it looked fluorescent, but I'd like to withdraw that comment. I don't mean to imply that it looked like it was self-illuminated. I got the impression it was reflected light. The brightest spot, by far, was in this area, on the inner rim of this distant crater. Now, I can't confirm that it was Aristarchus.

QUERY What you said makes very good sense, though, that it's very much what would be expected from the ray or from the higher albedo in the vicinity.

ARMSTRONG

So, that was significantly brighter than other places.

We thought about zero phase point from earthlight and various things and tried to piece together the story; but, in retrospect, it didn't all add up completely in my mind. The bright spots in these areas did not seem to be particularly dependent on what the local slope was or on things of that nature, and this was generally a brighter area throughout. Sometimes, there were significant differences in slopes; but in many cases, there were fields and high-land areas that had obvious slopes to them, yet we could not correlate these slopes with the brightness. At least, I couldn't.

NEWMAN

On the coronal picture which you saw, which has a good three-dimensional clarity and which shows a spectacular ... difficult to photograph, but was there any clear sense of structure in it, like streamers, balls, tense sources of light, or color variations?

ARMSTRONG

No, I didn't observe any phenomena like that. It's more like zodiacal light than anything else I have seen, except that it was considerably brighter. But, the same kind of change in illuminosity with radius was evident as you would see with observation of zodiacal light, even more like the long time photographs of zodiacal light. It

ARMSTRONG
(CONT'D)

was more like that than where the light and the light variations had been accentuated with a long time exposure. It was that kind of photograph, in other words.

RHODES

Can you estimate the largest angle on the lunar surface at which you saw this coronal — zodiacal light?

ARMSTRONG

Which dimension now, this one?

RHODES

Yes, the radial dimension in particular.

ARMSTRONG

I thought I made a comment on the air-to-ground at the time, and gave some fraction of a radius; I don't remember what I said. I'm sure that my observation at the time was better than my recollection, but this was considerably less than the radius.

RHODES

In the other direction, the wings — about a diameter or so — of the Moon ...?

ARMSTRONG

It's not a lunar diameter. As you know, like a zodiacal light, this becomes less and less, so that it is not a sharp line; it just fades out, and depending upon the point where one picks that line, the corona will come out to be one lunar diameter, or if you're looking very closely at the illumination, two lunar diameters, or maybe three.

QUERY Going back to the lunar surface, I wanted to ask two questions. Did you see any texture as you walked up onto the side of the big crater, some Moon-like texture; and did you try to photograph it, or was nothing like this visible?

ARMSTRONG Are you talking about inside the crater or the crater walls?

QUERY No, I mean on the external rim.

ARMSTRONG On the external rim, I was looking for the kinds of things that would relate to something that I might have observed here — or in craters on Earth, and I really didn't see anything. In general, this crater, like a number of others, had quite a well-rounded rim; there was no sharp edge here. But, it had a saddleback which I haven't drawn here very well, but these slopes were all relatively uniform, and all were of fine material. There were some rocks here and there, but the difference between the rocks in this kind of rim is that the percentage of rocks in the rim was not grossly different from the percentage of rocks in the local countryside. That's not true in many of the smaller craters; in many of the smaller craters (the 3- and 5-foot-diameter craters), there weren't any rock in the rims; there was fine material in the rims.

ARMSTRONG
(CONT'D)

But in this one, that wasn't true. There were rocks in the rims; there were rocks lying in various places and exposed to varying degrees. There was no evidence — I was hoping that when I got there and looked inside the crater, that we were going to see some bedrock at the bottom, that we were going to see something that really made some kind of story. There were sizeable rocks in the bottom of the crater; but there wasn't anything on the inside or on the outside walls that were related, as we had seen material from the inside that we could definitely identify with material on the outside. I couldn't do that.

QUERY

No texture in the fine-grained material on the rim that you walked over upon to the big crater?

ARMSTRONG

None that was anything significantly different from the surrounding area.

QUERY

On some of the closeup pictures, one may see this peculiar phantom that we've referred to as "elephant hide" or "tree bark". On large-scale pictures, if you recall what we've seen on large-scale pictures of slopes, you know in Orbiter pictures, one may see this sort of characteristic pattern on the steeper slopes. An interesting

QUERY
(CONT'D)

observation is that we see exactly that same appearance but on a minute scale, in the closeup photography. Did you see this tree-bark pattern in the smaller craters? Was it common, or was I just lucky in catching some of these features on these pictures?

ARMSTRONG

I don't recall the pattern; maybe if I looked carefully at some photographs I might see something that I - -

QUERY

But it didn't strike you at the time?

ARMSTRONG

No, it didn't.

QUERY

I have a specific question for Mike about our future orbital science. Do you feel that while the surface missions is going on, you're essentially underprogramed, so that we could plan for various small science tasks for the orbital astronaut to do, as long as we didn't eat into his fuel budget. Is that essentially correct?

COLLINS

I think it would be much better to program those for the time after the LM has returned from the surface and successfully rendezvoused, for a number of reasons; fuel is one, time is one, and having two other people on board to help you is another. I think I would approach it from that viewpoint. The Command Module Pilot is fairly busy

COLLINS
(CONT'D)

with the necessary monitoring of the various systems, plus having various tasks in conjunction with the rendezvous and during the descent; and, of course, during the ascent, he's completely worried about the rendezvous and his time is consumed by those tasks during that part of the mission. During the time when the LM is on the surface, it was my experience that, at least for our particular flight plan, I had very little time to devote to anything except those essential housekeeping, communications, and other supportive chores. I would say that the opportunity for additional testing presents itself after the rendezvous.

QUERY

I have some questions on the visibility of the lunar surface. How well does the 16-mm film, taken during descent, simulate the view that you saw, especially as to the downrange portion which comes through somewhat washed out on the film?

ALDRIN

First, I think I'll say the view is not the same. The 16-mm camera location is high in the window and pointed down at an acute angle to the window pane. It is looking closer along the x-axis of the spacecraft (that is, the engine axis of the spacecraft), looking down along the line of the engine, much more closely than the crewmembers look. Their general field of view is at a considerable

ALDRIN
(CONT'D)

angle to the camera angle; so, they are, in effect, in the final phases of descent, looking much more out toward the horizon than the camera is viewing. Is that the kind of answer you are looking for to the first part of the question?

QUERY

Yes, I'm concerned with the washout and if that caused any problem in examining the surface, say at 1000 or 2000 feet?

ALDRIN

The second part of the question has to do with what you call washout, and I assume you mean the zero phase point where your eye is co-linear with the sun rays.

QUERY

That's right.

ALDRIN

Is that what you mean? The film exaggerates that from my point of view. The films look very washed out at the zero phase point and accentuated, as compared with the eye's view. We could see into the zero phase point surprisingly well to make out craters, rocks, and so forth. In some cases, the lighting is such that it is even a little difficult to point out where the zero phase point is; in other cases, where you have a shadow, you can look right at that and then pick out the area where the zero phase washout occurs. Generally, you'll have a

ALDRIN
(CONT'D)

shadow of the spacecraft; or if you're out walking around on the surface, there will be a shadow of your head. In general, as the eye sees that area, it's far less obvious than I might have guessed. I think, from an operational point of view, we can have trajectories which are less dependent on margins away from zero phase point.

QUERY

One more question, which is concerned with the dust problem. Can you make any estimates of how badly visibility was degraded during the last few feet of descent? Could you not see the surface at all through the dust, or could you see it reasonably well?

ARMSTRONG

It's very much like looking through a thin ground fog. The visibility is probably degraded about 75 percent or something like that. In general, 75-percent visibility degradation doesn't really affect the ability to do a landing task very much, compared to a ground fog or something like that — that kind of thin layer of ground fog. The difficulty arises from the motion of the particles, the fact that this degradation, is moving at a high rate in front of the fixed ground from which I was really trying to make my altitude, altitude-rate, and velocity determinations. So, the fact that they are moving rapidly distracts one from what he is looking at. I think that

ARMSTRONG
(CONT'D)

is a thing that could be learned very well. I suspect that were I to go back to the same situation today, I'd be much less distracted by this moving dust layer than I was the first time.

ALDRIN

I think when we're looking out to make some discrimination as to velocity, we're generally used to making a scan and the mind looks at this scan and is able to interpret an overall velocity. It's not required, in general, to look at specific objects; but the situation that we were in, where the general scan gave us one of motion away from us, required us to search out specific objects and then try to relate their motion against our frame of reference; looking through the window with this obscuring affects the velocity that's around whatever little object we're looking at, so it requires a good bit more attention and a frame of reference. One can't just look out and get an overall motion view; it's considerably disturbed. But I feel that one doesn't need large objects, that he is able to penetrate through this to pick out small surface irregularities, which tend to show up quite well. The horizon gave the impression of being hazy. I couldn't see any particular cloud billowing up; but, during the period that this dust was moving outward, it also tended to obscure what little I could see of the horizon.

ARMSTRONG It is probably worth noting at this point that some observers had predicted that, after shutting the engine down, we might get this rebound effect which would send a big cloud up. That didn't turn out to be the case at all. We didn't see any evidence of that effect whatsoever. The engine quit, and it was just shortly thereafter that the radial streaks of dust stopped, and everything was clear.

ALDRIN People were expecting some absorption of the gases and then a subsequent outgassing that would toss particles. We never saw anything coming up; it all was moving outward.

QUERY With respect to seeing things on the descent or ascent, I know that you looked for the Cat's Paw both times and looked for other recognition features, and that you could see the tops of these in your 16-mm photography. Does that pretty well represent what your visual view was or your view on the way down?

ARMSTRONG In the final descent, we could see considerably more than the pictures indicate. Of course, we didn't observe where we were very well, and we didn't observe very much out the windows to tell us where we were. I don't think that we can predict that that will be true in the future. I

ARMSTRONG
(CONT'D)

suspect that, if given a chance to look into the landing area during the 10 000- to 5000-foot-altitude range where one actually has a fairly good plan formed of what he is seeing, he will, in fact, know where he is.

VAN ALLEN

Can you make any judgment as to how far the dust sprayed from the landing; how far that went or what the velocity of the spray was? Could you say you saw it in motion? Can you now reconstruct in any way the velocity at which it was moving or the distance to which it sprayed?

ARMSTRONG

To the limit of my ability to watch it, my impression was that it was going out parallel to the surface. And I suspected that if we had waited a little while, it would have come around the back side and hit the back end of the spacecraft,

VAN ALLEN

That would account for little contamination in the immediate vicinity because most of the stirred up stuff, in fact, went a long way.

ARMSTRONG

If that's a factor, that's right. We were impressed on lift-off from the surface that the separation debris had a similarly long flightpath; as I may have noted in the technical debriefing, one piece of insulation or Kapton

ARMSTRONG must have followed us for a number of miles before hitting
(CONT'D) the surface right below us.

LOBB This is in regard to the 16-mm descent film again. As we
look at it, it seemed that the dust first appeared just
as you were passing over that last crater. Does this agree
with what you recall or is this question too specific?

ARMSTRONG I believe Buzz thought that our altitude as we went past
that place was more than 100 feet. Perhaps we'll be able
to reconstruct the trajectory when we have sufficient data
to provide an exact number. I would guess that we were
seeing some evidence of dust at approximately 100 feet.

LOBB I was just trying to correlate what you saw with what we
seem to see on the film itself.

ALDRIN Well, I called out having seen the shadow of the LM; while
looking at the two altitude callouts on either side of us
and the time in between, I thought I observed the shadow
at an altitude of about 240 to 250 feet.

LOBB Could you describe how the landing and lift-off may have
affected the windows?

ARMSTRONG In general, the kinds of situations you have on the window
are as follows. You have the window structure, or window

ARMSTRONG
(CONT'D)

frame, in the crosshatched area; and then there's a little bit of the window sealer, RTV or whatever the silver trim is, that's along the edge, and then the glass. Immediately outside of the RTV on the initial part of this is a very thin line that is apparently completely clear; so, in observation, this is maybe one-sixteenth or one-eighth inch. Then, from that point, you start to build up a haze. This haze varies with time, but it may be one-fourth to three-fourths inch in size. In our case, it was brown, and I think it probably related to the sealing compound in some way; and that disappears. Then, you have a fairly clear area of window; and then, starting from the center of the window out, you usually get some haze on the window, which appears to be a condensation of some sort. It starts in the middle of the window and builds outward with time, and whether or not you see that depends on the lighting angle. It takes quite a while to decide just what the window condition is. In addition to this, there will be little spots on the window that are frozen liquid particles, I suspect. They are ejected from the spacecraft; they bounce into another particle and come back. It was like molecules out there bouncing around; and once in a while, one of them will bounce back into the spacecraft and stick. More stick going to the Moon than coming back

ARMSTRONG
(CONT'D)

because the LM is on the front, and apparently a lot of particles ricochet off the LM and come back toward the windows of the command module. On the way home and after these particles had sublimed away, you did not see as much of these little dots. I suspect that, in most cases, the camera doesn't ever see them.

