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# The Glory Days
## *1966*

### THE TURNING POINT (DECEMBER 1965 – JANUARY 1966)

Sometimes people are aware when history is being made. So it was, at least for the technological world, on 4 October 1957 and 12 April 1961, and certainly for most of humankind on 20 July 1969.

But sometimes progress is spread out over a longer period and milestones can be detected only in retrospect. Consider 1966. More American (NASA and military) space launches, 73, took place in 1966 than in any year before or since. NASA's spending peaked during 1966.[1] The Soviet Luna 2, Luna 3, and Zond 3 and the American Rangers 7, 8, and 9 had aroused great interest but were only low-resolution reconnaissance flybys or spot-check crash landers. In 1966 both countries achieved the next two plateaus: soft, survivable landings and long-duration circumlunar orbital surveys that were advanced tools for scientific exploration. The Soviets apparently flew no manned missions in 1966 but the Americans more than took up the slack with an overlapping series of five final Gemini flights and three newly initiated tests of the upgraded and eventually "man-rated" Saturn IB that gave 1966 more American manned flights and tests of crew-carrying systems than any other single year before or since. Not least from the geologic viewpoint, a triumphant new understanding of the home planet that had been brewing for years finally broke through into the consciousness of geologists in 1966.

Hindsight also shows, I think, that events at the turn of the year 1965–1966 signaled the victory of the United States in the race to the Moon, although the laurel wreath would not be awarded for another three years. The Soviet Union had led in the exploration of space ever since Sputnik 1 in October 1957: first to hit the Moon, to image the far side, to launch a man into space, to fly a three-man mission (Voskhod 1, October 1964), and to "walk" in space (Leonov, Voskhod 2, March 1965).[2]

Then the worm quietly turned. Gemini 7 with Frank Borman and Jim Lovell was launched on 4 December 1965 and stayed in space 14 days. On 15 December Gemini 6 with Wally Schirra and Tom Stafford followed and rendezvoused in orbit with Gemini 7 six hours after launch, though they did not actually touch.[3] The Soviets had not achieved this essential feat, though apparently had tried with Vostoks 3 and 4 in August 1962 and Vostoks 5 and 6 in June 1963.

But the real turning point may have occurred in a tragic way on 14 January 1966, though the event was hardly noticed in the West at the time. The Soviet space program received a staggering blow when the man to whom the Soviets had always referred only as the "Chief Designer" died in Moscow. The rest of the world then learned his name: Sergei Pavlovich Korolev (1906–1966).[4] Korolev had become fascinated with rocketry in his youth, met Tsiolkovskiy, and then was caught in Stalin's late-1930s purges. After he emerged from the gulag he assumed a greater role in the design of both rockets and spacecraft for both manned and unmanned missions than that played by any half dozen Americans. He died after surgery performed personally by the out-of-practice USSR minister of health. The already shaky Soviet space program did not recover for many years, while the American program briefly surged ahead until it, too, received a painful setback a year after Korolev's death.

## LUNA 9

At the time, a change in space leadership seemed unlikely to those counting firsts because the USSR, only two weeks after Korolev's death, became the first nation to land a spacecraft safely on the Moon. The Luna 9 capsule was launched on 31 January 1966, parked temporarily in Earth orbit, accelerated toward the Moon during the first revolution, decelerated at the Moon, braked from an altitude of 70 km, dropped from a carrier rocket just above the surface, and landed safely on Oceanus Procellarum at 2145 Moscow time (1845 GMT) on 3 February 1966.[5]

Until the mid-1980s the Soviets kept their intentions close to the chest and their failures secret. One Soviet account referred to failures by such terms as "provided the opportunity to improve space vehicles."[6] Westerners have reconstructed the missing links between the well-publicized third and ninth spacecraft in the Luna series. Not only did Lunas 4–8 exist, there were also unnumbered Lunas and apparently Moon-bound spacecraft with the catch-all name Kosmos (appendix 1).[7] Two unnumbered Lunas were launched in January and

February 1963, but these failed to reach, or reached and failed to leave, Earth orbit. The Soviets considered the launch of Luna 4 in April 1963 a partial success because they gave it a number; however, it missed the Moon by 8,500 km. Two more unnumbered Lunas fell short of Earth orbit in February–March and April 1964, and five tries at soft landings called Kosmos 60 and Lunas 5–8 failed in 1965.[8] Some progress was evident as Lunas 5, 7, and 8 got progressively closer to their target area, which was in Oceanus Procellarum within about 20° latitude of the equator and about 62°–64° west longitude, a location that permitted vertical approach trajectories.

