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GARY LOFGREN
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is October 1st, 2009. This interview with Dr. Gary Lofgren is being conducted for the Johnson Space Center Oral History Project in Houston, Texas. Jennifer Ross-Nazzal is the interviewer, assisted by Sandra Johnson. Thanks again for coming in. We certainly appreciate it. Know you've been busy. I thought we'd start by talking today about the Mars Sample Return Project. Can you tell us about your involvement in that in terms of preparing Building 31N?

LOFGREN: Well, the preparation to bring samples back from Mars has two issues. One of them is planetary protection. In other words, is there anything on Mars that we could bring back in the samples that could conceivably be dangerous to life here on Earth? Nobody knows the answer to that question. The answer is probably no, but the caution is that nobody wants to really take the chance. So as a consequence there needs to be a quarantine-type facility that those samples can be returned. That facility has been conceptualized as to what the issues are with it. Nobody has done a detailed architectural design. There's been conceptual designs, but not true building designs.

You compare this to a BL-4, which is the kind of facility where you work with the most dangerous diseases like Ebola and those kinds of highly contagious diseases. Those are studied in what they call a B[S]L [Biosafety Level]-4 facility where the individuals work in suits that have their own air supply, they're totally contained with separate air supply type suits, this is serious isolation for the people.

However, those kinds of facilities would not be good to return Mars samples to because if you did put them in there and there was life, but it wasn't much different than what we have here on Earth, which is a possibility if there is, you wouldn't know the difference because those samples would be immediately contaminated. There's no way to isolate them from the effects of life here on Earth.

This facility has to be able to do two things. It has to totally protect the Martian samples from the Earth environment, but it also has to protect the humans from the Martian samples. So this is a double duty. The two aren't totally compatible. That dual isolation concept, has not been totally designed. People, conceptually they want to do that, but how you're actually going to do that has not yet been worked out in detail. If you have a place where things are that might infect you, you'd want to have them in a negative pressure relative to where you are, so the air from you leaks in. But if you've got Martian samples in there, you don't want the samples coming in contact with stuff from you that might leak in. You've got to have a double barrier where stuff can leak in and stuff can't leak out. You can see the complication, because there's got to be some kind of buffer zone where both leak into it and that gets evacuated. It gets complex when you try to figure out how to do both of those concepts at the same time.

The idea is that you're going to have to start building that facility, designing it and building it, at least ten years before the samples would come back, to give you time to truly design it, build it, test it fully before the mission actually leaves. It's a two-year or three-year roundtrip mission. So to have it tested before it leaves, that means if you start ten years ahead, you've got to be ready seven years [before]—so it's a very long lead time to do that kind of facility. So that's the big hurdle.

Like I say, nobody's done the detailed design. A couple years ago it looked like we might have a Mars mission in the 2018, 2020 timeframe. So people hurried up and started thinking about this facility. I got appointed to the Planetary Protection Committee, which deals with that issue. I was listening to these discussions. Now all of a sudden in the last couple years, the Mars program budget has been overrun by this next mission that's going, the Mars Science Lab is overrun by $1 billion or something. It's affected sample return.

Now sample return has been pushed off to 2025, so again everybody's relaxing again. There was this hurried rush to start thinking about this building, and now there's another five years to get ready for that minimum. We're not going to have to start doing that till 2015 at the earliest. The pressure is off again. It seems like every time the Mars mission gets closer to ten years, it gets postponed again. It's just happened several times, so it's become a joke in the community. "Oh, we're getting close to ten years. They've got to postpone it again." Sure enough, it seems to happen, one way or another. Something seems to happen to push it off.

Then once you have this facility and you have the samples in it, and then you start testing them. Sitting on the Planetary Protection Committee is an interesting experience. Most of the people on this committee are people who are in the business of protecting people from other stuff.

ROSS-NAZZAL: Like public health?

LOFGREN: Like public health, or like B[S]L-4 facilities and this kind of thing. They're people who are very knowledgeable about how to protect and what can be dangerous. But the interesting thing is that if somebody asked the question, "Well, how would you verify that the samples are safe?" They go, "Well, we don't really know." You'd think that would be a very straightforward issue, but apparently in the biological community it's not a straightforward issue, because how do you prove a negative? You always hear this. How do you prove something isn't? If you see something, you can prove whether it's good or bad. But if you don't find anything, have you really not found it, or are you just not good enough and you just didn't have good enough testing and you didn't find it? How do you prove a negative is difficult because you never know to what level you've got to test it to prove a negative. It's a tough question.

You try to get the people who need to do the passing on it, what kind of tests they would do to verify this for sure, and they don't want to pin themselves down to what those tests would be, because they can say they don't know, and they will find out when they start testing. It's like "leave us alone, we'll tell you when we're ready to tell you." That doesn't satisfy the other part of the science community which wants to know when they're going to get samples and what condition the samples will be in after these people have worked with them to study them. Will they be worth doing science on after they get through with them?

That's another one of the big issues. Will the biologists deal with these samples or the planetary protection people deal with these samples so extensively that there's no good science left to do on them, they will have contaminated them so badly that there's not much you can do with them, and that's an issue. They say, "No, that won't happen," but the rest of the community isn't so sure. It's one of these little crossruff kinds of things. If in fact they do verify that the samples are safe, then they would leave this facility and go to a curation facility like we have in 31N.

ROSS-NAZZAL: That's what you were primarily involved with?

LOFGREN: Yes. Well, I'm aware of all these other issues, but then you would then have a facility not dissimilar from the one we have for lunar samples to protect the Martian samples. It would probably be a very similar kind of facility, but it would have to be a new facility. Well, depending on how much sample we got. The first kinds of missions, they're talking about maybe a kilogram, a couple pounds of sample in a sample return. For that you don't need a whole building. They might be able to isolate a portion of our existing building for that or build a small annex or something, but that's so far away that nobody has really pinned down what they're going to do there.

As well as nobody has decided where they would put this quarantine facility if and when they build it. That has not even been decided. As you can imagine, the locationing, positioning of B[S]L-4 facilities can become a real issue with people. "Not in my backyard will you put that stuff." They tried to put one in Boston [Massachusetts] somewhere, and that turned into a nightmare, they never have built the facility because they never could get a location that people would accept.

The Galveston [Texas] facility which has just been finished, a lot of people don't even know it's there. There is a brand-new B[S]L-4 facility on Galveston Island as part of UTMB that just opened last year. So that was very quietly done, although there was all the proper notifications and meetings. Nobody really objected to it like they did to this other facility. In fact, Galveston considered it a bonus because of the extra economic impact that it would have. I've been there and toured it and it's a very good facility, very modern. Incredibly well designed. It's going to do the job they need to do. I don't think people need to worry about that one. If there is a real serious threatening hurricane, they'd basically incinerate everything right now. So a lot of testing would go down the tubes because tests that were started and stuff would have to be interrupted, and all the results. They'd have to start these things over again, which could kill a year or two's worth of research in some cases, but that's what they would do. They've got incinerators right there. So if there's a serious threat, the stuff goes right in the incinerators, and boom, it's gone. So there's not really a threat.

If there were a serious hurricane coming, they'd do that, and that's it. When [Hurricane] Ike came they'd got the facility fully operational but they hadn't gotten any bad stuff in it yet. So they didn't have anything to incinerate when Ike came through last year. They tested. The facility came through fine. It's up high, so there was no chance of flooding. It's on like the third, fourth, and fifth floors of a very strong building, and it wasn't affected at all by the hurricane. That was comforting. They didn't have anything to incinerate yet.

They may by now, I don't know exactly when they were going to start really doing serious work in there. The point is nobody has zeroed in on a location for this quarantine facility. Some people want it, a lot of people don't want it. People I think that are knowledgeable, and most people that are into this business are quite certain that there's not going to be anything on Mars that's going to be a threat. There are certain people that aren't too worried. They'd love to have it. Again, no serious talk has really gone on as to where it'll be.

The curation facility will be here at JSC, and it's just a question of how big the sample return looks like it's going to be as to what kind of facility they actually produce. At least as of right now that's the NASA policy, all extraterrestrial samples come here, once they're deemed safe biologically.

Now there is this concern too that with the biologists—I keep calling them biologists. That's not probably fair. The people who would do the planetary protection aspect, they are reluctant to give us criteria for releasing them. The fear is that they'll never do that and they'll never release them, even though they may be perfectly safe. They'll never feel safe releasing them, because like I said they'll never be certain that their tests are good enough to really be sure absolutely, unequivocally, 100% positive for sure. They'll never feel that good about it, no matter even though they have continuous negative results. There are people concerned about that.

So this quarantine facility may in fact become the permanent curation facility. Who knows? They even talk about setting up research facilities in there so that the samples never have to leave. The research facilities are right there, but that has its drawbacks, too, because you're talking about some pretty darn expensive equipment to sit there and only work there on those samples at some time and not do other stuff. The kinds of instruments you would use to analyze Martian samples around the world wouldn't spend that much time analyzing them, and they analyze a lot of other stuff too. If you put all that kind of expensive equipment in this one place, and it's only used for that, then it's a waste.

