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### III. Lunar Receiving Laboratory

Action was quickly taken after the memorandum outlining the need for a receiving facility for the samples arrived at the directorate level. The lunar samples could suffer degradation due to terrestrial contamination unless they were carefully handled in a controlled environment. For example, contamination with trace elements and isotopes could lead to false conclusions about the age, history, and origins of the Moon rocks. Furthermore, some analyses and examinations were either critically time urgent or were necessary to distribute the samples intelligently to the proper specialists.

Flory and I nervously awaited a reply from the directorate level. We feared the worst—not getting any reply at all—but our wait was short. We were summoned along with our boss to a meeting with a member of the directorate staff, Aleck Bond, a cautious, methodi-

cal, and reasonable man who listened to our case and asked appropriate questions. Bond was convinced we were wise to an aspect of the Apollo missions that had been overlooked. He advised us to give the receiving laboratory our full attention and to prepare a more detailed set of requirements for the facility. When we had assembled the facility description, he would review it with us and present it to his boss, Max Faget.

Our progress in preparing the facility proposal was crippled by our inability to predict the properties of the lunar samples. Would the samples react with the Earth's atmosphere? What were their major and trace element compositions? We decided to prepare for the worst case; the samples should be maintained in an environment as close as possible to that of the lunar surface. This meant that initial handling and examination of the lunar samples would have to be performed in sophisticated, hard vacuum chambers at very low total gas pressure—technically possible, but expensive and operationally complex.

With Bond's help, we presented our plan to Faget, who recognized the significance of a lunar sample receiving laboratory. He was concerned, however, about how to establish the detailed requirements and specifications for the facility in order to convince the scientific community that the lab was necessary and reasonable. Faget suggested we present our concepts to several NASA advisory committees, particularly the NASA Office of Space Science and Applications (OSSA) Planetology Subcommittee. We prepared visual aids, organized and rehearsed our presentation, and got on the agenda for the next meeting in Washington, D.C. We felt confident about this meeting with fellow scientists, and as we hoped, our presentation was well-received. One member of the subcommittee, Dr. Clark Goodman, a physicist from the University of Houston, was enthusiastic. He suggested forming a "working group" with the proper expertise to advise NASA on the lab's requirements. The effort had to begin immediately in order to have everything ready in time to handle the first lunar samples. We settled on "Lunar Receiving Laboratory" (LRL) as the name for the facility, and the

special advisory committee, first known as the OSSA Ad Hoc Committee, became the LRL Working Group.<sup>10</sup>

Soon we began to hear rumors of concerns over potential biological back contamination from the Moon. Dealing with such contamination would greatly complicate the sample work. The report of the Space Science Board of the National Academy of Sciences from its Conference on Potential Hazards of Back Contamination from the Planets, held in July 1964, sealed our fate. We argued that because of the lunar surface environment the Moon presented no potential hazard. The hard vacuum, large variations in surface temperature, high UV and hard radiation, absence of free water, and constant bombardment of the surface with meteoroids would discourage the most resilient microbes. If you wanted to design a sterile surface, you would make it as much like the Moon as possible. Furthermore, space scientists generally agreed that secondary ejecta from lunar impacts reach the Earth more or less continuously, and no infections were related to contact with meteorites. All the same, when pressed with questions, we could not guarantee the lunar surface and shallow subsurface were sterile. The design requirements for the LRL took on new dimensions.

