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APOLLO: THE LEGACY

2.1 Introduction

You are hereby directed . . . to accelerate the super booster program for which your agency recently was given technical and management responsibility.

President Dwight D. Eisenhower
Letter to T. Kieth Glennan,
NASA Administrator
January 14, 1960

I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth.

President John F. Kennedy
Address to Congress
May 25, 1961

> We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one we are willing to accept, one we are unwilling to postpone, and one which we intend to win . . .
>
> President John F. Kennedy
> Address at Rice University, Houston
> September 12, 1962

IN considering a Return to the Moon, it would be illogical as well as foolish not to examine the origins and legacy of the first human exploration of that small planet – Project Apollo (Figure 2.1). Much can be learned about the benefits to expect and the lessons that should be remembered. The lessons from Apollo will figure prominently in later chapters; here, it may be helpful to conduct a brief review of the Cold War origins of Apollo and its broad, beneficial legacies in the national, cultural and scientific histories of the United States and the world.

2.2 ORIGINS OF APOLLO

The initial catalyst for Americans venturing into deep space was the Soviet Union's October 1957 launch of Sputnik I, the first artificial satellite of the

FIGURE 2.1 Earthrise from behind the Moon, one of the lasting symbols of Apollo. (NASA Photo AS17 152 23274)

Earth. It burst upon the American consciousness as one of the defining moments in the history of the United States. Although a temporary propaganda coup for the Soviets, the law of unintended consequences took over as a technological giant became focused on the obvious long-term importance of space. Thousands of young Americans began to think of space in the context of their personal futures and the future of the world and began to plan their education accordingly. The Eisenhower Administration and the Congress poured money into the public school system and into mathematics and science in particular. Other young aeronautical engineers in the National Advisory Committee for Aeronautics (NACA) began to study human space flight in general and flight to the Moon.

President Dwight D. Eisenhower's special message and legislation recommending the formation of the National Aeronautics and Space Administration (NASA) was sent to Capital Hill on April 2, 1958. Shepherded through Congress by Senator Majority Leader, Lyndon Baines Johnson, the resulting "Space Act" built NASA initially from the personnel, three field laboratories, and Washington Headquarters of the NACA. Eisenhower appointed electrical engineer T. Keith Glennan,[1] President of the Case Institute of Technology in Cleveland, to head the new agency. Hugh L. Dryden, last Director of the NACA, became Deputy Administrator. The President told the new Administrator, in Glennan's words, "he wanted a [space] program that would be sensibly paced and vigorously prosecuted."[2]

By the time NASA began operations on October 1, 1958, the nation had a strong foundation in aerospace technologies pertinent to the tasks ahead. For example, the NACA, from which NASA arose, had been established in 1915 "to supervise and direct the scientific study of the problems of [atmospheric] flight, with a view toward their practical solutions."[3] Gradually, the NACA moved from advisory coordination of the aeronautical research of various governmental agencies to a research agency status. It received funding in its own right with the Langley, Ames, and Lewis Research Centers conducting research in cooperation with industrial and federal engineers and scientists. In February 1958, General James H. Doolittle, hero of the early World War II bombing of Tokyo and chair of the main NACA advisory committee, had requested the first internal study on long-term research goals. Within its first year, NASA moved forward with these internal studies and one major set of contractor studies to define how human flights to the Moon and a landing on its surface might be accomplished.

On Glennan's initiative, the Army's Jet Propulsion Laboratory, managed by the California Institute of Technology in Pasadena, California was added to NASA near its beginnings as an agency.[4] Glennan, strongly supported by Eisenhower, also wanted Wernher von Braun's rocket development group in Huntsville, Alabama; however, the Army resisted this transfer for over a year. Finally, Eisenhower put his foot down and the new agency's initial field center configuration was completed in January 1960 with the final decision to transfer the Army Ballistic Missile Agency to NASA.[5] The Army rocket team, led by von Braun, became the nucleus of the new Marshall Space Flight Center to which also was transferred the Army's Missile Firing Laboratory at Cape Canaveral, Florida, later to become the Kennedy Space Center. The transfer of the Army Ballistic Missile Agency on January 1960 came with Eisenhower's personal directions "to accelerate the super booster [Saturn/Nova] program."[6]

