NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

FAROUK EL-BAZ
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is November 2, 2009. This oral history interview is being conducted with Dr. Farouk El-Baz in Boston, Massachusetts, for the Johnson Space Center Oral History Project. Interviewer is Rebecca Wright, assisted by Jennifer Ross-Nazzal. We certainly would like to start by telling you thank you. We know you're a very busy person with a very busy schedule, so thank you for finding time for us today.

EL-BAZ: You're welcome to come here, because this is part of the history of the United States. It's important that we all chip in.

WRIGHT: We're glad to hear that. We know your work with NASA began as early as 1967 when you became employed by Bellcomm [Incorporated]. Could you share with us how you learned about that opportunity and how you made that transition into becoming an employee there?

EL-BAZ: Just the backdrop, I finished my PhD here in the US. First job offer was from Germany. It was in June 1964; I was teaching there [at the University of Heidelberg] until December 1965. I went to Egypt then, tried to get a job in geology. I was unable for a whole year, so I came back to the US as an immigrant in the end of 1966. For the first three months of 1967, I began to search for a job. When I arrived in the winter, most of the people that I knew

were at universities, and most universities had hired the people that would teach during the year. I wasn't getting much response, so I tried to apply to mining companies, oil companies, or whatever I could get.

Very little was happening. I had been getting all kinds of professional magazines. One of them was *Physics Today*. In this *Physics Today* there was just a one quarter-page ad [advertisement] for Bellcomm. It said, "We need geologists to work on the Moon" from photographs that have been taken by Lunar Orbiter missions. So I thought I would apply there too. My wife was the one typing all the letters of applications. I had sent by then, by end of February, something like 120 letters of application. I was sending them as fast as I could, so this would have been the 121st letter. That evening my wife was beginning to feel tired, it was like 11:00. I told her, "Here is one more."

She said, "What's this about? I'm tired now."

I told her, "Well, send out one more."

She said, "What's that about?"

I said, "Well, they said that they need geologists to look at the Moon."

She said, "And what do you know about the Moon?"

I said, "Nothing, but I can learn." She grudgingly typed the letter. There were two typos; I did not ask her to redo anything; I corrected them myself neatly. We sent the letter and that was the letter that I got the first response from.

They said, "You'll come and interview," I think the first of March or something like that, so I went down for that interview. Two people stood out in my mind from these interviews. The first is Ed [Edward C.] Nixon, who was the brother of President [Richard M.] Nixon. He was a geologist with a master's degree. He said, "Well, I tried to work in geology, I didn't find

anything, I couldn't, so I moved out and now I'm a personnel guy." He was the head of personnel at Bellcomm. "Geology, I suppose, trains you for all kinds of things, and here I am, I'm doing fine. I still remember geology. I read some books here and there, but it's all gone."

Then the other guy that stood out in my recollections was a geologist from Germany. His name is Bruno [E.] Sabels. He said, "Well, this is a lousy job, it's a paper-shuffling job. We get these reports from the US Geological Survey [USGS] geologists. None of the NASA people like to look at all these reports, so all our job is just to summarize these damned reports and give it to them. We know that nobody reads them anyway, so it's a paper-shuffling job."

I said okay. When I went to work, I was right next to him after I accepted the job; my office was right next to Bruno Sabels. I told him, "When you get these reports from the geologists, give them to me. I'll summarize them for you." He said great; he liked the whole notion, so I did. He gets these reports, supposed to summarize them. He gives them to me, I summarize them in one paragraph and give it to him. That went on for a long while very nicely.

Then there was another geologist who worked for NASA by the name of Donald [A.] Beattie. He reminded me of the story himself not long ago. He said, "When you came, you were green as anything. You came to my office, shook hands, introduced yourself, and you said you were going to be working for Bellcomm. You looked at this huge stack of filing tables in my office, you said, 'What are these?' The Moon. That's the lunar pictures. There are too many of them."

He opened the drawers and showed me the pictures and I began to look at them with interest. He said, "Listen, if you want to take them, go ahead and take them, I don't want them anymore." I said sure, and took all the pictures. This was the beginning of the pictures that I

began to look at. I was fascinated, and I thought I'd begin to study these, and began to do that for myself.

Not long after, there was a meeting of the geologists in one of the NASA Centers in Virginia, Langley Research Center [Hampton, Virginia]. Don Beattie was going. He called me up, he said, "I'm going to Langley Research Center for a geology meeting. Want to come along?" I said absolutely, so we hopped in the car and he drove his Mustang—he was quite happy with it. We went down to Langley; I forget the town. The hotel was called Strawberry Banks. Norfolk, Virginia, I think.

We went to these meetings inside the Langley Center. The geologists began to report on their findings. These were geologists mostly from the US Geological Survey. Some of them were seconded to NASA, some of them were completely supported by NASA in Flagstaff, Arizona. There was a branch of astrogeology in Flagstaff, Arizona, with a small component of the same branch in Menlo Park, California. These were the US Geological Survey geologists that were supported by money from NASA to work on the geology of the Moon. Many of these people would stand up and talk about Copernicus Crater and various hills, features one by one by one by one.

This was the first meeting. Then the second meeting went on; the same thing happened. I began to realize that I really needed to get more familiar with all these pictures so I could communicate with my buddy geologists. I went to NASA Headquarters [Washington, D.C.] at the library and asked them, "Where are the lunar photographs?" They told me in such and such room. I went to that room, and there were piles of Lunar Orbiter pictures just like the ones with Don Beattie. Totally disorganized, and just shoved all over. I went to the librarian and said, "These need organization. Can we have some tables? We'll fix them."

He said, "Sure, what do you need?"

I said, "Nine tables."

He said, "Sure. They're going to be ready 9:00 in the morning." So he did. The following day I had nine tables ready to go. I had brought in clean sheets from the house to brush the dust off the papers and organize them. It took me three days to organize all the pictures that had been collected by Lunar Orbiter then and put them in stacks by the mission and by the numbers and all like that. I began to look at them.

These [geology] meetings were very regular, so we went back down to Langley. Again everybody stands up for one hour and speaks about a lunar feature or another and would sit down, then somebody else speaks. Some questions or no questions, then it's followed; every day, a single day. That third meeting I think, I realized that yes, we're seeing details about these features, but there is nothing that connects all of these things together. What's connecting all of these things? Why are we looking at these different things in different places on the Moon?

There was one old gentleman sitting right next to me. He had a beard and beginning to get some gray hair, I thought he would be kind to me. I asked him whether there is a report or a paper or something that talks about all the different types of lunar surface features and their distribution on the Moon. He said, "What do you mean?"

I said, "Just a list of the different types of features and their distribution."

He said, "Well, we know what they are and where they are." I thought to myself, all right, they know where they are and what they are, I should begin to know what they are and where they are. So I went back to this library room with all of the Lunar Orbiter pictures. The librarian had actually given me the key and allocated the room to Bellcomm, because I was

Bellcomm. Although we were all at NASA Headquarters, this room became kind of my play place. All the lunar pictures.

I sat down, after I did my official work of summarizing the reports for my buddy, I would go to that room, sit down, take all the pictures one by one, see what's in it, take one three-by-five card, we didn't have computers and none of these other things that you guys are familiar with. But we had three-by-five cards we'd buy. I'd write the mission number, the frame number, and then write some notes on what that picture contained, what features, one by one.

Went through them all, couple thousand of them, and organized them, and then when I finished I asked myself just a very simple question. Why does NASA need geologists? It is to select landing sites on the Moon, so if we want to go and land next to every single type of lunar surface feature, which means that we would sample every kind of lunar material or rock, if all of these features have different rocks, where do we go?

I took my list, the card file, one by one, went through them all—this is here, this is here, this one here. I came up at the very end with a list of 16 places on the Moon. If we go to all these places we would see every single type of lunar surface feature and therefore we would have sampled every kind of lunar rock, if these features have different types of materials or rocks.

I liked that whole notion, so we had a plan for the next meeting of this bunch of geologists. I asked who's organizing the next meeting. They told me who, and I found his phone number. There was no Internet to find that phone number. It took me three days to find the phone number of that guy in Flagstaff, Arizona. I called him up, and I said, "At the next meeting I would like you to give me a chance for one hour just like the other guys."

He actually said, "Who are you?"

I said, "My name is Farouk El-Baz."

"Where do you work?"

"At Bellcomm."

"What are you going to talk about?"

"About 16 sites on the lunar surface."

"16 sites. What sites?"

I said, "Well, these are features—"

"Give me an example." So I gave him one. "Give me another example." I gave him another one by telling him where we would go and what we would find. So he said, "How about that—another example," so I gave him a third example. He said, "Well, that's interesting. I'll put you on the program."

So he did. He put me on the program. I prepared my viewgraphs. There was no [Microsoft] PowerPoint [software] then; we had viewgraphs, which are huge sheets like that. I'll show you an example of it. We put it like this [demonstrates] and it projects it on the screen. I had my viewgraphs of this and what were the 16 sites, what they show, and how many of these features we'll see, and this and this and that. I finished my presentation. All kinds of questions came up.

During the question period, the same gentleman was sitting next to me; Bob [Robert P.] Bryson, who was from the Lunar Exploration Office. He stood up and he said, "I'll have you all know that this young man—," he didn't know my name from Adam, "the last time we were here he asked me about the lunar surface features and their distribution. I told him we know what they are and where they are. I want to thank him publicly, because he just showed me that we didn't know what they were and where they were."

That was it; that was the key. That statement made me among my own peer group, the geologists themselves. Upon return to my office after that meeting, I would get phone calls from Flagstaff, from Menlo Park, from Houston [Texas], from the guys, from many geologists. [They] would call me up and they said, "When you said that the various sites would be such and such and such, what was that based on?" I had all of my cards in gray metal canisters right on top of my desk.

I'd flip over the Lunar Orbiter one and pick up the number and look at it and say, "Well, Lunar Orbiter I frame 82. If you look in the lower right corner—" because I wrote that in my card, "you'll find such and such."

"Gee. Thank you," from the other end. Somehow I became a source of information. This kind of got me into my peers as an equal. It took a lot of work to do, or a lot of thinking, because first I'm a foreigner. At the time there was no diplomatic relations between the US and Egypt. I had not been a citizen yet, I spoke funny, I look weird. My name—nobody could pronounce. All of these things combined are against me, so you had to have a lot to counteract all of this so that you can be accepted as one in the group.

WRIGHT: So you used knowledge for your entrance.

EL-BAZ: It was knowledge. And it was work like hell, figure out everything yourself before you open your mouth, then when you open your mouth make sure that you're going to add something, because every single one of them is adding something. You've got to add a lot more than they do so that you as a weirdo can be accepted amongst them. That was it.

So I became part of the geology group and slowly but surely I became the spokesman of geology at NASA Headquarters and with the NASA engineers in Houston. Wherever it was, I became the guy that speaks on behalf of the geology community.

WRIGHT: Share about the relationship of Bellcomm and USGS and NASA scientists, NASA Headquarters. So much is going on, trying to get to the Moon by the end of the decade. How did everyone work well together? As you mentioned, we had no Internet, faxes, you even had to look up phone numbers. How were you able to exchange information so everyone could be up to date?

EL-BAZ: First, Bellcomm as part of NASA. I consider it one of the strokes of genius of [NASA Administrator] Jim [James E.] Webb, who just conjured that we're going to have problems in communicating with astronauts, and that takes a lot of engineering and a lot of communication expertise. Who has that kind of thing?

At the time there was only AT&T. There was no Verizon and this and this and that. None of these existed, so AT&T was the main place for all of this high-caliber engineering, particularly at the research headquarters of AT&T, which was in Holmdel, New Jersey. So Jim Webb writes a letter to the chairman of AT&T requesting AT&T's assistance in the nation's quest, and asking that AT&T put together a team to work with NASA to resolve all the problems of communication that we're going to encounter, not just with the astronauts, but from the Moon, behind the Moon, because we don't know what we're going to deal with.

