Lunar Seismology Background

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The Apollo Passive Seismic Experiment consisted of four seismic stations deployed on the lunar near side between 1969 and 1972 (Apollo 12, 14, 15, 16). These operated continuously from inception to mid-1977, when funding was cut and the data were no longer recorded. Each station consisted of a 3-axis long-period seismometer (sample rate 6.6252 Hz) and vertical-axis short-period seismometer (sample rate 15 Hz.)

Types of events detected:

- Naturally occurring deep moonquakes
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- Naturally occurring impacts (meteorites)
- Artificial impacts (booster rockets and Apollo lunar modules)
- Thermal moonquakes

Deep moonquakes:

- Occur between 700 and 1000 km depth (about halfway to center of Moon)
- Are numerous (~6000 detected over the whole experiment)
- Originate from some 300 distinct source regions, many of which have been located
- Occur with tidal periodicity (~27.5 days)
- Each source region produces repeatable events which correlate with all other events from that region (can be stacked)
- Are small (on the order of body wave magnitude 1 or less, with stress drops of 1 bar or less)
- Dominant period 1 Hz
- Strong P and S coda which obscure other arrivals
- Long decay time (~1 hour)
- Typically appear only on LP channels

Shallow moonquakes:

- Occur in the upper 100 km of the Moon
- Are rare (only 28 detected over the whole experiment)
- Are large (magnitude 3-5 by some estimates)
- Appear on both LP and SP channels

Impacts:

- Artificial impacts strongly constrain shallow seismic structure (events of known location and origin time)

Thermal moonquakes:

- Small, "ping" events with impulsive onsets, associated with the lunar day/night transition
- A source of noise on all stations and channels

Recommended reading:

Lammlein, David R. et al. (1974). Lunar seismicity, structure, and tectonics. Reviews of Geophysics and Space Physics, 12(1). https://doi.org/10.1029/RG012i001p00001
- Instrument description and response
- Early interpretation of seismicity

Nakamura, Y. et al. (1982). Apollo Lunar Seismic Experiment - Final Summary. In: Lunar and Planetary Science Conference, 13th, Houston, TX, March 15-19, 1982, Proceedings. Part 1. (A83-15326 04-91), Washington, DC, American Geophysical Union, p. A117-A123. https://doi.org/10.1029/JB087iS01p0A117
- Description of signals
- Early deep moonquake locations
- Early velocity model
- Good schematic cutaway showing the lunar interior from a seismologist's viewpoint

Nakamura, Y. (1980). Shallow moonquakes: How they compare with earthquakes. In: Lunar and Planetary Science Conference, 11th, Houston, TX, March 17-21, 1980, Proceedings. Volume 3. (A82-22351 09-91) New York, Pergamon Press, 1980, p. 1847-1853.
- All about shallow events

Larose, E. et al. (2005). Lunar subsurface investigated from correlation of seismic noise. Geophys. Res. Lett., 32(L16201). https://doi.org/10.1029/2005GL023518
- Application of modern noise correlation techniques to extract the Rayleigh wave from geophone data

Dainty, Anton M. and Toksoz, M. Nafi (1981). Seismic codas on the Earth and the Moon: a comparison. Physics of the Earth and Planetary Interiors, 26(1981), 250-260. https://doi.org/10.1016/0031-9201(81)90029-7
- Diffusion and single scatterer models for lunar codas

Horvath, P. (1981). Correction of lunar seismograms for instrumental and near-surface effects and constrains on the velocity structure of the lunar interior. In: Lunar and Planetary Science Conference, 12th, Houston, TX, March 16-20, 1981, Proceedings. Section 1. (A82-31677 15-91) New York and Oxford, Pergamon Press, 1982, p. 867-889.
- Seismometer response, ground coupling, and near-surface scattering corrections