COLLINS

When you were given a window, a glass area like that, and were given the fact that the central portion of it appears obscured and a peripheral area is clearer, you would suspect something thermal. I'm not sure that you would say that this is colder; therefore, there is some condensation on it, whereas this is being warmed by structures. That's just one guess; I don't know, but it's peculiar that way. This effect was much more noticeable on the larger windows, number 1 and number 5 as we call them, rather than on the rendezvous windows. On windows 2 and 4, the smaller recessed rendezvous windows, I did not notice what Neil is talking about.

KUEHNEL

I'd like to request that we keep the questions as photography-oriented as possible in this session because we also have a science debriefing this afternoon, and I'd hate to repeat it all. I'd like to get back to the question of radiation. The photographic laboratory had made some

KUEHNEL
(CONT'D)

preliminary analyses and will be doing more in detail. I think Dick Underwood would like to say a few words on that.

UNDERWOOD

In the colored film, we found a D-max loss of 0.14, probably mainly in the blue layer (the fast layer in the film); and in the black and white film, we found a loss of 0.01, which is negligible. In fact, both don't have much effect on anything. That's just on our first test, and this will be in our report on processing and preliminary handling of the film — a quick summary.

QUERY

Could I have a clarification on this haze? You said the spots are outside. Is the haze between the panes or outside?

LOBB

Helmut, can I interject here a moment?

QUERY

John, could you hold one moment? We'll have ... for you.

LOBB

Helmut, may I interject for a moment? I believe this business on the windows probably fits in better with a later session with the structures people. Joe Kotanchik, I think, is planning to get together with them in a couple of weeks; and this window business is pretty deep in his area.

QUERY I think that's a good point; let's see if we can just answer this one question and try to cut most of the window stuff rather short.

ARMSTRONG Well, I think that the haze, generally is on the inside of the outer pane; but I made some fairly detailed remarks into a tape recorder on looking at the window. Maybe, I'd better review those remarks before I answer that question specifically. We tried to identify where each thing was — on which pane and so on, and we had that; but I don't have it available to me right now.

HOLT Holt speaking here. You mentioned earlier about changing both f-stops and shutter speeds while you were on the lunar surface taking photographs with your camera. I'd like to have some comments about the difficulty of this, whether you feel this is an easy thing to do and if future operations could include more f-stop and shutter-speed changes.

ARMSTRONG Well, we made some modifications to the cameras fairly shortly before flight to allow for this sort of change. It had to do with increasing the size and location of the tabs that run the f-stop and shutter-speed rings and with putting some special decals on so that we could, in fact,

ARMSTRONG
(CONT'D)

see the depth of field and so forth from the location that we had established as being desirable. That's still a fairly hard job. It was an acceptable level of job to change those exposure settings, but you always accept some risk whenever you do a lot of exposure changes in a period when you have a lot of other jobs to do, as you normally do on the surface. I think we were lucky that so many of the pictures seemed to be an acceptable exposure value. It's harder than it ought to be, but it was acceptable.

QUERY

About how long does it actually take to change an f-stop or a shutter speed, and which is easier to change?

ARMSTRONG

They're both about the same. If it is on the RCU mount so that the camera is being held and if you can be doing whatever you're doing with one hand and just reach up and change it, it's only a 5-second job; but with bulky gloves and very hard conditions to work under, you have to use a good bit of caution so that you don't make an inadvertent motion on one or the other rings.

ALDRIN

The f-stop setting was considerably easier because the tab was visible. The speed was not; it was obscured from view when it was on the RCU mount. It was a question of feeling the tab and then making the change.

- QUERY On camera operating procedures, were there any other situations, camera operations, or photographic procedures that were difficult? Was this a particular problem?
- ARMSTRONG I guess we don't have any answer to that particular point.
- COLLINS Not being professional photographers, we spend a lot more time on it than we would have liked to, trying to get pictures. That's both in training and during the flight.
- QUERY How many more pictures do you reckon you would have taken if you only had to press a button and do nothing else to take them?
- COLLINS It probably would have been limited only by the film.
- QUERY Alright, let's go back to your Aristarchus observation. You must have been looking up fairly well toward the horizon to see Aristarchus, and I wonder if you had any sensation of a glow about the horizon?
- COLLINS No, I could see it in the vicinity of the crater and on both sides. It appeared to be rather elongated, and it seemed to me I could see beyond this. This was not the only object on the horizon, but I couldn't discern any upper reflection from this area.

QUERY So this area was very close to the horizon window?

QUERY Anders reported considerable problem of handling lots of magazines, various lenses and filters, and various other pieces. Was this not a problem for you? Could you have handled more than you did handle?

COLLINS We took his advice and greatly simplified the lens/filter/magazine combination; so, I really had only two choices of lenses, 1/80 and 1/250, neither of which required filters. Either black and white or color magazines was the only choice, and they were roughly the same ASA number; so, two lenses and two different types of magazines on one camera is no problem. When you get more elaborate than that, I think it becomes just an exercise in how much time is available to get everything worked out, and so forth, not only during the flight but also during training and the rehearsals.

ALDRIN It's factual; I'm sure you would have been amused if you could have seen inside the cockpit during an exercise in which we were trying to do a very simple thing like looking out toward Aristarchus or taking a picture of crater 320 or something. You have camera backs and a couple of lenses; then you get the 16-mm camera out and a couple of

ALDRIN
(CONT'D)

magazines; then you try to decide which kind of film you are supposed to be using. The monocular and the recorder are there. In addition, you are probably trying to eat lunch at the same time; and about 20 different kinds of food packages, a lot of other books, and claptrap are floating around. It really looks very much like two guys eating lunch in the window of a camera store.

QUERY

You described the appearance of the corona and the zodiacal light during translunar coast. The Apollo 10 described the same phenomena in lunar orbit, and they said they could see it for 12 minutes after sunset, which corresponds to 36 degrees. Did you observe these phenomena in lunar orbit?

ARMSTRONG

Yes, we did, and it's very much like their observations.

QUERY

You would agree that it was something like 12 minutes?

ARMSTRONG

I don't recall that we made time hacks of that, but that would seem like a reasonable ...

QUERY

Under these circumstances, did you see any structure close to the Sun in contrast to the general cone-like appearance far away from the Sun?

ARMSTRONG

I did not.

HILL

We have the pictures covering C-130 prime; and you indicated, I think, to Bob Savory that you may have pointed on a slightly different place from the last mission and also for A-1 checkpoint. After this is over, I wondered if I might hold them up to the window in lieu of a better way to do it and see if we can't identify them.

COLLINS

I have a good photograph to show you on A-1; and on C-130 prime, none of the photographs that I've seen have enough resolution really to point out what I'd like to point out. Maybe you have some better pictures than I have. We'll do the best we can.

QUERY

I have one specific question for Buzz on the 16-millimeter photography for the ladder descent. There were four changes in exposure. These may have been both in f-stop and time, and we went from an underexposed value to an overexposed value. I wonder if Buzz might remember what these various values were.

ALDRIN

I don't recall all the four different changes that were made. I recall making one exposure change because he would be moving from the area of the ladder out into the more sunlit area. I think the change may have been inadvertent with the changing of the film speed from 12 to 6 frames/sec.

QUERY

Let's get back to walking into the Sun. Do you feel that some type of glare shield would be desirable if you were making, for example, a long rover traverse into the Sun?

ARMSTRONG

Yes, I don't think it's necessary, but I think it's probably worth trying. I think it would be helpful but not necessary.

MORAR

Morar. The next question is somewhat related to that one. What do you estimate your visibility to have been in the directions of walking directly into the Sun, as well as walking directly away from the Sun? My concern would be driving something like a lunar roving vehicle directly into the Sun. Would you be able to discern objects, craters, et cetera, and be able to take evasive action fairly early; or, in your mind, would this be a problem?

ALDRIN

I believe you can see well enough into the Sun to traverse at 10 miles an hour or 15 miles an hour irrespective of what your mode of locomotion is. I think you can see fairly well out to the horizon; however, I expected that I would be able to see the big crater and the large rocks, which we observed during the final trajectory when we got outside the spacecraft. I really thought that big crater rim would be right out there and that we might even

ALDRIN
(CONT'D)

consider walking part of the way back and getting pictures of it; however, it was nowhere in sight. I don't believe that this is related to the Sun. I think had we been on the other side of it, we still wouldn't have been able to see it; but I really can't prove that point.

QUERY

I have one more question regarding the soft spots that you mentioned. I believe you said that, in the rims of these smaller craters, you did put your foot in those and perhaps they went in about 5 or 6 inches or something like that. Did you find that same kind of softness prevalent in the rim of the large crater that you went back to visit on the slope going up to the rim?

ALDRIN

I don't recall getting that same feeling of stepping into a very soft area as I climbed the rim of the big crater.

QUERY

I think we are getting ahead of ourselves. Any more specific questions related to photography?

QUERY

My name is Grosbeach. In the same bank of the crater, were you able to estimate the slope of that 8-foot crater, when you were there, as compared with the slope that we get from photography?

ALDRIN

Are you talking about the slope of the inner walls?

QUERY The estimate of 45 degrees for those who didn't see
the ... (laughter).

ALDRIN Not quite. Not quite.

QUERY I'd like to terminate the photographic debriefing. If
the crew will bear with us for one moment, we have
Mr. Colton and some of our flight planning people who
would like to go over some of the onboard charts you had.
It will take a few minutes to go over those.

GENERAL OBSERVATIONS

COLLINS Through the glass, I was able to - using my own ...,
except everything was reversed and everything that stood
out was a pit.

QUERY ... everything in focus, you tell me which way, please.

COLLINS Yes, that's fine. The depth of field is very clear.
I'll look at this thing right here - -

ALDRIN I think we are going to try to be over there ... do any-
thing?

COLLINS Yes, they certainly appear rounded in there. They give
me the impression of being flat-surfaced.

COLLINS This is a small crater, and this is a land slide ...

ARMSTRONG We'd like very much to have something like that inside.

COLLINS - - stands out is a white light-colored funnel-shaped
thing - -

COLLINS Yes, that's it. I think you can see it. See that little
light spot in there? See that area where it's light?

COLLINS
(CONT'D)

Now, over on this wall, there are numerous smaller craters, and I picked the central one of those, but it's over - yes, ... above the shadow right over there. I have to have a bigger picture to show you accurately.

ALDRIN

Camera takes very good pictures.

ARMSTRONG

Here it is, Buzz; here's a question about this -

ALDRIN

Yes, but that one isn't quite right, is it?

QUERY

Can you identify the plane you track when you're in the command module alone?

ALDRIN

I'm not hearing everything you say. I think that what's on here is adequate. Well, I found the overlay to be very useful in setting the yaw angle.

QUERY

I could hear you better through the glass.

ALDRIN

Well, I think that these lines are unnecessary. That's right. They are of no use. A more useful ..., but I don't think it's required, would be some circular lines. They would be of more use than these.

COLLINS

... can give you one of those maps -

ALDRIN You've got the different windows on there, huh? Oh, yes.

QUERY How are you relating this to gimbal angles? Yes - where's your index?

ARMSTRONG You know that folded-up IM map covering 360 degrees, I never used it. Can you hear me alright?

QUERY Yes.

ARMSTRONG Can you hear me? Yes, I still think that the one I never used is better than the map; but through a strange combination of circumstances, the map got unpacked first. One of these guys got the map out, and then there was the map; and it was used because it was there. It was just easier to use it rather than to go in and dig that thing out. I still think that it is probably superior to the map.

ALDRIN I think that would be very useful. Can you hear me now? I'm not sure that everybody else would agree with that, but I think that having the roll angle and the various windows on there would remove having to stop and figure out what this really means in relating what you're seeing in the platform to what you are able to see out the window.