It seems that the chairman of AT&T took this to the board and the board loved it and they all voted absolutely, put all your best into this thing. They agreed to get all of the big minds of

AT&T with their own support teams and move them lock, stock, and barrel to NASA Headquarters as part of NASA Headquarters to work for cost, because this is working for the nation. It was a national quest we're working on, so there should be no profit in this. We're doing it for the good of our country. So Bellcomm was then put as a component to support NASA Headquarters to work for cost plus $1 a year. That was in the contract.

WRIGHT: Amazing.

EL-BAZ: Genius. Now, what's the real genius behind it? The real genius behind it is that these people in Washington, DC, were not NASA employees. We had a boss in New Jersey, so the immediate boss and so on is irrelevant, because the real boss is in New Jersey. None of these people have a boss right there, so when we're asked something we answer it for the good of the program, regardless of whose idea it was, who in NASA Headquarters would like it, and who would not like it. It is irrelevant. It is for the good of the program, period. So at NASA Headquarters, we could say anything to the Apollo program director, to the NASA Administrator, to anybody in the group, to the engineers, to anyone, for the good of the program, because he has nothing on me. My boss is out there.

Then, when we worked with the Centers, when we went to any of the Centers, we had a badge that said NASA Headquarters. We had a kind of one-upmanship with people at the Headquarters with the Centers, because we represented NASA Headquarters. We could get things done outside of the realm, within the structures at the Centers, because we were outside. We are Headquarters; we say we need this, and we need this by Friday. And we can say that, and it happens because we're representing NASA Headquarters.

It was unreal. I've never seen anything like it before. The way it worked is that Bellcomm offices were always in the same building, and in many cases on the same floor as the Apollo Program Director Rocco [A.] Petrone. Rocco Petrone was the dynamo behind the success of Apollo. Very little is written about that man; no books were ever written about him. He didn't write a thing. I tried to push him like crazy when he retired. He wouldn't. He was an Army officer, football player, big and bulky, as tough as nails. Smart as hell, because he had a PhD, even though he was a football player and in the Army.

He became the director of the Redstone launch operations [Development Officer, Redstone Missile Development, Huntsville, Alabama (1952-1955)], then he put together all of the launch sites at the Cape [Canaveral, Florida]. He was launch operations director at the time of the first Apollo missions. After Apollo 11 he then became the Apollo program director. He replaced [Robert C.] Seamans, [Jr.], so he really was this incredible character that knew how to motivate people, knew how to push to the absolute limit, knew how to be cordial, laugh with the astronauts and do this and that, but push like crazy. He wouldn't take no for an answer. He was just a master of management.

I'll never forget my first interaction with him in a real-life situation where there was some problem at JSC [Johnson Space Center] in Houston and I knew about it. So he calls me up because he knew that I was there. Calls me up. "Farouk, what's the story?" So I told him. He said, "Do you know what group in Houston is doing this?"

I said, "Not clear."

He said, "Just get on a plane, go down to Houston, figure out exactly who is doing it. The small group, tiny, down in the bottom, that will do this job. Because from [JSC Director] Chris [Christopher C.] Kraft I get all kinds of smoke and mirrors. I want to find out who's

doing this because we need to finish this. We need to finish on time, so just find out who and where at NASA Houston is doing this."

So I go down to the small group that's doing it. There's one guy and six engineers. I get his [phone] number and name and this and that; I found out what the real story is. And, there are complications between him and layers above. So, I go to Rocco the following day and I said, "That's it, I found out yesterday that this is the story."

He said, "You got his number?" I said sure; I gave it to him. He said, "Okay, give it to Virginia, please." Virginia was his secretary. Said, "Virginia, call this number for me." She takes it from me and calls the guy. This is the Apollo program director in Washington, D.C., and he calls this guy. "Hi, John," he says, as if he knows him. "Farouk here tells me that he was with you yesterday and you're doing a great job." The other guy I'm sure is shaking like this [gestures]. This guy has never talked to Chris Kraft who's directing NASA in Houston, and he's never ever seen Rocco Petrone from NASA Headquarters.

He tells him, "Listen, John, this is the problem that is standing in front on the road of that mission. You are the only man that can fix this problem now, and your group has the key to this mission. Do it and fix it; we're going to have that mission successful. If you don't, we ain't going to, so John, I want you to go to your guys. Get all your guys together, and tell them. Tell them that the whole program depends on that one little thing.

"I want it, and we need to accomplish that by next Thursday. We thought about Friday, but now it is next Thursday." This was Tuesday. "So John, the whole thing is in your hands. I know that you can do it because Farouk tells me there is nobody like you. You're a dedicated guy. John, if you need anything during this time you get your people and you get them together and tell them, 'Hey we're going to do this thing.' If you need anything from me, here is my

number." He gives him his phone number. "Just in case you need anything at night or something, here is my home number." He gives him his home number in [Arlington] Virginia. "Okay, John. Godspeed. I'll wait to hear from you, John."

I'm sure the guy at the other end has fainted already. He collected all of his guys and pumped them up like crazy. They worked I'm sure 48 hours nonstop and they fixed the problem.

How much more motivation can you do for anybody, that the topnotch guy in NASA Headquarters calls that little engineer and pumps him up and tells him you are great and the whole program depends on you and Farouk tells me that you're the best, and you got to do it? He's going to do this thing, no matter what it takes. That I think is motivation. That is the modus operandi of Rocco, the way he fixed things one by one.

WRIGHT: Your 16 sites that you suggested to be considered for site selection—how did this progress over the next couple years as the Apollo missions, the lunar landing missions, began to move forward?

EL-BAZ: It was not necessarily all the same thing, but it was the principle of it all that we need to sample different types of features. We need to sample different types of rocks. Most of the Apollo sites that we visited really fall within the same range of the 16 sites, not necessarily exactly the place, but within the range. It was more we had developed—after [Apollo] 11 and while we were doing 12, Houston had established the Group for Lunar Exploration Planning, GLEP.

The Group for Lunar Exploration Planning was under Wilmot [N.] Hess. GLEP had to consider all of the scientific aspects of the Apollo missions: the chemistry, the rocks, the

geology, looking at the Earth from the Moon, the solar/laser reflectors, the seismometers, all of the measurements, the heat flow measurements, all the experimentation, all the science that will be done on the Moon's surface.

This had all kinds of scientists from outside of NASA to suggest you should do this or shouldn't do that or whatever, and the reasons for doing it. It included some NASA people. Then within that group, because they did not have the ability to think in detail about geology, they made a site selection committee from this GLEP. I was in this. Then the site selection committee included members from the NASA Headquarters, members from the US Geological Survey, myself, and Noel [W.] Hinners from Bellcomm. Noel was actually the chairman of the site selection group.

NASA usually tried to do that when there was a committee that looked into something or other. They made the chairman of the committee from Bellcomm, so it's not aligned, because we were kind of their boys. They could use us anywhere, so they get one like that, then there will be no jealousy from within NASA. Noel Hinners was the chairman of the site selection committee, and because of my connections with the geologists, which Noel didn't have, I was the secretary-general of the site selection committee, so at our deliberations we would do the following.

We would go—actually not Noel, but I would go with all the geologists of Headquarters and the geologists at Houston, because we still had a whole bunch of geologists in Houston even though most of them were preparing themselves for the lunar rocks only. Some had been training the astronauts for fieldwork and hammers and what do they do with the samples and this and that, then all of the geologists at Flagstaff, Arizona and Menlo Park, California, so there were geologists all over the place. There really were a few geologists also working with us that

dealt with impacts and age-dating and all of that from [NASA Ames Research Center] Moffett Field [California].

There were geologists all over the place, so that required in my real life my flying all over the place to be in communication with all the geologists, and their perceptions of what do we do where and so on, so I can prepare the arguments that will go from the site selection committee to the GLEP. GLEP was the mother organization, the Group for Lunar Exploration Planning. GLEP was to make the recommendations to NASA, so that's how things developed.

We would do all of our geological laundering, so to speak, and then I would sugarcoat it to present it, then it becomes a GLEP decision to NASA. That's how the site selection kind of went. Once in a while we had a lot of people to say, "Oh that's lousy, that's a terrible thing." We would reduce it down, then Rocco Petrone would be one that whenever he hears any misgivings about any of the sites that we recommended, he would call me up.

He said, "Farouk, what's this story? Okay, bring them up, bring them up here. Sit down and talk with them and see where you go, and state your arguments, so you want to see what's there. I'm going to come along to listen to this." So he wanted to see what the objections, and be shown the details—let me see what the story is.

WRIGHT: What an interesting man. Where were you for the first landing on the Moon?

EL-BAZ: Oh, right in Mission Control.

WRIGHT: Can you share with us the feeling of that moment, of being in the midst of that historical time?

EL-BAZ: Like some of the astronauts themselves, we really did not either see or feel the incredible impact on history at the time. We just wanted to make it to the Moon before the Russians; it didn't matter where or how.

Everybody was charged with this race, because our view, it had a reflection on our ability as a nation. Whenever once in a while the argument would call for any discussion about let's do this, let's not do that, or we can do that, immediately you would hear somebody say, "Guys, listen, we're not going to let the Russkies beat us. What the hell is this? We got to do this, we got to do it right, we got to do it on time." They would say that with gumption, so this was certainly part of this whole thing.

For us scientists, the issue was is it going to be right? Are we right in thinking that this dark area is made of basalt and volcanic rock, and this is the way it is and that was what it means about the history of the Moon or not? Is it going to be really safe for the guys to land or not? There were all kinds of people that told us that the Moon has been so bombarded, that there is a very thick layer, maybe up to 30 feet, of lunar dust. The spacecraft is going to go down like this, and will disappear in that. This was not a joke. It was a physicist with a PhD, the classmate of my boss's boss. Dennis James of Bellcomm was the boss of Noel Hinners, and Noel Hinners was my boss; his buddy was that guy, so we had to deal with him at that level. It was Tommy [Thomas] Gold.

Tommy Gold just shook the hell out of everybody's thinking. He would come to us and say, "Well, Farouk, you say that this layering proves that this actually is rocky material from the outside and that it was deposited as rocks."

"Yes, look at these rocks in the walls of the crater."

He said, "Well, what if it is dust that was compacted by the impact into these layers that you think are rock layers?" You stop to think, that's right, because if you smoosh it, it will look like this. It wasn't just because he was a first-rate physicist, so we had to get together with all kinds of thoughts. That was the first mission. We just didn't know.

The thing that shook us to the root is the fact they did not land where we thought they would. We made every conceivable calculation that they will land in this place, and this is the first mission. We had the area swept for number of craters. That was supposed to be the flattest place on the Moon; that was the safest place on the Moon.

Poom! They don't land where we thought they would. That really shook us considerably at the time. That happened because of something that we had no idea; that something is the fact that all of the dark places on the Moon, the things that make the features of the "Man in the Moon," the dark round things, are made of a rock that has a lot of iron and magnesium rather than silicon. Iron and magnesium are much heavier than silicon, with the other stuff that is in the other rocks.

With iron and magnesium in great quantities in these types of dark rocks, they are heavier. Therefore, they have more of gravitational pull. So here is the Moon and there is the one round area that the astronauts are flying over. Their orbit is where we think they are, but in real life their orbit drops in like this. Just as it passes over one of these dark places, it dips down a little because it was attracted to this thing. It moved again and it dips down again; every time it dips down, it gets actually closer to the surface of the Moon, which means it will land farther out from the spot that we thought it would.

Here they are and they don't land right away. Neil [A.] Armstrong takes over and keeps on moving. We don't know why he's moving. We finally realize that he was moving because

we were landing him in the middle of a very rough crater with house blocks where they would have been lost. They would be dead on the spot. He moved until he found a place that's safe enough to land, because of this gravitational pull. We called it mass cons later, mass concentrations, so with this in mind, we were just completely and totally focused on the astronauts and the safety of the mission and the success of the mission. At the time, we never really thought about all of the repercussions.