Practice makes perfect. Luna 9's landing was semisoft (or semihard), the type intended for the capsules of Ranger blocks 2, 4, and 5. After it landed on a crater wall in the nominal (that is, intended) target area at 7° N, 64° W, four petal-like protective and supporting covers unfolded away from the 60-cm teardrop-shaped capsule. Panoramic pictures were built up as a mechanical scanning device nodded up and down, rotating slightly between each scan. On 4–6 February the images were transmitted in digital form in four bursts of about 100 minutes each, the spacecraft shifting slightly between the second and third transmissions.[9] At last the cosmonauts and astronauts could see what their future stomping ground looked like.

Before the Soviets could report the results, Westerners jumped the gun, providing some amusing vignettes in the history of lunar exploration. Sir Bernard Lovell, director of the Jodrell Bank radiotelescope in Cheshire, England, smugly stole the march by intercepting the signals from Luna 9. The Soviets had provided their transmission frequency in advance, yet were accused of withholding their data as usual. Lovell had the transmissions recorded directly on a standard wire-service facsimile machine borrowed from a newspaper. These Jodrell Bank pictures quickly hit the streets and showed a jagged and frightening Chesley Bonestell landscape.[10] Gene Shoemaker told the press that the United States had also snatched the pictures but could not release their version because the interception technique was secret (and further complained that the cancellation of the capsule-landing Rangers had kept the United States from being first). So Lovell scored the coup, leading to the second vignette. The *Oakland Tribune* immediately took the pictures to Hal Masursky at his home in Menlo Park for some instant commentary. It was a Saturday (5 February), and Hal was no doubt fatigued from holding off the forces of ignorance during the work week; the Menlo Park office was then a beehive of activity by some 25 professionals and many helpers. Hal said that the surface looked like a volcanic terrain, probably like glassy, scoriaceous lava that would tear up a pair of boots. No dust was visible. The reporter pressed him to explain the implications of a volcanic terrain, probably saying something like "Oh, you mean like where they find gold?"

Hal said yes, veins of precious metals fill fissures in volcanic terrains. He added that he was "morally certain" that volcanism was still occurring on the Moon. This was the era of Kozyrev, lunar transient phenomena, and the Moonwatch, and Hal observed that streams of solar protons caused volcanic gases to light up like neon signs. What came out first in the *Tribune* and then nationally was that Luna 9 had found a vein of gold on the Moon!

After enjoying the spectacle of Western presumptuousness, the Soviets released their pictures the next day, 6 February. The pinnacles fell flat. Not only was the surface relief enhanced by the very low Sun angle (7°), but Lovell's wire-service machine had compressed the pictures laterally by a factor of 2.5. Now, the lunar surface appeared strewn by large and small rocks — as in fact it is. The Soviet experts, American experts, and Tommy Gold could proceed to measure grain sizes and estimate the dust thickness and bearing strength.[11] No evidence of the porous, open structure that had been predicted from astronomical data was seen. Otherwise, all the investigators saw their own opinions confirmed. Kuiper's statements to the press showed that he still held to his view of a solid, dust-free surface of vesicular volcanic rock. Many craters were visible, and true experts about the nature of the surface layer — Don Gault, Bill Quaide, Verne Oberbeck, Henry Moore, and the USGS Surveyor team led by Gene Shoemaker — knew that Luna 9 was looking at a surface debris layer created and repetitively reworked by impacts. Everybody was impressed by the apparent thinness or absence of dust, but Gold explained it away by saying that those things that looked like rocks could be clods of adhering fine powder. Everybody except Gold also drew the obvious conclusion that the surface was strong from the fact that it supported the 100-kg Luna 9 capsule. Gold said it could, in fact, be very weak because the capsule had probably rolled into position before the petals unfolded, and anyway had later shifted in position — a fact conversely interpreted by Shoemaker to mean that the surface was so firm that the capsule could not dent it enough to stay put.