COLLINS I thought all that stuff was good. I don't have any comments on it, really. I didn't use everything that you had stowed, but it's a small packet and - -

ALDRIN I didn't get all that.

COLLINS No, the problem with locating the LM is - you see on this LAM ...

ALDRIN No, we didn't make as much use of that because these angles across the top did not relate to gimbal angles at all. I think that maybe the polar - -

COLLINS - - one or two of those ... here; the next time it's here, the next time it's there, the next time it's there and I was looking over here. I would never see it; I'd just be scanning this area or I'd be scanning this area. The problem was not in the map; it was simply in this uncertainty as to the LM's location.

ALDRIN We didn't use that one as much because it didn't have an angular reference to it, and I think that would be enhanced greatly by this one.

COLLINS Maybe there's a button you could push or something. When you push the button in, ask a question.

QUERY During the powered descent, maybe the ... descent ... if that would possibly have been of any value?

COLLINS No. I guess I still don't follow exactly what you mean here. Sometime after we got out of here, we can sit down and talk about it; but, no, I didn't have any trouble.

ALDRIN Yes, we made use of that in the LM as a general orbital star chart.

COLLINS I don't think that would help. Maybe it would; maybe there is some way you can make it work, but for little deviations to the left or right, you would have to know precisely on time where they were against the background. It would be very difficult to look at a map and determine exactly where the LM is, then get over to the sextant and start scanning that area, and then come back to the map. The situation changes so rapidly during powered descent. While you are going into the beginning of powered descent, he is 120 miles in front of you; and at the end of it, he is 200 miles

COLLINS
(CONT'D)

behind you. So, you're whizzing by overhead, and the line of sight is changing; the background is changing. If you were just a little bit off on time or a little bit off out of plane, your map would be completely useless. You'd have a hard time trying to correlate time versus position and look through the sextant at the same time.

QUERY

These two charts, then, are necessary to where they are?
We'll keep flying these?

COLLINS

Yes, that's the LM one. This is the command module.

QUERY

We'll keep these the way they are, unless you have any ...
you want to make to them.

ARMSTRONG

I said I was going to draw this on scale. I haven't; it's about 50-percent oversized from what it really is. It's really about 8 inches long, perhaps 3-1/2 inches on top of the ground, and 4-1/2 inches underneath the surface. That looked like some sort of erosional process that made a distinctive pattern on top. That was the exception - not the rule. That was the only one of that sort of thing that I saw, but we certainly saw rocks that were more

ARMSTRONG
(CONT'D)

rounded on the top than they were on the bottom. The bottom had relatively sharp angular corners; not so the rounded-off tops.

QUERY

Along this same line, perhaps you, Neil, and Buzz could tell us about any of the other interesting rocks that you saw but which there was no time to collect. I remember you commenting on seeing many things you had hoped to collect for the documented samples but didn't have a chance to bring back. Were there any others beside this one on which you could give us some detail?

ARMSTRONG

The most striking thing was one that I discussed this morning in the photography debriefing. To review that for the benefit of those of you who weren't here this morning, we saw, in the very bottom of some of the small craters, a collection of pieces of material that appeared to be blobs of liquid solder; and it splattered flat on the bottom, had rounded corners, and were of various shapes. They had a metallic luster and smooth surfaces as viewed by the eye, and I wanted very much to bring some samples of that back. At the time I was looking at them, I had no means of collecting them or no place to put them. I intended to go back, but that opportunity did not arise. I had looked for some during the period when I was collecting the documented samples but couldn't find any. We had

ARMSTRONG
(CONT'D)

seen this kind of sample in the bottoms of six or eight different small craters, all approximately 3- or 4-foot-diameter craters, and collected in a pile like a handful of woodchips. We did get one or two pictures of these with the stereo camera, and I think some of you who looked at that probably recognized what they are. From looking at those pictures, they really were surprising to me. It doesn't look anything like what I would have guessed I would see if I'd reported just on the basis of a visual observation; that is, the little coatings and little bubbles and so on that I didn't observe. A third kind of sample that I thought was interesting and hoped to collect but wasn't able to were some things that we both observed, both from the cockpit before the extravehicular work and also during the stay. They were what I would call transparent crystals of fairly good size. One that I observed from the cockpit appeared to be about the size of a walnut. It looked like a piece of quartz crystal with polished faces and things like that, and I thought it was transmitting a large amount of light. We saw several of these of different sizes on the surface; and I found that when I looked at them from different angles, I couldn't always see through. In other words, from some views, they appeared to be opaque; from others, they appeared to be translucent. I don't know

ARMSTRONG
(CONT'D)

if this was an optical illusion or whether we really were seeing crystals on the surface, but some of these kinds of things were observed; and I was unable to get samples of those and bring them back in the documented sample period. I couldn't find any. In retrospect, the one thing that I felt was a real shortcoming of our planning was the fact that we were unable, when we saw something of interest, to collect it at that time; we had to try to remember where that was and hope that we had time later to come back. I would recommend that in our future work, we not make that mistake and that we improve our ability to pick up samples of interest and record them at the time we see them. This will require a somewhat different kind of planning that we've done with respect to who has what kind of cameras and at what times. Also, this bares on the most restrictive problem that we have -- our inability to get down to that surface readily and pick up things. We didn't have picking-up kinds of tools with us all the time. We didn't have places, pockets, or bags to put things in all the time we were doing other operations, and I think this is an area in which we could certainly improve on productivity of our time.

QUERY

Buzz, do you have any other observations?

ALDRIN

Yes. We took this monocular with us into the LM from the command module. I am quite glad that we did. In this approximate area, there was a small boulder that protruded above the surface. On the face of it, there appeared to be something about the size of a quarter, maybe a little bit smaller. It gave a definite glint from the cockpit. At that time, we couldn't really tell whether it was rounded or not. We were able to observe several of these things. It seemed to be imbedded in the surface, but this is the ground mass. At the same time, there seemed to be slight rays wherever we saw one of these. Over in this area, I saw the rock that has been described as somewhat purple. I had made some reference to this in a joking fashion. It did have a brown cast to it; it also had a good bit of the sparkly material that we have been talking about. From my view of it, lying on the surface, it was mostly imbedded underneath the surface. There was a somewhat concave area here; and all in this area appeared, from my view of about 4-1/2 feet away, to be very fine grained, mostly on the order of a millimeter. It reflected back to me and with a slight gold tinge to it. It was my distinct impression at this time that these were indeed flat surfaces. It doesn't appear that we've recovered any of these; and, looking at some of the closeup camera

ALDRIN
(CONT'D)

pictures, I believe that this could very well have been the same type material we saw that was more spherical.

QUERY

The first question that I have would be addressed to Neil and concerns the 80-foot crater that you went out to visit. Did you observe any boulder trains or evidence of a rolling rock on the walls of the crater?

ARMSTRONG

No, sir.

QUERY

The second one is the tunnel feature that you can see at the left edge. There is an alignment, more or less against the shadows, that slopes into the crater almost like a confetti stratification. Would you comment on that?

ARMSTRONG

Yes, I see the area to which you're referring. I don't recall any particular observations of that area at the time, although I did observe it in general throughout the inner walls of the crater. Generally, there was some evidence of lineations on the surface in a generally radial direction all the way around.

I would just like to say that I would have liked very much to spend a couple of minutes really observing this crater. This was done very late in the game, and we had very little time. Because I thought this might be of some interest, I thought it would be worth while just going back and

taking a quick series of pictures across the crater with the hope that we could put the pieces together here. I really had only 1-minute total time to look inside the hole.

QUERY

In the lower left-hand corner of this other photograph is a radial alignment and also a cross alignment. I was asked to have you comment on that cross alignment and to tell us whether it had anything to do with the surface ...

ARMSTRONG

I think I can just see the feature you are referring to, and I did not note it at the time I took this picture; however, some characteristics of that surface are not evident in this picture, at least not to my eyes. That is, the area where the seismograph is located is one of the few level spots in this surrounding territory here, and it is surrounded by craters. There is one in the right foreground, one just to the right rear of the seismograph, and a fairly large one on the left that is very shallow. These are all types of the very shallow craters. They have a very high width-to-depth ratio, but it was difficult for us to find a sufficiently level place to put these two packages out in this area.

QUERY

You told us about the interesting things in the bottoms of the small craters. ... peculiar materials. Did you

QUERY
(CONT'D)

observe whether this filling was higher on one side than the other, and were the craters themselves filled from one direction rather than from the other?

ARMSTRONG

With respect to the small solder splatters, those were not aligned in any particular direction. Generally, I would say that they were very evenly distributed on the dead-center bottom of the crater.

QUERY

During the EVA, you described briefly the little bit of streaking out from the DPS skirt. We think we can see this on the photographs, also. Do you think the contingency sample was taken from an area that was appreciably disturbed by the DPS?

ARMSTRONG

It was not visually evident that there was any sculpturing of the surface done outside the landing-gear footpad radius. In other words, I am sure that there was some material moved out there, but you couldn't see that it had been removed. The contingency-sample location is recorded in the 16-mm film. I made an effort to get as far away as practical from the exhaust-plume area, but our observations of the surface after and during the landing lead us to believe that the material that was eroded from the surface and blown away tended to go a long way from the LM

ARMSTRONG
(CONT'D)

as opposed to a short distance away. I suspect that some of those particles went a very long way from the LM.

QUERY

Can you describe more precisely the location of the documented sample? How far out did you go? What was the farthest distance you went to get samples and in approximately what direction?

ALDRIN

The samples that were in the bottom of the bag (which I am not sure that you will be able to tell which came from the bottom of the bag). The bottom one-third of the samples roughly came from this area, and the top two-thirds of the samples came from this area.

The rocket exhaust had washed the area which we see here.

QUERY

We have noted that there were some rock types that you weren't able to collect; but, in general, how representative do you think the bulk-sample rocks are? Do they pretty well cover the limit of what you saw in terms of composition and shapes of each?

ARMSTRONG

I made an effort to get a piece of hard rock along with every scoop, and they were of as many types as I could find in the bulk-sample area, which was also generally out in this area. The hard-rock bulk-sample fragments had to be somewhat smaller than this to fit into the scoop.

ARMSTRONG
(CONT'D)

Consequently, I couldn't really take samples from the big pieces of rock in the area. I couldn't confirm that we included samples from the big fragment kind of rocks, although I couldn't visually detect that there was appreciable difference between — the big ones all seemed to be big black basalts in the picture of the last couple of late frames out of the stereo camera, which are taken on the basis of large rocks which are, by and large, just barely visible above the surface. In other words, most of the rock was immersed in the surface. One was somewhat larger than 1 foot by 3 feet, and I don't know how deep it went into the ground. That appeared to be just one or the other kinds of basalt, and a lot of the small pieces seemed to be a similar kind of material; so, I hope that we got a fair scattering of the types of rocks in the immediate area. I certainly couldn't say that we had all of them. We just didn't have very much time. Only on two occasions could I afford the luxury of looking at a rock in my hand and saying something like, "I think it's a black rock" or "I think it's a white rock." In most cases, I had to look at them when the surface was near. I was standing, and that's not a very good position from which to select rocks.

QUERY

You mentioned that you thought that the big ray might be related to West Crater. Was it possible to infer where any of the rocks that were brought had come from? Could you make any kind of guess or judgment as to where some of these fragments that were picked up originated.

ARMSTRONG

I could not. In the area local to the LM, I couldn't see any evidence of rocks being tied to any particular event. The big boulder field out on the right, we felt, was quite likely a big throw out from a big crater, the big West Crater or something. That tied in with everything we had seen during the descent, but not the local area.

As I say, the tops of some rocks were flat with the surface; others were buried 50 percent. Some had 10 percent showing. Others seemed to be lying directly on top. There was the depression of the rock; and some pictures, I think, show rocks lying on the surface which essentially seem to be big rocks that only go that far into the top. How we could explain the variation of the depth to which various rocks were buried, I wouldn't even want to guess. We talked about one on the TV camera. I looked at the TV, and you really can't see it; but, it was a rock that long, this wide, that thick, and relatively parallel on this end; and it was sticking in on it's end. I don't know how far

ARMSTRONG
(CONT'D)

it went in the ground, but it was this wide and sticking up that high out of the surface like a tombstone.

QUERY

You stuck the flagpole in several times, I believe. When you removed it to try again, did the material fall out of the tube or not?

