A new moonquake catalog from Apollo 17 geophone data

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Summary

1) The Apollo 17 Lunar Seismic Profiling Experiment (LSPE)* operated in ‘listening mode’ for ~250 days, yet this dataset has not been systematically analysed for moonquake events (Figure 1).

2) We created an event catalog using the Hidden Markov Model (HMM) automated detection technique (Figure 2).

3) We have made about 50,000 detections from 3 different event templates. The detections are periodic, and have different temporal characteristics depending on template type (Figure 3).

4) Hand-picked Apollo 17 events correlate well with ‘n1’ HMM events as well as the diurnal signal in the Apollo heat flow data (Figure 4).

5) We are looking for ways to use this dataset to better understand lunar surface processes such as regolith production.

Apollo 17 'listening mode' seismic data

Figure 1. Apollo 17 LSPE example data from geophone 1. Data were filtered, despiked, demeaned and detrended to provide a 'continuous' input dataset. Three different event type templates were extracted from the continuous dataset (d1, d2 and n1).

Automatic catalog creation using the Hidden Markov Model (HMM) technique

Figure 2. A 'target' event can be represented as a set of states and probabilities, which can be searched for in the full seismic volume to find other similar (though not necessarily identical) events and thus form a catalog. A) A continuous data stream is represented as a set of features (in red). B) Features for a given 'target' event (e.g. n1, d1, d2) change over time with respect to one another. C) Their evolution traces a unique path in n-dimensional feature space. D) The path is then modelled as a sequence of multidimensional PDF's.

Detections per hour for 250 days of Apollo 17 LPSE 'listening mode' data

Figure 3. Histograms showing the number of HMM catalog detections over 8-months of passive-mode Apollo 17 geophone data.

Hand-picked detections versus Apollo 17 heat flow data

Figure 4. Sunrise peaks in the heat flow data** align with the peaks of the hand-picked moonquake data. The hand-picked moonquake data mostly reflect 'n1' event detections, which are generally the highest amplitude.

*LSPE dataset courtesy of Yosio Nakamura. **Heat flow data are from Langseth et al. 1976, courtesy of Matthew Siegler and Richard S Miller.