



I. The Space Center

The Manned Spacecraft Center (MSC) did not yet exist as a physical entity. Center personnel and organizations were spread out in more than a dozen locations, mostly on the south side of Houston. Headquarters was located in the Farnsworth-Chambers Building, an old construction company office building that appeared to have been inspired by Frank Lloyd Wright's "organic" period. My unit was located in old, remodeled barracks at Ellington Air Force Base, which had been a pilot training facility about the time of World War I.

It was mid-August when I arrived, and the miserable Houston summer was totally oppressive. Austin could be hot, but the typical Houston summer climate is hot and humid, with about the same temperature and humidity statistics as Calcutta. For many years the British Consulate personnel working in Houston drew hardship

pay because of the climate, an unpopular fact with the Houston Chamber of Commerce. To make matters worse, my ancient car was not air-conditioned.

With the help of an Air Force security guard, I found the building that housed my new boss' office. I became completely soaked in sweat just walking from the parking lot to the building. On the way in I spotted Clanton at a desk. After a brief reunion, he took me in to meet my new boss. After 40 minutes of conversation, I went away completely discouraged. I soon met and chatted with some of the other chiefs and administrative personnel and became depressed for a couple of months. No one in authority in this part of NASA appeared to have any real concept of science or its progression. Most of the lower- to middle-level managers and administrators were extremely insecure and spent most of their time trying to understand or affect internal politics. I assumed that somewhere in the hierarchy above the managers I had met worked a group of very bright and capable managers and scientists because, after all, NASA worked! From my local vantage point, however, it was clear I would be fighting an uphill battle to include much consideration of scientific matters in my organization's work. I was working in a purely engineering-oriented environment where directives from above were rarely questioned—hardly the kind of group I was accustomed to.

I was further perturbed by the dress code. Even the lowest bureaucrat wore a coat and tie on the hottest day. I was used to the comfortable old shirt, worn sweater, and slacks or jeans of my graduate student days. At NASA, however, status was based on wearing a jacket and tie. Many of my NASA colleagues dressed in checkered or plaid jackets worn with checkered or plaid pants, a white or blue shirt, or even strawberry slacks with a white belt and shoes. I felt like I was surrounded by a band of California golf pros.

In addition, I slowly realized that I had been hired into a three-way political battle between MSC, the USGS, and NASA headquarters. The USGS wanted to handle all of the geologic support for the lunar program, and some parts of NASA headquarters had agreed

to this, in concept. While this agreement was negotiated, however, MSC hired its own geological staff. We were in the middle of a power struggle between MSC and NASA headquarters in addition to being embroiled in inter-agency politics. A working agreement was reached whereby the USGS and MSC would each furnish about the same number of geoscientists. We were glad to have some additional scientists around. We got along well at the working level, but our superiors spent a lot of time working on their ulcers.

My first order of business was to learn about the Moon. As I suspected, there was not a great deal known about the Moon, particularly the geology and topography of the surface. Few astronomers had continued interest in the Moon. Most went on to "more sophisticated topics," and the Moon had been left to the attention of only a few professionals such as A. Dollfus, E. Whitaker, E. Opik, Z. Kopal, and G. Kuiper. Clanton suggested a book by Baldwin⁶ as a good place to start. It was a recent, up-to-date work by a man originally trained as an astronomer but whose work had earned professional recognition in geosciences and planetology. I quickly finished this and several other volumes. A few weeks of critical reading took me as far as I could go.

A large amount of the literature current at the time was devoted to arguments over the origin of lunar craters. Through the years the debate narrowed to volcanic versus impact origins. The side for impact origin of lunar craters was represented by Shoemaker, and the volcanic origin side was capably argued by Dr. Jack Green, a geologist who worked for an aerospace contractor. This was an important argument as far as the Apollo program was concerned because the different crater origins would produce different rock types and small-scale morphology of the lunar surface. It appeared to almost everyone that the impact origin side had better grounds, which were strengthened by the recent recognition of several large terrestrial impact craters.

⁶R. Baldwin, *The Measure of the Moon* (Chicago: University of Chicago Press, 1963).

Another argument about the nature of the lunar surface was put forth very aggressively by T. Gold of Cornell University. He theorized that fine lunar dust was transported to lower areas of the Moon by electrostatic processes and that this could lead to dust accumulations more than a kilometer thick. These fine dust accumulations would have little strength to support objects on the surface and might prove to be serious hazards for astronauts and spacecraft. NASA was quite concerned about this hypothesis, as you might imagine! It was a difficult idea to refute, and Gold was very outspoken about it. We needed a way to deal with this idea and either prove or disprove it. The final answer came from the several unmanned spacecraft, both Soviet and American, that successfully landed on the Moon.