ALDRIN

I don't think that end of the flagpole was open.

ARMSTRONG

I can't remember what the end of the flagpole was like. I don't recall, so I don't know.

QUERY

Did you have any problems walking up-Sun or down-Sun; and if so, should geologic experiments ... and directions to be avoided?

ARMSTRONG

Down-Sun is a very little problem. Looking into the zero-phase point is not a problem. We had somewhat less resolution in the area surrounding it, but it's not an area in which you can't see craters, rocks, and a path to follow. Up-Sun is a little more difficult, not because of the ability to look into the surface, but because of the high glare into the visor from the Sun. When I went back to the crater, I was going almost straight into the Sun; and I didn't find it to be a problem, although it's extremely bright. Probably, a sunshield of some sort would be helpful.

ALDRIN

I think you'd be far more apt to pick up interesting features when going cross-Sun. Going into the Sun is pretty much of an annoyance with the glare that tends to divert your attention away from that particular area. In walking down-Sun, though, you can see most of what is there; the contrast is washed out. I don't think you would be as apt to identify the interesting features until you were right close to them. I think you would be able to identify varying shapes, sizes, glints, and so forth much easier when going cross-Sun.

QUERY

I have a couple of questions on the focus setting that you used during the photography. First, were the detented focus settings always used during the EVA? As part of that, were the detents positive enough so that setting the focus could be accomplished without difficulty?

ARMSTRONG

I thought the detents were alright, but I didn't use them frequently. I made an effort to sort out the combination of depth and depth of field that would result in the most useful information, and I didn't find it to be a particularly difficult job to put it the distance that you wanted it. It's a practical thing to do.

ALDRIN

For any particular picture, I don't think the detent has a value. I think it tends to retain the camera at that

ALDRIN
(CONT'D)

particular point. If you want to make several pictures by using the detent, it would tend to keep it from rotating too far away from the particular value that you have; but for any particular setting, I think I agree with Neil. You tend to estimate, and even if you were near a detent, you probably would pick to be off that somewhat, depending on what your estimate was at a distance.

ARMSTRONG

We made some mistakes. Now and then, we took pictures, for example, where we just forgot to reset the distance.

QUERY

Could we go now through a short discussion of the various tools and have your comments on their handling, their effectiveness, and interface problems you might have had putting the tools together, and any recommendations you might want to make on modifications? How about starting with the hammer?

ALDRIN

I didn't fit the hammer together with anything. I used it as a separate item. In general, I found that using the side of the hammer as an instrument of impact onto the core-tube extension was far more effective. I didn't feel as though the ability to steady the core-tube extension, coupled with the arm motion of the suit, would dictate the use of the flat face of the hammer. Even at that, a few strokes were missed. Another factor involved

ALDRIN
(CONT'D)

here is that the core tube, despite difficulty I had in driving it into the ground, did not seem to reach a point where it would stabilize itself and would stand upright without support from my hand. I feel that attaching the core tube to the extension is a bit awkward, and I would hope that we could improve that somewhat. It just doesn't work too well with the gloves and the dexterity that's present in the suit. I believe that one end of the core tube was loose. I think that we identified that tendency in one of the bench checks beforehand, and evidently it did come off on the second core tube and was unfastened.

QUERY

Okay, how about the tongs? They seemed to work quite well.

ARMSTRONG

We had very good luck with the tongs. Practically all the documented sample rock were collected by using the tongs. We found the kind of difficulty that you invariably have in the Earth simulations, that of the rocks falling out of the tongs because of the high gravity. Only on one or two occasions did I drop a rock with the tongs; so, by and large, they worked very well. I still believe that maybe we've got the wrong hand motion in those tongs, but I think we can talk about that separately.

QUERY

Any comments on the scoops?

ARMSTRONG

Those of you who have looked at the one-sixth g simulations of using a scoop appreciate the difficulty of picking up things in one-sixth g. It just keeps floating away from you. We realized that there would be some problem here; but the difficulty is keeping things in the scoop as you lift it out, no matter how slowly you lift it. When you grab something and lift it up and then start to slow that scoop down, the contents just keep going away from you. I would guess that on the average, we would be able to retain only 50 percent at best of the material in the scoop on each attempt. That fact, coupled with the fact that it was a relatively long trip from the area where I was collecting the bulk sample back to the scale, resulted in a much longer expenditure of time on the bulk sample than I would have liked and had planned on. It was a large number of trips back and forth. Again, that's an area we probably didn't do quite as much planning on as we should have, and we could make that a more efficient operation. It also took more time because I was somewhat more selective than I had planned to be in trying to get a bunch of representative samples in the bulk sample, because I wanted to buy some insurance against getting no documented samples at all later.

QUERY

Any comments on sample bags?

ARMSTRONG We used only the big sample bags. We didn't have the opportunity to use the little ones. We hadn't had very much trouble with them in simulation, and I didn't see anything on the lunar surface that led me to believe they wouldn't be practical in their current configuration.

QUERY Any comments on rock boxes?

ARMSTRONG Two, I guess. One is that they were not well enough retained on the table. In one-sixth g, they really tended to slide out of the little support structure that we had for them. Second, they are very hard to close. They were at the limit of my ability to close. It took about the last ounce of strength I had to make the seals. We had actually closed real rock boxes on the surface here on Earth, and we thought we understood that; but perhaps the temperature effects on the seals or one of those things influenced the difficulty. They really were hard. I understand they held okay.

ALDRIN I think some more thought could be given to the packing material and putting small things like the core-tube caps and environmental containers in rolls when, at the same time, you have other rolls that are just in there for packing. There isn't a convenient place other than the lid to place this packing material as you remove it. In

ALDRIN
(CONT'D)

simulations once or twice, we dropped some of the items that were inside there. I think we need some way of identifying exactly which item is in a particular roll and of calling attention to that in contrast with the other packing material.

ARMSTRONG

I think there's also some room for improvement in our planning on where things that are inside the boxes go when they're outside on the table. We need some kind of spring clips or things to hold these items so they don't get away from us; also, we need some way to improve the efficiency of handling and the time required in handling objects on top of the table. We probably spent more time there than we should have. Again, when you've got limited time, it's very important to minimize all these unnecessary little motions. You would rather be spending that time out on the surface doing something useful.

QUERY

Maybe you can answer a couple of questions on samples procedures. First, did you encounter any problems in collecting samples? Were the procedures that you learned here on the ground the proper kind of procedures?

ARMSTRONG

I don't have very good comments there. As I understand, there has been some very good work done in streamlining the sampling procedures in the last 6 months before flight,

ARMSTRONG
(CONT'D)

which we were exposed to and didn't get much chance to practice. We probably would have benefited by practicing. As it turned out, that part of the experiment was poorly done because of the time constraints. I think, if we had had more time to work up there, we would have had some fairly good documentation of the samples. As it turned out, we didn't. I'm sorry, maybe next time.

QUERY

You've already made some recommendations for improving sampling procedures, mainly the capability to collect samples when you see them and also the capability to get onto the ground. Would you add any other recommendations?

ALDRIN

This implies having some container with you at all times, having a means of getting this container into a handy position, and at the same time, being able to pick up an object. Although we weren't equipped with that, we did have it in our timelines to be able to do this. I think it also means that, as an individual, you'd like to photograph something, to be able to pick it up, and then to put it away.

ARMSTRONG

If you could do that without requiring a whole backpack full of equipment to get a picture and to pick a sample. The way we're equipped right now, I think you would agree why this fairly sizeable amount of claptrap that you have

ARMSTRONG
(CONT'D)

to have with you to do that kind of job to put them together and package them. I think we have plenty of room for trying to streamline the ability to sample accurately and to document something that isn't really planned. That requires some minaturization of equipment that we have now.

QUERY

We have a question on the core tube. Did you drive the core tube into a disturbed area? Let me explain a little bit. When we look at one of the pictures, we can see the core tube driven into the ground and the core-tube area surrounded by what looks like disturbed material. Did you put the core tube through that material or was that material kicked around after you drove the core tube?

ALDRIN

I think the localized area, within a radius of a foot, was generally clear of any foot imprints. I think it is quite possible that there could have been some particulate material scattered from the shuffling around that I was doing to erect the solar wind. I guess that's about all I could say. Both areas were selected to be free of any footprints within about a foot.

ARMSTRONG

They were also in areas where we did quite a bit of previous work.

QUERY

I would like to ask something about the consistency and the nature of the fine material on the surface. I see on the pictures that, in different regions, you sank in quite different depths. In particular, near one crater you sank in several inches, 5 inches, I think. Was it your impression that the material there was altogether lighter and fluffier or that the degree of hardening of the material was less as you went down into it? In other words, was it tough material that you sank in more, or was the tough material itself of a different consistency in the places where you sank in more?

ALDRIN

As far as I could tell, it was the same consistency all the way down. It appeared to have just a thicker layer before you reached this region of increased compactness, perhaps.

QUERY

Would you think that, if you had landed in a region that is of this nature all over, it would have given you trouble? Also, think about the points (a) first, whether the spray from the rocket in landing would ever be possibly aggravated; (b) second, if you had to walk through stuff all the time and you were sinking in as much as the deepest parts you reached, would that have been any discouragement to you?

ALDRIN

Well, I don't feel that the varying depths of this top layer would have been affected appreciably by the rocket exhaust. That seemed just to skip off a very superficial top layer, and it didn't seem to make any difference what this depth was. As far as traversing areas is concerned, you are not really able to tell just how deep you're going to sink. It certainly has a disconcerting effect on your ability to move. It's like walking in snow. It's that kind of impairment to your mobility, so it's a little bit harder.

ARMSTRONG

I agree with Buzz. I think these kinds of places were deemed to be limited to the rims of small craters which had essentially no rocks in them but were just a thicker layer of fine material in the rims. You tend to go in a little bit farther in those areas. Similarly, on the inside slopes, particularly at the upper edge of inside slopes, you tended to sink in farther — 5 inches, maybe more in some cases. On the rim of a small crater, this general area tended to be very fine material with very few rocks in it; when you sink into that, your foot might go in like this. At this edge, it might go in only a couple of inches; but, over on this end, on an inside slope, it might be 6 or 8 inches.

QUERY

You described driving in the core tube, but it's rather peculiar that you appeared not to be hitting any hard surface; yet, the tube would not go in. Is that correct?

ALDRIN

That's right. Each blow with the hammer seemed to move it a small amount. The tube didn't rebound in any way as if there were a very hard surface. The core tube seemed to be moving in, but from the cumulative effect of the last three or four blows, it appeared that I didn't gain more than about a quarter inch.

QUERY

It seems that there are two types of explanation. I wonder if you could give us any hint which is correct. One is that, in each case, you happened to intersect a stone small enough so that you did not feel any rebound, but large enough not to glance off the end of the pipe, large enough that the whole stone was dragged down. You shake your head, so I'm sure the answer is no. The other possibility is the phenomenon of friction encasement of the rod, which sometimes occurs in frictional, fine powders when the rod gets clotted on the exterior with material that makes a conical piece; it may not have been visible, but possibly so. If compacted, it could make the rod very thick, as it were, and the clot goes down with the rod.

ALDRIN

If there were any frictional drag on the edges, I don't think that it would have been on the outside at all, because the rod was very easy to move; it tended to fall over quite easily. There may have been some internal forces on the core tube; but I thought it had an adequately sharp edge, and the material seemed to be of a consistency that there wouldn't be any difficulty in driving this material further into the tube.

ARMSTRONG

We pushed various tools into the ground to various depths on numerous occasions. The first was the contingency sample rod, which I poked into many different spots; other objects included the flagpole, the solar wind device, and the core tubes. Our experience was always the same on this wide variety. On some occasions, we would hit rock, and it was clearly evident when we did that. When we hit buried rocks, we knew we had hit a rock. In most other instances, it was quite different. We would just go in, the force would keep getting higher and higher, and suddenly we just couldn't go further.

QUERY

You said on another occasion that the powdery material that covered the stone made it feel slippery. Would you amplify that statement a little? In general, one thinks of powder in a vacuum as causing noticeable friction. Is

QUERY
(CONT'D)

it really that the friction of that powder is remarkably low as you walk on it?