Once the von Braun team had been established as a NASA unit, momentum increased steadily in the development of what became known as the Saturn family of heavy lift rockets and rocket engines, particularly the F-1 and J-2 engines.[7] The Army had started the development that led to these huge engines in December 1958 on the basis of a post-Sputnik recommendation by von Braun.[8] On several occasions, Eisenhower's personal intervention was significant in the continued development of huge launch systems.[9] The flight of Sputnik I, and growing belligerence on the part of the Soviet Union in relation to space and missiles, clearly left their mark on Eisenhower – as they had on many of my generation as well. In Washington, Eisenhower enlarged President Truman's President's Science Advisory Committee (PSAC).[10] To be its chair, he selected Dr James R. Killian, President of the Massachusetts Institute of Technology and thus the first presidential science adviser. Killian apparently was very influential in space-related matters during late 1957 through 1959.[11] Eisenhower's commitment to Saturn development, however, appears to be a prime manifestation of his personal concerns about space and the Soviet Union. On the other hand, to his subordinates, he occasionally professed a lack of enthusiasm for manned space flight in general[12] and flights to the Moon in particular.[13] Eisenhower's apparent antipathy toward man-in-space, particularly military man-in-space, only increased when the Soviets shot down Gary Powers' U-2 reconnaissance plane in 1960.[14]

In spite of such contradictory indications, it is difficult to believe, in view of his push for Saturn development, that Eisenhower had anything in the back of his mind other than human flights to the Moon.[15] As Glennan himself admitted in October 1960,[16] to what other reasonable use, in that day and age, could a 7.5-million-pound thrust rocket stage be put? The military had no defined requirements for thrust anywhere close to this level and no conceivable commercial satellites needed this capability. Only in 1960 – his last year as President, and in the preparation of the Fiscal Year 1962 budget he would hand to his successor – did Eisenhower attempt to hold federal spending for space and everything else into exact balance with projected revenues. This effort appears to have been based on principle and on regret that he had not done better in keeping his election promise to submit balanced budgets during previous budget cycles.[17] He undoubtedly realized that his successor and Congress would add significantly to his last budgetary requests for many parts of the government, including NASA. Indeed, this is exactly what happened.[18]

In retrospect, Eisenhower seemed split between his concern about the role of the United States as the protector of freedom in the world during the Cold War and his commitment to control the federal budget and the "acquisition of unwarranted influence ... by the military–industrial complex.".[19] Still, on Eisenhower's watch, NASA came into existence, public education in math and science was enhanced, studies of manned flights to the Moon progressed, and a manned lunar booster project was aggressively pursued.

The most important managerial and political step taken early in the Kennedy Administration, unrecognized at the time, was the selection of the right person as NASA Administrator. This took place a little less than three months before White House consideration of a Moon landing initiative began. The leadership of NASA – one of the last positions to be filled by the newly elected President – had been the focus of a tug-of-war between Kennedy's science adviser, Jerome Wiesner, and Vice-President Lyndon Johnson.[20] In late January 1961, Senator Robert S. Kerr of Oklahoma suggested that James E. Webb, President Truman's Director of the Bureau of the Budget (now Office of Management and Budget) be considered. Weisner and Johnson both knew Webb well and were comfortable with the suggestion. Webb had many reservations about becoming Administrator, but with the assurance from Kennedy that Hugh Dryden would continue as Deputy Administrator, he took the job. Innovative management, and not reacting to Soviet actions, would be Webb's stated focus while Administrator.[21] The President even made a flat statement to Webb that he had no space policy and Webb would be responsible for creating one. Kennedy, however, may have influenced Webb by reportedly saying, "There are great issues of national and international policy involved in this space program. I want you because you have been involved in policy at the White House level [and] State Department level."[22] This could have sounded to Webb like an invitation to be bold.