We anticipated performing the first descriptions of the lunar samples in hard vacuum, but we hoped if the samples were non-reactive with dry nitrogen that we could execute the preliminary examinations in one-way barrier glove boxes. Now we would have to perform the procedure behind two-way, gas-tight biological barriers—one way to protect the samples from terrestrial contamination and the other way to protect the terrestrial biosphere from potential lunar organisms. In addition to providing quarantine testing for the lunar samples, we had to provide quarantine housing for the crew and the returned spacecraft. NASA once again needed expert advice and requested the creation of an Interagency Committee on Back Contamination, to be staffed by official representatives

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<sup>10</sup>J. C. McLane, Jr., E. A. King, Jr., D. A. Flory, K. A. Richardson, J. P. Dawson, W. W. Kemmerer, and B. C. Wooley, "The Lunar Receiving Laboratory," *Science*, vol. 155 (1967), 525–529.

of the U.S. Public Health Service, National Academy of Sciences, U.S. Department of the Interior, U.S. Department of Agriculture, and NASA. This committee continued to follow the design, construction, and check-out of the LRL from a biological hazard-containment perspective.

We knew nothing about two-way biological containment, so we visited some laboratories involved in the business. The U.S. Public Health Service Communicable Disease Center in Atlanta and the Fort Dietrich, Maryland, high hazard pathogen containment facilities were particularly instructive. They handled high hazard pathogens with success, only rarely losing a lab technician because of personal negligence or accident. I held my breath a lot while touring the facilities. One thing was clear: working on lunar rocks with microscopes and even relatively simple analytical equipment behind barriers was not going to be easy.

With the LRL Working Group, we strived to nail down the scientific requirements for the lab. At the same time, we were coordinating the quarantine and pathogen detection requirements with the Interagency Committee. The biological requirements involved a number of artistic, if not arbitrary, decisions. For example, in order to ascertain the length of the quarantine period, we had to estimate the incubation period of the mythical microbes. Similarly, in case of a break in the biological barrier, we needed to know how to sterilize the potentially contaminated area. Should we saturate the area with sodium hypochlorite, fuming nitric acid, or Scotch whiskey? What did it take to kill a potentially harmful lunar organism? "Heat to incandescence!" was a favorite phrase of the time. After criteria for sterilization of the lunar samples were established, we had the option of sterilizing a sample and working with it outside the awkward containment system—provided the process of sterilization itself did not seriously degrade the sample.

During the quarantine period, many biological test systems would be exposed to the lunar samples to detect any pathogenic reactions. We were concerned about the scale of the quarantine testing because each test required lunar samples. We wanted to keep

the amount of lunar samples used for quarantine testing to a minimum. Obtaining scientifically priceless samples from the Moon and then using a significant portion of them for injections into mice or soil or wheat seedlings seemed absurd. At one point, Dr. Harold Urey, Nobel Laureate in chemistry and an enthusiastic student of the Moon, volunteered to eat some of the lunar sample himself if it would simplify the quarantine requirements. In the end, voices of reason prevailed, and the scope and duration of the quarantine were something NASA could live with. The spacecraft would be returned to the LRL, sealed, and isolated for the duration of the quarantine. The crew would be sequestered in a special habitat in the recovery area, returned to the LRL, and isolated in the Crew Reception Area there, where they could be debriefed across a biological barrier. The Crew Reception Area was a vacant hotel. It was designed to house the three-man crew, some support personnel, and any scientists or technicians exposed to potential lunar pathogens in case of an accidental break in the biological barrier.

When we compiled a nearly complete set of requirements for the LRL, NASA requested proposals for the detailed design of the lab. Contracts also were signed for the fabrication of the high vacuum system in which the samples would first be opened and visually examined. Similarly we initiated design and fabrication of various gas-tight glove boxes required for quarantine testing and the preliminary mineralogical, petrological, and geochemical examinations.

The LRL was taking so much time that the directorate decided to form a small organizational unit, or "office," whose primary responsibility was the LRL. Jim McLane, an experienced NASA engineer, was selected to head the office. Although McLane was uncomfortable with the science involved in the LRL, he was a level-headed, practical manager who knew how to get things done within the space center and the agency.