ARMSTRONG

That was in the LM shadow; as well as I can recall, the rock that I referred to had a 10- to 15-degree slope, maybe a 20-degree slope. I noticed that, when I put my foot on it initially, it gave me a little uncertain feeling, then, I moved off and just tried to slide. I was impressed with the ease with which, having a certain coating of dust on it, it would slide. I think it was a combination of the boot material and of filling in the small pockmarks in the rock surface that made the rock very slippery. The material compacts very well, as you can see, with each footprint.

QUERY

Did you observe any phenomenon in the way the fine material sprayed around your feet or, when you disturbed it, any phenomenon in which the particles behaved other than with discrete trajectories? In other words, did you see electrostatic effects of any kind? Did the particles cling to any particular parts of your suit or of your boots by other means than mere surface adhesion?

ARMSTRONG

No, I couldn't attribute the behavior of kicked materials to anything of a nonballastic nature. I was impressed with the trajectories. This may just be because of the vacuum;

ARMSTRONG
(CONT'D)

but there seemed to be a definite pattern that apparently depended on the angle of impact when we kicked our boots into the ground. The material was very evenly distributed in size and impact location. A small amount of material landed in a linear pattern, but most of it landed in general areas and radially away from us. There was a certain obvious direction of the initial imparted velocity. Kicking at the same angle with different forces didn't seem to make that much difference in extending the pattern. The materials that were observed going out and striking the ground seemed to be of a very uniform distribution; there was no large grouping in one particular direction. Some particles continued, but I was quite impressed with the groupings in one particular radius outward.

ALDRIN

It makes sense, but it really is strange when you kick the surface and everything goes up. On Earth, one always has some residual cloud that moves around before settling slowly. There wasn't anything like that. That's what one would expect, but it's still surprising when one sees that there's no little cloud to settle back to the surface after kicking the ground.

QUERY

Buzz, we have two other flight crews in geology training at present and another coming up soon. Do you have any

QUERY
(CONT'D)

specific comments on material we might be able to incorporate into the training now underway? Would you recommend more lectures in some areas, less in others, field trips, and so on?

ALDRIN

My overall impression of the actual situation as contrasted to the one we were prepared to carry out was that there was so much more of interest to study than we expected. There were so many different kinds of interesting areas to select from, it was difficult to decide which type area we wanted to spend our time on. We did a good amount of work and saw many different types of areas in trying to select which would be the most productive. I think that is the area in which we could have well afforded some more worktime, but I'm not quite sure how to accomplish that. That's the problem with which we were faced. With so many interesting things to do, deciding which one would really be productive is difficult. Our timeline was very crowded and didn't afford us much time to explore unplanned areas. I hope our future timelines will afford a few brief intervals in which one can decide what to do on the basis of what he has seen after he lands. I would think that, on the basis of the many photographs that we have, we would be able to simulate conditions in the immediate vicinity of the LM with greater fidelity, and perhaps

ALDRIN
(CONT'D)

make changes from one exercise to the other. I think the more operational factors and the more realism that could be brought into the training, the better it would be for training crews to handle those particular situations that arise.

QUERY

How about the lighting? Do you think that is important enough sample collecting that you would want to simulate that with as much fidelity as in geology?

ARMSTRONG

No. I think we can describe sufficiently well what effects and constraints the lighting has, enough to enable a crew to do any job within that range of lighting. A high degree of simulation is unnecessary. I think it's probably a good idea to do a better job in training the crew for photography, which requires making all those camera settings and exposure changes at the proper times.

ALDRIN

That is a difficult requirement to implement if one doesn't have the proper lighting.

ARMSTRONG

It is time-consuming, continually trying to obtain the correct camera settings.

ALDRIN

I think you do need some special light source for that particular training, rather than trying to simulate lighting in terms of Sun direction. I think it would be very helpful. A searchlight — it certainly wouldn't have to be of a collimated nature — could be used. This would tend to increase the contrast that one gets looking cross-Sun.

GAST

I'd like to go back to the discussion of the distributor-cap-sized rock. Was this the only rock that you tried to unbury this way? Just how long did this take? How much time was involved in learning what you told us? Is it possible to unbury larger rocks like this one? Are the rocks very rigid or do they move around?

ARMSTRONG

That rock took just a very small kick to unearth — unmoon. I suspect that one could dislodge a considerably larger rock than that. Perhaps I was influenced by the fact that the rock was not deep enough to be in the highly compact subsurface; perhaps at a place such as that where we couldn't penetrate with the core tube, a rock that has reached that depth might be considerably harder to dislodge.

GAST Is the reason you are frustrated with being unable to bring the rock back that it was just too big?

ARMSTRONG I think I might have tried to bring it back in the documented sample if I had been able to get back to that area. I probably would have tried to do so.

SIMMONS One thing we would like to collect, possibly on the next mission, is just such a large rock. Do you foresee any real difficulty in collecting it, using your distributor-cap-sized rock as an example?

ARMSTRONG I think that the rock sizes we brought back are at the limit of the pick-up ability of the tongs. We have to find another way of lifting the rock. I'm not quite sure which of several possibilities we might choose.

QUERY To go back to the moonslide, did you see any evidence from orbit or from the ground of dislodging of materials along the slopes of craters?

ARMSTRONG In the slopes, certainly.

QUERY From reasonably small craters?

ARMSTRONG Did we see any evidence of material sliding down the inner-surface of small craters?

QUERY Yes, those approximately 20 or 30 feet in diameter.

ARMSTRONG Not much, except for the things that we noted collected in the very bottoms of small craters. Many other craters were more uniform in rock distribution across the bottoms of 20- to 10-foot-diameter craters. We really didn't have many 20-foot craters to look at. Perhaps the best example we have is of the two elongate craters close to us. We have many pictures of those, and you are better able than I to determine the distribution and sizes of rocks across the bottom. I think you would agree with me that there's not a large collection of things right in the bottom.

COLLINS

The rockslide that I remember was in crater 130, which is a little crater on the rim of a much larger one, just north of the landing area. In some pictures, you can see that a little zone in the center on the far wall is lighter in color. Using the 28-power magnification of the sextant, I could clearly see that this was a slide area. I think the pile of talus at the bottom was covered by a shadow, so I really couldn't describe the characteristics. This difference in color was clearly the product of a landslide; you can almost determine that with the naked eye on some of the photos.

ALDRIN

Some fresher craters on the back side had a rather sharp lift; from the side, they appeared to come up like this, reach a definite flatter area on the bottom, and then come up the same way. There seemed to be several regions around there of a very light near-white-colored material that would come down as a talus; it seemed to collect along the rim. Because there were regions of concentration of this material and other areas of less concentration, this seemed not always to result in a large collection down

ALDRIN
(CONT'D)

here but in a fairly uniform distribution in this region. On one occasion, in one of the craters on the backside, I noticed what at first appeared to be a rather irregular-shaped shadow area in here. Upon using the monocular, I was surprised to discover that this looked like the very irregular, fairly large height-to-depth ratio crevice in the wall of the crater. It appeared as though all of it was shadow area down. There was nothing protruding upward. It was very flat across the top. This detail doesn't appear in photographs that I've seen.

FRONDEL

Was the famous purple rock actually picked up and returned?

ALDRIN

No, it was not. I wouldn't really describe it as a purple rock. It had a tinge of brown to it, which had a suggestion of a rosy nature.

QUERY

About what time did you first see dust being kicked up by the descent-engine exhaust?

ARMSTRONG

We disagree — I shouldn't say disagree — but we observed different things. The first time I saw any substantial haziness, I guessed I was about 100 feet; but Buzz said that he first saw evidence of disturbed material at about 240 feet.

QUERY How far out from the LM do you think this dust was carried?

ARMSTRONG My impression was that it was going a long way, and most everything I saw, I'm sure, disappeared over the horizon or something. It went a long way.

QUERY This is a question on the impressions on the rock distribution. You said that some rocks were about half sunk, some about 10 percent sunk, and some were on the surface. What is your impression regarding the rocks? Were they being uncovered or were they being covered? In other words, was it a rock-strewn field that was getting covered, or were there rocks that were being uncovered in the course of time?

ARMSTRONG My impression was that we were observing a steady-state process in which rocks were somehow being deposited on top; as time went by, the rocks were being covered and new rocks were being thrown on top.

QUERY Let's look forward to Apollo 12 when hopefully we're going to have two EVA's and a little more time to do the EVA. If you had been able to locate yourself on the maps, would it have been useful to try to preplan your traverses beforehand, or do you think it would have been better to let them be free-form once you got out on the surface?

ARMSTRONG If one has a specific objective that can be definitely identified as being very worthwhile, I suspect one can preplan that. I foresee one difficulty. Let's say that one is very successful in getting where he wants to go and has a 600-yard traverse to get to the point where he wants to go to make his observations; this distance seems like very practical in the light of the performance of equipment and ease with which one is able to move around the surface. The only difficulty one would have is in covering that 600 yards. There probably would be 20 places one would want to stop to observe some feature because there would be many items of interest along the way.

QUERY I understand that you attempted to land in the boulder field of a large crater. Let's say that there had been a large boulder near where you came down. Would it have been easy for you to land immediately adjacent to it?

ARMSTRONG I think that, given half a chance and some confidence in the levelness of the field, one could, in fact, land pretty close to where he wants to go. However, in the case of that boulder field, I was initially inclined to try to land short of the big crater to get a look at this area that really seemed to be of substantial interest.

ARMSTRONG
(CONT'D)

It was a really big, sharp-rimmed crater, with many large rocks in the area; but it didn't take me long to change my mind. That field was really rough. When one has that many large rocks in the area, when the descent starts — one can just begin to see the area north of West Crater where these numerous rocks are. Believe me, out my left-hand window, it looked 10 times worse from two viewpoints than those pictures show. Probably, the first was because I really was looking much more closely at the crater and I was looking into a much larger boulder field; and the second was the fact that the eye accentuates angularity, topography, and so forth. I think the eye makes things look much rougher than the camera does. I think one can go where he wants to go, but I certainly wouldn't have wanted to go into the middle of that boulder field.

QUERY

Did you use the hammer to hit a rock, or did you use it only for the core-tube driving?

ALDRIN

I think it was only used for the core tubes.

QUERY

Assuming you knew exactly where you were when you landed and you had some pretty good road maps down there, do you think you could have navigated half a mile or a mile, maybe even out of the line of sight of the LM, and found your way back again?

ARMSTRONG

It's very easy to tell direction. The shadows are strong, and there is no trouble in knowing directions, but there was more trouble than I would have suspected in telling what was ahead. Let me give a couple of examples. First, I really thought that, when we got outside the LM and looked around, many rocks and the big rim of West Crater would be behind the sun horizon, but we couldn't see it. It was just over the hills from us, which was a big surprise. At the time, I didn't think we were very far down-range from what I thought was a big crater. Similarly, out on the horizon, we could see things that appeared to be fairly good-sized craters, but we couldn't be certain; I'm sure some were and some weren't. Therefore, the ability to take a map and say there is a crater in a certain direction, then to look in that direction to see that the crater exists is more difficult than I thought it would be. This difficulty exists because the general areas, in terms of local fields, slopes, and things you can't specifically identify as being craters or crater rims, are rougher than I thought.

QUERY

Did you have any trouble estimating distances? I realize you didn't go out far, but would you have had difficulty closely estimating the distance if you had been 300, 500, or 1000 feet away?

ARMSTRONG

We reported seeing some hills on the horizon which may have been associated with the rim of the Cat's Paw; we couldn't accurately estimate that distance. On short distances, such as the distance I took the TV camera, we thought while we were walking on the surface that our estimate was fairly close. However, when we returned to the cockpit and looked out, the distance appeared to be shorter. In other words, when looking from the cockpit, the experiments and the TV camera seemed to be much closer than they appeared to be when we were on the surface. I estimated that the crater distance was about 200 or 250 feet, maybe 300 feet, and I think that estimate was fairly close. We have conflicting data to corroborate with our estimations, so one could say we can or we can't estimate distances, depending on which data are used. In general, it's more difficult to estimate distance than I would have guessed.

ALDRIN

I think the local features tended to stand out much more when we we're down on the surface. I wasn't able to locate the hills off to the front and to the right. However, I could see a general area of increasing slope, but I wasn't able to identify the same order of things. Most of the hills tended to disappear or to flatten out considerably when we reached the surface.

ARMSTRONG I think this effect is similar to a person swimming and bobbing in ocean waves that are only 4 or 5 feet high. Even though the waves aren't high, he still has difficulty seeing very far. He can see 50 to 100 feet but not much farther; it's the same type of effect.