There's all sorts of issues around it that people just haven't dealt with yet. If a Martian sample becomes a reality they will have to deal with them, and that'll be interesting how they do that. You'll see some real finagling going on, politics and all sorts of stuff, fearmongering I suspect, going on around that kind of thing.

But we know how to curate them, that's not an issue. We know how to take care of them. We know how to protect them. That we can do. We just don't understand this other aspect of the potential biological hazard and how to deal with it apparently.

ROSS-NAZZAL: Have you made any suggestions in terms of what you learned from working in the LRL [Lunar Receiving Laboratory]? Has that been taken into account? Or is that just disregarded because the Moon was very different a planet?

LOFGREN: I'll say this delicately. The LRL quarantine was probably not all that effective. The modern people look at that and they say, "Ooh, that wasn't too good." It was designed by the people at Fort Detrick [Maryland] who are the nation's type place for studying dangerous things. One of the first, I don't know if it was the first, but one of the major B[S]L-4 facilities in this country is at Fort Detrick, which is near DC. People from that facility came here and designed the features in the LRL. They did a lot of things well, but there were some things that weren't done so well.

If you think about what you saw on television when the crews returned from the Moon, how the capsule landed in the water, then the crews got out of the capsule and got on the helicopter without any quarantine, then got on the ship, and then went into a quarantine facility. You think about that for a minute. There were weak points, let me say, in the procedure. They're talking about being far more rigorous now than anything during the LRL days. If anything they've learned to improve upon rather than learned anything positive from the LRL experience.

The testing that they did then, I don't think the people today consider that testing adequate. I'm not an expert on that, but they certainly weren't impressed with the testing that was done in those days. We certainly have far more sophisticated instruments to detect evidence of life at a much, much lower level in terms of the amount of it present in material. They understand how to do that where they didn't even begin to understand how to do it then. Basically back then they fed stuff to mice and rats, and that was their test. They can be far more sophisticated today.

They still do that, don't get me wrong, but there are other tests they can do today that they couldn't have done back then, analytical tests for just certain kinds of molecules and biological substances that indicate life, or life indicators. You can do this down almost to the molecular level nowadays with analytical instruments that they couldn't even begin to think about in the '60s. It's a different ballgame today in terms of that kind of analytical stuff. They haven't learned too much from the LRL experience.

ROSS-NAZZAL: What was your involvement with the Genesis mission?

LOFGREN: Functionally as an observer, just a very close at hand observer. I was there when all this was going on and witnessed it. They carved out a couple of rooms in the lunar building for the Genesis labs. They took one room. The early '90s, I guess, somewhere along in there, they stopped having all of the walking tours on site. It used to be that people could walk around the site, they could go into the lunar building and view the samples in the observation room. On the first floor they had restrooms there for the visitors. They had a big room with a bunch of displays in it and that sort of thing that they could look at, twice the size of this office say or maybe a little bit bigger than that, but a room adjacent to the restrooms with some displays and stuff so they could learn something about what they'd seen upstairs.

In the early '90s, that all went away. They didn't have walking tours on site. People couldn't access this building. Even JSC people couldn't get in there. They locked it up. We do tours all the time, but even as a JSC employee the chance to go in the building and just wander around is gone. The room that was used for displays had become a storeroom. The restrooms weren't used anymore. They were turned into storerooms.

When the Genesis mission came along, they decided to take that room, the restroom area, and one other room that we were actually using as part of the lunar lab, and create this special clean room for processing the Genesis samples. This was all done in '97 to 2000, something along in there, in that two- or three-year period. The plans were on the books when I became curator in '97. That was November of '97. They hadn't done the work yet, but the decisions had been made and the plans were already there. They had been designed. So I witnessed the construction of the facility.

They built a class 10 clean room, which is about as clean as you can get. The people who use class 10 clean rooms primarily are the semiconductor people. They need very clean rooms when they start making these tiny little semiconductor pieces and putting all the circuitry on them and etching them. They need to do that, when they're very clean, because just one little particle of dust in the wrong place can screw it all up. So they have these class 10 clean rooms.

Basically what that means is the number of particles in a cubic meter is like ten, and that's really pretty darn clean. When you figure this room is probably 100,000 particles in a cubic meter. So that's the difference. The lab was built. I was there when they brought the final space prepared hardware to do the final cleaning. They basically created these wafers that were about three inches by six inches roughly. They were hexagonal shape. They had several trays. I think it was five trays that were about three feet in diameter. They put about 50 or 60 of these wafers in each tray, and they were mounted in each tray.

The wafers were of different kinds. The mission involved exposing these materials to the direct solar rays from the Sun, the solar wind. The idea was that these particles would hit these surfaces and embed themselves in these surfaces, in these wafers in these materials, which were, I don't know, less than a millimeter thick. But these particles would only embed themselves a few atom diameters into it. You would bring these back and then people would analyze exactly what's coming off of the Sun.

The different trays were exposed for different times during different solar events. If you have a solar flare, you'd want to know that that had happened while you had certain trays exposed to the Sun. The mission spent two years at what they called a Lagrange point, which is the point between the Earth and the Sun where the pull of gravity is equal, so it's a neutral point gravitywise between the Earth and the Sun. Obviously it's much closer to the Earth than the Sun because the Sun is so much bigger, it's got higher gravity. It's easy to stabilize something at the Lagrange point so it stays there in this orbit around the Earth. It's a very stable place for it to sit for this two-year period.

They shuffled these trays in and out and exposed them for different amounts of time. There was I guess on the order of 250 to 300 of these wafers. Some of them were silicon. Some of them were coated with diamond. Some of them were gold. Some of them were pure aluminum. You wanted the elements that came from the solar wind from the Sun embedded in these particles to be enough of a difference in their atomic weight from the material they're embedded in that you could see them. To be able to analyze all the different materials that come off of the Sun, you've got to have different materials here so that you have wafers that are compositioned enough different from the atoms that are impinging upon it. That's why you have so many different kinds of material. There's about eight or 12 different kinds of materials in these trays.

We had these 300 wafers of these different compositions all nicely put in these trays. Then everything went absolutely perfectly until the return. Most people know about what happened on the return. The spacecraft crashed into the landing site because the parachute didn't open, and the best determination of why the parachute didn't open is that this little special gravity sensor which senses gravity and tells the parachutes to open was upside down, so it never sensed gravity. So the parachute never opened and crash!

Stardust, which was a mission that came home a couple years later, it was the one that went around a comet and collected comet dust. It left earlier, too, because it was like a seven-year mission or an eight-year mission. The Genesis was only like a two-and-a-half-year mission from launch to return. The Stardust mission had to go all the way out to this comet and back, so it was like seven years. It launched in '99 and came back in '05 or '06. Forget exactly which year. It had exactly the same setup, but its sensor switch was put in properly, and the chutes opened and performed like it should.

The one test that wasn't done, as I understand it anyway, or I've been told, is that on the Genesis mission they got a little rushed for time and money and they didn't do the centrifuge test which would have told them. They would have found out real quick that the sensor was in upside down. They'd have found that out right away, but they didn't do the test. So they didn't know. That was part of the faster, better, cheaper concept. They got a little bit too cheap, I think, in some aspects. They learned their lesson that that doesn't work too well. You've got to go through all the steps. They didn't go through all the steps.

In spite of the crash, a very high proportion of the science will still be done. The crash eliminated the problem of how to subdivide the wafers, because the 300 wafers became over 20,000 small pieces, so they were already subdivided for you. You just had to find the right ones. They did one clever thing that was really good. The wafers in every tray were all the same thickness, but the wafers in the five different trays were all a different thickness, so you could determine which tray your wafer was from by the thickness of the wafer. That saved the day, because without that, with these 20,000 pieces they would have not known what tray they were in. They wouldn't have known what their exposure history was. It's important to know what the exposure history was.

That was one good thing that they did. So now you can take these particles out. They have to be cleaned, because a lot of them are dirty from the impact. They opened the spacecraft up, and it was exposed to the mud and the dirt on the surface of the desert out there in Utah. So they're cleaning them, but the saving grace is that the things that you're analyzing for are embedded in the particles and not on the surface. A lot of the scientists actually in the end weren't all that concerned because they would ion-etch the surface and clean it up and then they'd go in and analyze the stuff inside.

Now, for some scientists it was more inconvenient than for others, depending on what kind of instrument they were using and exactly what they were doing. For the most part they weren't all that concerned about the little bit of dirt that was on the surface because they could clean that off themselves. So in that sense, a lot of science has been done on the Genesis samples. In addition to that, one of the most important parts of that mission was to determine the concentration of light elements, particularly oxygen, that come off of the Sun. What's the solar ratio of the different oxygen isotopes, 13, 14, 16, 17, 18, all those different isotopes of oxygen? We use these ratios throughout planetary science to distinguish materials from different parts of the solar system. One of the real important aspects of this mission was to find out what's the ratio of these elements as they come off the Sun.

In other words, what's the fundamental ratio, and then how do things vary as you get into different parts of the solar system. Then you can start talking about why they vary. Until you know what the initial state is, sometimes it's hard to understand. You know that these places got different, but you don't know what the starting point was, and you don't know then how they varied or how much they varied from some common starting point. This is one of the most important parts of this mission was to determine that for carbon and for oxygen.

