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## LUNAR SCIENCE STATIONS CEASE FUNCTIONING OCT. 1

On Oct. 1, science instruments left on the lunar surface by the Apollo astronauts will no longer be operated, and the ALSEP Control Center at NASA's Johnson Space Center, Houston, Tex., will be dismantled.

The stations have completed their scientific objectives and the data that can be obtained by continued operation is judged to be of lower priority than competing requirements for the financial resources, NASA spokesmen said.

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Since July 20, 1969, scientists have been receiving a continuous stream of information from the five ALSEPs (Apollo Lunar Scientific Experiment Packages) left on the lunar surface by the Apollo explorers. Much of what has been learned about the Moon has been based on these data.

There are five operating stations, one each for Apollo missions 12, 14, 15, 16 and 17. The Apollo 11 crew placed a prototype station on the lunar surface in July 1969. That first station, with a design life of only 14 days, lasted 45 days and quit due to power supply failure. The remaining five Apollo stations have performed in an outstanding manner.

Specifications called for a one-year operating life for the first four ALSEPs and two years for the Apollo 17 station. Apollo 12 ALSEP is now well into its eighth year and Apollo 17 ALSEP its fifth year.

More than 153,000 commands have been transmitted from Earth and executed by the Moon stations. More than one trillion ($10^{12}$) bits of lunar science and engineering data have been received on Earth. The total accumulated operating time for all ALSEP stations exceeds 29 years, although the equipment was designed for a cumulative total of only six years.

The stations were built to provide long-term lunar surface geophysical and electrical data. The surface experiments included measuring the heat produced by the Moon's interior, the kind and amount of charged particles in the Moon's tenuous ion atmosphere, the magnetic environment and providing seismic data on moonquakes and meteoroid impacts.

Because of the extended life of the ALSEP stations, Earth scientists received two real bonuses from the science stations: all four seismometers (one each on Apollo 12, 14, 15 and 16) have been operating as a seismic network for the past five years. This network has greatly enhanced the analyses of the few large quakes which occur each year.

Secondly, a three year accumulation of data from the heat flow experiment was required before scientists became aware of a long term trend in the data. After much thought they realized it was caused by changes in the thermal properties of the soil created by the act of emplacing the probes. This understanding solved the argument between geochemists and geophysicists about the amount of radioactive material in the Moon.

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It is primarily the seismic experiments which have intrigued scientists. From information based on moonquakes and meteorite hits scientists felt that they might finally be able to answer one of the Moon's most perplexing questions: "What is the deep interior of the Moon like, and does the Moon have a molten core?"

To answer the questions, lunar scientists needed at least one large (greater than $10^{19}$ ergs) event on the back side of the Moon, according to Dr. Gary Latham, principal investigator for the ALSEP passive seismic experiment. On May 13, 1972, a front side event with energy of 1,100 kilograms (2,925 pounds) was recorded. On Sept. 19, 1973, a large back side seismic event -- with energy of $10^{18}$ ergs -- took place on the Moon. Since then, lunar scientists have been waiting for a third event -- "the big one"; it hasn't yet happened.

The overall scoreboard is as follows: approximately 10,000 moonquakes and 2,000 meteorite impacts.

At the end of this fiscal year, the ALSEP stations will be left on their own, all but their transmitters muted. Funding for the technical and scientific support needed to maintain the stations will cease on Sept. 30, 1977.

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The past eight years have been a time of tremendous increase in the knowledge and understanding about the Moon. The returned lunar samples have played an essential part in this knowledge explosion, but for some aspects of the Moon, only the ALSEPs could have helped.

The ALSEP seismic information, magnetometer and heat flow experiments have contributed the principal information about the Moon's interior. It is now believed the Moon's crust is multi-layered and from 60 to 100 kilometers (40 to 60 miles) thick, with the secondary boundary occurring about 20 km (12 mi.) deep.