Utility and excavation work began on the LRL site, and the lab began to take shape. Two special scientific laboratories were identified as part of the LRL. One of these, the Radiation Counting Labo-

ratory, a state-of-the-art gamma ray spectrometry laboratory fabricated from low radiation background materials, was constructed 50 feet below the ground floor offices and housed the latest large-volume detectors and electronics (Figure 2). This facility was important for measuring the natural radioactivity of the lunar samples, some of which is caused by cosmic rays. Because the radioactivities of

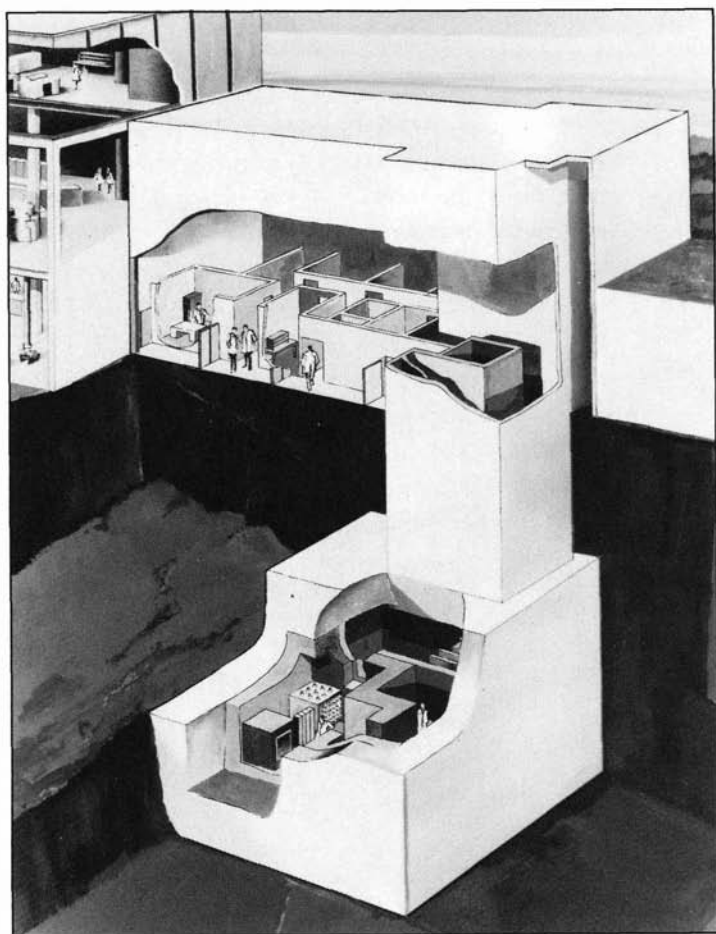


Figure 2. Artist's cutaway view of the underground low level gamma counting laboratory of the LRL. (NASA photograph S-66-50256)

some nuclides have very short half-lives, they would have to be measured during the quarantine period or the data would be lost. Even with the cosmic ray-induced activity, the total radioactivity in lunar samples was expected to be low—thus the need for very sensitive, low background measurements.

Another specialized lab, the Gas Analysis Laboratory, constituted the third floor immediately above the main vacuum system (Figure 3). The samples would be returned in two vacuum-sealed metal boxes, enabling scientists to analyze any gases emitted from the samples when the box was opened in the main vacuum chamber. Also, gases that might be released during unpackaging or splitting of individual samples could be monitored by a sensitive gas chromatograph-mass spectrometry system. Part of these early measurements would include gases evolved from a specially collected sample maintained at ultra-high vacuum.