They had a special device in the very center of the spacecraft which didn't move and was exposed the whole time. They called it a concentrator because it was designed so that all these light elements would tend to be pulled into it, so they'd get a higher density of materials to study. That part of the spacecraft survived pretty well actually, almost undamaged. It was way down deep in the heart of the spacecraft so that it did survive better than some of the stuff that were in these trays. That material got broken up pretty much. There were four of these wafers in the very center of this concentrator, three of them were totally intact, and one was about a third was broken off of it. The wafers right in the center of that concentrator were in good shape.

That was a saving grace as well. They're going to do all right. I don't know. It's hard to put a percentage on what they lost, but it's not much. It's down in the 10% level, what the science they've lost because of the crash. It's a little more difficult to deal with the samples, they're dirty, and to curate them is a nightmare because you got so many pieces to deal with.

They ask for a piece from this tray, then you got to hunt through all these pieces and measure the thicknesses of them all and find the ones that were from this tray, which can be a rather tedious job. It's made the curation more difficult and the allocation more difficult, but it's doable.

ROSS-NAZZAL: Would you tell us what your tasks are as lunar curator? I thought we'd talk about your position and a number of things associated with that.

LOFGREN: The primary task that the lunar curator has is to oversee the preservation and protection of the samples. Protection is important, but the threat is not that high. So really the big thing is the protection of the samples from the Earth's environment, to make sure that that is rigorously done and observed. We do that primarily by keeping the samples in a very pure form of nitrogen gas, and then keeping them packaged very well in three materials which are allowed to come in contact with the lunar samples, which is a 304 stainless steel alloy, aluminum alloys technically in the 6100 series, which have the fewest impurities that the scientists object to, and Teflon. Teflon is the flexible packaging material, and then aluminum containers and stainless steel containers, aluminum foil used to wrap things, are the packaging materials.

That's worked out pretty well. These are very artificial manmade materials, they're not going to be confused with anything from the Moon, and tend to be pure enough that they don't contaminate anything. That has proven to be the case. We have to work in a flowing environment, with the gas flowing through the cabinets that contain the samples because we have gloves. These are glove boxes. The gloves are made of a flexible material, neoprene. Neoprene is not totally impervious to the migration of oxygen through the glove. It actually can go through the glove. If you created a static cabinet with gloves in it, and you got it down to the five ppm [parts per million] oxygen and water where we try to keep those levels, it would be up into the thousands in a matter of days. Moisture and air in the room would go through the gloves eventually and work its way into the cabinets. We constantly flow gas through the cabinets at a steady rate, and that's the only way that it really works.

We analyze the cabinets. Every cabinet is analyzed several times a day from the analytical system. There's the cabinets in the vault and the cabinets in the processing area. Every ten minutes, each cabinet is sampled and analyzed. Then it goes through these cycles constantly. It's constantly monitoring the oxygen and water content and the gas in the cabinets, as well as monitoring the gas coming into the building, which of course is your primary source.

Monitoring the cabinets for leaks—big leaks. If a big leak occurs somehow, some big slice of glove or something like that where it really allows a lot of stuff to come in. So that's the primary preservation, and that has worked. That has worked quite well. No matter what material you use you sacrifice something. Back in the '60s when they chose nitrogen as the gas partly because it's reasonably priced, reasonably available compared to almost any other gas you could use, and nobody studied isotopes of nitrogen at that time. Now they do, because the instruments are getting better and you can actually do that now, when you couldn't even do that back in the '60s and '70s. It complicates a little bit analyzing nitrogen isotopes in lunar samples because they're stored in nitrogen and you have to worry about what the ratio of the isotopes are in the gas they're being stored in is relative to the nitrogens, the environment they're trying to study. It's not a huge issue, and nitrogen hasn't become a really important element to study. So it's still not an important issue. Nitrogen is still the good gas to store them in. That probably would be true for other samples as well.

We certainly use it for the meteorites, but the Genesis samples and the Stardust samples more or less have to be processed in air, and they are processed in air. They're not immediately affected by moisture like the lunar samples would be. The lunar samples came from an environment in which there was absolutely no water. When I say that, you're going to say, "Yes, but they found water on the Moon." Well, they found water on the Moon at just incredibly low levels. You can pick up almost any lunar sample that's come back from Apollo, and you don't even see evidence of that water. What they found on the Moon is a particular phenomenon that occurs largely in the colder areas of the Moon and not at the equator where we returned samples during Apollo. So there are issues, but the samples have been kept quite clean and relatively free of water throughout their history.

Beyond that, my job is to work with the science community to get samples to them for study. Although I do not choose who gets to study samples. There is an independently commissioned committee, commissioned by [NASA] Headquarters [Washington, DC], that actually evaluates requests for lunar samples and determines whether the studies are worth doing and are appropriately conceived and are "good science." The requests are submitted to me, and then the committee in fact meets next Monday and Tuesday of next week. They meet twice a year typically, and the meeting happens to be next week. They have requests that they will discuss and decide whether these people should get samples. Most requests are successful because we don't get frivolous requests. You might think you would, but in fact it's very rare that we get what I would call frivolous requests.

Lots of times the committee will make suggestions, make changes, ask more questions, ask questions about technique and these various kinds of things just to make sure the people know what they're doing. If their proposal or request doesn't explicitly describe these things, the committee will put them through another series of questions and answers before they get samples. But it's not too often that they categorically turn down a sample. They try to get samples out there to be studied. As long as the scientist is a recognized scientist and the science is good science, they'll work with the people to try and make sure they get the kind of samples they need and be sure they're doing what they say they're doing.

So it's a system that has worked quite well over the years. We've been doing this kind of evaluation of requests from the very beginning. This was part of the original premise on how they would deal with sample requests. It's continued to this day and really has changed very little. The samples, we're still allocating somewhere between 300 and 400 samples a year. It goes up and down a little bit, but several hundred samples a year still are allocated to scientists around the world. It is an international program, not just US. There's no requirement about being a US citizen or anything. The requirement is basically the committee evaluates a scientist. Is he a recognized scientist of good repute, [that] has a good scientific reputation? That's one of the first things they look at.

ROSS-NAZZAL: So you couldn't necessarily be a junior scholar and be awarded a [sample]?

LOFGREN: Well, the best way, junior scholars usually work through a senior scholar, but you have to have proven yourself at some level. You're not going to come right out of college and the first thing with no track record and get lunar samples. The science system works where you come out of college, you usually apprentice—that's not the word they use in science. You get a postdoc [postdoctoral fellowship], or you work in another prominent scientist's lab for a couple, three years, after you've gotten all your degrees. It's like doing a residency in medicine or something, you're proving yourself beyond the formal education stage. So they'll usually get samples under the auspices of the more senior person. Within three or four years you can usually, if you're good, develop a reputation to where you can stand on your own. They want to bring young people in, so they find good young people, they'll allocate them samples. It's good to keep young people coming into the program.

ROSS-NAZZAL: Is this committee the CAPTEM [Curation and Analysis Planning Team for Extraterrestrial Materials]?

LOFGREN: Yes.

ROSS-NAZZAL: How big are the samples, normally? You said 300 or 400 a year, so how big is a sample when you get it?

LOFGREN: Oh, samples are small. Average sample is less than a gram.

ROSS-NAZZAL: How big is that?

LOFGREN: There's 28 grams in an ounce, 28.3 actually grams in an ounce. A half-gram sample would be the size of an aspirin tablet or smaller, more like the size of a mini aspirin.

ROSS-NAZZAL: Oh, like the children's aspirin?

LOFGREN: That's probably 100 milligrams, something like that. So that's the size of a sample roughly. They might go up. A ten-gram sample, which again is like a third of an ounce, is a big sample for allocation purposes. A ten-gram sample is a huge sample for the scientists analyzing, too. The typical amount of material that they do a single analysis on is less than 100, 200 milligrams at a time. The techniques have gotten to where you just don't need much sample to do your work. There's a few instances where you do, and where concentration levels are incredibly low people might get three-, five-, maybe even a ten-gram sample, but that's not too common. So 300 or 400 samples is still probably only a couple, three ounces of material.

ROSS-NAZZAL: How much was collected during the Apollo Program?

LOFGREN: Eight hundred forty-two pounds. We still have over 700 pounds of pristine material that's been in pristine storage ever since we got it. We got another 100 pounds or so that are out in the remote storage facility. We've probably only consumed 40, 50 pounds in terms of serious study. A lot of scientists will destroy most or all of the sample they get to do their analysis. If you analyze samples with a mass spectrometer, which is the typical instrument to do very very low concentrations of elements or to do isotopic age dating, you totally dissolve the sample, and then you deposit it on an electrode, you put the electrode in the machine, you burn the electrode, that frees the ions into this stream around a magnet, and then you separate the atoms by weight as it goes down around this magnet. then you analyze the individual atoms based on their weight. You don't need much material to do that, but you do destroy it in the process.

Some samples go out, nothing comes back. That's still a small percentage. Less than 3% by weight of the total collection has been destroyed in scientific analysis. More samples have been used for education allocations than for science by weight, not by number, because the typical display specimen might be 100 grams, a quarter of a pound, whereas a typical allocation is a gram.