The astronauts themselves were of the same mental state. Many of the astronauts, after they came back, they said, "The only time I thought about the mission was after we finished and we were on the way back. Guys, you left us no time to think of where we were. We're flipping something from the thing to pick up from this and that. We were on the Moon, but it felt like a simulation. We never had a minute to say, 'Oh my God, I am on the Moon taking pictures, taking samples.'"

It's really true. Even during the time from mission to mission, we would concentrate so much on the mission, we never really reflected, especially the astronauts. We too, I'm one of them, we never reflected on the meaning of this and where this is going and what this means to the world and all of these things, until it was over.

We were not taken by the enormity of the event at the time, because we were too heavily involved and too thoroughly obsessed by the details of how do we do it and how do we do it right, so we never really reflected at the time.

WRIGHT: What about the moment that it happened, when they landed? Then of course when they began the exploration?

EL-BAZ: Again, at the time we were very focused on every word they say. Everything, because the words they say mean a lot to us. When they said, "Oh, there is a sparkle, these rocks are such and such, and sparkle." Oh my God, so this means to us that something is crystalline and some of the crystal faces are shining so this was crystalline, so even one, so we're so focused on what they say and what it might mean to us. We don't want to miss that, because they are not going to remember to tell us these things [after they return].

So that is living for the moment and completely focusing on the moment. We never really had the time to think about what did we do.

WRIGHT: When did it start to be discussed that the Command Module Pilot [CMP] could begin to do more and do your vis obs, your visual observations? Tell us how that evolved to where you began training the astronauts to do that.

EL-BAZ: From the outset we knew that while they are circling they've got to do something, because it's very important to take all of these details from the landing sites that we will visit. Generalize what that means as far as the Moon is concerned, because you're going to do lots of analyses of a tiny little area within walking distance or driving distance from the landing module, but how does that tie to the rest of the Moon? Is this representative or is it a unique thing? Is this such and such? How do we begin to figure that out?

From the outset I knew that whatever they can tell us from around the Moon, the regional views, it's going to be essential to putting these samples into context. Otherwise, it would have little samples from here and there, and they cannot relate them, so it would have to be related. Even these dark spots [maria], we have to relate them to each other. Did all of the dark material

form at the same time? Different times? Did it come from the same source or from different levels within the Moon so they would be different compositionally, or what is the story here? So how do we tie all of this together?

NASA accepted this notion of while the astronauts are circling the Moon they can photograph targets of opportunity. The targets of opportunity are places that we really shouldn't leave it to them, because they don't know about the geology of the Moon, so maybe we should label the targets of opportunity for them. But, it doesn't work, the targets of opportunity—it worked against the thinking of the whole thing. However, it became the modus operandi. These guys are going to be there, they are pilots, they don't know geology from Adam. Therefore we're going to give them something to hold in their hands and figure out when. We can even tell them while they're orbiting, "You're coming up on target 16." So they can look at the chart, [and think], "16 out of window three, so window three, I take the pictures."

From the Apollo 11 time, we didn't know whether all three are going to be involved in this some way or another, because they will all be going around the Moon together for a while. With a little bit of emphasis on the Command Module, but it is best to get the commander involved, because the commander has a lot to say. We go and talk to the crew on these targets of opportunity, so we spread the sheet. It has targets of opportunity in color with the revolutions on it, and we just discuss about why some of these things are important, this and this and that. They would all be fine with it and so on. Maybe the other two would leave, then we'll have an hour extra with the CMP and [discuss] this and that. That was okay for [Apollo] 11 because they didn't have time to spare.

With Apollo 12 we had a little more, only because Dick [Richard F.] Gordon was fascinated by the whole thing. He was also a Navy pilot or something, but he didn't really give a

damn about the geology of the Moon, but he thought the whole thing was interesting and fascinating. He was very spirited, so we worked with him and told him about some of the problems that Bill [William A.] Anders had with Apollo 8, because he didn't know from nothing.

If you know something, then you're not going to do as Bill Anders did, who put color filters on black-and-white film, so what do you expect? Gordon would listen a little more. There was a lot more give-and-take with him, but they were still limited. They were not really still talking about the Moon as an object of study, and that they, themselves as human beings, their eyes can see all kinds of shades of color, and the brain can process some of this—it was not there yet.

I realized that it is really not going to work to our advantage if we just let them be like this and continue like that. We've got to find somebody that will begin to learn something more tangible. It's all in discussion with a colleague geologist from NASA in Houston, who was one of the people that was helping in geology, with the Branch of Mapping Sciences, the ones that actually made the original maps or selected the targets with my presence to send maps to the Army Map Service to make us the maps to send with the Apollo astronauts. He was the middleman, so I was talking to him. He said, "Well, the only guy that you might want to talk to is Ken [Thomas Kenneth (T.K.)] Mattingly [III], Apollo 13, he might be the only one that would listen to you."

I told him, "Please go and ask him for one hour." That's when the story began. The connection with Mattingly giving me one hour, and did that one hour, and from there on it was a lifelong relationship.

WRIGHT: You approached Ken Mattingly differently than other geologists had. Share with us how you were able to very visually show him how important it was for him to learn those concepts.

EL-BAZ: It was very clear to me that the vast majority of astronauts didn't want to do a damn thing with geology, period. For their geological training, they were taught the way I was taught geology, and the people came, put them in a classroom, and told them about the chemical composition of rocks and this and that, and even showed them some microscope, and the different—and they were just, "What the hell?" and would get annoyed.

They would say, "When I've seen a rock, I've seen them all, what the hell? We're not going to have a microscope on the Moon to look at these things, why am I looking at that?" They had a point, so there was really no point in telling them this kind of geology. I knew that if I continued that approach or anybody continues this approach, we're doomed. We'll not be able to get to any of these people.

I now began to think about them as pilots. What do pilots do? They fly aircraft. What do they use when they fly aircraft? They use charts. Where are these charts made? From the Aeronautical Chart Service. Give me one of those to look at. To look at where do the points between one place and the next they fly between these two places. They said, "The VORTAC" [Very High Frequency Omni-Directional Radio Range Tactical Air Navigation Aid].

"What do you mean, VORTAC?"

They said, "That's what it is. A point in here that's called VORTAC, and another VORTAC, which is given a number, and I fly straight between these VORTACs, which have communications with other airports."

So I said, "Fine, let's live with this, and we'll talk about VORTACs. What do they do at the VORTACs?" Well, to reach that VORTAC, they have to visually hone on someplace on the flying so that they can get to this and then fly to the next one. "Oh, so they use this as visual to get to the VORTAC."

"Yes."

"Then they communicate."

"Yes, and they fix the spacecraft attitude towards this, yes."

"Okay, so," I said, "what if we are now in the spacecraft?" We had been giving the astronauts, or were planning to give the astronauts, locations on the surface of the Moon under the orbits that were called "landmarks." They gave them something like seven; if they get three or four, they're fine. The landmark is a place where the astronauts are familiar with looking through the sextant to see things in the stars and their locations relative to the stationary stars, so they look with the sextant, which they use, [gestures] up this way, towards the Moon. They wait until they see that little feature, then they say "*mark,"* as soon as that feature comes into the crosshair. When they say mark, we hear them in Houston, so we figure out exactly when did the orbit come on top of this landmark.

Okay, good, so let's work with landmarks. When I went to see Mattingly, I only wanted to talk to him about landmarks, nothing else, no geology, no features, no nothing. I put the pictures of the Moon around the table, the dining table in the crew quarters at the Cape, and marked the landmarks, and put their orbits, the first two orbits, because they are most critical as far as the location might be. [I] went to him to say, "We're going to look at a setting of landmarks, particularly the approach to the landmarks, so when you look at the sextant you begin to see something that will alert you to the landmarks coming [up]."

They miss many of the landmarks when they are not used—they look, they miss that, so they look at the other one, and so on, and they may get that one and miss that one, so I said, "Why don't we get all landmarks? Let's figure out how to. What is behind this one until we get to it, so it will alert you that that landmark three is coming up." We looked at the shapes of things. That's all, we looked at the shapes of things. Said, "Oh, look at this thing here. This looks like a cross, okay? Let's call it cross. Snowman—a whole bunch of craters on top of each other, so let's call it snowman. That one such and such."

One by one he went through all the landmarks. He described them, I thought what the lead to the landmark is, each and every one. He was very happy with that. We even stopped looking at the picture and said, "Now tell me what's ahead of landmark three."

Said, "Landmark three is coming in. Oh, that's the snowman." I said yes, then he was delighted with this whole thing, and then it became his kind of thing. He's the one that said, "When do you come next? When can you come back?" That was it. With coming back, he would bring in the rest of the crew, then I would sit down and have dinner with them and become just a member of the party and will get more. They would ask me, "How about can you get these guys to not write such and such on the chart?"

"Yes, we'll change it."

"How about such and such?"

"Oh, that's interesting. Here, why don't we add such and such? We'll do that." They became participants in the whole process. It became very clear that Ken Mattingly became a different kind of an astronaut. He started showing off in Building 4, Astronaut Office on the second floor. He'd talk about it, and he'd get pictures of the Moon and put them up on this wall. He sat there. People would come and say, "This landmark such and such." People began to talk

about Ken's stuff. That led to that scene that I sent to you with Stu [Stuart A.] Roosa. I was going to see Ken one more time; I was going into the astronaut building, two glass doors. One guy was coming out and I was coming in. He looked at me. Kind of military-looking guy.

He said, "Hey, are you *Farak El Baez*?" I said yes, so he said, "Listen. My name is Stu Roosa, I think I'm going to be CMP on Apollo 14. Listen, I want you to make me as smart as Ken. Hell no, I want you to make me smarter than Ken." This is really when that's it, I said I knew then that I got them. The competition has begun in knowledge of the Moon rather than on flying the spacecraft. These guys are going to be competing about how much science they get, they bring back. That was it.

WRIGHT: T.K. Mattingly says that you taught them how to approach a problem with curiosity.

EL-BAZ: Yes. This is after he believed in this business of looking at this thing. He would say, "That's going to be going fast enough that I will not be able to see that."

"Well, when you look at it, if you see a difference in color that's enough for us. That's going to tell us something. If you see there is a variation in the texture, that's enough. That would tell us something else. If we see—"

He said, "What do you mean *texture*?"

"Okay, let's look at this here is a different texture from here."

"Yes, I see what you mean." They began to absorb slowly what are all these different variations that we build theories around. You would not get that unless he would tell you about peculiar things, and he would not tell you about peculiar things unless he was curious about the whole thing.

WRIGHT: Was this a turning point for the whole visual observations part of it?

EL-BAZ: I think it was a turning point for the whole program, it really was. It was the initiation of competition in scientific knowledge about the Moon. That's these two. Started it way back, then we saw it continuing to the very end, to the extent that we had a geologist land on the Moon. Jack [Harrison H.] Schmitt, but his commander would not want to make him look, sound, or feel that he knows more than Gene [Eugene A.] Cernan. Gene Cernan was competing with him head to head so that nobody can say that the geologist knows more than him at all, so it continued to the very end. The competition became fierce, because these are very competitive people. That was the initiation of competition in scientific knowledge of the Moon. That clicked right there, I knew it.

I knew that I'm not going to have to fight the system anymore. These guys are going to come to me, and they did.

WRIGHT: The astronauts had the enthusiasm, but how did the management feel about their [astronaut] time for training being taken up with this whole new aspect?

EL-BAZ: In real life it didn't matter, because their schedule did not include any of this at all. The astronauts would invite me to go have dinner; I go have dinner. We sit down until the mealtime. Nobody has a damn thing to do with their personal time. They will go to the Cape, run for an hour, take a shower, go to dinner 6:30, we sit down, finish by 7:30. I begin from 7:30

until whenever, until they are tired, and they want to go to have a beer, period. Most of it had nothing to do with the system, or it was done on their own time.