In addition to Dryden (63), Webb (54) also retained Robert C. Seamans Jr (43), as the third member of the top management team.[23] In Dryden, Webb had a respected and experienced scientist and science administrator, and in Seamans he had inherited a top-notch engineer and engineering manager with strong contacts throughout the aerospace community and at MIT, where Seamans had taught. Webb, himself, had the Washington political and managerial insights necessary to operate in that competitive, cut-throat, political environment. He soon found that his primary adversary in the Washington environment, on the issue of space science versus manned space flight, would be one of his sponsors, Jerome Wiesner.[24] Weisner's efforts to control NASA would be backed by many of the scientists on the President's Science Advisory Committee that he led.

For a few months, Wiesner and the Bureau of the Budget, led by David Bell, were able to show progress in developing manned space flight capabilities. Events, however, began to take a life of their own. Kennedy personally approved going forward with ''long duration Mercury flights'' after budgetary discussions with Seamans and Bell on March 22, 1961, as they revised and augmented the FY1962 budget.[25] The ''Mercury Mark II'' project quickly evolved into the two-man, Gemini spacecraft. At that same March meeting, Kennedy also agreed to the restoration and enhancement of funds for Eisenhower's ''super booster'' as well as funds to ''expedite supporting technology required for attainment of lunar goal.'' These actions signaled Kennedy's strong interest in manned lunar flights three weeks before Yuri Gagarin's flight into space and two months before committing NASA and the country to a lunar landing.

On April 12, 1961, the Soviet Union placed Gagarin in orbit around the Earth and returned him safely. Faced with the fact of the Gagarin flight and its obvious impact on Americans and the world, Kennedy held a Cabinet meeting two days later at which he asked what options the United States had in overcoming the Soviet lead in space. After the debacle in Cuba at the Bay of Pigs, an abortive rebel invasion that began on April 15, Kennedy's interest in a space initiative seemed to increase. Kennedy again brought up the possibility of a manned Moon landing in a memorandum to Johnson.[26] Kennedy asked: ''Do we have a chance of beating the Soviets by putting a laboratory in space, or by a trip around the Moon, or by a rocket to land on the Moon, or by a rocket to go to the Moon and back with a man? Is there any other space program which promises dramatic results in which we could win?'' At an April 21 press conference, Kennedy followed this with, ''If we can get to the Moon before the Russians, then we should.''

On April 24, in a meeting that included Webb and Wiesner, among others, Johnson received (that is, forced) unanimous agreement of his Space Council that a Moon landing should be recommended to the President. While Webb urgently gathered together the studies George M. Low and others had done to see if such an initiative were technically feasible, Johnson kept intense pressure on Webb to make an official, supportive statement to the President. On May 3, a still reluctant Webb told Johnson that (1) a manned Moon landing was one project the US could beat the Soviets in accomplishing, but only if (2) there was a sustained political commitment over ten years.[27] Through all of these deliberations, Weisner and others on the President's Science Advisory Committee gave only lukewarm support for human space flight.[28]

The situation changed even more rapidly on May 5 with Alan Shepard's successful and very public suborbital flight as America's first man in space. The next day Webb met with Secretary of Defense Robert S. McNamara, several of their respective senior staff, and Willis "Shap" Shapley[29] of the Bureau of the Budget to discuss what should be recommended to the President.[30] That evening, Seamans, Shapley, and a senior Department of Defense representative, John Rubel, prepared a draft report supporting a manned Moon landing. Later that same evening, Webb personally crafted this report into a formal presidential decision memorandum. The memorandum, signed also by McNamara, clearly affirmed that NASA, not the Air Force, would be the lead agency for the effort. In addition to outlining in considerable detail what would be required for the project to be successful, based on what was known at the time, Webb included identification of the need to support activities in space science and education. Important flexibility for developing space science activities in the future was created by this action.

Kennedy accepted Webb's decision memorandum, changing only one phrase. Then, on May 25, he announced to the nation that Americans were going to the Moon "before this decade is out."[31] The legacy of the success in meeting Kennedy's challenge resonates throughout the modern history of the Cold War, of human society, and of science.