Jack McCauley was in the final throes of his study of the Hevelius quadrangle when Luna 9 happened to plop down within the quad's borders. Jack had time to add a note to his 1:1,000,000-scale geologic map about the probable geologic unit at the landing site, which is still a little hard to pinpoint but appeared to be a dark unit Jack had called the Cavalerius Formation and interpreted as a pyroclastic blanket with some lava flows. These were the days of the dark = young equation, and Jack dated the blanket as Copernican. This young age might explain the sharpness of the rocks viewed by Luna 9. No features suggestive of a blanket were obvious in the surface appearance, so young lava was the best guess. It still is; no one I know of has followed up the significance of Luna 9.

## SISTERS OR STRANGERS?

Many early Moon geologists — though not Gilbert or Shoemaker — thought of the Moon as a little Earth. By 1966 it was clear that the maria or the ringed impact basins do not look like Earth's ocean basins and the terrae do not look anything like Earth's continents except that they are relatively light-colored and elevated above the maria. But the telescopic and Ranger data could not establish whether this difference in geologic style was matched by a difference in chemical composition.

Astronomers had early contributed a factual basis for speculations about the Moon's bulk composition by showing that the bulk Moon and Earth's mantle have about the same density and so could be composed of about the same material.[12] The chemistry of that material is often assumed to resemble that of *chondrites*, stony meteorites that apparently were assembled from pieces of the early Solar System and have remained little changed ever since. Chondritic material is *ultrabasic;* that is, poorer in silica and richer in iron and magnesium than basalt. So, then, Earth's mantle and the Moon have long been thought to be ultrabasic.

But that is the *bulk* composition. Different layers or different provinces could vary compositionally as long as they all added up to the bulk density and satisfied the (weak) constraints imposed by the librational wobbles. The Moon could have accreted in shells or blobs (a noncrazy idea that survived into the 1980s) or differentiated into a crust lighter than the average and a mantle and possibly a core that are denser than the average. Urey's cold Moon could not easily differentiate; thus its crust might be ultrabasic like the chondrites. Kuiper's molten Moon would readily differentiate into lightweight and denser melts.

Basaltic magma is the juice usually sweated from ultrabasic planetary interiors when they heat up and partially melt in ways determined by their temperature, pressure, and composition. Therefore the presence of basalt on a planet or asteroid indicates a differentiated, evolved, non-Ureyan body that was once hot enough to melt some of its rock. Fluid morphology, dark color, and low elevation had led most investigators to accept the maria as basaltic plains. Baldwin further suggested that since the Moon apparently never produced a true earthlike continent, the terrae might also consist of basalt, either of a different kind from the maria or the same kind but altered in a different way.[13] Astronomers had tried valiantly to extract the crust's composition from the properties of the surficial material but could not do so unambiguously. Here was another job for spacecraft.

On 31 March 1966, two months after Luna 9 and two weeks after Gemini 8, the Soviets achieved another first with the launch of a very different kind of Luna.[14] Luna 10 was the first spacecraft to orbit the Moon. Its main scientific purpose was to determine the composition of the lunar crust by measuring the gamma rays emitted from the surface. The data it assembled during 460 orbits over 57 days in April and May 1966 were a little crude but at least suggested the absence of any large bodies of granite, silicic ashflow tuff, or other rock more radioactive than basalt.[15] This evidence against extreme differentiation was bad news to those whom Urey derisively called the "tektites from the Moon people," a populous and respectable group that included Nininger, Kuiper, Dietz, O'Keefe, Chao, Shoemaker, and Gault, though not Urey or Baldwin. But Luna 10's readings did not exclude the presence of small silicic bodies or decide whether the Moon, the terrae, or the maria are basalt, ultrabasic rock, or something else low in radioactivity.