The lunar upper mantle has been determined to be fairly homogeneous and to extend about 500 km (300 mi.). It is believed to consist of olivine or olivine-pyroxene matter, although other compositions also have been proposed. From 500 km (300 mi.) deeper, the seismic data indicate the Moon may be iron-enriched, although there are insufficient data to determine whether or not the Moon has a molten core.

Moonquakes have been discovered to show periodicity and to recur at several places in the interior. The mechanism for this has been hypothesized as release of tidal stress in the region between 1,100 and 1,500 km (684 and 932 mi.) depth and may occur along possible previously existing faults or local inhomogeneities at depth. The time cycle of the deep-focus moonquakes follows the tidal cycles so closely it appears likely that tidal forces are a major factor in triggering deep-focus moonquakes.

Charged-particle, supra-thermal ion and solar wind experiments have also provided important data for a new understanding of the Earth's magnetosphere and the interaction of the magnetosphere with the solar wind. Ion measurements also detected a lunar surface electric potential of about +10 volts in daylight and about -100(periodically to -250) volts at night.

These experiments also provided new information concerning the electrostatic lines of force associated with the transition of the terminator across the lunar surface. The phenomenon is thought to be the result of a cloud of hot solar wind electrons near the terminator (the cloud presumably generated by the limb shock of the solar wind).

Extensive lunar soil sputtering resulting from solar wind impingement was also measured by the ALSEPs and further augmented by sample analysis on Earth.

Even though the experiments will be terminated, the transmitters will continue to serve Earth as a reference point in astronomy. NASA's Jet Propulsion Laboratory, Pasadena, Calif., will continue to use the signals from the ALSEP transmitters to assist in the Laboratory's deep space work including geodetic and astrometric studies and spacecraft navigation. Also, the motion of the lunar orbit will be accurately monitored against a background of extragalactic radio sources to test gravitational theories.

During the past eight years, many of the instruments associated with each ALSEP station have experienced engineering problems. Since July, engineers at Johnson Center have been performing more than their usual maintenance and engineering functions on the ALSEP stations. In preparation for the Oct. 1 shutdown, the ALSEP stations have been put through a slightly different routine to extract the last ounce of engineering data possible.

There are a few engineering mysteries still puzzling the Johnson Center team, but each station over the years has developed a "personality," and a final understanding of that personality will assist in the design of similar stations. The Moon and Mars are the only planets now equipped with remote sensors, but it is expected that other planets will have them too, and a thorough understanding of the harsh environment involved and the effects of time will enhance further the reliability of these devices.

One station in particular, the Apollo 14 ALSEP, has a rather dramatic history of engineering problems. The ALSEP 14 station started working correctly and continued this for four years, then it quit for two days in March 1975, and started up again. Then it quit again; then it started up again. This "on-again, off-again" performance was repeated six times in the last two years.

The problem has been diagnosed as an intermittent short circuit in one of two power conditioning units. The short seems related to the temperature of the unit, in turn related to the position of the Sun over the lunar landscape. It is problems like this, however, that need to be fully understood to insure proper performance of future generations of remote science stations.

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Over the years the ALSEP program has cost approximately $200 million, including the design and development of the stations themselves, support engineering work in Houston and the science analysis work performed in dozens of university labs throughout the world. The stations have been costing about $2 million a year to operate. The program has involved hundreds of engineers and scientists and has produced a tremendous source bank of information about the Moon, both as a planet and as an object wading through the electric and magnetic environment of the Earth and Sun.

NOTE

Bendix Aerospace Corp., Aerospace Systems Division, Ann Arbor, Mich., was prime contractor for the ALSEP equipment and provided technical support for the Johnson Center control operations.

General Electric Co., Aerospace Group, Valley Forge, Pa., furnished the radioisotope thermoelectric generators which provided electric power.

Johnson Center provided project management, operations control and integration; and NASA's Goddard Space Flight Center, Greenbelt, Md., provided tracking and communications with the stations.

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