QUERY What is the maximum travel rate that can be sustained over a 15-minute period?

ALDRIN Using the loping gait that we found to be comfortable, probably three to five rest periods, or periods of slowing down to a walking gait, would be needed. I don't think we could sustain the pace associated with loping for a 15-minute period. The loping pace has been estimated to be approximately 5 to 7 miles per hour. I don't think that we would want to sustain that pace for 15-minutes.

QUERY Could any stars or planets be seen from the surface?

ARMSTRONG Although I made a specific effort, I was not able to see stars, but I could see one planet very easily.

QUERY You walked up the side of the crater a couple of hundred feet away. Did you walk in and out of smaller craters; in other words, what's the maximum slope that you tried to walk up or down, and did you have any difficulty? Did you slide or dig in?

ARMSTRONG I would guess that I never went up a slope that was greater than 15 degrees. I would have liked to have gone into the close-by elongate crater that had walls somewhat steeper than that, but I didn't.

QUERY Then, there was no problem in walking on a 15-degree slope, which is the same slope of the crater in which Surveyor III rests?

ARMSTRONG That is correct.

ALDRIN Sideways traversing of that slope would be avoided. I think that we would prefer to go straight down and straight up. The footing is not secure because of the varying depths of the layer material, and the layer material tends to slide in an unpredictable fashion.

ARMSTRONG I think our overall impression was that we could get about on the lunar surface easier than we had guessed before the flight.

QUERY Were any of the observed rocks covered with a glaze of splattered glass? If so, did this have any relationship to the position relative to the LM?

ARMSTRONG I didn't observe any splatter-glass-glazed rocks.

ALDRIN I wouldn't say that anything we observed that was of a glassy nature or of a sparkly phenomenon was a coating on the rock. I think what we observed was a portion of the rock itself.

QUERY Did you walk over some small clumps or rocks, and did they sink into the ground or disintegrate? If you walked over some, did they all seem to act the same way?

ALDRIN I remember observing material that I thought was a rock at first, but upon stepping on it, the material appeared to be a clod of some sort. This clod gave way quite freely. Especially in the shadow area, it was not readily apparent that this was not a rock.

ARMSTRONG Several things I saw were clods. However, these clods were a small percentage of the visible hunks that were on the surface — probably only 10 percent or less of the material that we saw sticking above the surface.

QUERY Was stability improved when carrying the EASEP? Did you try carrying the EASEP at various levels?

ALDRIN No, I don't believe I carried it at different levels. After looking at the photographs, I think I tended to bend at the elbows and tended not to let both packages

ALDRIN
(CONT'D)

fall naturally. I think this was because I was uncertain whether there might be a tendency to slide sideways. Also, I thought it might be better to have the EASEP up higher, thereby avoiding contact with the surface. I don't believe my stability was appreciably increased by carrying these.

ARMSTRONG

The photographs don't indicate much roughness between the LM and the areas where the EASEP was deployed, but that wasn't our real-time impression. At the time, we thought the surface was very rough, with many slopes, and we thought we had to be careful in picking a route to the EASEP deployment area. There was one small, level area just beyond the area where the seismograph was finally located. We considered going farther out to another level area. However, the level areas were, in general, a small percentage of the available space on the surface, but the surface looks blah in the pictures. However, that wasn't our impression at the time.

ALDRIN

I think those who have read the debriefings will remember the comments on the rather poor ability to discern the local vertical or the areas that were level because of the very poorly defined specific force acting upon us and because of the rather wide range of stable areas where we worked. There is a much wider range than we have on Earth.

ALDRIN
(CONT'D)

We could lean considerably further on the Moon before we would detect we had leaned. We also commented in the debriefings that the natural position appeared to be to the rear of the neutral-stability point rather than to the front.

FRONDEL

You noted that the surface color was a function of Sun direction. Was this a variation in the intrinsic color of the material itself or was it partially caused by reflection from a surface material, as if there were small, horizontal mirrors in the local area?

ARMSTRONG

I understand the question, but I can't answer it. I'm baffled by that effect. The 16-millimeter pictures gave what I consider to be a relatively accurate representation of what was observed in terms of color and light reflectance.

QUERY

Was it observed that the landing site was on or near any major structural feature such as a ray or something of that nature? I don't mean miles away but in the immediate vicinity.

COLLINS

No. The landing site looked like the 1:100 000 map I had, the one called LAM-2. On it, I could not detect any

COLLINS
(CONT'D)

visible rays. I think there is one that goes across the eastern part of the landing site; but, in the vicinity of the toe of the footprint, there were no rays visible on the map nor were there any visible through the sextant.

QUERY

Is the illusion of the Earth as seen from the Moon similar to the Moon illusion as seen from the Earth where the Moon looks smaller when it is higher in the sky ... horizon. Does the Earth, as seen from the Moon, appear to be a different size when it is high in the sky as compared to rising or setting?

ALDRIN

I don't believe we had the opportunity to evaluate the illusion phenomenon. To evaluate this phenomenon, we would have to be able to look up high and compare the object with some surrounding horizon, and the field of view of our windows was not adequate for that evaluation.

ARMSTRONG

There is the illusion of a gigantic Moon on some evenings, when the Moon is just above the trees, and it might be expected that a gigantic Earth would be seen at earthrise. However, we took many pictures of earthrise, and we saw many earthrises, but I don't recall an occasion when the Earth at earthrise looked like gigantic.

QUERY During descent, did it take a long time for the thin, foggy dust cloud to settle?

ARMSTRONG No, it took only a very short time. Again, I had the impression that when the dust particles departed on their ballistic trajectories, they left a clear surface with no dust-particle fog in the air. The dust fog cleared quickly; there was no lingering dust cloud or anything of that nature.

QUERY Were the LM windows dusty?

ARMSTRONG No.

QUERY Beneath the LM descent stage, you reported that there was no appreciable topographic changes. Was the surface beneath the descent stage harder or softer than the area away from the LM?

ALDRIN We didn't have the opportunity to penetrate the surface underneath the descent stage; so, perhaps all we can do is comment upon the appearance. It appeared that the area underneath the descent stage was flatter with fewer small, local variations than the area away from the LM. This was approximately 5 feet inside the gear, or approximately 3 feet inside the footpads.

QUERY As you walked away from the LM, the soft and hard spots seemed to be randomly situated, except for soft spots situated around the rims of small craters; is that correct?

ALDRIN No, I think all the deeper areas of this upper surface could be associated with a small crater, and these were generally on the rims of the craters.

QUERY When walking along the slope of these craters, did the material directly under your foot compact or was it displaced?

ARMSTRONG I would guess there was a slight displacement.

QUERY Did it behave like soft snow, for instance? Did your foot just go in?

ARMSTRONG There was a slight down-slope displacement. In answer to the previous question, I threw a number of objects, trash and various things from inside the rock boxes, underneath the LM. In every case, the objects stirred up approximately the same amount of dust that would be expected if the objects had been thrown away from the LM. In other words, there was still loose material underneath the LM, and it was close to the engine bell.

QUERY You mentioned that there were some rocks that were split by the LM descent-engine exhaust. Were these rocks or clods of material?

ARMSTRONG My observation from the cockpit, not from the ground, was that they were rocks.

QUERY Then, you did not have the opportunity to ascertain whether these were rocks or clods of material? Also, did the clods that you stepped on disintegrate or become drastically deformed?

ALDRIN I don't think they deformed; I got the impression that they crumbled.

ARMSTRONG They behaved like a clod of Earth. In answer to an earlier question, on the footpad and within the footpad dish, there was no material deposited that could be identified as having come from the exhaust or having been kicked up by the exhaust. Neither was there anything such as a coating of soot sticking to any observable part of the footpad.

QUERY What about other portions of the LM? Was a thin coating observed on the landing gear?

ARMSTRONG No, I think the photographs probably show in detail there was no coating; we didn't see anything either.

QUERY If there had been no ribs at the bottom of the boots, do you think that your traction would have been endangered?

ARMSTRONG No.

ALDRIN By looking at the way the footprint was so well defined, the boot ribs must have afforded some increase in resistance to any great amount of slipping. Now, when I was on the surface of a rock, I don't think it would have made much difference whether or not the boot was flat-bottomed. The tread would not have changed the amount of force needed for walking.

QUERY Should something that will enhance the traction of the roving vehicle, especially with respect to slow-climbing capability, and with respect to obstacle negotiation be provided? Also, will this slipperiness cause the vehicle to keep spinning its wheels on rocks?

ALDRIN I could only guess as to where the slipperiness was encountered, but I would think that it was encountered more between the boot and the fine surface than between the fine material and the rock underneath.

QUERY You mentioned that the material tended to compact. Does this mean that, when you walked over previously walked-on surfaces, you had better traction; that your mobility was enhanced?

ALDRIN That would generally be true. If you were to look at the volume, it would be obvious that when a foot went down in the material it was considerably compressed.

QUERY Did you feel that you sank more while carrying the EASEP?

ALDRIN I think so. I did feel that increased weight had a tendency to cause me to sink deeper.

QUERY Did you think you hit a harder surface, possibly rock, while driving the core tubes in the lunar surface?

ALDRIN There seemed to be an exponential decrease for a given force of impact on the core tube to get a given penetration.

QUERY Since there is no apparent change in the consistency of the material unpacked from the core tubes, does this mean that, if you had penetrated a harder material, this material was lost when the tubes were retrieved from the ground?

ALDRIN I wouldn't think so.

ARMSTRONG There didn't appear to be any discontinuity to me. There wasn't a finite place where the material suddenly hardened. It was simply more compact and cohesive as the tube was driven in deeper.

QUERY Do you feel that you hit rock?

ARMSTRONG No.

QUERY Are you going to look at the photographs of the rock samples that have been taken in the Lunar Receiving Laboratory and try to identify the locations from which they were collected?

ARMSTRONG Yes, we are going to try. I think we'll remember some of the rocks.

SIMMONS Was the hole made by the core tubes left intact when you removed the tubes?

ALDRIN It seemed to be intact. As I removed the core tube, I was more interested in not having the contents of the tube spill than I was in what happened to the hole the tube left.

QUERY What percentage of the rocks you observed looked like pumice?

ARMSTRONG I don't recall any looking like pumice.

ALDRIN I'd like to mention one thing. We have a photograph of the boot that pushed away the surface a little bit, but in the photograph I believe only a small crack of the surface is shown being broken. However, there was one occasion when I put my foot in and pushed and, relative to the size of the boot, this amount of material remained intact; it appeared to have some slippage or fracture beneath the surface. It was similar, I believe, to some of the Surveyor experiments which pushed the material so that it tended to fracture in a roughly circular and irregular pattern. However, the fractured material remained intact and slid along an irregular surface underneath as a pushing force was applied.

ARMSTRONG I noticed some evidence of a crust. However, the crust was very weak and thin.

ALDRIN I wouldn't have called this a crust. If there was a crust, it would have been in the upper layer of what was moved. It seemed that the entire surface was moved.

SPEAKER Buzz, was the seismometer firmly seated, or was it placed into more or less fluffy material?

ALDRIN It didn't appear to be seated in fluffy material. Once I had it down, it was rather difficult for me to change the slope of the package by moving some of the surface material. Each time I tried to move the little ball to get it to come around to the other side, it seemed to take a considerable amount of sideways motion to move enough of the surface material to change the slope.

QUERY The primary signals that we recorded from your activity normally were associated with your being in contact with the LM. Did you observe or sense vibration of the LM structure?

ALDRIN I don't think that I did.

ARMSTRONG I didn't.

QUERY After deployment, could the EASEP package have been located where a stream of gas from the vent might have impinged on it?

ALDRIN The venting took place well before the EVA, and most of it would have been directed to the rear.

ARMSTRONG The only venting activity that I was aware of while we were on the surface was that the ascent stage had a water boiler operating, and upon egress and looking back at the ascent stage, I could see a few particles emanating from the top of the LM, which I assume were water boiler exhaust.

QUERY It appears that you were able eventually to level the ball on the seismometer quite well, and, from your description, it seems to me that the BB is simply not damped well enough. Would you agree with that from your reflections?

ALDRIN Yes, wholeheartedly.

QUERY Do you think this problem is serious enough to warrant replacement of it or, at least, to put another normal-level level along the side of it?