Earth was not well understood either at this time. Robert Jastrow's comment that geology was in the stage of butterfly and beetle collecting before the mid-1960s was insulting but not far from wrong. The relatively sparse, largely descriptive pre-1966 geologic literature did not resolve such fundamental matters as why the continents are silicic, whether granites are igneous or metamorphic, or whether the crust of the ocean basins is ancient or young. One idea was that the silicic igneous rocks such as granites and rhyolites originated as grains of silica-rich minerals deposited in water and subsequently melted or metamorphosed during the formation of linear mountain ranges. As both water-laid sediments and linear mountain belts seemed to be absent on the Moon,[16] this model for the origin of silicic rocks on Earth would be weakened if such rocks were abundant on the Moon.[17] At this stage, therefore, many geologists regarded the Moon as a key to some of Earth's major puzzles.

But in 1966 the pieces of the puzzle came together. The history of plate tectonics superbly illustrates the development of an idea by the great communal Brain of science.[18] The notion that the continents had drifted had been championed by Alfred Wegener and American glacial geomorphologist Frank Bursey Taylor (1860–1938), both of whom also studied the Moon.[19] Most Northern Hemisphere geologists, though not Harry Hess or Robert Dietz, scorned the idea. Cambridge geophysicist Harold Jeffreys rejected it before and after it was demonstrated because he could think of no mechanism that might drive it. Vertical crustal movements had been championed by Joseph Barrell and V. V. Beloussov as the origin of Earth's ocean basins and by Barrell and Kurd von Bülow as the origin of the Moon's maria.[20] But 1966 was not a good year for vertical crustal tectonics. Although no single person accomplished the revolution, its wide acceptance can be traced to papers presented by British geophysicist Fred Vine at the April 1966 meeting of the American Geophysical Union in Baltimore and the November 1966 annual meeting of the Geological Society of America in San Francisco. Vine summarized data that had been accumulating since the 1950s on stripelike magnetic anomalies caused by magnetic-field reversals and arrayed symmetrically on both sides of the globe-encircling mid-ocean ridges, and he set up a target for testing by specifying the rates at which the basaltic oceanic crust spreads away from the ridges as new basalt is erupted there. I attended the San Francisco meeting but did not hear Vine's talk because of my general impatience with lectures. However, I happened to be milling around in front of the meeting room (the ballroom of the Hilton Hotel) when the talk let out. People swarmed out abuzz with excitement. They carried the new idea home with them and pursued its implications; namely, that the entire crust of the Earth consists of giant plates that move away from the ridges and collide, plunge downward, or slide relatively laterally where they meet other plates. Major mountain chains and silicic rock bodies owe their origins not to geosynclines created by downwarps but to plate interactions. Terrestrial geology has not been the same since 1966.

The closest anyone came to finding evidence for earthlike megaplates on the Moon was Jack McCauley, who suggested that a "mid-ocean" ridge might explain the alignment of three complex volcanic centers in Oceanus Procellarum: Marius Hills, Aristarchus Plateau–Montes Harbinger, and Rümker Hills.[21] By this analogy, Marius should be one of the warmest and volcanically most active spots on the Moon and so should be favored as a late Apollo landing site. But plate tectonics are not the answer to the Moon's geologic riddles. Silicic rocks and volcanoes would have to form by some completely unearthly process if they existed on the Moon. The two companions in space looked less and less like sisters.

On 24 August and 22 October the Soviets launched two more orbiters, Lunas 11 and 12, about the time the Americans were doing the same. Luna 11 was apparently designed primarily to improve the resolution of gamma-ray measurements.[22] Luna 12 was photographic, but few of its pictures were ever released; *glasnost'* was highly selective in 1966.[23] In November, as Lunar Orbiter 2 reaped vast quantities of high-resolution images, Jim Lovell and Buzz Aldrin closed out the Gemini program with GT-12—only 18 months after the first unmanned Gemini test. The Americans were now far ahead of the Russians in space man-hours, and NASA's confidence was soaring.

