Lunar Seismic Profiling Experiment

NSSDCA ID: 1972-096C-06

Mission Name: Apollo 17 Lunar Module /ALSEP
Principal Investigator: Dr. Robert L. Kovach

Description

The purpose of the Apollo 17 Lunar Seismic Profiling Experiment (LPSE, S-203) was to acquire data on the physical properties of the lunar near-surface materials. Specific objectives included measuring the lunar seismic signals produced by detonation of explosive charges on the surface, monitoring natural seismic activity resulting from moonquakes or meteorite impacts, and recording the seismic signals resulting from the liftoff of the LM and impact of the spent LM ascent stage. This experiment yielded detailed information on lunar geologic characteristics to depths of 3 km.

The equipment consisted of four geophones, marker flags, a geophone module with a marker flag, an electronics package in the ALSEP central station, a transmitter, an antenna, and eight explosive packages. The explosive package major conponents were a receiving antenna and receiver, an explosive train, a signal processor, and a firing pulse generator. The crew deployed the geophones and the geophone module marked with flags and then photographed them during EVA 1. The antennas and electronics package were also deployed and connected to the ALSEP central station. The explosive packages were deployed at designated sites during the three EVA lunar traverses up to 3.5 km from the geophone array. The entire system, not including the explosive charges, had a mass of 9.33 kg. The maximum operational power was 6.8 W. Passive listening mode alone required 5.3 W. No system survival power was necessary.

Central Station Electronics

The central station electronics package had a mass of 1.68 kg. The geophone signals were conditioned by a four-channel amplifier and a logarithmic compressor housed in the ALSEP central station. The analog output of the compressor was converted to 7-bit binary by an analog -to-digital converter and transmitted to Earth through the ALSEP communications network. The 7-bit encoding provides for an amplitude resolution of 1.277 dB (~16%).

In order to return useful seismic data, the LPSE had to be operating in high-bit-rate (HBR) mode. Due to the high-bit-rate formatting, when the LPSE was operating in HBR mode no data could be returned from the other experiments, so LPSE operational time was limited.

Also in the central station was a transmitter which sent out a repetitive pulsed carrier signal once every 29.55 seconds. A set of three pulses properly spaced would prompt a FIRE signal from the signal processor within the explosive package and detonate the explosives train.

Geophones

The geophone array comprised four identical geophones and a geophone module. Each geophone was connected to the geophone module by a separate cable. The geophones were moving coil-magnet seismometers, the coil suspended by springs in the magnetic field acting as the inertial mass. Relative movement of the coil in the magnetic field generates an output proportional to the ground velocity (above 7.5 Hz, the natural resonant frequency of the geophones). Each geophone channel was sampled 118 times/sec to provide a minimum of 5 samples/sec at a frequency of 20 Hz.

The geophones were housed in small cylindrical cases with a spike at the bottom to hold them vertically and ensure good contact with the ground. The geophones were 4.2 cm in diameter by 4.9 cm high (12.2 cm including the spike), and had a mass of 177 grams.

The geophone module was a 25 x 22 x 17.4 cm box situated roughly 10 m south of the central station, connected by a cable. The geophones were set out in a T-shaped pattern, effectively forming a triangle with a geophone at each apex and one near the center of the triangle. Geophone 1 was set about 45.7 meters east of the geophone module, geophone 2 45.7 m west, and geophones 3 and 4 placed 26.8 m and 79.2 m south, respectively. Geophone 1 was about 148 m northwest of the Lunar Module. Geophone 2 was 244 m from the LM, geophone 3 was 190 m, and geophone 4 was 187 m.

Explosive Packages

The eight explosive packages (designated EP-1 to EP-8) are identical except for the amount of high explosive in each one and the preset runout time on the mechanical timers. Each package was held in a small box with a handle and a 165 cm antenna mounted on the side and three pull rings on top. The explosive was contained in a nickel-plated fiberglass housing, which comprised the bottom portion of the box. Above this was the electronics and SAFE/ARM assembly, mounted on a magnesium baseplate. The assembly was composed of the end detonating cartridge, the SAFE/ARM slide, the SAFE/ARM slide timer, the receiver, signal processor, firing-pulse generator, thermal battery, and thermal battery timer.