The general plan of sample flow called for 1) introduction of the

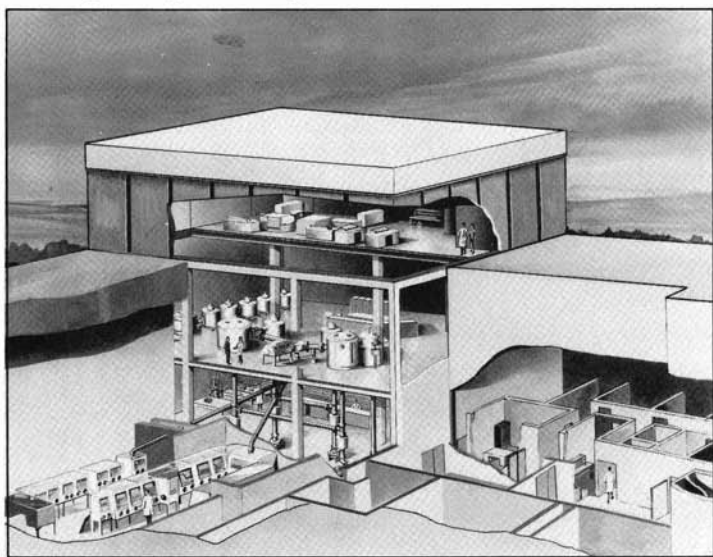


Figure 3. Artist's cutaway view of the LRL gas analysis laboratory (third floor), main vacuum laboratory (second floor), physical sciences and biosciences test laboratories (lower left), and office space (right). (NASA photograph S-66-50257)

rock boxes into the main vacuum system, 2) opening of the rock boxes, and 3) visual inspection of the samples in the main vacuum system. Two small chips of each sample would be taken. One would be sent down a metal pipe to the physical-chemical test area where it would undergo preliminary scientific examination and characterization; the other would go down a similar pipe to the quarantine test area for pathogen testing. Specially packaged samples would be removed from the vacuum system, sealed in three biological barriers, and transported to the Radiation Counting Laboratory.

The bulk of each sample would be retained in the high vacuum system for long-range storage under ultra-clean conditions in specially prepared containers. Storage and curation of the lunar sample collection would be an important long-term responsibility of the lab.

We were under pressure from the LRL Working Group to appoint a leader for the LRL. McLane was offered the job but declined because he felt more qualified for an engineering assignment. The Working Group identified Dr. P. R. Bell of the AEC Oak Ridge National Laboratory as a potential candidate. A well-respected scientist, Bell had a lot of experience with high-vacuum systems. Also, he had served on the LRL Working Group and was intensely interested in the LRL and the lunar samples. Bell agreed to interview and was subsequently named director of the LRL (Photo 39).

The MSC science staff knew Bell from his contributions to the Working Group, but we got to know him a lot better as a passionate, energetic man. He tended to be opinionated, but frequently he was right. His ability to take part in an argument without taking it personally was one of his greatest traits. Meetings in Bell's office were often audible at the far end of the hall, but he gave everyone a thorough and fair hearing. No matter how heated the discussion became, tomorrow was a new day.

During the construction and equipment installation phase, we spent a lot of time identifying construction errors by checking actual "bricks and mortar" against blueprints and specifications. We be-



Photo 39. The Lunar Receiving Laboratory (LRL) during construction at the NASA Johnson Space Center, aerial view looking northwest. (NASA photograph S-67-20397)

gan to publicize the laboratory to the community of scientists who would be working with lunar samples (Photos 40–41). In order to qualify to receive lunar samples for research, researchers had to submit a lengthy proposal stating the nature and amount of sample required, purpose of the research and the means by which it would be accomplished, qualifications of those working with the sample, compliance with sample security requirements imposed by NASA, and information on a number of other matters. This proposal was reviewed by a peer evaluation process, and the successful proposers were designated “Lunar Sample Principal Investigators.” This designation meant the investigators would receive substantial NASA funding to upgrade and modernize their laboratories and to train and support a sample analysis team. Investigators were virtually guaranteed to receive lunar samples for analysis if the correct

