and Dunn suggest, in broad brush fashion, a variety of other challenging possibilities.

In addition to new organizational arrangements, perhaps new sources of financing can be employed, such as taxing the huge profits of commercial broadcasting, or assessing a direct, media-supporting tax on advertising. It may even be judged desirable to finance regional or national networks out of the income tax, as the best insurance that *all* citizens will receive the quality service they deserve.

The opportunities for experimenting with organizational and social engineering are as enormous as the potential rewards. Probably never has technology been more in need of informed and intellectually inspired guidance than it is now, as we move into the era of the all-pervasive "wired city." An understanding of the history of broadcasting, in this country and elsewhere, can supply guideposts to help us figure out ways to proceed—and routes to avoid.

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The Aftermath of Apollo: Science on the Shelf?

The Apollo moon voyages belong to history now. And it will be for history to judge whether the scientific returns of six lunar landings were worth the expenditure of 12 years' effort and $25 billion. Whether historians will have a fair chance to make that judgment, though, is a question of growing concern to many of the scientists who helped to plan the lunar expeditions of the past 3½ years.

At the Manned Spacecraft Center near Houston—the focal point of lunar science and the main repository for all that Apollo has returned—a number of scientists and research administrators have an uneasy feeling that the hundreds of pounds of samples, the thousands of photographs, and the miles of magnetic data tape now on hand will not receive the study and the protection from contamination and deterioration that they deserve in the years ahead. As Paul Gast, the chief of planetary and earth science at the MSC, expresses it, "There is a real concern that, with the end of the Apollo flights, lunar science will lose its patrons. And really, the science is just beginning."

To be sure, lunar science is healthy enough now. This year the National Aeronautics and Space Administration (NASA) will spend about $20 million to collect and process data from the Apollo orbital experiments and from the five instrument stations still operating on the moon; to care for all the photographs; and to analyze, preserve, and catalog the collection of moon rocks and soil. University researchers will receive about $8 million of this in contract grants directly from NASA, a figure that puts the space agency on a par with the National Science Foundation as a leading government supporter of geoscience. NASA has asked the White House Office of Management and Budget to let it spend the same overall amount for lunar science in fiscal 1974, but whether the OMB will consent is still an open question.

The point of concern, though, is not so much what happens to lunar science this year as what happens to it 3 to 5 years hence, when the excitement of flying to the moon has receded in the public memory and the expense of bank-rolling scientists to pick tediously through lunar soil is balanced against the cost of more captivating ventures, such as the unmanned Viking lander destined for Mars and the Venus probes that are rising on NASA's wish list. Will the care and feeding of lunar research come to seem more like a nuisance than a national obligation? As one prominent lunar scientist at the MSC phrases his concern, "We have a commitment from NASA headquarters and from Chris Kraft [director of the center] to support this work. But the question is, How long will it last?"

Such fears are not without foundation. They spring from several sources, among them the sheer success of the landing missions and the sudden realization of the moon's complexity. The quantity of lunar rock and soil now on deposit at the MSC is far greater than anyone dared anticipate before Apollo 11, the first landing mission, in 1969. Whereas scientists once talked of having to preserve and study as little as 3 to 5 pounds of a "grab sample" snatched from the moon somewhere along the way—or at best 100 pounds or so—the landings in fact amassed more than 800 pounds of samples, counting that returned by Apollo 17.

Only about a quarter of this has received more than a cursory inspection, and detailed analysis is going to be a painfully slow task. In part, this is because lunar history is turning out to be a much more subtle affair than most knowledgeable people had expected. The notion, for example, that the moon was a dead hunk of the "primordial" material from which the terrestrial planets coalesced now seems as quaint as the Ptolemaic idea that it was all shining crystal. It now appears likely that if any bits of primordial crust do remain, they will have to be tracked down laboriously in the samples of soil, a task rather like hunting for pearls on a beach.

Certainly the moon's complexity and heterogeneity make it a more interesting place, but as a Rosetta stone of cosmic history it is turning out to be as difficult to decipher—and therefore as time-consuming and expensive—as the earth itself.

Concerns for the future of lunar science also stem from the well-known dichotomy between the scientists involved in mission planning and the engineers who dominated the management of Apollo. Nowhere was this division more evident than at the Manned Spacecraft Center, where scientists fought long and hard—and, ultimately, with success—to increase the scientific content of the landing missions. The pulling and hauling between the two sides abated somewhat with the last three landings, all of which were immensely productive, and with the inclusion of a scientist-astronaut, Harrison Schmitt, on the final flight.