WRIGHT: Mattingly didn't get to fly on [Apollo] 13.

EL-BAZ: That's right. After all this, after starting this whole thing. It's very clear that he was so focused on it. Jack [John L.] Swigert [Jr.] was totally unfocused, because this was the very beginning of the interest. That was a Mattingly thing. It wasn't a crew thing really, except for the fact that Jim [James A.] Lovell [Jr.] actually supported this whole notion. He had curiosity of his own. When I began to explain things to the whole crew, he was the one that was most lively. You could see it in his eyes, his thinking. Calling things things, and calling them by name, and getting interested in it.

The one guy that didn't really want to even listen was Jack Swigert. Jack Swigert was the least trained of all of them. He would say, "Farouk, goddamn it, it's 10:00, let's go for a beer," while we're sitting and we're in the middle of something tangible. Jack, God bless his soul, was not really well trained for this mission at all, but he did it, because he was a superb pilot. He was what they called a seat-of-the-pants pilot. He was very good in the machine, but we were always terrified during the Apollo 13 mission that he'd put his fingers in the wrong place, because the guy just didn't know exactly what to do, and he didn't care, because he knew how to fly, so all of these things were irrelevant to him.

The one thing that he had to do for us he didn't do that well either, with the picture of the Command Module, when the Command Module separated from the Service Module. We had to—and Rocco is a man that can think of things all at the same time and plan for them right. As

soon as we learned about the disaster, Rocco called me up from the Mission Control Center at my position, because he sat in the upper level. He said, "Farouk, we're going to need to take pictures of that Service Module. There was an explosion there and we don't know what the hell it did. We want to find out whether there are pieces off of it. You're the one that's responsible for the photography. You go ahead and plan how to photograph that module upon separation, whatever it takes."

I knew immediately that's a very damned important thing, and we have to do it, and Jack Swigert is not a photo man, and he was not well trained, and we've got to do something really tangible. I began to figure out what it is. It took me like two and a half days maybe, to figure out the details of what is this separation. I went to ask the flight engineers—while they're busy with other things—and asked, what's the speed at separation, when they separate like that, what's the speed, and they told me, "Farouk, we're not doing this now."

I said, "Yes I know but I need that data. Is there going to be a roll for the spacecraft when it separates or no roll?"

"Goddamn it, Farouk, we'll do it later."

"No I can't. I have to do all of these things so that we can see where he is supposed to be inside, what window he should be looking out. [It's only] going to be a few seconds. What window he should be looking out, what camera he should hold, which way is it, and what would he do so that he'll be prepared so that when he gets this thing in view he'll take a picture of the place that we want. If it rolls like this, then it's going to be take a picture of a place that's not affected, so we need a place of where the thing exploded."

So I'm working on that, and where is the Sun going to be? Is there going to be light at this angle, and on what side, what Sun angle it's going to be, because that will control the

exposure rate. If it's in the shadow they have to use different film. If it is in sunlight completely, then it's different. If it is partial sunlight—"

All kinds of calculations that you don't know until you really are certain that when they separate it will be such a speed and it will roll like this, how fast it rolls, and where is the Sun, and which is separating this way, and looking through what window, so I worked it out completely, and zipped all of that to Jack Swigert to write. These instructions, write it down one by one.

We did it. He took the picture. It was just a little bit out of focus; his hands were not right, although it told us all what we needed. It could have been sharper, but it told us all we needed. That is the thought of Rocco Petrone at the time when he heard about there is a problem, then we need to photograph this to know what was the problem, because nobody knew.

WRIGHT: Did you have a background in photography as well?

EL-BAZ: No, I was a very good photographer in general, because in geology we do this a lot. I liked it, and I was good at it, and I had my own camera and photo lab, enlargers, myself. I made my own prints with the slides from microscopes, so I was very interested in photography. I read about it a lot, I had all kinds of books, and I did a great deal. I did all of the pictures for my research myself as a geologist.

WRIGHT: This became a very needed skill for you to be able to help them adjust.

EL-BAZ: Very needed skill then yes, because of the film speed, film sensitivity and all of that. Yes, absolutely.

WRIGHT: Did you work closely with the photo labs?

EL-BAZ: Yes. After the missions we did. We realized that all of the color film that we were using was not real color [film]. There is something better, there is something that is not working very well here. We communicated actually with the US Navy about color film. We were able to get them to cooperate with us, because they were working with things that were classified, but they cooperated with us only by the time of 1975 and the Apollo-Soyuz [Test Project] mission, then they gave us the color. They had paid [Eastman] Kodak [Company] to make a color-sensitive film, which we could have used, but they wouldn't allow us. After some time I suppose when they developed a better film, they allowed us to use then the special color film that was from a batch that Kodak had developed for the Navy for a classified program, but they developed something better and they allowed us to use that.

WRIGHT: I believe you shared with me that the astronauts, the colors of the photos did not match the colors they remembered. How did you adjust for that?

EL-BAZ: We didn't know this at the beginning. We knew that there would be some differences, but the differences became so gross from the first mission. The television that the Apollo 8 crew took to the Moon was all black-and-white; there was no color television then. Actually

throughout Apollo 11, we did not have color television. We didn't have color, so throughout Apollo 11 we did not have color television.

When the Apollo 8 crew conveyed to us or beamed to us shots of the Moon while in real time Frank Borman was talking about it with voice, and he would say the Moon is all one color. It's all "Plaster of Paris," it is "gunmetal gray," it's as if you're looking at gunmetal gray patterns. I really think he was looking at the television monitor, the little thing that you shoot the picture so like this. They're looking at it, because that was gray. There is no visual with all the things that he's seeing on the Moon.

Then Apollo 10 carried a color television on board. Here comes Tom [Thomas P.] Stafford. He talks about the browns of the maria and the corners of the maria, chocolate brown. Of the same places that Borman was talking about, so that became, "Huh? What is this story? Something is wrong."

In the meantime neither the gunmetal gray was exactly true nor the chocolate brown was really true. The gunmetal gray was due to the fact that what Borman was looking at was at the Moon at very high Sun angles, Sun is right on top. What Stafford was showing was a grazing angle, to very low Sun elevation, which adds to the color tints.

We knew there was something wrong in here and we've got to do something. We need to have some color balance in the film and we need to have some color balance in the pictures. This is when we tried, I began to talk to the photo lab people, then we went to Kodak and we sat down and said, "What is this film that you're giving us? It's not doing the right thing."

They told us about, "Well, we can't give you the color-sensitive film, because we have one for the Navy, which we can't give you."

So we said, "What if we talk to the Navy?"

Said, "You go ahead."

We talked to the Navy. "No, we can't give you that." So we knew that we had to wait. "We can improve the balance, and we can tell you a little more about how do you develop it. We'll send a guy from Kodak to work with you in the photo lab in the processing." He came and he helped with the photo processing, I would be standing there at the end with Noel [T.] Lamar, who was the head of the photo lab then, and Dick [Richard W.] Underwood was the photo man at NASA. He was from the CIA [Central Intelligence Agency] but joined NASA.

We all three would begin to look at the pictures after they are processed. Improved, but never really right on the mark, but improved. Then we realized that the Moon's surface changes a lot to the perception of the eye as well as the color film. More so for the color film, with changing Sun angles, how high is the Sun, if it's right on top of you or on the side, either side.

We began to take that into consideration. I tried to make the visual observations tell us a little more about that. Many of the astronauts did a little better, but nobody would accept this whole notion of a "color wheel," which we finally did for the Apollo-Soyuz mission. If we had that on the Moon, we could really tie down [the color] completely, because they did that with deserts and oceans and so on on the Apollo-Soyuz mission whereby they picked up the colors like that [gestures].

You put the color wheel at the window of the spacecraft and just read the number, that's all. You push it around and push it around, and just read the number that comes close; read the number of this here, A, B and C, and the number, and A or B, and that becomes as closest to the scene that you see by your eye, so the human eye is looking at both of them. The scene on the ground and the scene or the piece of the color wheel at the same time.

WRIGHT: Now they did not want to use it because of the weight? Is that what they told you?

EL-BAZ: Yes, they said, "Well, the wheel is going to be of metal. The metal will be such and such and will add weight. Who asked for that?" Just me, so forget it, guy.

WRIGHT: You assisted the CMPs in creating their list of tasks for what they were to do while they were there. What led you to determine what the priorities were; what was the most important for each mission? Tell us that process.

EL-BAZ: We had emphasized like two or three different things. Number one, what is the relationship between what your buddies are going to collect on the ground to the big picture. That was an important component of all of them. Look at that site, tell me that it represents what? Does it represent the whole section of the Moon going like this, or it's a weirdo that is a unique setting that we cannot generalize from it around? So what's the relationship between where the crew members landed and the regional setting? What's the big picture here? Whatever they collect, can we generalize about that? That became the relationship between the landing site where the lander is going to be and the rest of the Moon.

Number two, we have questions about the area that you're going to fly over, and we need you to answer these questions. We will tell you what they are. We'll train you to some of this and tell you what is it that we need to get out of here.

Number three, you are not an instrument. You are a human being with a brain that can do us a lot of good. There are many things in the places where you're going to fly that we have no idea. None of us flew there, we have no idea what they are. If you really look with enough

curiosity and enough intelligent vision, you can add a hell of a lot to our knowledge of the Moon. These were three different components that all of them had to be put together in the mission time for the plan.

The places, the thing that we worked on before the mission—and we planned it right—are what are the things that we know that we want him to do, then let's look at that landing site with great care, then you can tell us the relationship between the landing site and the rest of it. Three, you're on your own, man. You can do us a lot of good or you can add zilch. It's up to you. It depends on how you look, whether you just look, or you really see and tell us what you see. Tell us in useful words.

WRIGHT: As you were teaching them, did you train them in specific terms as well?

EL-BAZ: Yes. How to say it, yes, so we said, "Here I am. I'm a geologist. I'm going to look at this. What is it? How am I going to explain this to a guy in the next room that's not looking at it? What I would say about that." Yes, he would know the meaning of the words. When I say, *striated*, that I mean something. Does this really mean fractures in it? When I say, *layered*, there is some huge communication that goes in the mind of the guy that's not there if you say layered. So is it striations or layers or lines or cracks? There is a difference between. There is a pattern in there, what you say about this pattern will mean a lot of things to a lot of different people.

WRIGHT: It's quite a challenge.

EL-BAZ: It was a challenge.

WRIGHT: They were zipping through there pretty fast.

EL-BAZ: That did not come easy with just looking at the Moon. That came only through the flyover exercises.

WRIGHT: You charted out places for them to go in the—

EL-BAZ: Yes, we just asked them where—before you fly anywhere, let me know. Going to fly? Instead of flying blind, I'll give you something to look at. That's it, that's the only difference. That also took some doing, because they usually fly blind. He wants to fly, and he's sitting there and thinking about life, and looking at the open air, and flying from one point until we get from one VORTAC to the next, and he will talk to somebody who's manning the control center there. That's it, then move on to the next and so on. They don't really give attention to what happens between these two VORTACs, so here I come with very specific things to look at between this point and that point.

That was really the only way to get these flying creatures to have a real feeling of: what do you mean that I can tell you a lot; what do you mean, I didn't see it; what was there that I could see? Well, there's a little wiggle in the ground, what does that mean, so what are you excited about, because to him it's land. When you begin to make him look for the land, and when you see it, and you see one piece is higher than the other, and that's a plateau and that's actually a fracture where this happened this way, and that happened in such and such time, and the piece that's higher is going to get different amount of water and would have different kind of

this and this one such and such, this would be exposed more to wind erosion, and so the soil will differ, and therefore—then there is a whole process of thinking about things that they become astute at identifying what is it that they fly over.

That then translated in their ability to verbalize what they are seeing on the Moon. Only because they were able to verbalize what they see on Earth through these flyovers with the book, which was identical to the flight book. I did it exactly the same way, I actually got a pilot to give me one of his books to put these things together.