ROSS-NAZZAL: Yes, it's so tiny.

LOFGREN: There's a major difference there, but 10% of the collection by weight has been either involved in scientific study or used for education samples. So that's 80 pounds out of 800 and something. There's still well over 700 pounds still remaining. Although people ask me, "Well, have you studied all the samples?" Well, yes. Every single sample has been looked at. Some are deemed more interesting than others so they've been studied more extensively because they're more scientifically interesting. Not every sample has been studied extensively, but it's been looked at well enough to know what it is and should it or should it not be studied extensively. They make that choice. They don't always make the right choice initially, but the sample is there, listed in catalogs, and if somebody eventually decides they want to look at that one more, then they can.

The scientists pore over the collection, and they determine the samples they want to study and what they think are important ones. That's pretty much the way it works. So we still have a fair amount of material, but we have milked the science out of the collection pretty well within the limits of the analytical capabilities of the instruments.

One of the reasons that samples continue to be studied fairly extensively is that the nature and abilities of the instruments improve all the time. We can do things analytically that we wouldn't have dreamed of 30 years ago or 40 years ago. So one of the primary reasons that significant numbers of samples are still studied is for that reason. People can do things now they just couldn't even think about doing. They may have wanted to do it. They may have thought about it, but the instruments just couldn't do it. Now some of these things can be done with the increased analytical sensitivity of the modern instruments.

ROSS-NAZZAL: Can you give us an example of some of the studies that people are doing today?

LOFGREN: Some of the most obvious ones are in isotopic systems. When we first started doing age dating, you would look at the various isotopes of lead to age-date things. The other one was the ratios of strontium and rubidium. You're analyzing tiny tiny fractions of a gram here. Now they can analyze to the picogram level, which is like 10-12 grams. When they're analyzing the ratios of these different isotopes of a single element, these are not big numbers weight wise, so it takes very precise instruments.

When we first started, we could do strontium-rubidium and we could do lead. Now there's like five or six different isotopic systems that we can study. Tungsten-hafnium, manganese-chromium, let's see, neodymium-samarium. These are elements that are present at two to three orders of magnitude lower amounts to analyze than we could analyze during Apollo days. There's whole new isotopic systems, like four or five, that you can study now that you couldn't. You knew they existed, but you just didn't have the analytical tools to do it. Now they do. This has allowed them to do age-dating. Different isotopic systems, you age-date based on the decay rate of certain radioactive elements into other elements, and then you do the ratios of those two elements and you know what the decay constant is for these elements. This element decaying to that element is a relatively constant decay rate. So you look at the amount of the daughter product and the amount of the parent product, and then you can do ratios and you can do age-dating. It's a little bit more sophisticated, but in a nutshell that's what's going on.

Depending on the decay rate, you're looking at ages in different age ranges. So now some of these systems we can do now allow us to fine-tune things that are going on 5 billion years ago in great detail, where just in the lead system or the strontium isotope system you had much higher errors when you went back that far. Now you can work in systems where the errors are very small way back in that early period, the early history of our solar system. So you can date events in the first 100 million years more accurately than you could even think about doing during the Apollo days.

That's helped us to understand the early history of the solar system and how things developed at that early stage. That's just one example. Understanding how the planetary differentiation takes place. As planets evolve, there's a lot of heat involved in the accretion process, the heat is captured in a planet. The Earth is still hot from that heat that was acquired during the accretion process, and that's why we still have volcanoes, because we got a lot of heat down in the center of the Earth, and it melts stuff, and that melted stuff comes to the surface and comes to the surface as volcanic eruptions. That's the primary way heat escapes from the center of the Earth is through that. There's a constant heat flow all the time, but you get a lot more heat out when the volcano erupts molten lava. You can get as much heat out in one eruption as the whole planet evolves in a year just through the normal diffusion through the normal crust. Where was I going with this?

ROSS-NAZZAL: We were talking about the samples and what people were studying today.

LOFGREN: Yes. So we can look at that early stage of crustal evolution. This isn't so much age-dating as looking at that process. One of the things that happens, the heavy elements tend to go to the center of the planet, to the core. So we have an iron-rich core on the Earth. One of the ways to study that is to look at a lot of other elements, not the major elements like iron and stuff, but to look at some of the elements that are there in small quantities, and look how they are partitioned between stuff on the surface and stuff in the center. One of those groups is the platinum group elements. They're not the elements you're usually thinking of, like osmium and palladium and rhenium. Those are all elements that are in the same group as platinum but are present at very much smaller quantities.

We can analyze now all those elements very accurately, where we couldn't do it during the Apollo days. So that is not so much age-dating things, but it talks about this process of planetary differentiation, and how the planets change as they mature or they cool down with time from their original state. There's all sorts of these kinds of things going on, but most of it is centered around analyzing for small amounts of material that you can use as indicators for processes that change things in the planetary evolution of planets.

That's how we understand those processes is usually with these small tracer elements that move around. The big elements, you don't see small differences in those very easily because there's so much of it, but the trace elements sometimes are much more informative. We can do those much better.

ROSS-NAZZAL: It's amazing. So we went to the Moon, and we learned more about our solar system, not just about the Moon then?

LOFGREN: Well, that's actually one of the major things about the Moon that not everybody understands. You can say a lot of people, they don't grasp it, is that we've learned so much about our solar system by studying the Moon. We've learned a lot about the Moon, but we've learned even more about the origin of our solar system. Primarily because the Moon is a smaller planetary body and was never as hot, and since it's a smaller diameter it cooled more rapidly. The active geologic processes pretty much ceased 3 billion years ago, plus or minus 500 billion years, so that the surface of the Moon is almost all older than the oldest rocks we have on Earth. We can find rocks of any significant amount, very few [are] older than 3 billion years old. You can find the odd little small area of rocks that are older. They're finding minerals now that are 4 billion years old, but they're individual minerals, they're not whole rocks.

They're very informative, they tell us a lot. But the rocks from the first 2 billion years of Earth's history are gone for the most part, or 1.5 billion years, are gone. The Moon is mostly those rocks. So the Moon is like a history book that stopped changing 3 billion years ago and we can look at that early history, but of planetary formation, not just the Moon. The same kinds of processes go on on the Moon as go on on other planets. Looking at the timing of events on the Moon tells you the timing of events on the other planets as well because they all evolved and formed in the same approximately timeframe, particularly the terrestrial planets: Mercury, Venus, Earth, and Mars. The gaseous planets are a little different: Jupiter, Saturn, Uranus, et cetera are a little different. Of course things get colder as you go farther away too.

The Moon basically has proven to be an open book for our whole solar system. It's not just the Moon. That's the thing: "Well, you've studied the Moon, you don't need to do that anymore." Well, we understand how the Moon formed, there's still stuff we'd like to learn about the Moon, but there's still a lot we'd like to learn about our whole solar system and how it evolved and where we came from. We still can learn from the Moon even more. We need samples from other portions of the Moon, different ages, and get a better idea. The earliest crust of the Moon is mostly on the back side. We haven't been there yet. We've seen it, but we haven't been able to sample it. So it's important to get around there and start sampling some things as well.

ROSS-NAZZAL: Since we're at this point, what impact did President [George W.] Bush's new Vision for Space Exploration have on your position? Did it change things?

LOFGREN: Well, it certainly changed my job. All of a sudden people got interested in studying the Moon more than they had been. Hasn't been a huge jump, but there's been a significant increase in interest in studying lunar samples since that program was announced. It's a broader variety of people. More younger people are starting to get interested. We had evolved into an established group of scientists that were slowly aging and getting older, but now we're starting to see a cadre of younger guys in their 30s coming in the program, which is good.

So yes, it's changed things. It certainly has invigorated the people and has increased interest in the Moon and in Mars, because they think well, there's a chance we may actually do something with these bodies. It looked like for a long time we were never going to leave low Earth orbit again. Now maybe we will. It's expensive, it's a problem, it's going to be difficult. When we're going to do it is still open to question exactly, but it's looking like there is the motivation to actually do it, I think. I could be wrong. Maybe it's wishful thinking. I like to think I'll still be in my rocking chair when we go back to the Moon, watching it on my porch. I won't be the curator anymore, that's for sure, because ten years from now I will certainly be retired. But it'll be fun to watch it. I hope it happens soon enough that I do get to see it happen.

ROSS-NAZZAL: One of the things I was reading about in that *ASK Magazine* article that we haven't talked about was the renovation of Building 31N. Can you talk a little more about it?

LOFGREN: When I became curator, it was readily apparent to me that I was looking at a 20-year-old building, and clearly there were things that were starting to show their age. One of the most important things and one of the critical things, was our source of the nitrogen gas that we need. We get our nitrogen gas by evaporating liquid nitrogen. The way we get our nitrogen is in the form of liquid nitrogen. We have a big storage tank of liquid nitrogen, and then we slowly boil off liquid into a gaseous form that we run through our cabinets. We purchase the purest form of liquid nitrogen, which gives us a very pure form of nitrogen gas.

