THE LUNAR GEOPHYSICAL NETWORK MISSION


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Overarching Principles:

1. Must be better than Apollo (coverage, duration, instrument performance).
2. Learn from the Apollo experience.

Global distribution of multiple stations. Each station should contain a seismometer, heat flow probe, electromagnetic sounder, laser retroreflector (lunar nearside).

Each station must be long-lived (e.g., ~10 years) to allow other stations (from other countries?) to be integrated with the anchor nodes to form the International Lunar Network.

Why LGN?

Planetary Science:
• Moon represents an end-member in planetary evolution (large small body, small rocky planet).
• Primary planetary differentiation preserved.
• Key to understanding terrestrial planet initial differentiation.

Lunar Science:
• Heat flow probes yield crustal heat budget estimates.
• Combined with EMS, the temperature profile of the deep interior can be modeled along with mineralogy.
• Seismic and LLR data also yield structure and compositional information of the lunar interior.
• High fidelity data from LGN would enhance the usefulness of the GRAIL and SELENE gravity data.

Human Exploration:
• LGN must be established prior to renewed human lunar activity; we do not know the exact locations or causes of the shallow moonquakes (SMQs) – the largest magnitude seismic events recorded by Apollo (1 event/year of magnitude ≥5; [4,5]).
• Establishing surface infrastructure near SMQ epicenters must be avoided.

Technology Development

Underway:
• Seismometer [6,7,8]
• Heat Flow Probes [9,10]
• Corner-cube laser retroreflectors [11]

Needed:
• Reliable landers. Leverage the MSFC International Lunar Network [1] experience, MoonRise, etc.
• EMS deployment mechanisms.
• Long-lived (≥10 years) power supply for each station
• Miniaturization, ruggedization, & cold electronics.
• Autonomous operations, data based decision making, and networking.

Seismometer: ≥4 sensors; ≥1 order of magnitude better sensitivity than Apollo; broader frequency range (0.1 to >10 Hz).
Apollo Passive Seismometer - three long period sensors (X, Y, Z, all with detection limits of 0.3nm at 0.004-2 Hz) and one short period sensor (2 with a detection limit of 0.3nm at 1 Hz).

Heat Flow: measure temperature every 20 cm to a depth ≥3 m (relative accuracy = 0.01%). Measurements every hour. Thermal conductivity determined at several intervals (e.g., every 50 cm).
Apollo Heat Flow Experiment: 2 probes ~11 m apart. Absolute temperature to ±0.5K. Thermal conductivity (0.009-0.014 W/mK) determined for 2 depth intervals with ~15% accuracy.

Electromagnetic Sounding (EMS): Measurement of electric and magnetic fields at each station yields an independent determination of conductivity structure (magnetotellurics) without requiring an orbital asset. Comparison of magnetic data between different stations (geomagnetic depth sounding) provides a complementary result.

Apollo EMS - used surface and orbital magnetometers. Suitable spatial and temporal overlaps have limited the usefulness of these data.

Laser Ranging: For the Moon, expansion of the network will constrain tidal librations. New retroreflectors must give at least a factor of two better return signal.
Apollo LLR - only active Apollo experiment. Limited by spatial distribution of the network.

Secondary Payloads

Ground/Lunar Penetrating Radar: Aid with heat flow probe deployment and shallow structure determination (e.g., Chang’E-3 Yutu Rover).
Gravimeter: Long duration tidal tomography.
MEMS (Micro-Electro-Mechanical-Systems) Seismometers