It's like a stenographer book—flip one page after the page with metal backing. One page after the other, because from VORTAC this to that VORTAC, that's flipped, then instead of just the VORTACs—I put the VORTACs on, so that he doesn't need the aeronautical chart. I took the aeronautical charts, based my points on the distances between VORTACs and then put the VORTAC number here, but then instead of in the aeronautical charts, this area between the two VORTACs is blank. I then put either questions or a little picture or a map of the stuff that he's going to get after 22 miles from here. He will look at this and tell me one, two, three; answer these three questions.

WRIGHT: You learned how to think like a pilot, didn't you?

EL-BAZ: I had to. I had to think of what the pilot was going to be. It has to be along with the way a pilot does it. Or else if I give it to him in something different that we geologists do or give him a geological map that he has to unfold like this, what the hell. He's not going to do it.

WRIGHT: In the Apollo 16 Science Report, one of the statements that you included was the "accuracy of the interpretation is less important than the fact that something was observed." You just wanted them to report back what they were seeing.

EL-BAZ: That's right, because when they report back what they're seeing, they would report—maybe it's not the proper language and maybe not the proper terminology—but he saw it and he verbalized about it, and it's up to us to figure out what it is. Which means that he was prepared and he did it right.

WRIGHT: You were named a principal investigator [PI] for the orbital visual observations and photography experiment for Apollo 15 and 17. Did that change your role, or did that just give you more of a title?

EL-BAZ: No, actually, I was doing that informally without NASA making me—because anybody that required time on the Apollo missions was a PI, a principal investigator, or else why NASA would allow time to do such and such? It was principal investigators that applied with a proposal and the proposal accepted and NASA gave the money to make whatever he needed, then it becomes part of the mission and therefore the flight planners would allow the time for the mission. Here I was, a little guy, taking time from the mission and putting things in the flight plan, and I had no official position. It was when [M.] Gene Simmons was the chief scientist at JSC and they were looking through all of the principal investigators. He said, "Goddamn it. What is Farouk? What's he been doing? You can't have him doing this on his own like that. He's got to be a principal investigator or something."

So they said, "Well, we can make him principal investigator of visual observations and photography." They made it official because I was functioning without a mandate. The flight planners were responding to me without mandates. I was supposed to be just a geologist at Bellcomm at NASA Headquarters doing what NASA Headquarters needs. I had no role at JSC.

WRIGHT: When you started, you were not even allowed to talk to the astronauts or the press, is that correct?

EL-BAZ: Absolutely. We were prohibited, from Bellcomm. We were told not to talk to astronauts and never to talk to the press of any sort.

WRIGHT: That changed in more than one route. Tell us about your dealings with the press.

EL-BAZ: The press started only really in preparation for Apollo 14. When the accident, disaster of Apollo 13 happened, we had plenty of time to prepare for the next mission, which was Apollo 14. During this time, we were thinking about a landing site in the lunar highlands. We said that the lunar highlands are not really photographed well. We need a good high-resolution camera.

Rocco Petrone said, "Sure. We have the time to add it up. Go ahead, announce." We said we were going to do that, so we pushed and we selected a company called Hycon that made high-resolution cameras that were not too enormous [Hycon Lunar Topographic Camera]. Big enough, but not really huge, so that Hycon camera was to be placed on Apollo 14.

At the time I was also a member of the Apollo Photographic Team that was headed by Frederick J. Doyle, the head of mapping of the US Geological Survey. The US Geological

Survey team of the mapmakers from the Geological Survey, the US Army Map Service, and the unnamed agencies—they included me in this photo team. I was heavily involved, so everybody else was really helping in the selection of the camera. I was the only one that really knew about the uses of the camera.

Why do we need that for the central highlands— a camera is a camera. The *Washington Post* got wind of the fact that NASA is putting a high-resolution camera to photograph things on the Moon, so they called NASA. The guy, George Lardner, the first reporter to ever interview me, called NASA Headquarters to get information on this camera and what it's used for. They said, "We can give you a pamphlet."

He said, "I don't want a pamphlet on the camera. I want, what is this camera going to do?"

"You can go and talk to the guy, Farouk El-Baz. He works for Bellcomm across the street," because our office was then moved from downtown to L'Enfant Plaza in Washington, so he calls me up.

"My name is such and such, I want to talk about that."

I said, "I'm sorry, I can't talk to you."

He said, "What do you mean, you can't talk to me?"

I said, "I'm working for a company called Bellcomm and we don't talk to you. Talk to NASA Headquarters."

Said, "NASA Headquarters is the one that told me talk to you." Hands up, not going to do something illegal here. Said, "Who's your boss?"

I said, "Dennis [James]. You call him. Here it [phone number] is."

So he called my boss. My boss said, "We're not supposed to by contract talk to the press."

So he said, "By whom?"

He said, "By NASA Headquarters."

Said, "NASA Headquarters?" Said, "Well, you talk to NASA Headquarters and let them see what they say."

My boss told them, "No, you talk to NASA Headquarters. Tell them to tell us to talk to you."

He did, so the *Washington Post* called NASA Headquarters saying, "What the hell is this? We need somebody. Nobody can tell us except that one guy. You told him not to talk to the press. What do you mean?" So NASA has to call the boss and clear this, and says let him talk to the press. So I did; I talked about the humongous camera to be carried on Apollo 14 to do this and this and that, to take pictures of the highlands, of the highly grooved terra in the central highlands of terra, and that we have the different kind of volcanism. It made a big story.

WRIGHT: Then the camera didn't do as well as you thought.

EL-BAZ: The camera started to whiz, and stopped, and could not—Stu Roosa would hold it. We'd tell him take that out. He'd say, "I did, nothing happened." Put it back, put it back. "Nothing happened." Back and forth. It ruined many sites for us, trying to fix that camera, because we were taking time from him by suggesting to him to do things, then we had the guy from Hycon sitting right next to us, [and we'd ask him,] what the heck is wrong with this thing?

Said, "Well, it might be such and such." We fix it and we tell Stu and he tries to fix it and nothing happens. It just died, yes.

WRIGHT: How did that affect what you decided to send up as part of the tools in the future, or what type of cameras for the observations?

EL-BAZ: We went to a higher level of cameras, much higher. That necessitated to go into the wall of the spacecraft, because we cannot take this high camera in the Command Module. The Hycon, we could squeeze in the Command Module, even though it was big and cumbersome, but we could squeeze it with the guys, but to go to a higher class camera we can't, so we have to go out. That's why we went into one side of the Service Module. Removed a wall, inserted these cameras and the electrical systems and the controls for the temperatures and all of these things. There was one side of the Service Module that had two enormous cameras—one a metric camera and one a panoramic camera for [Apollo] 15, 16 and 17.

WRIGHT: You were pleased with the results of those?

EL-BAZ: Very much so, yes. That required—they were loaded before the mission and ascent. That Service Module is something that we throw away anyway. That required the astronaut to open up, go out, walk outside of the wall of the Service Module, open it up, take the [film] magazines one by one and put them back into the Command Module, lock it up, and get off. So that required an EVA [extravehicular activity] in space. The guys actually enjoyed that a lot,

because they would go out, and they are between the Earth and the Moon after they finish the Moon mission.

On the way back and then they have to go out by themselves out in the open, and climb outside of the module and go into the Service Module and clear it up to open to get the stuff and make sure that it's locked up because somebody's holding you with a tether, like a dog, because if you let it loose, he's gone.

Then they, all of them, just looked up and saw this incredible blackness. They tell you, "It is jet black, I don't know what jet black is. You just don't know what jet black is until you see this thing. Jet. Jet black, with these stars as tiny little dots. Tiny little dots you don't see, because they don't twinkle. It's just absolute tiny sources of light. Some are brighter than others, but in this absolutely black vastness." They said that's when you really look at the whole universe, like that. When you know, not just feel, that it's not just human beings are an atom in this whole big universe, but the whole Earth, and maybe the whole solar system, is nothing but a little atom in this vast universe.

WRIGHT: I believe [Alfred M.] Worden talked about being in that wonderful position of being able to see the Earth and the Moon, which you could not do—.

EL-BAZ: You could not, yes. It is interesting that in most cases it's on the way back from the Moon that any of them thought of what they just did. None of them would actually think about it, because they're too busy. From the Earth to the Moon they're really getting prepared, and they're anxious—"we got to do it and do it right; everything is going to work out." All of that is still on their minds.

After they did it, on the way back, they have the very first time to reflect on the fact that they actually did that, and what does that mean. It's fascination. Look at the beautiful Earth. Look at the sky. Or look at the Moon. The whole Moon is like this, so the only time when they just realized what they just did, yes.

To the extent that Jim [James B.] Irwin, God bless his soul, once told me, "Farouk, when we were coming back, I looked through the window, and slowly but surely the whole Earth full globe just came very gently like this, as if it stopped in the middle of the window. I was looking at it, I thought, how beautiful, look at that, beautiful, fragile-looking glassy blue thing. You know what I thought?"

"What?"

He said, "I thought, so beautiful, I wanted to open the spacecraft window and hold it in my hands. Then I thought, my God, it looks so fragile, I don't want to break it. I stopped. Isn't this weird?"

I said, "Yes." [laughs]

WRIGHT: Share with us about the debriefings, the formal and the informal ones, when the astronauts came back, and what you were able to learn from them to help prepare for the next mission, and then just some of what you reflect on.

EL-BAZ: The debriefings were really very important. We would learn then whether or not all of the things that we prepared for them were the right preparations or not. We were all like buddies, and they withheld nothing, for the good of the program again. They tell you that you

really messed this up because of such and such, shouldn't do this again. Whatever they say, it is right with us. Whatever we tell them at the time also is okay with them.

Because it's good for the program, they were quite open with no chocolate coating of anything. Would say what they felt was right and what they felt didn't go as well as it could. They sometimes would say things about the fact that the comments that came back from the CapCom [Capsule Communicator], they knew that Flight [Flight Director] was the one that told them that, and that is was uncalled for—when we're too busy, keep interrupting. [The crew would say,] "We're telling you that we're busy doing this and that, and you interrupted; interrupted our thought processes," which is true. So, it was really very good to have these debriefings. This is one of NASA's best things.

Before the mission, they sit down and talk about nearly all aspects of the mission and how do they feel prepared for it and how do they think, what was missing in the preparation. These were sessions that the whole crew lived with, with the prime crew, the backup crew, the mission scientists and Deke [Donald K.] Slayton. That was a huge important thing that Deke, God bless his soul, Deke Slayton did. Deke Slayton was one of these people that held us back by force of arms kind of, away from the astronauts. He would say, "My boys are not going to spend the time in this nonsense."

"Okay, Deke." He had a huge job, because he was the only one of the magnificent seven that did not fly, the only one that didn't fly. He became the head of the Astronaut Office, and he assigned the crews. If you are on the wrong side of Deke, you're doomed, so you need to gingerly go around. When he's mad, you just let it be. One of the best things he did was to sit with the crew and the mission scientists and discuss all aspects of the whole mission. What did

they think was done well? What did they think was not done that well? What did they think was missing? That was translated to the rest, mostly through the mission scientists.

Then after the mission—and that is even more important, the debriefing. NASA was very clever in dividing these debriefings into levels. Deke Slayton and the crew talked about how the crew worked together. If there were any problems between the commander and any one of them, what was that? How did it develop? Where did it end? How could we have avoided them?

Then the management debriefing. The three astronauts sit like that and the whole management slew of NASA Headquarters and JSC and you name it, whatever management is, sits and the crew explains the mission and tells the management what they think. The management asks questions and they would answer. That ends. This is one session.

Then we have several days. That was a concession from Deke, that we have the crew and the scientists. We can go over step by step on everything. You said this was finer, what do you mean finer? Was it the fine-grained or maybe it was covered by—exactly what finer-grained means to you. Asking, "Finer-grained than what?" so they can get every conceivable squeeze out of their observations. That could last like three days. It's a little more informal, which is fine.