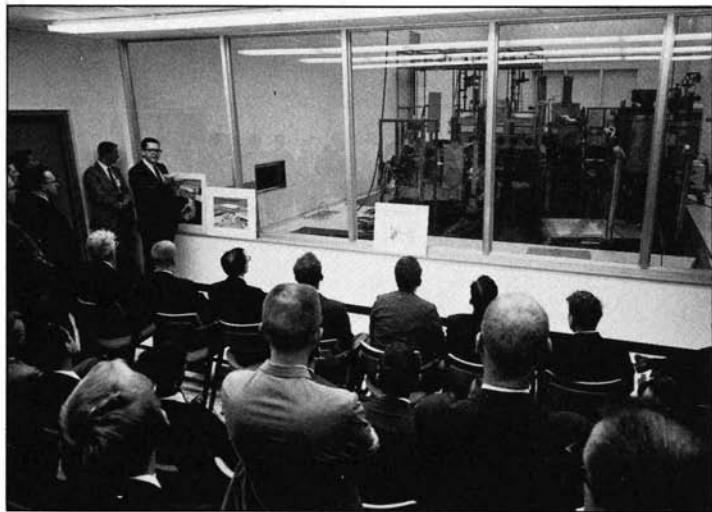


Photo 40. A group of lunar sample investigators getting an orientation lecture from the author (left) on the operation of the LRL main vacuum laboratory. The group is in a visitor viewing room adjacent to the vacuum laboratory, which is only partially completed. (NASA photograph S-67-45454)



Photo 41. Author (left) shows Prof. Wolf von Engelhardt of the University of Tubingen, West Germany, details of the two-way biological barrier cabinetry in which the lunar samples will be examined in a dry nitrogen atmosphere. (NASA photograph S-67-45452)

samples for the work were returned in sufficient abundance. In addition, researchers could count on receiving support from NASA as long as they turned in important and interesting lunar sample research results. Naturally, the status of lunar sample principal investigator was highly coveted.

One of the worst jobs associated with the LRL was writing the detailed procedures for all the laboratory operations, an Interagency Committee prerequisite for the facility to be certified for quarantine operations. NASA managers liked to see volumes and volumes of procedures for everything. We spent a lot of time, together with support contractors, generating prodigious piles of paper.

The scientific functions of the LRL were carried out by a small group of resident scientists who were thoroughly familiar with the facilities, but the LRL also relied on a number of expert visitors from universities and other government agencies for much of the preliminary scientific work. Two groups were involved with LRL lunar sample operations: 1) the Lunar Sample Preliminary Examination Team (LSPET, or PET), which performed all the initial sample investigations in the lab on a double-shift basis, and 2) the Lunar Sample Analysis Planning Team (LSAPT), which evaluated the sample data and recommended the precise distribution of lunar samples to the scientific community after the quarantine period. LSPET members had to be selected and trained as soon as possible in order for them to gain sufficient experience with actual sample operations and to comprehend the written procedures before the lunar samples arrived. We suggested potential team members to NASA headquarters, and with few exceptions they were appointed.

Shortly after I moved into my office in the LRL, I heard that Harold Urey was looking for me. I knew Urey had been appointed as a visiting scientist. I had heard one of his lectures but couldn't imagine why he wanted to see me. While I was on the telephone trying to locate him he walked in the door. We had met previously, but this was our first opportunity to converse privately. It turned out that he wanted to talk about the Moon. A full Moon photograph hung on my office wall, and we discussed the possible origins of

various features. Then he came to the question that really interested him: What were the lunar maria composed of? To me, it was a simple question, and my answer boiled down to a composition of rather normal basalt. Disappointed in my response, Urey stated his reasons for believing that the maria might be rich in organic compounds and be some variety of carbonaceous chondrite, a rare organic-rich variety of meteorite. We strongly disagreed over the matter, and after an awkward moment as we realized our minds were firmly set on the issue, we shifted the topic of the conversation to comets. Comets were safe ground since neither of us knew much about them and our ideas about comets were still flexible. We continued our genial conversation for more than an hour.

I was appointed curator of the LRL in September 1967, landing me the responsibility of all the sample collection, preparation of catalogs, logging sample data, dividing and distributing samples to authorized investigators, and keeping track of sample contamination histories, etc. It was a sizable responsibility, one which I took very seriously.