Still, the battle scars remain in the form of a latent mistrust of the engineer-managers. "Face it," says one scientist at NASA headquarters in Washington. "The space agency has a reputation for flying missions and then losing interest in the results. In this sense, support of post-Apollo research will be an important test case to see whether things have changed."

Some would say that things have not. Certainly there have been signs, even during the years of the moon flights, that lunar science was not immune to the vagaries of budgets. About a month after Apollo 11's successful landing, a feat that came close to failure when an overworked computer triggered a series of false alarms, and thus had all the earmarks of a lucky fluke, NASA, in one of its periodic moods of economy, sharply cut back the funds of a number of the "principal investigators" with whom it had arranged to analyze the first moon rocks.

"It was a pretty traumatic blow," one MSC scientist recalls, and one which was rectified only after a small delegation of prominent researchers "went to the top" in protest.

Last fall, the budget axe struck again. This time it cut deeply into nearly every activity at the MSC, including that of the curatorial facility where lunar samples are preserved, cataloged, and prepared for distribution.

This new retrenchment apparently originated with an order from the White House budget bureau reducing the MSC's operating allowance from $615 million to $475 million during the current fiscal year. In response, the center laid off nearly 1500 contractor and civil service employees during September and October. (Another 100 are due to go in January.) Among those who have already left were 30 of the 90 technicians and scientists in charge of the lunar sample collection.

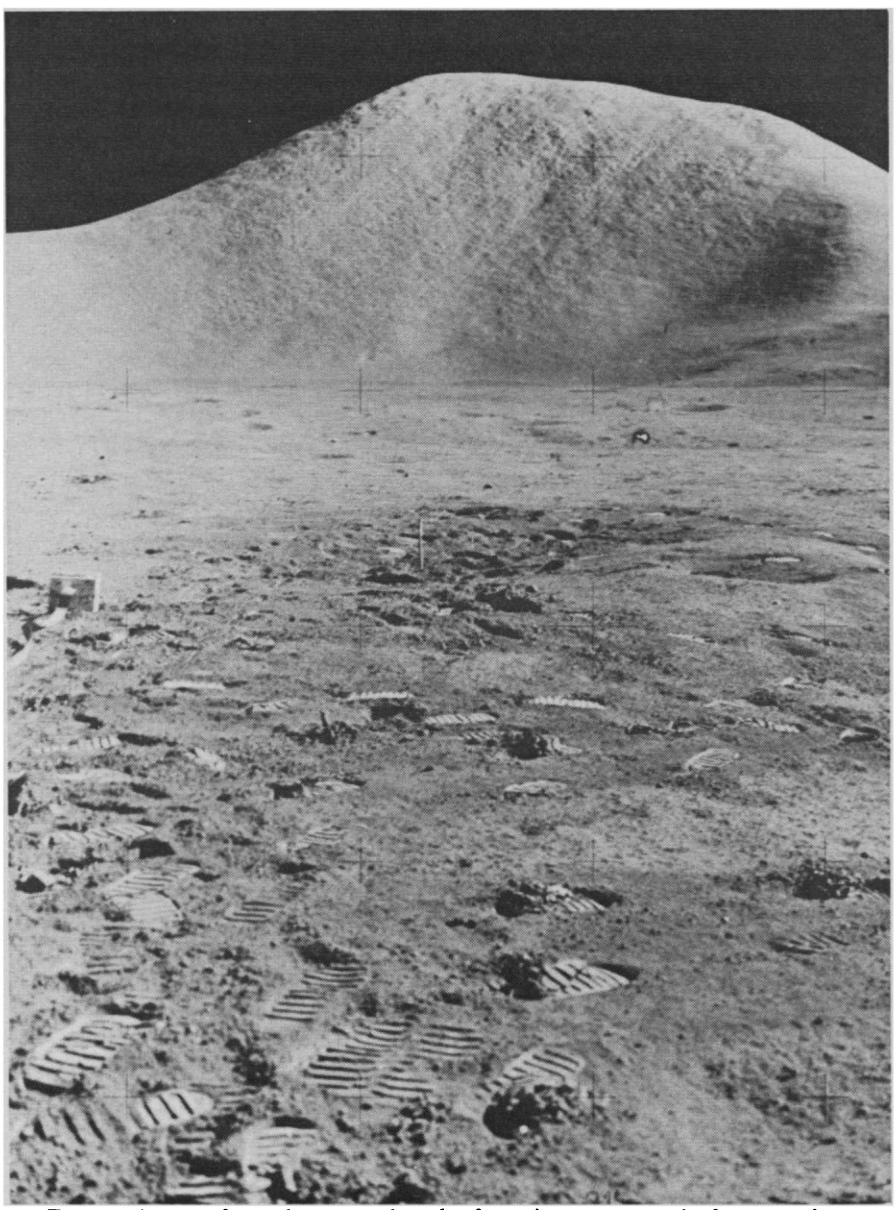
Part of this reduction had been planned, but not for another 8 months. While it appears to have caused lunar science no lasting harm, the cut is regarded by some research administrators as false economy and a worrisome precedent.