ALDRIN I would recommend replacing it with one similar to what was on the reflector.

QUERY How many and what kind of packages were ejected from the LM?

ALDRIN Four all together, weren't there?

ARMSTRONG - There were the two PLSS's, the lithium hydroxide canister, the interim stowage assembly, which contained the boots and RCU's. Those four packages reached the surface. A smaller bag containing paper, flight plans, and so forth was ejected but did not reach the surface. It stayed on the porch.

QUERY Of the objects that we saw come out, most of them tumbled down the ladder. Is that correct? Also, could you have pushed them out in such a way that they would strike the surface directly without tumbling down the stairs?

ARMSTRONG I think each of the objects touched the porch on the way and bounced, and I think it's unlikely that we would be able to clear the porch, although it may be possible. The difficulty exists because we don't want these objects to hit the hatch seal when they are being discarded. If they hit the hatch seal, the integrity of the seal and crew wouldn't jeopardize the integrity of your seal and so would be jeopardized.

ALDRIN I would not have thought that any of the objects would strike the ladder, unless it was at the bottom. I think that there was enough velocity to miss the ladder, even though the objects hit the porch. The angle is such that

ALDRIN
(CONT'D)

you aren't able to observe those things directly, but it didn't appear as though they would strike the ladder.

QUERY

As far as you could tell, these objects hit the porch and then bounced onto the surface.

ARMSTRONG

We could not see the ladder well from the position that we had to assume in order to discard the objects, so we couldn't really say what happened down there; but it seems unlikely that they hit very much of the ladder as they were coming down.

QUERY

Were there any serious problems in deployment?

ALDRIN

I don't think there were any serious problems. One retainer had to be manually moved, and the handle came out even though I could not see it going into the detent. It came out quite smartly and seated itself quite well. If we had had to scrape away a good bit of the surface, the handle would have been at too great an angle to be useful for scraping.

QUERY

Did you notice whether or not there was any dust on the solar panels for the passive seismometer when you deployed it?

ALDRIN

In two of the four corners, there was a small amount of dust which was the result of that panel striking the lunar surface. When the panel came out, the package moved a little bit, and I think it struck the surface at that point. After the panels were out, however, it appeared as though there wasn't any part of the panel that was closer than 2 inches from the surface.

SPEAKER

From the pictures that were taken of the deployed laser reflector, it's difficult to see the shadow mark. Neil, were you able actually to put the gnomon mark shadow on the particular compass-rose mark?

ARMSTRONG

Yes. There were no difficulties in aligning in azimuth. There was some difficulty in leveling because of the nature of the surface. It tended to have a three-point suspension for a while, and it rocked back and forth corner to corner. The final resting position did not seem to have any rocking characteristic; however, it was not quite level. The bubble was perhaps 10 to 20 or 10 to 15 percent of the radius from the center and the southwest direction.

QUERY

But, there were several lines on the bubble level. Were you inside the innermost division?

ARMSTRONG Yes, the bubble was completely inside the innermost division.

QUERY Were you able to see Kapton shredding and general debris going out from the descent during take-off?

ARMSTRONG We saw a good bit of debris at separation. We did not observe the experiment, and it was my impression that, consistent with the dust patterns, the tendency was for the debris to go to much greater distances than I would have suspected. I would be surprised if much of that debris fell close to the LM.

QUERY An umbrella effect had been predicted. How far would the umbrella have extended?

ARMSTRONG During ascent, we saw one piece that flew underneath us for several miles before it hit the surface.

QUERY Could you form any estimate of the distribution and sizes of the shredded Kapton?

ARMSTRONG The one that was flying underneath us was about that big. My impression was that there was a large variety of sizes.

QUERY Were you able to see stars through the LM windows?

ARMSTRONG No.

QUERY

On the night before your reentry, there was a small experiment with the McDonald Observatory of getting your spacecraft in view. Was there any attempt to look out the windows as you were preparing for sleep, and did you see anything?

ARMSTRONG

Yes, we stayed up an extra hour to watch, and every time we were rotating through the appropriate quadrant, we made an effort to look. We were quite unsuccessful in that attempt; similarly, there were some cities on the northwest coast of the United States that attempted to turn their lights on.

COLLINS

As I remember the view, it was something like this. Does it seem possible there was that much light? In any case, this was the terminator. I guess it was - more like this.

ARMSTRONG

It was more like a crescent. That's right.

COLLINS

More like this. This was lighted and this was the terminator band; the northwest United States was way up here. It seems to me that the central U.S. and Texas were somewhere in here; and it's quite close to a lot of very light area - -

ARMSTRONG

This is Fresno.

COLLINS - - Pacific, and it is very bright; so you're looking immediately adjacent to a very large and bright area, and you just don't see much in the terminator. It would have to be a very bright light source to see it. We could tell where the laser should be, based on surrounding geography.

QUERY Do you ... think a filter might let you see that?

ARMSTRONG Perhaps.

SPEAKER These apply for ALSEP. Do you have any trouble with the bubble level on the LR³ at all?

ARMSTRONG No.

QUERY Do you recommend that we continue this way on other experiments?

ARMSTRONG Yes, it's much preferable to the seismograph problem. You want to know the level when you juggle the package around, and the LRRR does a much better job of that than the other approach.

QUERY Did you see the Kapton more in certain sectors?

ARMSTRONG I'm quite sure that such a distribution exists, but I couldn't see it.

QUERY Do you foresee any mobility problems with the barbell carry under ALSEP as opposed to what you had?

ALDRIN I think the barbell carry will be easier.

QUERY Describe the problem you had when taking the lanyard out of the bay.

ALDRIN There is a rather small thread that goes up and through a pulley that has a couple of keepers that restrict the thread from going too far. Then, it approaches the pit pin, and at the end of the cord there is a wire that goes through to the pit pin. This wire ring came loose and appeared to have a clean break as if it were not completed, not welded together.

QUERY Did it elongate and break or just pop off?

ALDRIN No, it bent; it opened up.

QUERY What is the maximum operating height for taking experiments out of the bay?

ALDRIN I didn't have any difficulty with the height that we used and I felt that I could have handled well over 6 inches more, perhaps even a foot more. I would not have been able to push the booms in again.

QUERY Approximately what height would that be, Buzz?

ARMSTRONG With the photographs we made, I think we can establish that precisely.

SPEAKER Estimate the distance of the deployed solar wind foil from the LM.

ALDRIN I would estimate 20 feet from the footpads.

SPEAKER Was there any dust that might have collected on the package as you set it vertically prior to deploying it horizontally?

ARMSTRONG I looked carefully at both packages after he left and I didn't see any evidence of this on either package with the exception of a few corners that we mentioned previously.

QUERY What about the decals on the packages? Were they visible and were they of use?

ALDRIN Yes, those decals are confidence builders. You know that you are not in trouble if you forget what to do next; you can read it.

QUERY In one of the previous briefings, you explained that you had problems associated with the interface of the gear to lunar soil conditions. You said examples were deploying the solar wind instrument and trying to level the seismometer. Should the gear have more bearing strength on the feet or something like this, as opposed to spiked feet?

ALDRIN I don't know what is needed, but I did have difficulty, as I mentioned before, getting it down into a level position. I'm sure that was the difficulty associated with trying to penetrate, with small sideways motions, an appreciable layer of the surface.

QUERY The front part of those packages has a rather large protuberance on each side where the pins go in, and they are not very sharp; they are blunt. Did that affect not being able to work the package in.

ALDRIN I think it did.

QUERY If you had the task of taking the seismometer and placing it on a rock ledge at the bottom of a small crater — that is, a crater deep enough to penetrate into the solid material — do you think it would be a difficult task?

ALDRIN I think you could place it just about anywhere you wanted, but I'm not sure you could have much success at getting it level.

QUERY Do you envision any difficulty in carrying and deploying the ALSEP 300 feet or more from the LM?

ALDRIN I think 150 or maybe 200 feet is reasonable.

QUERY Do you think that the presently planned 300 feet is too far?

ALDRIN It is just going to take a little longer. I don't think that's unreasonable.

QUERY In the voice transcript, there is a statement that says, "... didn't know you could throw so far, did you? You can really throw things a long way up here." What was it you threw and how far did it go?

ALDRIN I didn't throw the contingency sample handle, but we threw objects such as the covering off the LRRR and the celluloid cover that covered the mirrors.

ARMSTRONG One object he threw out the door of the cabin, and it sailed over my head. I think that is the object that was referred to on the transcript.

QUERY While using the scoop to collect the bulk sample, did you cut sharp edges?

ALDRIN Yes.

QUERY How did the material collect? Did it come out like chunks of clay or like loose sand, or --?

ARMSTRONG My impression was that, in general, as you cut with the scoop, the remaining material left a solid edge like wet sand, but the material that went into the scoop did not maintain any shape at all; it crumpled into loose material, with no evidence of coagulation of any of the particles.

QUERY Did you have a chance of remolding the loose material into clods, or did you check any of those little hunks that you created by compacting the material?

ARMSTRONG I don't recall doing that.

WISE In view of the ease of throwing things, would it be possible to transfer some of the material from the lunar surface up to the LM and back by tossing?

ALDRIN

I think it's possible to do that, but it would take some learning, either in one-sixth-g airplane studies or on the lunar surface.

On the lunar surface, an astronaut would have to make a specific effort at throwing, and see how well he did at throwing and catching. However, I don't think an astronaut would do a very good job on his first couple of tries.

SWANN

Concerning the next mission and the surface operations, the possibility of using the big scoop in the loose material to trench down to a depth that is easy to trench. Then, when trenching starts getting difficult, the astronaut would use the camera as a mattock to break up the material in the trench bottom; then he would specifically sample and bag separately the material that seems to be harder to penetrate. Does this sound like a reasonable procedure?

ALDRIN

Yes, I think you could do it. However, it's not an easy task to apply a good force in one-sixth g. We can't lean over very far with too much application of force to perform a scraping job. I think it would take repeated strokes to be able to penetrate to that depth.

ARMSTRONG If we had gotten to the documented sample as we planned to do, we would have tried to do something like that, at least to get a sample of the material about 8 inches down where it seemed to be getting quite hard to penetrate.

QUERY Are you going to look at the photographs to see if the subtle grain and directional properties noted in them are real?

ARMSTRONG I will try.

QUERY I'm thinking about contingency possibilities for ALSEP deployment. Could you estimate how much farther down you could have reached toward the surface? I gather you had no difficulty getting to the seismometer handle, but could you have gone farther down and how much?

ALDRIN I think we could have gone down quite a bit farther. If you remember, I was able to get the retainer off by pushing it away. We both agree that it's easy and quite feasible to get down lower, even to get down on your knees and actually pick things up off the surface. However, this procedure would take time, and I don't think you should design the equipment to be operated that way; but I think, under contingency cases, there is no limit to what the

ALDRIN
(CONT'D)

astronaut could actually do. It would help if he had some support at the time he was reaching down, if he could put his hand on the upper part of the package.

QUERY

Could an astronaut support himself with something like the UHT tool?

ALDRIN

Yes, I think you could use it.

LOBB

Concerning the LEC, when we were speaking a short time ago of transferring items from the ground to the spacecraft or vice versa, I believe you said you did have some thoughts about the LEC.

ARMSTRONG

Yes, we used the clothesline conveyer, and we used it for both sample boxes. It works, although I don't like it much for a couple of reasons. One, it's a nuisance — keeping the straps unfurled, keeping from getting tangled up in your feet, having to find places to store them, and keeping them from twisting. In addition, it tends to pick up a lot of particulate material because of the fabric that is used in the straps; and this material is carried into the LM and poses a housekeeping problem. It tends to bind in the pulleys, and you can actually feel the gritty material getting caught up in the rollers of the pulley. Then the material that escapes comes out on

ARMSTRONG
(CONT'D)

the downward side of the pulley and brings soot down on top of the astronaut.

The tops of the rock boxes were covered with fine soot-like material that fell off the conveyer on top. We have made several suggestions to EVA Operations personnel on other ways that might be considered. Some of the methods which we had tried before the flight can improve the situation; and we hope that by the time Apollo 12 is due to be launched, we will have settled on some improvements.

LOBB

In regard to the stereocamera setup, there were some remarks it was difficult to keep it in position after it was set for taking the pictures. Was this because of the handle location or was this because on the lunar surface itself it was hard to find a place that would support its direction?