None of that went out of the system, except maybe within the management debriefings that things that needed changing or something may come out. With the crew and Deke Slayton, none of us knew exactly what happened, because there would be problems naturally—three guys stuck together 12 days.

That just was always crew business that none of us knew anything about, because it's about personal interactions between them. Then the science, nobody really cared about it outside

of the scientists. It's in the management debriefing that things that had to do with the interaction between divisions within JSC and Astronaut Office and this and that, that things became talked about—happened within the management debriefings. Some of these debriefings, it was just a nice talking and nice atmosphere, about the positiveness of the mission.

Ken Mattingly—after Apollo 16, in his management debriefing, Rocco Petrone came out from a management debriefing with him. "Farouk, you should be happy about that."

I said, "What?"

He said, "Ken said you were the most essential man in the Apollo program."

I said, "What do you mean?" I laughed. I knew what he meant really, then somebody asked somebody and showed me the script [transcript].

Ken Mattingly told them, "In the Apollo program we have a backup for everything, but the single point failure in the Apollo program is a guy by the name of Farouk El-Baz. For everybody and everything we have a replacement, except for Farouk."

WRIGHT: You were a team of one, weren't you?

EL-BAZ: Team of one, yes, so he can say things like that in front of the big managers, what he feels. Anything that comes to his mind.

WRIGHT: Well, being a team of one, at least it gave you full control over what you wanted to do.

EL-BAZ: What do I say and what do I do, yes.

WRIGHT: Tell us about your position in Mission Control and what that was like, having a console. Then also if you'll talk too about the interaction with the CapCom and how important that was that the CapCom also understood what the astronauts were observing.

EL-BAZ: Very good question because you can tell the CapCom something, and then by the time it's translated, it's wishy-washy. We were very lucky that the CapComs were either backup Command Module pilots on the last three missions or mission scientists. The mission scientists in general were really very into the training aspects. Many of them are geo-related or science-related, but they would understand that geology is important and is good. We had the mission scientists began with [Apollo] 13 with Tony [Anthony W.] England. He was himself an Earth scientist, then the mission scientist that played a huge role in the mission was Joe [Joseph P.] Allen, Apollo 15. He played a very considerable role.

Then we had Karl [G.] Henize, who was also an astronaut and an astronomer; Bob [Robert A. R.] Parker. Had Karl for 16 and Bob Parker for 17. All of these would attend nearly all of my briefings with the Command Module pilots, and participate and really ask questions, so they were very easy to communicate with.

Mission Control. I don't know how it happened, but I was able to slip in, because you had to have a special MC kind of notation on your badge to be allowed in Mission Control. A big M, Mission Control. MC, big ones. That's added to your badge, to allow you to do that. I honestly don't recall how did I get that for the first mission, but I had no place. I had no job, because as I said I had no mandate, so I would be roaming around.

The guy that would kind of call me to sit with him or on his console a lot was Doug [Douglas K.] Ward, he was a Public [Affairs Office (PAO)] man. Very pleasant guy. He would

just see me and he would go like this [gestures] and I would go up on the upper left in the Mission Control and sit with him. He would just bug me about the details of what this is and what it means, because he's the one that usually goes to talk to the press. I said, "Fine, let me help him, what the hell? He is a nice guy."

Whenever he had an opportunity, he would call me, and I'd go sit next to him. Otherwise I would be roaming around. Something happened, and we need to do something about it. Or go in the back room to see what the people are looking, like Apollo 11, where did we land, it was mostly outside. Looking at the people that are looking at the things. Or with Apollo 13 roaming around between the flight controllers and this and that. Some even outside of the Center to get some information and whatnot.

Until, when they called me principal investigator, this would allow me then to have a place, so I can have my own plug-in, because I used to plug in on anybody's position. There are usually many plugs you can put your plug-in so you can hear what's happening. Now I had my own sitting place.

WRIGHT: Can you share with us any of the memorable comments that came through? I'm curious about the things that might have happened that were unexpected. The astronauts have said that you trained them so well that as they traveled around the Moon they felt like they'd been there before, but I know reading through some of the reports there were some observations that just weren't expected. For instance the orange dirt.

EL-BAZ: Totally. Absolutely.

WRIGHT: I believe the cinder cones. Al Worden. Could you share with us about those or any others that you can remember.

EL-BAZ: Sure. The things that were totally unexpected started with [Apollo] 14 with a feature that looked just like an honest to God caldera. We had not seen any of them before. Identical to the calderas on Earth, the volcanic calderas. Not seen any of that, because most of the volcanic rock on the Moon came through fractures and not through volcanic vents.

It was Stu Roosa that started describing that. This was totally unexpected and totally unknown. It was very interesting, because from there on we used it as something peculiar, that's what did it. He is the one that told us that this exists like that, so they all became attuned to the fact that they can add to the knowledge. That became a very important and very significant driving force for them.

Then came the shaker of all time, which is, "I see a whole field of cinder cones, all of them having dark halos, and a summit pit on top. This is a whole field, I'm telling you." This was a stunner, a whole field of volcanic cinder cones on the Moon in any one place. What is this? We had a big thing with one caldera-looking thing, and this is a whole bunch of them? We know about cinder cones, the way he said it. Made them similar to volcanic vents near Flagstaff, Arizona, because I had him fly over there like three times. That's the only place where he really looked at cinder cones, so he's talking about a whole field of the ones that he saw around Arizona. My God, where is that? How in hell did we miss all of this?

This became like a topic of discussion throughout the command center, Mission Control, to the extent that it was I think Jack Schmitt that came out from the back room where the

geologists are to sit right next to him. "What the hell does that mean? Is this such and such? What is that going to figure?"

Then Rocco Petrone himself came down from his seat and came over to me. Said, "Hey, Farouk, I think Al might have picked out a landing site for you." Then we continued with this, and it certainly made a huge impact on site selection for Apollo 17.

Then Ken Mattingly made an observation of some dark flow coming from the middle of a crater on the far side. This was to us—the only way to explain this will be what we call an igneous intrusion, meaning some molten material that was intruded into a solid rock. That would have not been part of our thinking of lunar geology, but here it is, and there is no other explanation to it.

Then Apollo 17, because these are different missions. Apollo 17, when Jack Schmitt mentioned orange soil at the site. "What do you mean, orange soil?" He talked about this might be fumarolic activity. "Fumarolic." Fumarolic activity is mostly at the very end of volcanic eruptions, meaning that it is rather recent, last million years or something. We had no idea that the Moon could have been surviving [alive] that long. Everything has died on the Moon three billion years ago we thought. Actually there is oxidation of the material, because this red-orange color can come with oxidation of iron. Does this mean that there is water vapor that is hot that oxidizes things on the Moon? This is another Moon altogether, what is this?

This is when I communicated to Ron [Ronald E.] Evans through the CapCom to see whether he can see that thing, orange soil. It is at Shorty Crater; he knows where Shorty is.

"Look at Shorty Crater, look at the northwest corner of Shorty Crater. See whether you see some orange color."

He said, "Yes, I can see, I can actually. There is some orange coloration on the rim."

"That's great. Now look any other place. Especially at the other edge of Serenitatis. Do you see any other, any similar color to that?"

He comes in. "Yes, I see a whole lot of them." So we thought that it's not a unique thing, it's not part of this, and it doesn't have to be fumarolic activity or oxidation. It is something that maybe impacted, so these were three or four individual observations that had an impact on our thinking about the Moon.

WRIGHT: For a different communication, Al Worden asked you to help him. He wanted to send greetings to the Earth. Tell us about that.

EL-BAZ: Yes. Al and I became—Al has just a delightful personality. You met with him?

WRIGHT: Yes.

EL-BAZ: He is just one of these people that grows on you. He is just a terrific guy. He was at the time divorcing and he had nobody, and every time I'd go with him. We'd spend the evening together, go to his favorite place to eat, the Rustler Steak House. We went to a bar after a training session. He asked the bartender to give him a White Russian, [and tells him], "I want to see what a White Russian does to an Egyptian." Al was just a delightful personality, whom I became very good friends with from far back. When he came to Washington, he stayed in my house, and he slept on the couch.

We became kind of like brothers. We talked a great deal about our background and where we are and this and that. I taught him some words in Arabic, and I was thinking that

maybe I will give him a copy of the first page of the Koran to protect them, because we knew that Apollo 15 was going to be changed dramatically. Everything was going to change. We need protection, so I'll give it to him. They all said, "Yes, we need all the protection we can get, so let's take it," and they did.

Then he asked me to try to figure out what do we name that spacecraft, because every spacecraft has a name. So well, let's talk about that, because we need to get something really super fantastic. I came home and asked my wife, and we had these three names, chewed them over and this and that and put them in order and took it to him and discussed it.

He said, "Absolutely, I love it, this *Endeavour*." I told him the story about *Endeavour* and the ship and the whole bit, so we got very heavily involved personalwise. He said, "Now I'm not going to say just one greeting. Why don't you teach me how to say the whole greeting in Arabic?"

So I said sure. Wrote it down, I said, "Say that." He said it and he did it beautifully. Said, "What if we give it to you in different languages and you just shake the hell out of everybody and say it in many languages? In Spanish and Italian and why not all of the languages? Except Russian of course, it's very awkward." So we did, and we gave it to him in a whole bunch of languages.

He didn't have time to say them all, but he said at least Arabic, and he said, "Marhaba ahle el-ard, min *Endeavour* aleykum salam," which is "Hello, people of the Earth, from *Endeavour*," name of the spacecraft, "greetings from *Endeavour*." That became the title of his book, **Greetings from *Endeavour***.

WRIGHT: Such a nice story of international communication. Tell us your thoughts when you learned that the decision had been made to start to close the Apollo program down.

EL-BAZ: We had wind of it before the other guys in the Centers, because we were at Headquarters. There were all kinds of feelers from the Congress, why don't we shut this program. We don't want another dangerous event; see what could have happened with [Apollo] 13, then other people saying, "Yes, I think the idea of shutting down after the first mission was a good one, why don't we think about that?"

Then there were all kinds of other things, so NASA Headquarters began to hear about these things, but to plan better than just shut it down, plan to think of what could we do instead. Right at the time we were very heavily involved in the planning with NASA Headquarters of the AAP, which is the Apollo Applications Program, so got down, including Rocco and everybody, that we think, "Okay, now when we finish Apollo, whenever it may be, what is it that we should do? We should apply the knowledge that we gained from the Moon to doing something else. What should be done next?"

Most of our feelings were, well, we have learned so much, we have better maps of the Moon than the maps of the US because of the cameras that we carried. We need to take this knowledge that we have learned from the Moon to apply to at least the Earth and look at the Earth and make the map, topographic maps, to get for the resources, get the environment, get this, so we began to think about how do we [transition] from the Moon to Earth.

This is as an application to what we learned in here, because we applied things to the Moon that we'd never done on Earth. We learned a hell of a lot about photography, mapmaking,

you name it, and satellite imaging, remote sensing, all of that. This is where remote sensing came from.

So how do we apply all of that to the Earth studies? Here came the notion of using the Saturn V as a housing for astronauts if astronauts stay in orbit rather than go to the Moon. That was Skylab, so we knew that at least two of these things that we've already produced and paid for, Saturn Vs, can be used for an Earth orbital mission. Before it was called Skylab it was called the AAP, Apollo Applications Program.

We had known that this was going to happen like that, and we thought we had up to [Apollo] 18, so 18, we had actually planned in our minds for a landing on the far side of the Moon, so this was the only contention, that 18 is going to have Jack Schmitt, the geologist. [Apollo] 18 is going to land on the far side; 18 will have all kinds of communications satellites. We'll not be able to see the astronauts, and the communications satellites are going to, because we had learned a great deal about communications by then. Not as much as now, but by then, that was huge. To have to make three communications satellites to go around the Moon, and who can actually keep us in constant touch with the astronauts while they are on the far side, the side that we don't see.