I asked around about what plans had been made for the receipt, proper handling, and examination of the lunar samples collected by the Apollo missions. As it turned out, this subject had received almost no serious thought, just a few disjointed ideas. Here was a scientific topic MSC could not ignore. I could really sink my teeth into this one. I talked to my boss about the topic, informing him that a facility would have to be provided to protect the samples and to gain enough scientific information to distribute them to the most qualified specialists for detailed investigations. After some discussion, my boss told me to prepare a draft memorandum on the matter. This topic was fairly broad, and I requested some technical help. The boss said that I could work with Don Flory, a chemist. After weeks of discussion, Flory and I drafted a lengthy memo pointing out the need for a carefully designed facility to receive and protect the lunar samples. We addressed the memorandum to the directorate level. This made our boss uneasy, but it was the only level at which anything significant could be achieved. The boss agonized over our draft for nearly four weeks. He didn't want anything too controversial to originate from his section. He called Flory and me into his office several times. He talked to us together and separately. Finally, he accepted the memo and instructed the secretary to type the memo in final form. Then he signed it and sent it out. The con-

figuration and content of the lunar sample facility took on many forms as it proceeded through different advisory committees and consultants before it was finally constructed, but this was the beginning of the Lunar Receiving Laboratory.⁷

The NASA geologists were quite concerned that none of the astronauts had any training in geology. This concern was shared by the scientific community, who wanted scientists included on lunar landing missions. Since the astronauts would be landing on some sort of "rock pile," it seemed appropriate for them to know something about rocks. The concept of a geology training course for the astronauts was quickly accepted, and we were told to prepare a detailed course outline. This would be a joint USGS and MSC staff activity. The MSC group was led by Ted Foss, a soon-to-be Ph.D. from Rice University who joined NASA at about the same time I did. The USGS group was directed by Dr. Dale Jackson (later Dr. Al Chidester), an experienced field geologist. Both groups worked together to compile a series of classroom lectures and geological field trips and exercises to provide the flight crews with general background as well as specialized information about the lunar surface. The Astronaut Office bought the whole package with minor modifications. It was clear we would be spending quite a bit of time training astronauts in geology, but we looked forward to it. After all, these were the guys who would land on the Moon.

Another function that fell our way was monitoring contracts for the design and development of various pieces of space hardware. This was principally an engineering task, one for which I felt totally unprepared. We spread the work around as equitably as possible, and I drew the development of a drill to be used on the lunar surface. I knew nothing about rock drilling, but at least I knew something about rocks. The prime contractor for the drill was located in Baltimore, Maryland, and the supervisor of the project for the contractor was a young engineer named Don Crouch. Crouch later be-

⁷J. 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.



Photo 3. The author with a test rig for components of an early prototype of the lunar surface drill, in an abandoned rock quarry near Baltimore, Maryland. (Photograph by the author)

came the engineer responsible for the design of the sampling arm on the two Viking spacecraft that landed on Mars.

The drill would be used to provide subsurface samples and to drill holes for placing instruments in the lunar surface. Drilling a hole in the lunar surface would be different from standard rock drilling on the Earth, mainly because we would not be able to use water as a drilling fluid to wash cuttings out of the hole and cool the bit.

After reviewing the literature on rock drilling and making a few engineering tests, we decided a rotary-percussive system with a core bit looked most promising and set about fabricating some components and test models (Photo 3). We tested the drill components in the lab and in an abandoned rock quarry in Baltimore. During one of those trips to Baltimore for drill tests, Crouch asked me what I wanted for lunch. Without hesitation I said, "Seafood." We drove to a little roadside cafe where I was introduced to Maryland soft-shelled crab. I wasn't exactly sure what I was ordering, but Crouch strongly recommended the soft-shelled crab sandwich.

When the sandwich arrived it looked grotesque. It was a whole crab with a piece of bread on each side and legs and claws sticking out everywhere, but I had to admit it was very tasty.

I was eventually relieved as technical monitor of the lunar drill contract, which I appreciated, but my experience with drilling led to an invitation to go to the Marshall Spaceflight Center in Huntsville, Alabama, to participate in a source evaluation board for a deep lunar drill. Marshall was the NASA center responsible for rocket development. During the course of a three-day board meeting I was invited to a cocktail buffet at a high-ranking manager's home. I arrived a few minutes late because the hand-drawn map I was following was incorrect. The party already had a glow, and I heard the dull roar of 50 simultaneous conversations as I walked up the driveway. I found a drink, recognized several of the other evaluation board members, and was taken in tow by my host, who introduced me around. To my surprise most of the old German "rocket mafia" were there—Wernher von Braun, Ernst Stuhlinger, and a host of others. I had never expected to see them. These were some of the same scientists and engineers who had developed the rockets that terrorized London in World War II. As the party wound down and thinned out, the Germans settled into a sofa-and-chair arrangement in the center of the main room. There was much talk of the Saturn "Moon rocket." The development and testing of the Saturn was going well. Although they had many concerns, these Germans were confident it would work. Their conversation was strictly in English, even their occasional reminiscence about "the old days" and sailing on the lakes in Berlin. I drove back to my motel pondering the curious chain of events that had placed me here in space and time. Perhaps the Germans had similar reflections.

Our section got a telephone call from the trajectory analysis group. They wanted to run some sample spacecraft trajectory calculations for the Moon and needed some coordinates for probable landing sites. We didn't have any, but the boss said we had better get some. Various engineering and mission requirements limited the early landing sites to a "bow-tie"-shaped area centered on the