## MEANWHILE, BACK AT THE OFFICE

The year 1966 was a high point not only of spaceflight activity but also of a publicly less visible activity by lunar geologists at the drafting board and typewriter: geologic mapping. As the coordinator of the 1:1,000,000-scale mapping effort, it was certainly visible to me. Dick Eggleton had dropped out of active participation in the mapping program between September 1963 and January 1966 to attend graduate school at the University of Arizona in Tucson. Hal Masursky kept authority over the mapping but did not busy himself with the technical details. In this vacuum the job fell to me, then the most enthusiastic mapper. I spent at least a quarter of my career constructing maps, and probably another quarter editing and managing their flow through the many arduous stages of the USGS publication mill.

Jack McCauley coordinated the mapping in Flagstaff with slightly less enthusiasm than I was showing in Menlo Park. Together, Jack and I helped the mapping evolve from the pioneering work of Shoemaker, Hackman, and Eggleton to a new, more elaborate style. As Shoemaker had always intended, more geologic units were being recognized than on the earlier Imbrium-dominated maps. We determined crater ages as precisely as possible from stratigraphic relations and degree of topographic sharpness. At my insistence, we separately mapped and interpreted the many different parts of craters (rim, wall, floor, peak) to ensure that we found any nonstandard (nonimpact) features that happened to exist. In a hunt for basins we searched non-Imbrium regions for signs of massifs, hummocky deposits, and radial structures like those of the Imbrium basin. We distinguished light-colored plains from other terra materials, most of which still had to be lumped in the catchall category we called "terra material, undivided." We subdivided the maria by albedo and, less successfully, by age. Mappers assigned to quadrangles that included mare borders found additional dark mantling materials of the type that Mike Carr had first described and interpreted as pyroclastic. We proliferated map units both for true special features like the Marius Hills and for all the spurious domes, cones, pits, and so forth that were still popular. All this was an effort to locate and describe every type of geologic unit, structure, and landform that might possibly exist on the Moon and might possibly play a role in exploration. I spent much time choosing colors for the map units that would highlight the important physical and chronologic distinctions while concealing our areas of ignorance about origin or age by using mixed colors like muddy purples or browns.

The first map published in this new era was Mike Carr's map of the Mare Serenitatis region, which included his work on the dark mantling units and the dark flows at the future Apollo 17 Taurus-Littrow site.[24] Unfortunately, no text accompanied the map, as had been planned, because Mike was in the hospital with a flare-up of his severe eye trouble. The first map with a complete explanation, terrestrial-style correlation diagram (for the Marius Hills), and geologically oriented text was Jack McCauley's map of the Hevelius region, finally published in 1967.[25] Jack presented this work along with the first general summary of the new-era stratigraphy at a NATO-sponsored conference attended by 160 others in

Newcastle-upon-Tyne, England, between 30 March and 7 April 1966 (the first week of the Luna 10 mission).[26] The USGS lunar geologic work was finally emerging from cut-and-dried geologic maps, literally and figuratively "gray" annual reports, and mission-oriented support tasks.

I think there was quality, but I know there was quantity. By the end of 1966, 8 of the 44 1:1,000,000-scale geologic maps had been published and 27 more had been completed in preliminary form. The preliminary maps were reproduced in-house by the ozalid process on big sheets, and 300 copies were sent out as part of the branch's annual reports, taking the pressure off our contractual obligations to NASA for the moment, though also taking the lives of many trees. For the July 1965–July 1966 annual report I prepared a summary of lunar stratigraphy as based on telescopic observations, a revised version of which finally saw the light of day in a more formal guise in 1970.[27] I was beginning to reveal a predilection for synthesis and summary, always built around the subjects of stratigraphy and relative age, which would appear several more times in the next two decades. Retrospect confirms the wisdom of this preference. Dan Milton used to complain that the 1:1,000,000-scale mapping should have been abandoned in favor of mapping at regional scales after completion of a few quadrangles proved it could be done. He illustrated his point by a comparison to the dog playing checkers: it's not amazing that he does it well but that he can do it at all. I thought Dan was just complaining about being diverted from projects he liked better, and anyway, we were being paid to map. But he was right about the mapping scale, as chapter 9 explains.