There were a lot of people that were against this from the safety point of view, but we worked up the plan for it, then that too got cut, out of fear that we might actually win and make it to the far side of the Moon. A lot of people were shaken by the whole notion that we can actually land them where we don't see or hear; they would land on their own without us hearing or seeing or doing anything.

So that was cut. This is when we realized that now the Apollo program will end without a geologist on the Moon. We have the geologist ready. He devoted two years of his life to learn

how to pilot. Jack Schmitt spent two years at Edwards [Air Force Base] just being a pilot, all of that, and he's the geologist, and we don't send him? We have a geologist like that and we don't send him to the Moon? That's ridiculous, so a push began to replace Joe [H.] Engle and put Jack Schmitt on Apollo 17 and it succeeded.

WRIGHT: Tell about how your work started to change at Bellcomm. Or how did Bellcomm start to adapt to the change in the mission schedule?

EL-BAZ: The mission schedule meaning what?

WRIGHT: Canceling 18.

EL-BAZ: The deal between NASA and AT&T was, "I'm going to give you all those people that you need for as long as the Apollo program is on. The day Apollo ends, goodbye, because these are my own people, I want them back in New Jersey." This was the deal, so we knew by Apollo 17 time when came the splashdown of Apollo 17, Bellcomm will fold. Everybody's moving, so people began to look for houses back in Holmdel, New Jersey.

WRIGHT: What did you choose to do?

EL-BAZ: At the time absolutely nothing, I wasn't even prepared to think about it. That same year Michael Collins of Apollo 11 was brought in by the Smithsonian Institution to head the [National] Air and Space Museum. There was a function where Stu Roosa and Michael Collins

were together, and Michael Collins was telling Stu Roosa that he's just accepted to be director of the Air and Space Museum. "They even want me to do scientific research there, and I don't know what the hell do they mean by that."

So Stu Roosa said, "Well, call Farouk."

Michael Collins calls me up, and he said, "I'm going to be the director of the Air and Space Museum, and they said that they want me to start [research]. I think that you should come and do this thing for me. I know I'm not going to understand half of what you say, but I know that you're going to do a good job. Why don't you come and do whatever the hell you want to do?"

I left Bellcomm in December 1972. I moved across the street to the Smithsonian on January 1, to start something that we called the Center for Earth and Planetary Studies as part of the National Air and Space Museum as part of the Smithsonian. I was there for ten years. This was a fascinating thing. It was one of the most fascinating jobs in my life.

WRIGHT: Please tell us about your first days and how they evolved.

EL-BAZ: At that time, that's three years before the building was built. We were in the tower of the Arts and Industries Building of the Smithsonian, the one next to the Castle [Smithsonian Institution Building], the old fancy one. Mike comes in and he says, "Now we're going to have an Air and Space Museum. We have no problem about all of the spacecraft, because we're going to own them."

I don't know whether you know that all of the spacecraft that NASA uses, the day they end their mission, that day a spacecraft belongs to the Smithsonian Institution, not NASA,

immediately by law, so NASA has nothing to do with it. When it's finished this thing is not mine, it's the Smithsonian's by law. It's a very interesting thing. When NASA wants to exhibit one of the Apollo, Spacelab, they have to request it in writing from the Smithsonian. It's not NASA's. It's the Smithsonian's, because it's part of the nation. This is the nation's attic.

"So we're going to have all of the spacecraft, coming out of the roof, but what do we talk about? Other things? Apollo? Yes, we can show something, something, but what do we say? What went on, or what was about the Moon and this and that? You guys begin to think about that. You go ahead and do whatever you want to do."

We begin to figure out what is an exhibit; so we talk to the exhibits people, and then the historians, and then the artists, so it becomes a whole different ballgame. I've been dealing with engineers and pilots for six years consistently, nonstop. Here comes this totally different kind of people. Painters, artists, exhibits people, historians.

So, what is an exhibit? We go through circles of first my education on what is this new business and how to deal with it. You pick it up, and you realize that it's really interesting to deal with these different kinds of people. We begin thinking about the Apollo exhibit. We thought that we will have an exhibit that would change maybe every three years. As you've seen it, the Apollo exhibit hasn't changed one bit for a thirty-five years now. We worked on it in 1973, the design, I remember this, I signed on my thing for it in the end of '73. It is still functioning to this day without a single change. They don't want to change a thing.

It was really very interesting to see this. Then, we began to think about a theme of looking around the Earth, then the thing about the cameras and the photography. We have one of the cameras that flew on the Apollo three last missions in there. A seven-foot camera, a big beast, yes. The panoramic camera from Itek [Corporation], because I worked at Itek after the

Smithsonian and was able to make sure that one of the Itek cameras was given to the Smithsonian for that exhibit.

An interesting side issue, because of the link to photography. You probably don't know the fact that I was very central to the IMAX movie system. We opened the Air and Space Museum on the 4th of July, 1976. It was the nation's bicentennial anniversary. We had President [Gerald R.] Ford [Jr.] come. We established the whole event in front of the museum, hoping that it will not rain. We had the ribbon and we planned the ribbon cutting by a signal from the Viking I mission from Mars, so there was a ribbon like this, and the metal thing like this [gestures]. The Viking mission from Mars would send a signal to this to heat the ribbon to cut it, at the time when we wanted, while the President is saying, "And now we're going to cut the ribbon from a signal from Mars."

Then he'll stop like this and look at it, and the whole world is looking at it, and we're waiting like this. It only took like three seconds. It fell. This is an *event*, it's not a small potato. No.

Okay, now, we then had plans for the Space Shuttle. Walked into my office was a guy from Canada by the name of Graeme Ferguson. He said, "I just came from NASA Headquarters, I was telling them about a camera that we produced. It's a very large format that we want to fly in the NASA missions. They told me you're the only one that can talk about it. The negative is 70-millimeter."

I said, "What do you mean, 70-millimeter."

He said, "70-millimeter negative, it's like this." He opened his briefcase and showed me a negative. Oh my God, this is the negative, so the resolution would be so fantastic. Like that [it

was on] my light table and looked at enlarging, and I was so enthralled with the resolution of this negative.

"How big is this camera?"

Said, "Well, it's big." Told me about it.

"How big is the roll of film?"

"Well, it's like that."

Said, "Yes, NASA is not going to fly that anywhere. Why don't we think about making something out of it first to show the quality before NASA can fly something like that?"

He said, "Why don't you guys do something, since you're an Air and Space Museum? Do something with it."

Said, "Okay, leave the negative with me. We'll talk about it." I went to my boss, Michael Collins. I said, "Mike, this is a negative that is 70-millimeter that we can make movies with this thing that will blow the mind of people."

He said, "What kind of projector and when?"

I said, "I will look into the projection." Because I had asked the guy how large can you project this.

He said, "Anywhere you want. I would say five stories high by eight stories wide you can project this thing, and it will still be sharp."

We were planning on a movie theater in the museum, so I called the engineer that is designing the museum. He was Japanese. I befriended him when we talked about the exhibit areas and design. Nice guy, kind of my age, so I called him. He was named Gyo Obata. "Gyo, we're going to talk about the size of the theater. How big can the building code take the screen?"

He said, "Screens, you can make it any "big," because it's going to be in this little room. It will go up to the ceiling for as long as you want."

I said, "What if we have a potential for a screen that is five stories high by eight stories wide?"

Says, "Well, let me look at it." He worked on the details of the drawings. He called me up. "Hey, Farouk, actually it is good, better for my structure."

Said, "What do you mean?"

Said, "Because I can take that wall and put it right to the ceiling, and you're going to use almost all of it. This is totally irrelevant, but if I put the wall all the way to the ceiling, then it's actually better for my structure."

I said, "Better? Good." I run to Michael Collins and say, 'Listen, [the screen, it's] better for the structure."

Said, "Well, okay, ask this guy how much it will cost to make a movie."

So I called the guy from Canada. "Graeme, we're fine with it. We can do it. We can build the screen big enough in the museum. You sit down and tell me a figure. Be careful and make it small, as much as we can possibly do, cut corners. Tell me how much it will cost us. We're government. We can't give you such and such. Tell me how much it will cost. Make it exactly 30 minutes. Make a movie of 30 minutes."

He said, "About what?"

I said, "About aviation. We're an Air and Space Museum, so aviation and maybe some space." He came back and he said $750,000, so I said, "It's a deal." I went to Mike, and tried to put it positive, "Mike, it's *only* $750,000."

He said, "Jesus Christ, what the hell? There's no more money in the building plans. I can't give you this money. The only way we'll do it, if we can get additions to the budget from the Smithsonian. I'll arrange a meeting between us and [Sidney Dillon] Ripley." Dillon Ripley was the secretary of the Smithsonian Institution. I had just befriended him the year before. He was going to Egypt; I went with him and I had him meet with the heads of the universities and Sheikh Al-Azhar and this and that. He had a fantastic trip, so he liked me. We go to Dillon Ripley.

We sit down and tell him we have an opportunity to start something that's unique in the museum and we will have to do this and that. He said, "And how much does it cost?" Mike looked at me; I said $750,000. He looked at Mike Collins and he said, "And how long would it take you pay us this money back?" Because it's an additional allocation because he gets money from Congress and this is it, we have to pay it back. Mike looked at me. I said four years, out of thin air.

So Ripley, he's a fantastic scientist, a great man. He said, "Well, four or five years, it's okay." He even gave us a year in addition, "Four or five years is okay." We went out delighted with the whole thing. We called the guy and I said, "Okay, we're going to give you the script. Have to stick to our script. We'll sign a contract for you to give you $750,000 to make that movie for exactly 30 minutes." We worked on the script, got the historians and exhibits people to work on the script of the film "To Fly!" Have you seen it?

WRIGHT: No.

EL-BAZ: You should go see it.

WRIGHT: I'll go see that one.

EL-BAZ: It starts with a balloon and ends up with the rocket to the Moon. Fabulous history of aviation with fantastic resolution and magnificent scenery. The Museum cannot take it off. People in Washington request it.

So we did it; we started it. We thought we're going to charge $1 so that we can get that money back. We made $2 million in the first year. Since we are a government agency, we cannot make profit, so what we decided—we'll call Graeme Ferguson of Canada and tell him, "You make the second movie for $1,250,000." We did. There, IMAX movies were born. Or else no one would have ever seen it.

WRIGHT: Amazing. What a great story. Thanks for sharing that.

EL-BAZ: Now IMAX would have died had it not been for this, "To Fly!" and the vision of both Michael Collins, as the director of the Air and Space Museum, and the Smithsonian boss Dillon Ripley for saying, "That's not too bad, and if you get the money in four, five years—" I told him four years. He said, "Four or five years is okay."

WRIGHT: Now the second movie. Did you provide the script or did you give them—

EL-BAZ: No, they actually came prepared with something about Planet Earth. Flying to different places, going to Egypt and photographing the pyramids, going to India, photographing

it. They did it for the $1,250,000. That bombed. Nobody wanted to see it, so we put it on a little bit and then put it with "To Fly!" and then cut it off.

WRIGHT: Actually going forward in your career, you worked with more of this Large Format Camera, is that correct? When you went to Itek?

EL-BAZ: Yes. It is in 1982 that I moved to Itek. This was basically because I had been promoted in the Smithsonian very swiftly and I reached a [pay] grade 16 [General Schedule (GS)-16]. It's government, I don't know whether they still have these grades or not, I got to grade 16. For five years I didn't move. There was no movement above grade 16, which was called [Senior Executive Service (SES)], whereby there is no more beyond that. For five years my salary was not moving up.

I think we were ceiled at $54,000. We were ceiled at $54,000, no more. For five years it stayed like this. This is when my four daughters began college. The tuition was like $12,000 then, a head. Where am I going to get that money? So it was right at that time, I got that offer from Itek Optical Systems to work as vice president for science and technology. It was enticing, because the president of the company came and he said, "You gave us hell when you were procuring," because I was the head of the committee that procured the cameras for NASA. I wanted naturally to get the best possible product from every engineer there the way we did it in NASA, so I would go to Lexington [Massachusetts] and then sit down with their optics people and push them to the hilt as far as the resolution and the quality, et cetera.