2.3 Cold War Legacy

Apollo clearly met the Cold War political goals set by Eisenhower through his quiet actions and by Kennedy through his political leadership, and met them far beyond either's original expectations. The intended intimidation of the leadership of the Soviet Union succeeded to the point where the success of the first test launch of a Saturn V booster convinced that adversary that the race to the Moon had been lost.[32] Apollo's example of what Americans could do when faced with an external challenge fed the Soviet's belief that President Ronald Reagan's 1983 Strategic Defense Initiative would be successful as well. That belief and the actual inability of a one-dimensional, military economy to compete in strategic defense was a major factor in hastening the collapse of the Soviet Union in the 1980s.

In parallel with Soviet discouragement, there came a rejuvenation of American pride. "If we can land on the Moon, why can't we —— (fill in the blank)" was the question often asked of astronauts making the speaking rounds. The answer is, of course, you can do "——," provided you can motivate young men and women to believe that achieving "———" would be the most important use of their lives. Those young men and women who were the heart and soul of Apollo, without exception in my experience, believed that putting an American on the Moon represented the highest achievement to which they could aspire. They gave youth, imagination, endurance, and in too many cases, their families to insure that the astronauts were safe as well as successful. Ten years of 16-hour days, eight-day weeks, required to meet John Kennedy's challenge would not have been possible without this willing and dedicated sacrifice.

2.4 HUMAN LEGACY

Apollo established a new evolutionary status for human beings in the solar system. The human species now has new, accessible, ecological niches away from the home planet (Figure 2.2), which expand our envelope for species survival. Our knowledge of the Moon, and now of Mars, shows that, eventually, humans can live on these bodies independently of support from Earth. The resources that are necessary to support human life exist on both. On Mars, large quantities of water-ice exist near the Martian surface[33] from which oxygen and hydrogen can be produced. The Martian carbon dioxide dominated atmosphere can provide methane-based fuels for many purposes.[34] On the Moon, solar wind derived hydrogen exists in the lunar soils at concentrations between 50 and 150 parts per million and even much higher in the polar regions.[35] The heating necessary to release the hydrogen causes it to react with soil minerals to produce water, estimated to be about one tonne of water per two tonnes of hydrogen.

FIGURE 2.2 Apollo 17 view of a nearly full Earth as photographed by the author from about 50,000 km on the way to the Moon. (NASA Photograph AS17 148 22726)

Local deposits of water-ice may also exist at high latitudes[36] although possibly not as much as some advocates may hope.[37] Helium and compounds of nitrogen and carbon are also released in significant quantities. As the fertility of the lunar soil is expected to be comparable to that of fresh Hawaiian volcanic ash, food production in properly shielded facilities appears to be feasible.

Importantly, for the economy of lunar settlers and for those left behind on Earth, about 1/2400 of lunar helium atoms are a light isotope, helium-3. Helium-3 has the potential to be a highly valuable export to Earth for use as a fuel for fusion electrical power production (Chapter 5). The major positive implications of this lunar resource on the personal and environmental well-being of human beings on Earth are discussed in Chapters 3 and 11.

Apollo also accelerated improvements in the human condition for billions of people on Earth. Its success gave hope to people world wide, as demonstrated by the reactions of those millions lining streets to see astronauts and cosmonauts on their world tours. It could be said, in light of subsequent history, that for many, such hope was misplaced. Indeed, the world and the United States did not build on the promise of Apollo. This neglect shows most egregiously in not using space exploration as a catalyst for education. Many in the world are worse off, or no better off, than they were when Armstrong first set foot on the Moon. This, however, is not a fault in the accomplishments of Apollo and its generation, but a fault in the socialistic human institutions that have stifled individuals who have attempted to realize its promise. On the other hand, the technological foundations expanded by, or because of, Apollo have revolutionized the world's use of communications, computers, medical diagnostics and care, transportation, weather and climate forecasting, energy conversion systems, new materials, systems engineering, project management, and many other applications of human ingenuity.