The state of the liquid nitrogen tank, which had been acquired from surplus in the mid '60s, was really showing its age. It wasn't so much that the tank itself was showing its age and was in danger of failing, but all of the controls for the tank were 1960s vintage controls, which were now obsolete, unrepairable, you couldn't get spare parts for them. So if you had a major failure in your control system, you were in serious trouble.

We first looked into refurbishing the existing tank and came up with a price tag of about $600,000. Then we looked into a new tank, and that was like $700,000. It was like a no-brainer. The final coup de grace that got us to a new tank, the old tank was over next to the Lunar Receiving Lab, which it was built to supply nitrogen to the Lunar Receiving Lab, and then when the facility moved across the parking lot to 31, we extended this supply line from 37 over to 31. Well, that was done in 1971 or something.

They came along this little space between the two parking lots that are between 37 and 31. There was a narrow sidewalk with some flowerbeds and stuff, and they'd planted a couple little tiny oak trees. Now the oak trees are like this [demonstrates], and the nitrogen line that they buried right next to those oak trees now looks like this [demonstrates], and had come to the surface in a couple places. It was buried 12 to 15 inches deep, and it had been bent enough that it had come to the surface by the roots getting larger and just pushing it up. That was just unnerving to see our two-inch stainless steel pipe pushed all the way and exposed at the surface.

Said, "Okay, now that that's happened, we're getting a new tank, and we're positioning it right next to 31." So that's not an issue anymore. So that was one of the first things we did. That was finished in basically '03. The other thing that happened had nothing to do with the age of the facility but was just our remote storage facility was in San Antonio [Texas], and in the mid '70s we had found a building at Brooks Air Force Base in San Antonio that had been abandoned and wasn't being used. It was a former munitions bunker actually, one that has dirt halfway up the walls, no windows, that kind of thing. It was the perfect building, and so we built a vault inside the building, a special vault.

We had the samples there until 2002 when we were forced to move them because the Air Force basically sold, donated, I don't remember which, a lot of this property to the city, San Antonio, including the area where our building was. Now we could have kept our building, but the Air Force was no longer providing security. So we investigated the price of security for our building, and it was going to be $250,000 a year with one of the private security firms to provide the kind of security that the building needed. We did a little back of the envelope calculation and decided that we could build a new facility for $200,000 and position it out at White Sands [Test Facility], which is the NASA facility near Las Cruces [New Mexico], and again take the benefit of existing security and not have to pay for security. That's what we did. We built a facility out there at White Sands [Test] Facility and moved the samples in 2002 from San Antonio there. That was one of the first things we did, and the tank came a year after that. Those were two things we had to do right away.

Then the other thing that was clear, just like the nitrogen tank, the air handling system, all of the controls in the air handling system were actually mercury relay switches, which are even against the law today. You can't even make them anymore. Obviously you couldn't get repair parts for that. So if the control system had failed, again we would have been without air conditioning for the samples.

That was the next big project, which we are just in the process of finishing right now. The project is fundamentally complete. We're doing a little fine-tuning on the air handlers, but the project is basically complete. That went successfully. Then thanks to the 9/11 event, we got our security systems replaced. Again, a lot of that was obsolete technologies. It's now much better and more secure. We didn't have to pay for that one, which was nice. One of the last things that we're going to have to do is the floor material is beginning to deteriorate and the wall coverings are beginning to become a problem. They developed in terms of clean room design, they developed new products that are much better for floors and walls that we will use. We'll basically just cover over our walls and floors. The ceilings were epoxy-painted, so we don't have to do anything with those, but the walls and floors will be redone, and that's yet to be done. That's probably the last thing of any significance.

Now there was one other project that was important. It was a computer problem, not a building problem. We had a database that we used to inventory all the samples and keep an accurate inventory of the samples. When we would allocate a sample, we would take one piece, split it into two pieces. Then you entered the new number for the new piece and put the old piece back, changed the weights. It was like a double bookkeeping system. Everything had to balance. So it was a sophisticated system, but the problem was it was designed on a computer with a software program that was specific to that computer that became obsolete about six years ago.

This was the VAX computers, which they stopped making, I don't know exactly when, but in the early part of this millennium. I like to say that. It was clear that we needed to migrate our database to PCs [Personal Computers] or modern computer systems with modern programs that would continue to be updated. We had come to a dead end. We had hung on to this program that was no longer supported. It was not as good as modern programs. The computers were about to die, and there were no replacements. Nobody else ran this program, only this one, DEC, Digital Electronics was the only one. Those computers were the only ones that could run this program. There were much better programs that had been written in the meantime. So we had to do that, and I figured, "Give me $50K and we'll do that." Well, it turned out to be about $1.2 million to do that job. It just boggled my mind. To make this transition it took five programmers 14 months.

All this money was salary, there was no hardware involved in this, very little. We did buy a new server, but that's $10K for a brand-new high powered server to handle all this. One hundred K was just salaries. You take five high quality programmers and put them to work for 14 months, that can run up in a hurry. It was expensive, but now we've got a modern database that we can use. If those [VAX]computers had crashed, it wasn't that we were going to lose any data, because it was all backed up, and we wouldn't have lost any data. We would have lost our ability to allocate samples, because we couldn't have processed samples. Or we would have had to enter them by hand into something. We have had nothing, no way to keep track of every time we made a new sample how to do that.

It was important to get this done, and that was finished up two years ago, something like that. I started worrying about it when I first became curator in '98. Well, it was virtually '98. I started talking to people and saying, "Well, how can we do this?" and exploring all the options. As early as '98, '99, I was asking people to start doing this and thinking about it. We had a couple, three false starts and didn't get anywhere, and the contractor would get a couple of their computer programmers over and sit them in a room and say, "Here's what we do, now make a new one." They'd puzzle over it for a month or two and say, "We can't do this, we don't know how to do this." It was just beyond them. They weren't high enough caliber people, they hadn't dealt with databases before, they had no experience dealing with sophisticated databases.

So it just took like five, six years before we even got to the point where we knew what we had to do and sit down and say, "Okay, this is going to cost real money, we're not going to do it for $50, $100K, this is going to be a big project." We got a serious estimate and produced a serious requirements document. In the end it was a little over $1 million. That's what it costs to do these kinds of things these days. You just don't get away from that.

As a result of that, we've got a crew of three people who deal with databases employed by us, because databases are a huge part of what we do. Every one of our collections needs a database. The person in charge of the Genesis Project had started producing a Genesis database, but it was limping along and needed an infusion of more people and better talent. The Stardust mission came back. They started trying to do this on the fly and found out no, that isn't going to work. We're going to have to do a serious database situation here. They've turned three or four people loose on that system. I don't know what it's going to cost in the end to get that database written. They're just now finishing it up. Databases are what we have to do to be able to allocate samples. So they suddenly realized, "Yes, okay, we need a couple database experts in our own organization to keep track of these databases and make sure they keep working and make the changes and the improvements that need to be made as you go along."

That's become a huge part of what we have now. Ten years ago people considered this a trivial sideline. No, it's a central theme. Without proper databases you can't do your work, period, you're just dead in the water. It took a while for that to sink in and people to realize that—the people who gave us the money and people who funded us. Everybody had to realize that. Eventually they all did, but it took some time. Those are the main things that we've done over the years. In the end I suspect it's going to be $4 or $5 million worth of renovations.

The Center put a new roof on for us. Like I say, we didn't have to pay for the new roof or the security upgrade. The Center did those, but we've had to round up money for the move for the new tank, for the computer upgrades, and the air handler upgrades. We've had to round up money for all those. The Center has contributed but only a portion. We've had to get other significant slugs of funding from Headquarters designated for these activities.

We're reaching a point now where the facility is largely renewed. The only thing left is floors and walls, which we consider the least critical, but we still want to do it. It's probably one of the least expensive. The estimate is somewhere between $150 and $200K to do all that. That'll happen in the next couple years as we round up the money for that. That's not going to create a disaster like some of these other things could have. It's not as high a priority, but it needs to be done. When that's done, I think the facility will be good for another 30 years. All the systems will basically have been renewed.

The building is very sound. It's a very simple building. There's no windows. There's no plumbing. There's no water in the building. Fundamentally, it's a simple building. The nitrogen distribution system is the only complicated system. Distributing the nitrogen gas to all the places that you need it, and doing that analysis scheme that I was describing to you. That's the most complicated system there other than the security, which is complicated. But the security people take care of that. If we have trouble, they get over and sort it out, but we have to do the rest. We'll be in good shape now for quite a while.

The Genesis facility is basically new. The Stardust facility is new. It's good for a lot of years. There's this predilection to just not doing maintenance. Routine maintenance is boring, it's not exciting. Who wants to spend money on maintenance, for heaven's sakes? You look around JSC now. We just had our third water main rupture of water coming into our building in two years, this last couple days. Where they come in in the morning and say, "Don't drink the water, restrooms are closed for the day." They get out there. They manage to fix it in a day. So they got it repaired. This one was repaired quicker than the last two, but then it takes two or three days where they test the water and make sure it's so you can drink it. You start thinking. The utilities at JSC are now 40, 50 years old, and it's time things are going to start to happen, and they are.