He said, "You gave us so much hell when you were procuring the camera for the Apollo missions, why don't you come and sit with me and do this yourself and manage the production of these cameras yourself? We'll give you $100,000 as a signing bonus just to say yes."

So, what do you say? What do you think I said? That was it, so I was there. It was fascinating to get into the guts of cameras and how do you actually work on the glass chunks, to polish them, and to maneuver so that the glass side with the curvature will be just exactly right without a wiggle anywhere, and to assure that the movement of film doesn't shake one iota, so that the film itself, when it is stabilized to take exposure, becomes to get these very crisp, very high-resolution images. It was a very good thing. We flew that on the Space Shuttle to take fantastic pictures. We're still using them to this day.

WRIGHT: Please share with us how that impacted the space agency. You were there with Apollo, then although you were not working with NASA anymore, but yet you were still involved with the space agency, because you were on the other side, so you were able to set those standards for the Shuttle and then also use of the data that came from it.

EL-BAZ: I never really left NASA science so to speak. When I moved into the Smithsonian, my office was just across the street from your building, NASA Headquarters now, on 4th Street, 4th, 6th. They had begun to plan for the Apollo-Soyuz mission. Since I was working for the government as a Smithsonian employee, even when the US government wanted to speak to the Soviet Union about joint programs, I was selected a member of the US commission to go. We were six people that went to Moscow to speak on behalf of the US government on a joint map of the Moon. We were going to get together our maps of the Moon that we had from Apollo. They

would get all their pictures of the Moon. We'd make together a map of the Moon jointly by the US and USSR [Union of Soviet Socialist Republics] so that it will be the standard internationally. Actually this didn't work. We just wanted to cut out, because they were hiding things from us, and it just didn't work right.

However, during the same time or right afterwards, President Nixon had the detente with the Soviet Union. One of the things that he talked with them about was the Apollo-Soyuz mission. Americans would send a spacecraft, and the Russians send a spacecraft, and the two link in orbit. They work together for several days and then separate and go down, and everything was hunky-dory. The director of the Apollo-Soyuz mission was the deputy director of the Apollo program. Captain Lee [R.] Scherer of the Navy was second in command to Rocco Petrone.

When Rocco left NASA, he became the director of the Apollo-Soyuz [Test Project] mission. Naturally he knew me, and he knew I am the photo man and this and that, so he called me up and he said, "Okay, do you want to get a team like the Apollo guys and work on observations and photography from the Apollo-Soyuz mission? That's your baby, the geology. We have that much money, and we'll give you that much money, $250,000, to put a team together and plan it." I said fine, and we did that, so I was very heavily involved with the crew, because I knew the crew members anyway. It was Deke Slayton, Tom Stafford and Vance [D.] Brand. All of them I worked with before.

We trained them well. We did that. We got lots of very good pictures and so on. We continued; I began to look at the pictures. I became interested in desert photography. By then we had images of Landsat [Program, Earth observing satellite missions]. The guys that ran Landsat are also colleagues that I knew from old days, so I continued with Landsat applications

of what do we do, then that continued all the way through the time when I moved to Itek, which made the Large Format Camera for the Space Shuttle.

In real life when Skylab began, Al [Alan L.] Bean was the chairman of the astronaut training for the Skylab astronauts. He still would call me to go and give lectures about training of the astronauts and what you see from space of the Earth rather than the Moon, so I never really left the NASA science activities at all.

I've been related to NASA science ever since, whether it is at [NASA] Goddard [Space Flight Center, Greenbelt, Maryland] or Houston. For instance, when we realized that there are different colors of sands in the desert, I knew that this may be due to some coating on the sand grains, so we need someone to look at them and tell us what is that. The only group that could do this is the Lunar Receiving Laboratory people, so they did. They would enlarge the sand grains for me 60,000 times. We'll find out what it is. We write about it and so on.

The guys at [NASA] JPL [Jet Propulsion Laboratory, Pasadena, California], a lot younger than I. People were working on the radar missions and I would call them up to tell them we need to take some radar images of the part of the Western Desert of Egypt that I'm working on. They would run it through, then we see the very first images of radar images where they penetrate the sand and reveal the buried ancient rivers. There's still a connection there I still have, I just was there two months ago with these guys for additional stuff. There has always been some relation or another within the science community of NASA, nothing formal, but informally I never left.

WRIGHT: Kind of how you started, wasn't it?

EL-BAZ: That's right.

WRIGHT: I just wanted to ask you a couple unrelated questions before we close this afternoon. What do you believe to be the lessons learned from what originally was called the vis obs effort, which is now of course remote sensing? What do you believe to be the lessons that you learned back in the Apollo program that are so valuable to today?

EL-BAZ: The key to success is motivating people to go even beyond what they think is possible. That I heard as a lesson from Rocco Petrone that he got from Jim Webb. I think I told you once, which was the statement from Webb was: "If each one of you can get from each one that works for you—," he said every man, "if you can get from every man that works for you—," we had no women then, "all what they think they are capable of doing, then we will surely fail, but if you can get from every man that works for you more than what they think they are capable of doing, then we'll succeed and we'll make it to the Moon."

That statement, when you read it, you really read between the lines a hell of a lot. That the manager's job is to highly motivate every individual and push them to the hilt so that they can do more than what they think they are capable of. That is really the pinnacle of success, because collectively you add these things together. You will get to the best possible position. I've noticed that wherever I went. Wherever it happened, that kind of result was reached.

WRIGHT: Looking back on your years of contributions to the space agency, what do you feel, if you had to sum it up, is your most significant contribution?

EL-BAZ: My interjecting scientific questions, and the importance of science, into the program, by planting it in the minds of people that know how to do it. I really felt that that was my contribution that I did—I was able to just allow science to get in under the skin of Apollo. Gently and nicely, and by total acceptance in the places where they really can do something about it.

WRIGHT: When you originally started, you began your career by going through series of thousands of photos. Did you put yourself back in that position before you left? Did you review all those photos that came back from your CMP students and was able to absorb all the knowledge or all the lessons that came out of those photos as well?

EL-BAZ: Absolutely. We always continued to pore over these photographs, then also I helped put together the team that NASA wanted to pay for to archive all the Apollo photography. That's an important thing, because also we made real honest to God archives. There was one archive that I made personally with all the Apollo-Soyuz photographs, a real honest to God archive that has the numbers, has descriptions, has every single picture that was taken, because this was the beginning of looking at the Earth from space.

We had a whole slew of people, 12 people, doing nothing but archiving all of the Apollo acquired images, because this is part of the history of science, and part of our understanding of the Moon, and part of the whole astronomy field. Definitely. That's very essential to keep at it and make absolutely certain that you say what you know and organize it in such a way that can be used by the newer generation or the next generation, whoever goes back to the Moon.

WRIGHT: You are teaching many of the new generation [here at Boston University].

EL-BAZ: That's right. Many of my students are running programs now. Many of the people that work—the guys that are running the Smithsonian now are the students of my students. The Center for Earth—the guy that is going to be the editor of the book I wrote a chapter for is a student of a guy that I served on his PhD committee for and I hired at the Smithsonian. Sure.

WRIGHT: That must be very rewarding.

EL-BAZ: Wonderful to see the students of your students doing something tangible. Sure.

WRIGHT: Well, we've learned so much this afternoon. Are there any topics that you feel we need to touch on before we close today? Jennifer, is there anything that came to your mind?

ROSS-NAZZAL: The only question I had for you is, as I sit here, I see Joe Allen's *Entering Space* [on the bookshelf]. I see the photo of STS-5 [on your wall]. Joe Allen had told us that he was very interested in photography and cameras. On STS-5 they took the first full crew photograph. Can you tell us about your work on STS-5 with Joe Allen?

EL-BAZ: I never really worked on STS-5 personally, as a Shuttle program specifically for photography, but Joe Allen was the science astronaut on Apollo mission 15. He attended every single briefing that I had with the crew of Apollo 15. By the time we finished with the Apollo 15 mission, he was as knowledgeable, as versed in Apollo photography, like any one of them or

anyone. He continued that throughout his Shuttle work. He took many pictures. He showed me many of these pictures from his missions, not just one. In Houston, he would call me and he'd say, "I'm going to go through—I want you to come and see, to look at these pictures."

Said, "Great, I will go down." We'd look at rolls of films, so he became as astute in photography as any one of the other guys. He's also a scientist, a PhD in physics. He was very good at it.

ROSS-NAZZAL: He is a Renaissance man, that's for sure.

EL-BAZ: Very much so. Very much so. I take him to the Arab world; I take him to Oman and the southern part of Arabia to speak about space and to speak about his mission. He just gets them floored. He's fabulous in the way he deals with them and the way he talks to them. The way he talks with ease. Bonnie, his wife, is just as fabulous. They're wonderful people, but Joe Allen is in a higher level than a lot of the astronauts or engineers or physicists or anything like that. He's just a super-duper guy, a delightful character and has very thorough knowledge.

WRIGHT: That is one thing you can say about your life. You have met quite a cast of interesting people, haven't you?

EL-BAZ: Quite a cast, yes. Joe Allen is the one that was fascinated by my beginning. [He would ask,] "When did you come out of Egypt? Why did you do such and such? What did you study in Egypt? What was that like?"

Once we were having—Apollo 15—we were having a briefing, but during the day they were off for something. It was a holiday, but we never took holidays, but it was a holiday. We decided okay, let's take an afternoon and go cook some hamburgers and have a cookout and some beer, and we'll come back. We did. So he and I were sitting next to the fire that we built to cook the hamburgers. The other guys were standing with some beers out in the distance. He said, "Farouk, who was your advisor?"

I said, "What do you mean?"

He said, "Your thesis advisor."

I said, "Oh, you wouldn't know him."

He said, "Why? He's got to be one of these guys," [Gerard P.] Kuiper or big names in astronomy.

I said, "No, no, you wouldn't know him."

He said, "What do you mean, you wouldn't know him? What do you mean? Where did you get your PhD?"

I said, "In something called the Missouri School of Mines and Metallurgy."

He said, "School of Mines and Metallurgy?" He assumed that I had it in some astronomical thing that relates to the Moon, because I'm the Moon man as far as he's concerned. He said, "What was your PhD on?" No, he said, "What was your adviser's name?"

I said, "His name was Chris [Christian] Amstutz. You wouldn't know him."

He said, "What was your thesis topic on, the PhD?"

I said, "It was about the lead and zinc deposits in southeast Missouri."

He said, "You're kidding."

I said, "Honest to God."

He said, "Lead and zinc deposits in southeast Missouri? That was your PhD?" I said yes. He said, "Hey guys! Come hear this. You're putting your lives in [the hands of] a guy who's an expert on lead and zinc."

WRIGHT: Stirring it up, wasn't he?

EL-BAZ: He's right. What the hell is a guy who's an expert on lead and zinc doing teaching astronauts about the Moon? He's the one that would later say that, "The only man on Earth that I've ever met that knows the Moon like the palm of his hand is Farouk El-Baz." Joe Allen himself, [said this] in one of the debriefings.

WRIGHT: It must be very interesting for you to think back where you were in Egypt working with the petroleum companies studying *under* the ground, and then you go to the Moon.

EL-BAZ: Then go to the Moon.

WRIGHT: It's quite an expansive career.

EL-BAZ: The only reason for success is really zeroing in on what is significant here, yes. What's the issue? What's the problem? What is it you have to do, and why? Then okay, if that's the case, then how do we do it best?

WRIGHT: You shared such great lessons with us, so we appreciate you for giving us your afternoon.

EL-BAZ: You're very welcome.

WRIGHT: Thank you so much.

[End of interview]