The end detonating cartridge held the detonator to ignite the explosives. The SAFE/ARM slide was a spring-loaded plate which would open a microswitch that would enable the end detonating cartridge to receive signals from the firing pulse generator. The SAFE/ARM slide was held in

the SAFE position by a pull ring and the SAFE/ARM slide timer. The timer was activated manually by a pull ring, at which point it would begin a preset countdown of 89.75, 90.75, 91.75, or 92.75 hours.

The thermal battery had a lifetime of at least 2 minutes and powered the receiver, the signal processor, and the firing pulse generator. The receiver detected the firing signal from the central station and the signal processor would transmit it to the firing pulse generator, which would trigger the end detonating cartridge. The firing pin mechanism would activate the thermal battery when prompted by the thermal battery timer. The thermal battery timer was set to trip 1 hour after the SAFE/ARM slide timer.

The explosive used was known as a plastic bonded explosive, or PBX, and was composed of 90% hexanitrostilbene (HNS) with 10% powdered teflon as a binder. These HNS/TEFLON charges were developed by the Naval Ordinance Laboratory and have roughly the same explosive capacity as an equivalent mass of TNT. Two packages contained 0.057 kg of explosive, two contained 0.113 kg, and the remaining four held 0.227, 0.454, 1.361, and 2.722 kg respectively. The point of the different size charges was that packages placed farther away from the geophone array would require larger charges to be detected.

The explosive package was activated by removing the three pull rings. Removal of the first pull ring activated the SAFE/ARM slide timer. The second pull ring released the SAFE/ARM slide from the constrained SAFE position. The third pull ring removed a constraint on the firing pin and activated the thermal battery timer. Approximately 90 hours after the rings were pulled, the SAFE/ARM slide timer would release the SAFE/ARM slide, and it would be pulled by the spring into the ARM position. An hour later, the thermal battery timer would cause the firing pin mechanism to initiate the thermal battery and close two microswitches connecting the battery to the electrical circuit. Within the next two minutes a pulsed carrier signal would be transmitted from the central station (repeated every 29.55 seconds) and received by the explosive package, initiating detonation.

Operational History

The LPSE was commanded on at 22:24:00 UT on 14 December 1972 to record the LM ascent, which took place at 22:54:38.424 UT. It was commanded on again at 6:36:00 UT on 15 December 1972 to record the LM ascent stage impact. The impact occurred at 06:50:19.60 (real time) at 19.91 N, 30.51 E, 8.7 km southwest of the Apollo 17 landing site.

The LPSE was turned on and put in HBR mode periodically to cover the explosive package detonations between December 15 and 18, 1972: EP-6 (Dec. 15, 23:48 UT); EP-7 (Dec. 16, 02:18 UT); EP-4 (Dec. 16, 19:08 UT); EP-1 explosion (Dec. 17, 00:42 UT); EP-8 (Dec. 17, 03:46); EP-5 (Dec. 17, 23:16);EP-2 (Dec. 18, 00:45); and EP-3 (Dec. 18, 03:07).

The first 30 minute passive listening mode took place on 22 December 1972. The LPSE was commanded on at 06:57 UT and high bit rate mode started at 07:10 UT. HBR mode ended at 07:40 UT and the LSPE was returned to standby mode at 07:43 UT. The instrument was commanded on each week after this for 30 minutes in passive listening mode. Eight extended (~100 hour) listening periods were also performed periodically from 1973 to 1975 to cover the full 360 degree range of Sun angles, and three other extended listening periods were performed at special request.

Alternate Names

- Apollo17ALSEP/LunarSeismicProfilingExperiment
- S203

Facts in Brief

Mass: 25.1 kg
Power (avg): 5.3 W

Funding Agency

- NASA-Office of Space Science United States

Discipline

- Planetary Science: Geology and Geophysics

Additional Information

- Apollo 17 Lunar Module /ALSEP
- Data collections from this experiment

Questions and comments about this experiment can be directed to: Dr. David R. Williams

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Selected References

- Nakamura, Y., *et al*., Apollo Lunar Seismic Experiment - final summary, *J. Geophys. Res*., 87, Suppl., A117-A123, Nov. 1982.
- Kovach, R. L., *et al*., Lunar seismic profiling experiment, in *Apollo 17 Prelim. Sci. Rept*., NASA SP-330, Wash., DC, 1973.