One effect was to delay the distribution of rock and soil samples brought back from the moon last April by Apollo 16. Inside the protective glass and steel glove boxes in the curatorial laboratories, one can still see core tubes of lunar soil from Apollo 16 that have not yet been opened and examined. Dozens of little plastic vials are still waiting to be filled with chips of rock and bits of sandy soil and sent off to investigators who, in the meantime, presumably have found other ways to spend the money NASA is paying them to study the Apollo 16 samples.

Noel Hinners, the chief scientist for Apollo exploration, says they have other sample work to keep them busy, although "this stretch-out philosophy is risky, in that you can ultimately stretch things out to a point where nothing is happening."

Michael Duke, the chief of curatorial facilities at the MSC, makes the additional point that the amount of money available for preserving the sample collection is partly dependent on the amount spent to study it. If, for example, support for research diminished to $2 million a year, Duke says, it might be hard for the MSC to justify, on purely economic grounds, paying $1 million in "overhead" to keep up the collection. The overhead item most easily reduced is the staff, but Duke maintains that there is a minimum staff level, about 20 key technicians and scientists, below which the lunar collection would probably be damaged through inadequate handling, maintenance, and record-keeping.

For the present, the curatorial facility is trying to keep the moon rocks in something approaching pristine condition while sorting them out and classifying them. The complexity, and thus the cost, of maintaining this high standard



Everyone's gone from the moon, but the footprints may remain for centuries.

is quickly apparent from a walk through the MSC's Sample Storage and Processing Laboratory (SSPL)—where samples are sawed, chipped, photographed, packaged for distribution, or just stored for future generations.

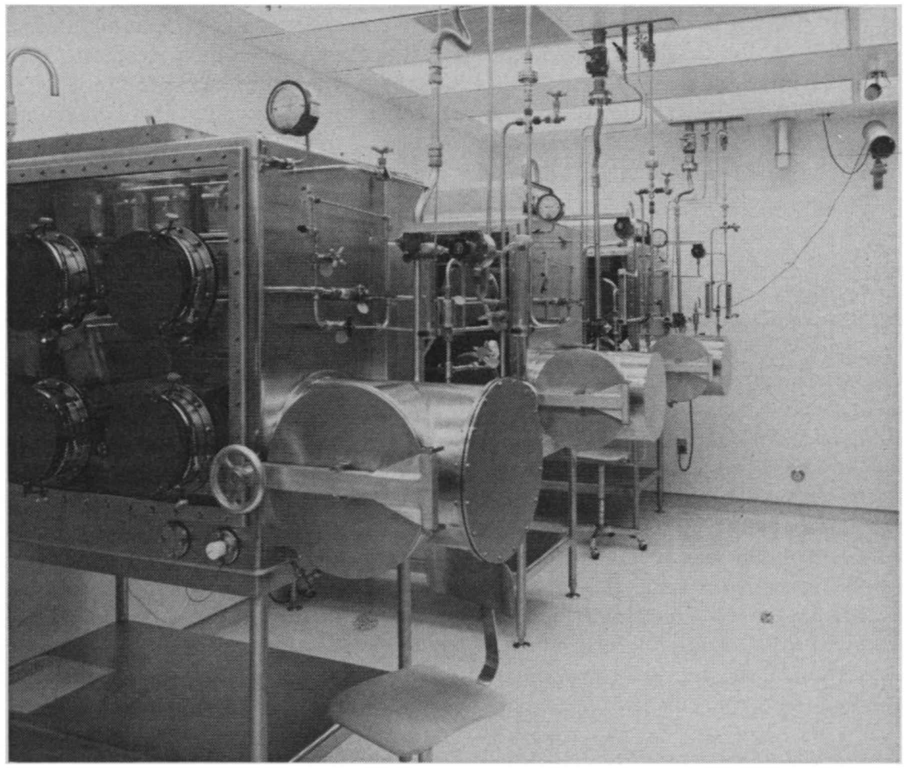
The laboratory combines the essential elements of a bank vault and a surgical ward. Located on the second floor of a two-story building a short distance from the Lunar Receiving Laboratory, the SSPL occupies a cluster of seven small rooms with about the same floor space as a small suburban house. The laboratory is surrounded by, but sealed off from, four hallways of ordinary offices, and the only indication that something unusual is to be found here is a steel door with two combination locks and a television camera that peers down one hallway.