2.5 SCIENTIFIC LEGACY

A great beneficiary of Apollo has been and continues to be the science of the Earth, the planets, and the solar system. From the samples collected and placed in context by the astronauts, there came a first-order understanding of the origin and history of the Moon. Debates related to specific questions about lunar origin and history continue,[38] particularly as to whether the Moon was formed by a giant impact on the Earth or was captured by it at a later stage. Competing hypotheses can be tested, however, using the real information from samples. The foundation provided by Apollo exploration has allowed calibration of global interpretations of subsequent remote sensing from lunar orbit by the Galileo, Clementine and Lunar Prospector missions. The combination of Apollo and remote-sensing information has given us a general perspective of the accretionary and cratering history of the inner solar system that is unavailable anywhere else other than, possibly, on the distant planet Mercury, which is currently inaccessible to direct human exploration. The inner solar system's cratering history, in turn, has provided a guide to the early history of Earth, Venus, Mars, and Mercury, including new insights into the conditions under which life's precursors and life itself formed on Earth, and possibly on Mars.

Lunar science, as developed from Apollo data – combined with our ever-expanding knowledge about the Earth – became the basis for the new discipline of "comparative planetology," now one of the most active and multidisciplinary aspects of science. The extraordinary interest in recent robotic exploration of Mars shows that comparative planetology also has captured the public's attention. Combined with the delineation of the potential of lunar resources discussed above, this was not too shabby a result for a Cold War stimulated effort that initially did not consider science as a potential beneficiary.

Notes and References

1. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, pp. ix–xxxii, 1–9; Dethloff, H. C., 1993, *Suddenly, Tomorrow Came . . . A History of the Johnson Space Center*, NASA SP-4307, p. 19.
2. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, p. 2.
3. Bilstein, R. S., 1990, *Orders of Magnitude: A History of the NACA and NASA, 1915–1990*, NASA SP-4406, p. 1.
4. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, p. 9.
5. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, pp. 10–12 and 31–59; Dethloff, H. C., 1993, *Suddenly, Tomorrow Came . . . A History of the Johnson Space Center*, NASA SP-4307, p. 27.
6. Brooks, C. G., J. M. Grimwood, and L. S. Swenson Jr, 1979, *Chariots for Apollo*, NASA History Series, NASA, Washington, pp. 13–14.
7. The F-1 burned kerosene and liquid oxygen and had 1.5 million pounds of thrust. Ultimately, five F-1 engines would power the S-IC first stage of the Saturn V. The J-2, originally called the 200K, would use liquid hydrogen and liquid oxygen and produce 200,000 pounds of thrust. Five J-2 engines would power the S-II second stage and one would be used in the S-IVB third stage or the Saturn V. Ultimately, this combination of stages for Apollo 17 would place 48 metric tonnes of payload on a trajectory to the Moon.
8. Wilhelms, D. E., 1993, *To a Rocky Moon*, University of Arizona Press, Tucson, p. 31; Stuhlinger, E., and F. I. Ordway III, 1996, *Wernher von Braun*, Krieger, Malabar, pp. 80, 153ff.
9. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, pp. 12, 38, 41, 47, and 226.
10. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, pp. 94 and 340.
11. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, p. 2; Swenson, L. S. Jr, J. M. Grimwood, and C. C. Alexander, 1966, *This New Ocean: A History of Project Mercury*, NASA SP-4201, pp. 82–101.
12. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, pp. 245 and 297.
13. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, pp. 245, 292 and 308; Dethloff, H. C., 1993, *Suddenly, Tomorrow Came . . . A History of the Johnson Space Center*, NASA SP-4307, p. 28.
14. Getting, I., 1983, personal communication based on Aerospace Corporation activities.
15. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, p. 226.

16. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, p. 255.
17. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, p. 157.
18. Brooks, C. G., J. M. Grimwood, and L. S. Swenson Jr, 1979, *Chariots for Apollo*, NASA History Series, NASA, Washington, p. 25; Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA, SP-4105, pp. 175, 270, 273.
19. Eisenhower, D. D., 1961, Farewell Address, in *The Annals of America*, Encyclopaedia Britannica, Chicago, 18, p. 3
20. Lambright, W. H., 1995, *Powering Apollo: James E. Webb of NASA*, Johns Hopkins University Press, Baltimore, pp. 82–84.
21. Lambright, W. H., 1995, *Powering Apollo: James E. Webb of NASA*, Johns Hopkins University Press, Baltimore, p. 87.
22. Lambright, W. H., 1995, *Powering Apollo: James E. Webb of NASA*, Johns Hopkins University Press, Baltimore, p. 84.
23. Lambright, W. H., 1995, *Powering Apollo: James E. Webb of NASA*, Johns Hopkins University Press, Baltimore, pp. 84-99; Seamans, R. C. Jr, 1996, *Aiming at Targets*, NASA SP-4106, p. 82.
24. Lambright, W. H., 1995, *Powering Apollo: James E. Webb of NASA*, Johns Hopkins University Press, Baltimore, p. 83; Gilruth, R. R., 1987, Interview #3, in G. E. Swanson, editor, 1999, *Before this Decade is Out...*, NASA SP-4223, p. 78.
25. Brooks, C. G., J. M. Grimwood, and L. S. Swenson, Jr, 1979, *Chariots for Apollo*, NASA History Series, NASA, Washington, p. 25 and footnote; Seamans, R. C. Jr, 1996, *Aiming at Targets*, NASA SP-4106, pp. 82–83.
26. Lambright, W. H., 1995, *Powering Apollo: James E. Webb of NASA*, Johns Hopkins University Press, Baltimore, p. 95; Dethloff, H. C., 1993, *Suddenly, Tomorrow Came . . . A History of the Johnson Space Center*, NASA SP-4307, p. 29.
27. Lambright, W. H., 1995, *Powering Apollo: James E. Webb of NASA*, Johns Hopkins University Press, Baltimore, p. 96.
28. Dethloff, H. C., 1993, *Suddenly, Tomorrow Came . . . A History of the Johnson Space Center*, NASA SP-4307, p. 30.
29. Glennan, T. K., 1993, *The Birth of NASA: The Diary of T. Keith Glennan*, NASA SP-4105, p. 356.
30. Lambright, W. H., 1995, *Powering Apollo: James E. Webb of NASA*, Johns Hopkins University Press, Baltimore, pp. 97-99; Seamans, R. C. Jr, 1996, *Aiming at Targets*, NASA SP-4106, pp. 88–91.
31. Lambright, W. H., 1995, *Powering Apollo: James E. Webb of NASA*, Johns Hopkins University Press, Baltimore, p. 101; Logston, J. M., 1970, *The Decision to Go to the Moon: Project Apollo and the National Interest*, MIT Press.
32. Émigré, 1986, Personal communication.
33. Feldman, W. C., G. W. McKinney, et al., 2004, The global distribution of near-surface hydrogen on Mars, *Journal of Geophysical Research*, 109, doi: 10.1059/2004JE002160.
34. Zubrin, R., 1996, *The Case for Mars*, Simon & Schuster, New York, pp. 148–156.
35. Feldman, W. C., S. Maurice, A. B. Binder, B. L. Barraclough, R. C. Elphic,

and D. J. Lawrence, 1998, Fluxes of fast and epithermal neutrons from Lunar Prospector: Evidence for water ice at the lunar poles, *Science*, 281, pp. 1489–1500.

36. Nozette, S., P. D. Spudis, M. S. Robinson, D. B. J. Bussey, C. Lichtenberg, and R. Bonner, 2001, Integration of lunar polar remote-sensing data sets: Evidence for ice at the lunar south pole, *Journal of Geophysical Research*, 106, E19, 23253-23266.
37. Schmitt, H. H., Gl. L. Kulcinski, J. F. Santarius, J. Ding, M. J. Malecki, and M. J. Zalewski, 2000, Solar-wind hydrogen at the lunar poles, *SPACE 2000*, American Society of Civil Engineers, pp. 653–660.
38. Compare Palme, H., 2004, The giant impact formation of the Moon, Science, 304, pp. 977-979 with Schmitt, H. H., 2003, Apollo and the Moon, in H. Mark, editor, *Encyclopedia of Space and Space Technology*, Wiley, New York, Chapter 1.

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