In early 1968, one of our big bosses phoned to ask what we could show to a very important visitor who might spend 15 minutes in the LRL. After Bell and I conferred, we decided to take the VIP to the main vacuum laboratory to show where the samples would be first examined. Our response only marginally satisfied the boss because he wasn't sure if the VIP would be allowed to go to the second floor. That puzzled us, and we were curious about the identity of the mystery visitor. A few weeks later, the big boss called again to tell us that a man was coming to talk about a possible VIP visit and requested that we cooperate with him. The man who came into Bell's office gave us a name but no organization. He was accompanied by a staff member from NASA-MS security. We talked with the man, who took notes, for half an hour. We were told the VIP would have 10 minutes to spend at the LRL and that we would get details later. Bell, whose vision was badly impaired, mused, "I wonder who it is?" "P.R.," I said, "the man was taking notes on White House stationery." The color drained from Bell's face.

On April 1, 1968, President Lyndon Johnson visited the NASA Manned Spacecraft Center. He came to the LRL accompanied by a peculiar entourage of about 10 people and a small dog that took every opportunity to mark this marvelous new territory, an activity his mistress pointedly ignored. Pistols protruded from the jackets of two of the men in the party—probably Secret Service men without their lapel pins pretending to be part of the presidential group. Various bureaucrats and hangers-on jockeyed for position to be in photographs with the president. The little dog ran out of pee. The whole affair had a “banana republic” or “comic opera” flavor. After Bell and one of our big bosses gave a 10-minute presentation, the president and the party were rushed away. On the occasion of his visit to MSC, President Johnson announced the creation of the Lunar Science Institute.<sup>11</sup>

We began practice operations with simulated lunar samples. One of the biggest problems we faced was working in the main vacuum chamber with its space suit gloves. Sample operations with the gloves were clumsy and slow, and the gloves commonly developed small atmospheric leaks. Early in the design stage, a decision was made to use a pressure glove system instead of mechanical manipulators in the vacuum chamber. In retrospect, this probably was an error. Sample operations elsewhere in the quarantine test and mineralogical, petrological, and geochemical glove boxes went fairly well. These just took a little practice.

The simulated sample operations were tricky because we didn't know for sure which samples were most like the ones we would receive from the Moon. O'Keefe still supported the idea that tektites came from the Moon. Urey argued that the lunar maria were composed of carbonaceous chondrites. Others suggested that different types of meteorites came from the Moon: ordinary chondrites, basaltic achondrites, mesosiderites, and so forth. For our test runs, we

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<sup>11</sup>Now known as the Lunar and Planetary Institute, located in the remodeled West Mansion on the shore of Clear Lake at 3303 NASA Road One, Houston, Texas 77058.

used a mixture of terrestrial volcanic rocks and meteorites, as well as some shock-damaged rocks.

In April 1968, we organized a meeting of all of the mineralogy/ petrology principal investigators on the east coast to precede the annual meeting of the American Geophysical Union (AGU), which would be attended by many of the investigators. The meeting, held in a Baltimore hotel, went well but it coincided with the riots in Baltimore and Washington. Bright flames and smoke were visible from the hotel windows. Many shops on the street were looted. The hooves of the mounted policemen's horses clattered on the pavement. I don't believe we made a very good impression on our foreign visitors. When the meeting was over, I took a cab to Washington to the AGU meeting. I rode with a Baltimore cabbie who did not know his way around Washington. We drove through some of the area worst hit by the riots, crossing fire hoses and passing burned-out buildings, but we encountered no trouble. Everyone just looked tired, especially the National Guard. The riots were over.

A big Saturn rocket with its Apollo 7 crew of Schirra, Eisle, and Cunningham lifted off from the Cape and went into low Earth orbit in mid-October 1968. The Apollo program space flights had begun. The first lunar landing and sample return were only months away.