Once through the door, the visitor has his shoes brushed briskly by a machine and steps into a small anteroom carpeted with a strip of sticky foam rubber pads. (The adhesive pads are supposed to catch dirt, but sometimes they work too well. A visiting congressman from New York recently lost the heel of one shoe.)

Next, the procedure calls for balancing on the pads, on the tips of one's toes, while slipping on white nylon booties, a long-sleeved coverall and a cap of the same material, and white cottony gloves. Regulations then call for an 18-second "air shower" from six nozzles to blow off any remaining lint or dandruff. Thus cleansed and clothed, one enters the four work rooms.

Inside, quarters are cramped. Much of the floor space is occupied by the 20 or so large glove boxes in which all the samples are handled. (One reason why there are so many boxes is that samples from two different missions can never be placed in the same box together). The boxes themselves resemble large hospital incubators, with ports for built-in arm-length rubber gloves. Inside, in an atmosphere of dry nitrogen, are saws and sterilized chisels, hammers, forceps, and other tools that would seem equally at home in an orthopedic surgeon's kit.

When the time comes to slice a rock whose position on the moon the astronauts recorded, elaborate care is taken not to lose track of the rock's original orientation and shape. Each time the rock is sliced, or a slice is subdivided, technicians take "before and after" Polaroid photographs of the rock. Next to it in the picture is a small, charcoal grey aluminum cube that looks like a



Most of the moon rocks from six lunar landings are stockpiled in these cabinets.

child's alphabet block. The cube indicates which side of the rock was facing up on the moon, and how it was oriented by the points of the compass. Later, an artist draws an isometric or "exploded" view of the subdivided rock so that it can be reassembled. In addition, each piece is indexed and its genealogy recorded.

Equally painstaking attention is paid to the tubes of lunar soil pounded and drilled by the astronauts. After each tube is sliced lengthwise, an elaborate process in itself, a staff specialist in lunar soils describes each of as many as 100 distinct layers, some no more than a millimeter or two thick. Each layer from half of the core tube is then dissected and placed in a separate container resembling a small plastic aspirin bottle. The other half is sealed in a bluish Teflon bag and stored in a glove box under dry nitrogen. (At first, lunar samples were handled in high-vacuum glove boxes, but that system was abandoned after it not only proved unwieldy but also contaminated the Apollo 11 samples with pump oil.)

Only a small number of the lunar samples, about 8 percent of the 600 pounds on hand before Apollo 17, have been distributed for study or display. Virtually all of the rest, nearly all $25 billion worth, repose in one brightly lit room within the SSPL cluster. Roughly the size of a one-car garage, the treasure room is guarded by additional combination locks, a television monitor, and a sonic alarm. Lining the walls are the familiar steel and glass glove boxes. Inside, the rocks and soil are bagged or sealed in metal jars and piled in open trays resembling the vegetable bins in a refrigerator. Fragments of this hoard are being passed out very sparingly, on the advice of a committee of lunar scientists. The working assumption is that moon rocks are essentially irreplaceable and that better use of them will be made as the years go by—but only if they are kept in a pristine state. Thus the cost of preserving them is not likely to decrease in the years ahead.

A look through the glass of the storage cabinets suggests the extent to which the space agency suddenly became a victim of its own success. The 50 pounds brought back by Apollo 11 is neatly stored on shelves with ample room for more. A few feet away, the bins of rocks and soil from Apollos 15 and 16 are crammed in every available slot and stacked three and four deep against glass, nearly to the top. "If we had any more flights I don't know where we'd put it all," Duke, the chief curator, notes.

The unsettled state of this collection is indicated by the varying estimates of what it contains. Duke guesses that there are about 2000 rocks and possibly another 500 soil samples. A study group convened by the nearby Lunar Science Institute last summer concluded that there might be 20,000 individual samples and that as these were subdivided, the number of accountable bits and pieces of lunar material might reach several hundred thousand. Only about 30 percent of the rocks and soil on hand before Apollo 17 have received preliminary analysis and most of the rest remain to be described and classified according to the 10 to 15 types of lunar rock identified thus far. Efforts to compile a computer library of what is known about the rocks, and to provide a cross-index to this information, are still in the formative stages.