It's not a new place anymore. Maintenance is becoming important. Because of Hurricane Ike, we got our roof about three years ago. I don't know if you've been on site, but they're replacing a dozen roofs right now all over the site. They're replacing roofs damaged by the hurricane. Parts of the roof blown off in several buildings. That's one way to get maintenance money. Not the best way, but they got some maintenance money that way. People are starting to think about that a little bit more I think. It's expensive to keep doing this little fix here and little fix there and then they just continue to happen. You've got to plan a little better than that, especially for critical facilities where you wouldn't want the lunar samples not taken care of. We tried to be very proactive once we realized we really needed to be.

People did respond, and they allowed it to happen. We convinced that it needed to happen. They believed it. You have to explain the situation. They understood that yes, that's right, these things need to be replaced, that's just pure and simple, it's got to be done. Air handling job right now is $1.6 million, something like that. You think jeez, what are we talking about, three or four air conditioners, but it's not air conditioners like you think of normally.

ROSS-NAZZAL: Well, you had mentioned security, and I was curious. I don't know if you want to talk about this on tape. I wondered if you would like to share with us the stealing of the Moon rocks in 2002 and what impact that had on your security.

LOFGREN: They were not stolen from our facility. They were stolen from one of the scientist labs in 31, not in the lunar facility. Lunar facility, it would be very very difficult to steal samples. Even this guy who stole these samples realized that that was not going to be possible. You wouldn't do it stealthily. The only way you could do it would be a smash and run, and you wouldn't get very far, because the alarms are all over the place. If those alarms go off, they shut down the site instantaneously, you wouldn't get off the site. Those alarms go off, the site shuts down, period, nobody gets out until they figure out what happened.

The samples were stolen from a lab. They were observing all the standard security procedures. This guy just figured out a way to defeat them and managed to get the samples off site. As a consequence of that, the security features in the building have been expanded. The video coverage has expanded. They had doors that the hinge pins were on the outside of a locked door. That's not always the best way to keep a door locked. They did have a feature where they weren't easily removed, but it just took a little more perseverance to remove them. These doors were not originally built to be secure, only to be a laboratory where you could just have a normal lock on it and don't expect people to be breaking in. They've now made these doors with these kinds of hinges even more secure than they were. People have moved their safes to places where the doors are more secure.

So that was a lesson learned. The average riffraff doesn't get into the Center, let alone into the building. You don't expect this kind of thing to happen. This guy that instigated this, [Thad R. Roberts], he was an honors student. He was a co-op, a very bright guy, except in certain matters. He was book smart, but lost a little common sense along the way, because he was caught right away. The samples weren't gone a week.

ROSS-NAZZAL: Were you involved in that investigation?

LOFGREN: I was in Japan when it happened. I was going there to give a lecture and carry a lunar sample over there. I got off the airplane in Osaka, Japan, and I had this immediate phone message to call home. The guy whose safe had been stolen had sometime earlier in that year or the year before given me an envelope with his combination, because he didn't have a consistent backup person to open the safe should it need to be opened. So he put the combination in an envelope, sealed it, with a signature across the seal. I had it in my safe in case we needed it. The first thing they wanted to do was to see that envelope. Okay. So I gave the combination to my boss. I was the only one that had the combination, but I gave it to my boss. He looked in there, it was still there sealed up.

They were thinking maybe he got into the safe somehow and might have gotten the combination and then stole the safe. Well, no, he never had the combination. You can go on the Web and you can figure out how to crack these safes that we use at NASA. The instructions are on the Web. You just have to go find them. That's a little discouraging. They tell you exactly what the weak points are and how to defeat them.

The thing that he did that was really interesting—he actually advertised lunar samples for sale on the Web to mineralogy clubs around the world before he had actually stolen anything. I guess he was just testing the market. Is somebody really interested? Will somebody really buy them if I steal them? So he put out this ad. The head of this club in Holland, Netherlands looked at this ad. He had had some personal experience. He said, "You can't do this, you can't buy Moon rocks." He knew that. Says, "Something's going on here." He actually forwarded the ad to the FBI [Federal Bureau of Investigation]. It went to their Orlando [Florida] office. They saw this and they said, "Okay, well, we're just going to say, 'Yes, we'll buy rocks.'" They set up a sting. As a result of that then he stole the samples, brought them to Orlando, and then tried to sell them to the FBI. He was caught pretty quickly. That's why he was caught so quickly.

I'm not saying that some totally determined very clever thief couldn't crack—I don't even know what all the security systems we have and how they work. The security people know. I know it's extensive security, but I don't even know the details. None of our people know the details. Security people are the only ones that really know the details of how the system works or where the weak points are and that kind of thing or how you might defeat it. It's not easily done. So I'm not too worried about things from our building. If you had some kind of huge armed assault, that's a whole other matter. In terms of stealth that would be pretty difficult. Security is better in our building.

I've not heard of any actual significant attacks on a PI [Principal Investigator] either in a university. They typically don't have all that much sample, as I told you. They don't get big amounts of sample. They don't have that much. Nobody has chosen to try and attack anybody out there. They have safes and locked rooms, but it's no more secure than what we have. It's not extensive.

Although I got an IG [Inspector General] officer at Headquarters sent me an email just this week. He had found some "lunar samples for sale" on Angie's List. I looked at the pictures. The pictures were not totally diagnostic. I couldn't say unequivocally that they weren't lunar samples, but I could be quite certain they weren't. But you can't be 100%. They had a superficial resemblance to some of the samples, and rocks are rocks, sometimes they're not all that different. Somebody had chosen some rocks that probably had looked [like] pictures of Moon rocks, and these in a vague sort of way resembled them. So they were trying to sell them. I told the guy I could state with reasonable certainty that these were not lunar rocks. We certainly aren't missing any from our collection. I know that for a fact. He said, "Good, thanks." I don't know what the guy is going to do about it. If the guy actually sells them, then he's guilty of fraud. I don't know what would come of that; NASA is not going to prosecute that.

Samples have come up on eBay far more often than they've come up on Angie's List. That was a new one. You can put an ad apparently on your own apparently on eBay, but then sooner or later somebody notices it, and "No, no, no, we don't sell Moon rocks on eBay."

ROSS-NAZZAL: Do they alert you or the IG's Office if that pops up?

LOFGREN: The IG's Office just keeps an eye on these things. I don't. They come and tell me. They have confiscated some of the things that were for sale on eBay. One of them that was particularly amusing to me, this agent confiscated it and then they brought it to me here in Houston. You're familiar with the red landscaping lava rock?

ROSS-NAZZAL: I don't think so.

JOHNSON: Yes.

LOFGREN: Okay, you know what I mean. You can buy them at Home Depot in bags. It's basically volcanic cinder.

ROSS-NAZZAL: Oh yes, I know what you're talking about now.

LOFGREN: It was a piece of that.

ROSS-NAZZAL: Did they just paint it black?

LOFGREN: No, it was still red. You could actually find black versions of that too. They have it in black and they have it in red. They didn't even bother to get a black one, because no lunar rocks are oxidized that much. No lunar rocks are red. That was a dead giveaway.

ROSS-NAZZAL: That's why I was asking you, "Did they paint it."

LOFGREN: So I took one glance at it and I said, "Come here. Let me show you." We went out to the back door, and there's a whole area in the garden full of this red rock. I picked one up and says, "Now does that look like it?" He goes, "Oh my God." He just went back, and he was satisfied. It wasn't a lunar rock. He just told the guy. Gave it back to him, said, "You better not sell this as a lunar rock. I'm not going to come after you, but somebody will. It's not my job, but somebody will sooner or later."

They caught one guy. I was involved in the case where he had sold over $250,000 worth monetarily of fake lunar samples. He knew they were fake. This person supposedly had been given the sample and thought it was real and they were selling it. That's the usual story. They agreed not to sell it and they didn't, and eBay didn't let him advertise it on their thing once they realized it certainly wasn't for sure. This was quite a while ago. This was right around 2000. I hadn't been in the job very long when this one came up. It was a federal prosecutor from Phoenix [Arizona]. The thing happened in Phoenix. So I was talking to the federal prosecutor. Actually wound up being a federal prosecutor here in Houston, Mike somebody. I can't remember his name. He died of cancer recently. Anyway, so he was a young guy actually, and he came here to Houston. The local IG person brought him to me, and we talked about it.

He showed me the samples. I took one look at them and I said, "Well, they're not lunar. I can tell you that." He said, "Well, we need hard evidence, because this could be a court case." So it wasn't just looking at them. I had to get some analytical data, which was easy to do. We got some analytical data which I could document they were not lunar.

The guy wound up pleading it out. He went to jail for 22 months, I guess. He had sold little tiny pieces about this big [demonstrates], and he had about four or five of these pieces in a little case, and he had made a nice-looking plaque to put them on. He was selling them for between $10K and $20K apiece. To get $250,000 worth, it was about 20 of these or something, I forget. They weren't all the same price. But anyway, around 20 of these had been sold to different people. People probably just lost. They had their thing, but it wasn't [real]. They could have sued. They could go after him, I guess, and sue him or something in a civil court. He went to jail for fraud, but then he's open to civil suits obviously. I have no idea whether anybody did that or not or just bit their tongue and took their loss. I don't know, but that's happened. That was the worst case of fraud that I've come in contact with.