I wish some way could have been found to divert more of our efforts to formal publication of synoptic maps and journal articles and away from detailed mapping and annual report preparation. Our branch chiefs told us that we were committed to the time-consuming annual reports, but persistent questioning by skeptical underlings failed to locate anyone in NASA or the Survey who required them. The ninth and last of the accursed things is dated April 1969. I am not sure in retrospect that the mapping commitment was cast in concrete either. Publication of accessible articles in the open literature would have made more non-USGS geologists and lunar scientists aware of what we were learning about the Moon and would have mitigated our reputation as a closed clique.

The Branch of Astrogeology was at full steam in 1966 and was still recruiting new geologists — the last year that new hiring slots could be obtained from the Survey without undue begging. So it happened that we were able to consider hiring David Holcomb Scott (b. 1916), a former oil company chief geologist and chief of exploration (and entirely unrelated to the astronaut David Scott). Geologist Scott came up to me after a talk I gave in February 1966 at UCLA —

which he missed — and said he wanted to do something new and interesting. He hurried through his Ph.D.[28] and in a few years took on a mapping load that three ordinary geologists could not have upheld.

Dave illustrates an important point about the transferral of skills from terrestrial to lunar and planetary geology: if you are good at one you can be good at the other. Only about three quarters of the mappers originally assigned to the 44 quadrangles made it to the preliminary ozalid stage, and only about half ended up as the authors of the published maps. A little phrase in the map credits, "Geologic sketch map by . . . ," usually indicates either who actually finished the map or who was assigned to it but could not finish it. Some reassignments were necessary because of diversion to more pressing projects or work overload in these hectic pre-Apollo 1960s. Garden-variety lack of interest, laziness, or inborn incompetence truncated other assignments. But more interesting was the inability of some bright and interested geologists to map the Moon geologically. Usually they had confined their geology to the office or the laboratory and had little experience in conventional field mapping. Good field geologists made good lunar maps and bad field geologists made bad lunar maps. The principles of mapping are the same whether one is walking and hammering on rocks or deducing their nature on a lunar photograph. Your job in both cases is to reconstruct the three-dimensional structure and history of a district or planet from a small amount of available information. Once a geologist with several years of fieldwork under his belt (even I had that much) was convinced that the Moon was not a dangerous nongeologic object and was shown a few simple rules of lunar mapping, he was off and running.

The Soviets closed off hyperactive 1966 by soft-landing Luna 13 on 24 December to obtain surface pictures in another part of Oceanus Procellarum north of the Luna 9 site (19° N, 62° W). Luna 13 also measured radiation and tested the mechanical properties of the soil. This Luna happened to land on another dark unit in another geologic quadrangle in the final stages of preparation: Seleucus, by Henry Moore; but the new data came too late for the always cautious Henry to speculate about its significance.[29] Anyway, other matters were more pressing. The era of more sophisticated missions had arrived, and Luna 13 was the last of its class.

## THEM VERSUS US

Science was part, but definitely not the driving part, of Apollo. The collection of scientific data was not a foregone conclusion when the project began. Throughout the space program, the purpose and significance of the venture into the new frontier were perceived differently by those who stressed its implications for national prestige and power, those interested in the technological and engineering achievement, and scientists.[30] But there was never any doubt that Project Apollo was primarily an instrument of national prestige. We have seen that many physicists and even some geologists perceived it as a diversion of the U.S. space effort away from serious science. The scientifically oriented unmanned program was restructured to support Apollo, especially when Ranger and Surveyor gave up ambitious scientific instrumentation in favor of taking pictures for Apollo. Lunar Orbiter was a soldier in Apollo's army from its inception. Scientists of a contemplative nature were uncomfortable with the fast pace of the program, which deprived them of the leisure to meditate on its findings. The sky scientists in particular regarded Apollo as a victory of the philistines over the forces of enlightenment, represented by themselves. On the other side, the Apollo and OSSA engineers and managers had a world-shaking task to perform and did not appreciate the parochialism of scientists who emerged briefly from their ivory towers to view a world that was not crafted to their specifications. Somewhere in the middle were the planetologists, whose science supported spaceflights including Apollo; among those mentioned in the present book, Homer Newell has singled out Harry Hess and Gerard Kuiper as particularly cooperative and Harold Urey as particularly uncooperative.[31] Apollo successfully incorporated all kinds of science, but only after the primary technological goals seemed safely in hand after the second landing and a surplus of storage room, payload weight, and operational time was available for science.