Much of the data gleaned from the Apollo instruments is in the same raw state as the sample collection. "A lot of vital information is still locked up in the heads of the people who designed and ran these instruments," Duke says. "Until they get the data in shape by annotating tapes and throwing out worthless sections no one can understand it, and some of this may never get done."

All of which suggests that the principal investigators constitute as much of a national resource as the moon rocks themselves.

Similarly, a great deal of work remains to put the 30,000 lunar photographs accumulated by the Apollo program in useful order. Since the layoffs last fall there has been little progress on this task, except to catalog the pictures and file them away. Were an outside scientist to try to find, say, all the photographs taken of the moon's Hadley Rille, he would, in a word, be out of luck. The necessary cross-reference system does not exist.

The upshot of all this is that access to the scientific results of Apollo has been more than a little difficult for outside scientists, a point of some frustration to the Lunar Science Institute, whose mission has been to serve as an academic way-station for outside investigators, encouraging them to use the MSC's laboratories, photos, and lunar samples. The LSI was set up in 1968 by the National Academy of Sciences and has since been run by a consortium of 50 universities. Supported by $750,000 a year from NASA, the LSI serves as a pleasant faculty club for the MSC research community, running a lecture series, conferences, and providing stipends for visiting scientists and graduate students.

In the post-Apollo period, the institute has aspirations of becoming a central spokesman for lunar research, and perhaps, the space agency's conscience in matters concerning the protection and study of the Apollo collections.

To this end, the LSI released a report* earlier this month outlining the scientific accomplishments of the Apollo program, the questions of lunar genesis that it has raised thus far, and a suggested strategy for post-Apollo research. As a general policy, the institute said, the space agency should be prepared to maintain its support of lunar research for a "time at least comparable to the time it took to mount and fly the missions."

The end of Apollo, the report emphasizes, "leaves the scientific tasks undertaken . . . substantially unfinished." To finish them, it recommends three main steps for the care and study of the lunar samples:

► By mid-1974, completion of the preliminary analysis of a "representative portion" of lunar rocks and soil, perhaps 25 percent.

► By mid-1976, completion of a "basic description" phase in which all samples are described in detail and thereby placed "on a museum footing." At the same time, sample analysis should be integrated with instrument data and photographs from collection sites, the report said.

► Accelerating through the mid-1970's, a "problem-oriented" phase of study distinct from the task of classification.

In between these stages, the LSI's director, Joseph W. Chamberlain, suggests, lunar science will have a difficult path to hew through economic minefields. In the end, the institute's greatest contribution to science may be, in Chamberlain's words, to keep the wealth of Apollo from being locked up and forgotten.

Given the cost of Apollo, that prospect may seem absurd, but the history of exploration is littered with unfortunate precedents. Not the least of them was the Wilkes expedition, America's first, if dimly remembered, great effort to explore the earth.

Launched in 1838, the expedition's five wooden sailing ships carried naturalists and cartographers along a thousand miles of unexplored Antarctic coast, north through Micronesia, east to the Oregon Territory, and home again after 4 years at sea. It was an extraordinary adventure, as welcome a source of national prestige as Apollo. But its scientific value was largely lost when the government failed to make provision for widely publishing its discoveries and for protecting its priceless collections of plants and animals, some of which had never before been classified. In time the collections deteriorated; some of the expedition's records and results never appeared in print.

"This has always been a problem with exploration," historian A. Hunter Dupree notes. "People don't realize that the process extends beyond the expedition itself."—ROBERT GILLETTE

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* Post-Apollo Lunar Science: Report of a study by the Lunar Science Institute; available at no charge from the LSI, 3303 NASA Road 1, Houston, Texas 77058.

Health Hierarchy: Marston Fired and He's Not the Only One

On Friday, 8 December, Robert Q. Marston got the word that President Nixon intends to appoint someone else director of the National Institutes of Health (NIH). Marston was told by outgoing Health, Education, and Welfare (HEW) Secretary Elliot Richardson, who said that the President did not mean to imply that he had not done a good job. Nevertheless, there would be a new director. In Washington parlance, Marston's pro forma resignation, submitted in compliance with the President's request to some 2000 high government officials, was "picked up." In plain English, Marston was fired.

Marston's firing, which was unanticipated, to say the least, by the biomedical community, is consistent with