Results from the Apollo 12 Passive Seismic Experiment

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ABSTRACT

Seismic signals from 208 natural events and from two man-made impacts have been recorded during the first 8 months of operation of the Apollo 12 seismic station. The natural seismic events are of internal origin (moonquakes) and external origin (meteoroid impacts). With few exceptions, moonquakes occur at monthly intervals near times of perigee. Thus, they appear to be induced by tidal stress. From the uniform polarity of the signals, the presence of tectonic strain within the outer shell of the moon is inferred. The moonquakes can be separated into ten sets of matching signals, implying the presence of at least ten active zones in the region of the Apollo 12 station. All of the moonquakes are small (less than magnitude 2 on the Richter scale). Total annual seismic energy release for the moon, assuming that the Apollo 12 region is representative of the entire moon, is approximately $3 \cdot 10^{24}$ ergs/year). The low level of detectable seismic activity, the presence of mascons, and the lack of visual evidence of relative lateral movement of lunar surface blocks, suggests that the outer shell of the moon is quite rigid and tectonically stable compared to the earth.

Both natural events and man-made impacts produce complex signals of long duration. These characteristics can be explained as resulting from scattering of surface waves in the outer few km of the mare. Absorption of seismic energy in this material is extremely low compared to typical earth crustal materials. The distribution of craters in the mare is sufficient to explain the observed scattering without recourse to other forms of heterogeneity.

The travel times of seismic waves from the man-made impacts are in approximate agreement with those derived from laboratory measurements on returned lunar samples. This suggests that the mare consists of material mechanically indistinguishable from the surface samples to depths of at least 15 to 20 kilometers. No major discontinuity equivalent to the Mohorovicic discontinuity which defines the base of the crust on earth, can exist in the upper 20 kilometers of the mare.

Meteoroid flux in the kilogram mass range is in approximate agreement with Hawkins' flux estimate, $\log N = -0.73 - \log m$ gm $km^{-2} yr^{-1}$, where N is the cumulative number of impacts with mass equal to or larger than m.