In 1966 NASA took several measures to satisfy the scientists. They established the National Space Science Data Center at the Goddard Space Flight Center, which is still in business as the most complete repository of space science data. In September 1966 applications were accepted for a second group of scientist-astronauts (the sixth group of astronauts overall). After the usual agonizing screening process, 11 men, including nine Ph.D.s, two M.D.s, and no jet pilots, were selected in August 1967. The astronaut corps now totaled 56. This large number should have troubled those who had been fighting the battle of scientist versus flyboy, but Homer Newell and George Mueller wanted more scientists in the program, and an elaborate long-term program of lunar exploration and Earth-orbital AAP missions was still envisioned in heady 1966. When reality set in, these new recruits named themselves the XSXI, the Excess Eleven.[32]

Many scientists regarded MSC as especially villainous, so MSC escalated its commitment to science in a number of steps that culminated in December 1966 with the fissioning of a high-level Science and Applications Directorate from cooperative Maxime Faget's capable Engineering and Development Directorate.[33] The first chief of Science and Applications was Wilmot Norton Hess (b. 1926), a physicist from the Goddard Space Flight Center. Hess was faced with the formidable task of getting as much science as possible past the other directorates at MSC and into Apollo. Hess's successor—for he needed a successor within a few years—would attempt to corner the market on science for MSC. We shall see who prevailed.

## FIRE (JANUARY 1967)

By the end of 1966 Project Gemini had ended and all parts of the Apollo stack had been tested except the lunar module (LM) and the crews.[34] Kennedy's deadline was looking conservative. But the gods would have none of this hubris.

The LM was not ready at the beginning of 1967, but the astronauts almost were. A mission tentatively called Apollo 1 and officially called AS-204 (the fourth of the Saturn IB series)[35] was preparing to send Gus Grissom, Ed White, and Roger Chaffee into Earth orbit to test the command and service module (CSM) and themselves. Grissom had had the unhappy experience of losing his Mercury capsule, *Liberty Bell,* to the Atlantic Ocean in July 1961. White had performed the first U.S. space walk from Gemini 4 in June 1965, and probably was the physically strongest among the astronauts. Chaffee had flown many of the photographic missions over Cuba during the October 1962 missile crisis. There had been grumbling about sloppy workmanship and management at North American Aviation, the builders of the CSM, but the shining record of 1966 was casting a glow of optimism on NASA and Apollo. Then, during a routine ground test on 27 January 1967, came the "almost casual announcement,"[36] "Fire. I smell fire," followed quickly by a shouted "Fire in the spacecraft!" and a scream. Pure oxygen at greater-than-atmospheric pressure had been employed as the atmosphere in the command module, and apparently some defective wiring turned flammable materials into an instant inferno. The three astronauts were dead long before the spacecraft's awkward hatch could be opened. The U.S. space program suffered its worst setback up to that time, and lunar studies may have lost, in Chaffee, one of their strongest proponents among the astronauts.

The disaster led to an expensive redesign of the spacecraft, tightening of safety precautions, an interruption of the fast-paced program of testing, and doubts about the wisdom of the whole Moon program. The Soviets soon underwent a parallel halt. Soyuz 1, the first of a long and still-continuing series of piloted spacecraft, was launched on 23 April 1967 and carried cosmonaut Vladimir Komarov to his death when the spacecraft's parachute fouled during reentry the following day.

The dark cloud from the Apollo 1 fire had silver linings for both the engineers and the scientists. It brought about improved reliability that may have prevented a later disaster in space, and it provided time for lagging components of the Apollo system to catch up in their development. Scientists and the unmanned program obtained a window in which to fly more Surveyors and Lunar Orbiters and analyze the results.