ARMSTRONG

I don't think that the handle shape had to do with this problem. Keeping it in position was difficult because first, it's difficult to find a level surface and second, because if you find one, you're not sure it actually is level. The difficulty with the local vertical also contributes to the inability to pick a place where it'll stay. It didn't take much of a bump to get it to fall over.

LOBB Would something such as an outrigger support it?

ARMSTRONG That is probably one solution.

LOBB Was the handle problem that it didn't line up with your
c.g. so you could hold it properly?

ARMSTRONG Generally, you want to have the subject that you are
taking the picture of in your field of view, which means
that it has to be out away from your feet. In addition,
you want to keep it out of all the loose material that
you're kicking up with your feet, which means that you
have to have it out to the side. When you have it out to
the side, the geometry of the glove and the wrist ring
makes it a very uncomfortable angle. It took a great
amount of force to pull the trigger. That probably con-
tributed to the small number of pictures taken.

LOBB In regard to the cable that twisted when you were moving
out from the spacecraft, the main problem was that it
maintained its twisted shape. Would there still be a
major problem if it would reel off the reel straight and
remain flat?

ARMSTRONG Yes.

QUERY What was the approximate proportion of vesicular rock samples on the surface?

ALDRIN It's a very low number, Bert. I saw only three or four samples that were definitely, clearly vesicular. They had holes big enough so that you could tell what it was from a standing position. I brought back a couple of these, I believe.

QUERY What was the maximum diameter of the vesicles that you saw in one of these rocks?

ALDRIN Half an inch.

QUERY Were any of the vesicles obviously stretched or elongated? Were any roughly spherical?

ALDRIN I don't remember seeing any samples that had any obvious compressional features or any squeezed vesicles.

QUERY Back to the mechanism of the dust when you were kicking it, did you accelerate clods of the dust particles?

ALDRIN Yes, that's what I meant when I said that they were a particulate size. I don't know whether I generated the clods or whether the material did not all go as a powder. It certainly didn't go as its finest particulate size.

ALDRIN
(CONT'D)

It tended to form something on the order of 5 or maybe 10 millimeters. That's a rough guess as to the size of it.

QUERY

In estimating the envelope that was covered by dust during your ascent, you said you could not see the EASEP. Did you notice any obscuring of the flagpole or the TV camera which would give an idea of the angle at which the dust was leaving the area of the ascent stage?

ARMSTRONG

Let me clarify something. Perhaps I left a false impression. I said we saw a lot of debris from the ascent staging, but I did not see any dust during ascent.

ALDRIN

I agree with that.

QUERY

What was the maximum size rock fragment that was moved by the descent engine?

ARMSTRONG

I never could distinguish a particle size.

QUERY

Neil, did you find the handle length on the tongs to be sufficient?

ARMSTRONG

Perfect.

QUERY

Have you covered the S-band antenna direction in any of the other briefings? It would appear from what you have

QUERY
(CONT'D)

said and from watching some of the operations that directing the antenna be a very difficult operation on the next mission. Do you have any comments on that?

ARMSTRONG

We were fortunate enough not to have to do it in a real case. I think it's fortunate because the operation takes time and energy, and I'd much rather be doing other things than building a radio system.

QUERY

I think it is planned to deploy it on the next mission.

ARMSTRONG

We weren't concerned about our ability to do that job. One man can perform the operation in 10 or 15 minutes if he has to, but we're glad we didn't have to.

QUERY

Did the lunar surface appear to have a wavy appearance? By that, I mean an undulating type of 1/2- to 1-meter topography. Also, do you believe that a vehicle could traverse this topography at a moderate speed?

ARMSTRONG

In answer to the first question, my impression is that the topography consisted of at least 1-meter undulations, with many bigger than that. The answer to the second question depends on what moderate means.

QUERY

I'm speaking of approximately 5 miles an hour. I don't think you're going to go much faster than 5 or 10 miles

QUERY
(CONT'D)

an hour with a wheeled vehicle, based on the dynamic aspects.

ARMSTRONG

That doesn't agree with my impressions. My impression is that a moving vehicle will be subject to the same kind of limitations a walking man faces. The limitations will be based on the local topography and the distance ahead at which you have to judge your path. These limitations are going to restrict your speed. Overall, I am less encouraged now about the capability of wheeled vehicles on the lunar surface than I was before the flight.

LOBB

In regard to wheeled vehicles, is the surface similar to a sandy or desert area, where you would have a problem with supporting the traction characteristics of a wheeled vehicle as opposed to a track-laying vehicle?

ARMSTRONG

My concern was with the local slopes, roughness, and size of the craters, rather than with the surface texture. A large piece of equipment or a big wheel would be required to traverse the kinds of slopes and the depths of holes that we observed.

LOBB

Were the particles you kicked deposited after they hit the ground or did they resume the appearance of having

LOBB
(CONT'D)

been there for some time? Was there a marked contrast between the kicked and undisturbed particles?

ALDRIN

I think most of the area in which I did the kicking had been disturbed previously. This area was between the LM and the television antenna. I wasn't able to identify the particular particles that had been kicked. They did not have any tendency to bounce.

LOBB

Is there a color difference between the material that is on the surface and the material that is below the surface? Did the kicked material blend with the new location as if it had been there for some time or did it show a marked difference, as you would have here on Earth?

ALDRIN

As I mentioned, there was no direct evidence of kicking up material and then observing to see whether a particular particle could be observed. However, there was ample indirect evidence that points to the fact that if you were to kick in a fresh area, you would certainly be able to see this material.

QUERY

You mentioned in one of the earlier debriefings that you felt that man, at least for this landing site, might be limited to a 1/2-mile walking radius from the LM. Was this statement based on concern on your part from the

QUERY
(CONT'D)

standpoint of fatigue in that particular kind of terrain or was it more of a line-of-sight consideration, or both?

ARMSTRONG

The question originally was asked in the context of the kinds of equipment that we had available and limitations that we had on this flight. I guessed that a half mile might be a reasonable radius, and Buzz felt that a somewhat larger radius would be a safe limit. The estimate was based on a combination of things: the distance we would have had to return to the LM in case of an emergency, the supplies we had available, and the amount of distance which could be practically negotiated by eye. Fatigue would not be the only factor.

QUERY

If you were in a lunar-rover-vehicle that was a distance of 5 kilometers, for example, from the LM and something happened to the vehicle that required you to walk back, do you think that that would be a serious problem in terms of fatigue, assuming you were able to navigate your way back successfully?

ALDRIN

Again, I don't think that fatigue would be the limiting factor. Time would be the major factor and whether you would want to do this when you know that your reserve system won't give you that much time.

QUERY

How would you approach learning to drive a four-wheel vehicle on the surface of the moon for the first time? I'm speaking here in terms of the dynamics of the vehicle as opposed to learning where things are and how it operates. Trying to simulate something like that on Earth is difficult, particularly from the three-dimensional point of view. Do you think it's practical to consider learning to drive the vehicle very slowly on the surface of the moon until you become somewhat educated as to what it can do and then step up the speed? Is this a practical approach?

ALDRIN

We recommended that this approach be used — that the major learning be accomplished by the individual. A certain amount of time, we feel, would definitely be allocated to a period of orientation, and a period should be set aside for further learning of the capability of the vehicle before it is committed to some particular return distance.

SEVERE

I have a question about the visibility in the shadowed areas inside the craters. The pictures of the 80-foot crater showed the shadows inside to be black. Were you able to make out detail in the shadowed areas of the

SEVERE
(CONT'D)

crater? Would you have been reluctant to venture into the shadow areas of crater from the standpoint of the visibility?

ARMSTRONG

The eye does fairly well in those shadows. It does particularly well if given time to adjust to the shadow. If an astronaut can venture into the shadow, he should get into the shadow area and then wait half a minute or a minute for his eyes to adjust. Then, he can proceed quite well and see a good bit of detail.

QUERY

If it had been early in the EVA, would you have hesitated to go into the 100-foot crater?

ARMSTRONG

I think if I could have spent time on the 35- or 40-degree slopes, whatever they are, and if I could have convinced myself that there wasn't any danger on those slopes, then I would have gone to the bottom of that crater, made a traverse, and come out.

QUERY

Would you agree that the mode that you might try first would be one of easing down, leaning forward, or perhaps easing down backward?

ARMSTRONG

That would certainly be one you would want to try in a familiarization period.

ALDRIN I don't think you would want to put yourself in a position where you would fall forward and have to recover with rapid steps. That's why I would think that you would want to transverse a crater like this by moving backwards, and this poses a visibility problem, in that one has to look to see what he's going to be negotiating and then turn around some way. Looking down is not one of the greatest advantages of our suit.

QUERY Was bedrock exposed anywhere, perhaps in the craters?

ARMSTRONG The only evidence that we had of possible bedrock was in West Crater. Those gigantic boulders in the vicinity of West Crater would certainly be contenders, I would think.

ALDRIN The pieces in the boulder field to the right of the LM are observable in some of the photographs on the north side; I don't know how big those rocks are, but there were probably some rocks in that field that were 3 feet or larger. They may, in fact, be contenders for pieces of bedrock that come out of West Crater.

QUERY Is the particle distribution on the surface representative of the subsurface material? We don't know if we're going to have to drill through rock fragments believed to be beneath the surface; we're trying to get an estimate.

ALDRIN

On the basis of the observation of the craters that we saw, the absence of layering, the absence of bedrock, the fact that we pushed tools into the surface and they hit rock at one time but not another, that some rocks lie on the surface, that some are partially exposed, that some are fully exposed, that there isn't any correlation that could be made within the observational limitation led me to believe that probably down to the depth of that 80-foot-diameter crater (which was 15- to 20-feet deep in that region) the West Crater area was an exception. The surface was a homogenous mix, with a wide variety of particle sizes. If I were to guess what could be found 12 feet below the surface in that 80-foot-diameter crater I would expect to see mostly fine particles, some rocks this size, and a few 3-foot boulders. I had the impression that there were little variations in the fine-grained particles on the surface, and that, when this surface was scraped away, just the very fine-grained particles appeared visible. Maybe this was because the larger particles were suppressed below. There did seem to be some local variation in the size of particles on the surface, but that was not always evident when I scraped down in the surface. The particles appeared to be of a more uniform size just below the surface.

QUERY In addition to this fine sooting material that adhered to the boots and to other parts of the EMU, was there any other kind of coarser-grained material that tended to adhere to the suit?

ALDRIN Not that I was able to observe; it was all very fine-grained material.

ARMSTRONG The largest particles that I could detect sticking to the EMU were about the size of fine or very fine sand.

QUERY Did this adhering material accumulate in any sequential manner? Did material gradually accumulate, then, after reaching a certain level, drop off the suit, allowing new material to accumulate?

ARMSTRONG I don't know. I do know that when I kicked the strut with my feet the majority of the particles fell off. However, they discolored the fabric.

QUERY Was your color perception when looking through the LM window different from when you were looking through your visor? Did you see the surface differently?

ALDRIN Perhaps, a little.

QUERY What was the touchdown velocity and the penetration of the LM footpad?

ARMSTRONG The touchdown velocity was zero fore and aft, maybe 1 to 2 ft/sec southward, and one-half to 2 ft/sec downward.

The photographs probably estimate the penetration better than we can, but it was 1 to 2 inches, at the most.

Because the footpads are lens-shaped, it's difficult to tell where the intersection is between the footpad and the surface. It's well back under the footpad, so the penetration was quite small, and there was no discernible throwout from the footpads.

QUERY Was the boulder field you mentioned on a level or sloped surface?

ALDRIN It was on a generally level surface, but our ability to perceive slopes less than 5 degrees was very poor.

QUERY We attempted to get a location of points for possible craters that Eagle flew over, and these are described in terms of the coordinates on the 1:100,000 scale map which is, I believe, designated the LAM-2. Is the coordinate system the best way to describe a point on the

QUERY
(CONT'D)

surface so that the Command Module Pilot can try to locate the LM from orbit?

COLLINS

Yes. I don't know a better way of describing the location than a coordinate system. However, I am not sure that the coordinate system we used is the best one that we could devise. I wasn't even sure before the flight what our coordinate system was. We have a system that uses letters and numbers, but I think it would be better if we used the regular Army map service grid-square system.

CHAIRMAN

That concludes the photographic and scientific debriefings, gentlemen.