The guy that stole the samples from our building, from 31, went to jail for eight years. He just got out this year. He was in federal [prison]. That was a federal case. You serve 85% of your term minimum, when it's federal. You don't get off at half your term. So he did eight years. He actually got out and wrote some article, a pretty bizarre article, about how he stole the samples. It was 90% fiction. He talked about putting on wetsuits to avoid the heat sensors in our security system. Well, we had no heat sensors in our security system, and that wouldn't have worked anyway. He put together this fantastical story about how this had all gone down, and even had sex with one of the postdocs on the bed with the rocks. This was really bizarre, I tell you. The guy, he's lost it, I don't know where he's going now.

There's no real profit in it, you're going to get caught sooner or later dealing with this kind of thing. Too many people pay attention. Too many people know that you can't buy real Apollo Moon rocks. You can buy lunar meteorites. There are lunar rocks that come to the Earth as meteorites that you can buy. They're out there, and there are guys that have them and can sell them, and there's a market. It's not cheap. Average price for a piece of lunar meteorite is $2,000 a gram. So calculate that out. Multiply that by 28, that's how much an ounce would cost. Multiply that by 16, and that's how much a pound would be. It's pretty expensive stuff. Price goes up to $50,000, $100,000 in a hurry. You can get it, but it's expensive. It's about the same price as Martian meteorite samples, about $2,000 plus or minus $500 a gram. That's a pretty well established price now. There's a lot of dealers out there. They don't sell it for less than that.

Scientists try to get their hands on some of these lunar meteorites, but they have to buy it. Scientists can get some of it because before a guy can sell it as a lunar meteorite, it needs to be verified. The typical scenario—if they think they have a Martian meteorite or a lunar meteorite, they'll give a piece of it to a reputable scientist who then will study it and publish about it, verifying what it is. Then this guy can sell it for big money. Without that kind of authentication, they're not going to convince people that it's real.

ROSS-NAZZAL: Not for those prices.

LOFGREN: Exactly. There has to be this authentication and this traceability to be able to get those kinds of prices. So scientists do get their hands on pieces. Sometimes the pieces are pretty big, and they'd like to get their hands on more of it than they get, but that doesn't always happen.

Some particularly spectacular pieces—a couple of the museums have bought some or traded even. They have a bunch of meteorites that were valuable too. They would trade a whole bunch of meteorites for one piece of this one. Some of the museums have done that kind of thing, but that's legal.

One of the frivolous requests I got was a guy who wanted to give his bride-to-be a piece of Moon rock on her ring. I said, "They're not very pretty."

ROSS-NAZZAL: They don't sparkle.

LOFGREN: "They just look like ordinary rocks, they're not going to be all that spectacular. I can't give you an Apollo sample for that purpose. But if you want to buy a piece of meteorite," I gave him a website. "You can go to this website. It's going to cost almost as much as a diamond. If you want to try and do that, welcome to it." That's one of the more bizarre emails I've gotten. I think the person was serious. I think he really wanted to do that. I never heard from him again, so I have no idea what he wound up doing.

I get little things like that once in a while. I'll never forget a guy named [A.R.] "Babe" Schwartz. You remember Babe Schwartz? He was a local state politician here for this area for many years. I don't know whether he was in the state senate or house. When NASA was young, he was one of the guys. Apparently when he retired, had a big retirement thing, he got this Moon rock. He got this rock. After he retired, he was going around to schools and showing off his Moon rock and talking about it and doing things. His son got this sample and sent it to me.

I looked at it. It was not a Moon rock. It was a model that had been made of a Moon rock. I was a fairly good plastic model, painted very nicely, on a little stick, mounted on a little plaque. The plaque didn't really say it was a model. It said Moon rock 10022 blah blah blah, on and on and on, but never really said this was a model.

Well, if everybody had rock 10022 and it was the whole rock, that means we didn't have any. The same rock had obviously just multiplied. It was a very nice model. I had to tell the guy, "Sorry, this is not. I'm handing it back to you. This is a plastic model. If you want to take a knife and carve into it you'll see, and ruin the paint job." He wrote a big article in one of the Washington papers about it, it was like an op-ed piece about how all this had happened and gone down. They published it. He sent me a copy of it. He was very disappointed, of course. He was glad his dad didn't find this out before he died.

That particular model has come into play half a dozen times. I had one just recently. They were describing this sample they had, and it was this model again. I just wrote back and said, "No, that's a plastic model. If you do this and this, you'll figure that out." It's usually, "No, no, no, no, it can't be, I have it on good authority that this was given by Neil [A.] Armstrong to so-and-so and they gave it to so-and-so and then my dad got it." The number of rocks that Neil Armstrong gave away would be half the collection if you believe every [story]. Neil of course wouldn't even give an autograph, let alone a Moon rock.

So it's all silly, but it's amazing the number of people. You have to burst their bubble. That gets sad sometimes. This one poor old elderly lady was just crushed when I had to tell her, "No, sorry, it's a model." She was just crushed. It was really sad. She really thought she had something. It has its bad moments, I guess, sometimes. You hate to do this, but you got to. You can't gloss it over. Just have to say, "No, sorry."

I have not yet found a real rock in the hands of anybody for all the supposed rocks that are out there. Not one has ever been real. There is this issue that's going on right now. You're aware of it, with these gift rocks. There was this one that [Joseph R.] Gutheinz did this sting and wound up confiscating this sample that had been presented to Honduras. It's a little unclear how this person got this sample, but it clearly was the sample from Honduras. He tells a story about it. Who knows whether it's true or not? So he had it in Florida, and then when Gutheinz put this ad out that he was willing to buy lunar samples, this guy tried to sell it to him.

I don't remember the details. There was a court case. The court allowed it to be confiscated. I don't know how legal that really [was]. It was no longer NASA property. Here was the NASA IG wanting to get it back on the basis that it had been presented to this country and really shouldn't be in private hands. I guess that was the basis that the judge gave it back to NASA, who then gave it back to Honduras in a formal ceremony in DC. They got the Honduran ambassador over and had a big ceremony and presented the rock back to him again. That's the only one of those I've seen. I've heard about others anecdotally. I'm sure there are others that got in the hands of private individuals. Particularly in countries where the leaders can be dictators, suspect. They think the rock was presented to them, and take possession of it, not the country, etc. So that kind of thing I'm sure has happened.

I know samples have gone out on the market. Gutheinz is unfortunately raising a little dust around because somebody needs to be more clear that these aren't NASA rocks anymore. So I've had to deal with that, as you well know.

ROSS-NAZZAL: Do you want to put that on the record? Because everyone keeps talking about how we should have the records.

LOFGREN: That's fine. No, I don't mind that being on the record.

ROSS-NAZZAL: So I keep explaining, but it'd be nice if we could say, "Well, check out Gary Lofgren's oral history. Here's the scoop."

LOFGREN: These samples were handed out to heads of state, and we presented the samples to the State Department, who took care of all the foreign presentations. The domestic ones I think were done through our PAO [Public Affairs] Office and astronauts if I'm not mistaken, but I don't even know that for sure. We turned them over to Headquarters. Headquarters either gave them to the State Department or did it themselves. I can't find all the records. I wasn't involved then. We just have records that they were allocated to Headquarters and taken off our books. That's all we know. You've tried to find out more and have not been successful.

ROSS-NAZZAL: Not at all.

LOFGREN: This last article I was reading made a big deal of that, quoted you.

ROSS-NAZZAL: Yes, I saw that. I think that's where that woman got my name and then my phone number.

LOFGREN: Yes. So that's created a little excitement recently. I just had an article from one of the *National Geographic* writers. Now they're a little more reputable publication. It's an independent person who does the fact checking for all articles that get published in *National*

Geographic. She sent an email to me and Lou [Louis A.] Parker asking a bunch of questions. The question of those samples came up not directly, but certainly was part of the article.

I did a few corrections to it. The guy was trying to talk about the Russian sample as detritus. I thought well, that's a little derogatory. They weren't detritus. They were legitimate pieces of lunar soil that the Russians collected and brought back. It was soil, it wasn't rocks, but little tiny rocks. It certainly wasn't detritus. That has a negative connotation. I said, "No, that's not appropriate." *National Geographic* does have one of our display specimens. He referred to that display specimen in his article as a gift to the National Geographic Society. I had to point out that, "No, there's a loan agreement that's renewable every five years that Lou Parker has on his books," and, "No, it's not a gift, it's a loan, and you're responsible for all this stuff, and NASA can recall them at any time if they choose to."

That had to be corrected. There was a couple other things that weren't quite right in the article, but she was very good. She was going to correct all these things. She said she'll send me a copy of the issue when it comes out, just a one-page thing. They had a picture of their display sample with a paragraph at the bottom. It was like a medium-size paragraph about the value of rocks, and how they've gotten precious, and until we go back and get more they're still precious things. All fair enough. It just had a few facts that were not really dead wrong but just not appropriate kind of thing. He just said, "Well, NASA is missing all these samples." I said, "Well, that's not quite right. Let's rephrase that. These countries are missing their samples, not NASA."

ROSS-NAZZAL: Big difference.

LOFGREN: I got an urgent email from a professor at the University of Minnesota [Minneapolis] that I know very well over the years. He's a lunar PI and I know him personally very well. He says, "Gary, this student of Gutheinz is coming to me and saying they want to find the Minnesota sample."

ROSS-NAZZAL: Yes, they've been all over.

LOFGREN: He says, "What is this stuff? Did Minnesota get a sample?" He didn't even remember the distribution of these gift rocks. I pointed out to him, "Yes, and I suggest that you go to whatever building the governor sits in, the state capitol or whatever that building is, different states call it different things." Sure enough, he went over there and inquired. The sample was on display in the state capitol building, appropriately. The kid was happy, went away. They found the sample. That's usually the answer I give. "Look at the building where the governor sits, it's probably there." Not always. Sometimes it's in a back room. It's not always on display, I've found. Sometimes they're stored away somewhere. They usually find them. I haven't heard any state ones that are documented as missing yet. Doesn't mean there aren't some, but I haven't heard of any yet where really they absolutely cannot find it. Most places when they seriously looked, they found it eventually.

That program had its ups and downs. It was nice to do it, but it's created a little bit of hassle. Nothing we can't live with, but it has created a little bit. Gutheinz actually called me earlier this week.

ROSS-NAZZAL: Oh, did he?

LOFGREN: Yes, he was asking me a question about something. I said, "You're creating a little bit of extra work for me." He says, "Yes, I know. I didn't really mean to do that. I try to tell them, too, but nobody wants to listen to me, nobody wants to hear that they're not NASA property. Nobody wants to hear that." I talked to the guy from the *LA Times*, and the minute I started describing all this he really lost interest. I could tell. He was all excited when I first talked to him. The more I described the program and what happened, I could tell he was disappointed.

ROSS-NAZZAL: Well, yes, it's a great scoop to say NASA lost these rocks.

LOFGREN: The story went away. It wasn't as big a story as it sounded like it might be initially. So yes, it's been really interesting these last few months with this going on.

ROSS-NAZZAL: Yes, I'd like to go over to Archives II [National Archives, College Park, Maryland] and see if there's any materials. Now I'm looking at my watch. It's after 4:00. I had a few more questions for you, but I don't know what your schedule is like.

LOFGREN: I can stay another ten, 15 minutes. I do need to get back to my office before I leave, before it's too late.

ROSS-NAZZAL: I'll finish up with these two questions we ask other folks. Then if we have time I'll ask you about the other two. What do you think was your most challenging milestone while working for the space agency?

LOFGREN: Working with the crews and those kinds of things were really challenging, but the biggest milestone and the thing I came to NASA to do was to build a laboratory to test a scientific idea I had basically as a graduate student. To build that laboratory, to do the experiments, to prove myself right, to get out, and prove it was definitely the biggest milestone of my career. Working with the crews was another big milestone, but that was self-defined. This other one was just open-ended. You really had to do it. Doing the training, I was part of a team, and if I didn't do my job everybody else would have. Everything wasn't dependent on me, where this other thing that I was doing, it was mine to do or not do right. That was probably a bigger deal. That was important for me scientifically to establish myself and my career. So that was important.

ROSS-NAZZAL: What do you think has been your biggest accomplishment?

LOFGREN: I'd have to say that again. Any young scientist coming out of school wants to establish themselves and be recognized for that. That is the accomplishment. Reaching that goal and doing it. Having this idea in your head. My idea was not the accepted norm. It was a little bit different, and it took a lot more to get it accepted than an idea that's much more in the mainstream of what science was doing. It was a little tougher to do that than some things. I don't know how to describe it any better than that. I don't want to go into all the technical scientific details. It was an idea that nobody had really thought of in quite that way. I was able to do the experiments and prove that that was the case. That has now become a field of study that other people are doing. That becomes the reward, I guess. Other people believe you, and they start doing the same kinds of things for other projects.

ROSS-NAZZAL: Would you share with us the details of putting that Moon rock on STS-119 that's now I think at the [Smithsonian] Air and Space Museum [Washington, DC]?

LOFGREN: Actually, it's sitting here in Houston in Louis Parker's safe for the moment. Louis broached the subject to me three or four months before the mission was to take off. They were talking about a 40th anniversary activity. They really wanted an Apollo 11 sample. We went, "Oh, well, hmm, this is not going to be easy, we don't have a lot of Apollo 11 samples left that we can use for display rocks," because that was the least number of material we collected, was during Apollo 11. There are several display samples out there already. The material is getting a bit more scarce.

"Well, it doesn't have to be real big." I said, "Okay, well, let me look and see what we've got." I did find a 20-gram piece in our return collection. It's about that big. [Demonstrates] You could say a square about that big. It wasn't quite square, obviously, but that would be a fair representation. We had a case. This had already been exposed to air. It was being stored in air. It wasn't a pristine sample anymore. It had gone to be studied, and they chipped off a few pieces and studied them, and this came back.

I talked with my boss, and we talked with the CAPTEM committee. They said, "Okay, yes, we can take this returned sample and we can do that. It's not going to disappear, we hope."

There's certain events in which it could I guess, but we don't want to think about those. We had one of the first kinds of display cases that we created, which didn't turn out to be very good. They were about this diameter. [Demonstrates] So it would hold this size sample pretty well. It had a little dome on it. Domes turn out not to be good things for visibility because they get reflections off them at all angles. It's hard to find the right angle to look at a sample in a dome. That's why we went to this triangular case.

This was the perfect thing for this. We were able to put a sample in one of these domes, and it was small enough that the whole thing weighed a couple pounds. Weight wise it wasn't an issue, although the ceremony turned out to be fairly anticlimactic. I did manage to see a two-minute clip where the commander of the—I don't know. Did you see that clip?

ROSS-NAZZAL: No, I didn't. I saw the article about the rock.

LOFGREN: He showed it and talked about it for about two minutes. It was shown on the NASA channel. Do you remember the Neil deGrasse Tyson event? There was an event the day before. Then there was an event on the evening of the 20th, and Neil Tyson was the emcee of that. That was the show. They had it on that. They showed the commander up in space on film. NASA had filmed this, obviously, and the clip was replayed. I recorded that show thinking it might happen, and it did. I do have it. I was able to pull that off my DVR, although I could probably get the clip from PAO with no problem. But anyway I have the clip. It was like a minute and a half long. It's anticlimactic, but it was done.

Now it's come back. It's here in Houston. I got a call from the guy who had it. He wanted to give it to me. Then I had a gas leak in my house, so I had to stay home last Thursday and Friday dealing with that and the plumber, getting a plumber out to deal with him, all that kind of stuff. They wound up giving it to Louis, and Louis said he has it in his safe now. There are some plans for it to go on display, but that's where it is at the moment.

It was interesting getting it on board. We brought it over. They wanted to know about all the materials ahead of time. I gave them samples of the materials from other cases that were assembled so they could test the materials for volatility and flammability. They don't want to take things up that can burn easily or that give off odors or that kind of thing.

This had been sitting around for 40 years, so if it was going to give off odors it gave them off a long time ago. They were happy with the materials, so it got manifested. Then I wound up going to two or three other evaluations. First it was going to go on as a personal kit kind of thing, which doesn't get treated so seriously, but then it got manifested. That was a whole other level of testing and verification. I went to a couple other committees and did the same kind of thing. It was no simple matter to get this sample on the Shuttle to go up to Station. Eventually it did, as you know. Now it's come back on [STS]-128 I guess it was, whatever.

ROSS-NAZZAL: I'm not sure.

LOFGREN: Went up on 119. Then there was 125 and then 128. I'm not sure. I think it didn't quite get on 125. Think it came back. Whatever one. It's the one that just came back. [Returned on STS-128]

ROSS-NAZZAL: We'll figure out which flight it is.

LOFGREN: It's been in Florida for quite a while. The stuff doesn't get taken off, and it gets stored there, and then it was a couple, three months before it came here. It wasn't the one that just came back. It's the one before that, whichever one that was. It is back here in Houston now, and it will go on tour at some point. It's a nice rock. It's actually a vesicular rock. It's got lots of sparklies and shinies. It looks nice.

ROSS-NAZZAL: You did say I think in the article that Neil Armstrong had picked up this rock. This is one of his rocks.

LOFGREN: Yes, he grabbed a bunch of rocks and threw them in the box in a hurry, and this was one of those. He didn't pick it up individually and say, "I'm collecting this rock." He was just putting things in the box as fast as he could, because it was clear that we were running out of time. He only had a few more minutes on the surface, and the rock box was sitting there empty. He says, "I don't want to bring home an empty box, that's not fun, there's just a couple little things in it." He got real busy and filled it up, which was great. Otherwise we'd have gotten a third or a fourth of what we got on Apollo 11 if he hadn't done that. That was good thinking on his part. He says, "I'm not going back with an empty box. Not on my watch."

ROSS-NAZZAL: Practical guy. We thank you very much for coming in today. I'm sorry for the delay in scheduling.

LOFGREN: That's okay. That hasn't bothered me, not at all.

[End of interview]