TITLE: Further constraints and uncertainties on the deep seismic structure of the Moon

CURRENT SECTION/FOCUS GROUP: Seismology (S)
CURRENT SESSION: S04. Advances in Extraterrestrial Seismology

Pei-Ying Patty Lin1, Renee C Weber2, Ed J Garnero1, Nicholas C Schmerr3

1. School of Earth and Space Exploration, Arizona State University, TEMPE, AZ, United States.
2. NASA Marshall Space Flight Center, Huntsville, AL, United States.
3. NASA Goddard Space Flight Center, Greenbelt, MD, United States.

The Apollo Passive Seismic Experiment (APSE) consisted of four 3-component seismometers deployed between 1969 and 1972, that continuously recorded lunar ground motion until late 1977. The APSE data provide a unique opportunity for investigating the interior of a planet other than Earth, generating the most direct constraints on the elastic structure, and hence the thermal and compositional evolution of the Moon. Owing to the lack of far side moonquakes, past seismic models of the lunar interior were unable to constrain the lowermost 500 km of the interior. Recently, array methodologies aimed at detecting deep lunar seismic reflections found evidence for a lunar core, providing an elastic model of the deepest lunar interior consistent with geodetic parameters (Weber et al., 2011 and Garcia et al., 2011). Here we study the uncertainties in these models associated with the double array stacking of deep moonquakes for imaging deep reflectors in the Moon. We investigate the dependency of the array stacking results on a suite of parameters, including amplitude normalization assumptions, polarization filters, assumed velocity structure, and seismic phases that interfere with our desired target phases. These efforts are facilitated by the generation of synthetic seismograms at high frequencies (~ 1Hz), allowing us to directly study the trade-offs between different parameters. We also investigate expected amplitudes of deep reflections relative to direct P and S arrivals, including predictions from arbitrarily oriented focal mechanisms in our synthetics. Results from separate versus combined station stacking help to establish the robustness of stacks. Synthetics for every path geometry of data were processed identically to that done with data. Different experiments were aimed at examining various processing assumptions, such as adding random noise to synthetics and mixing 3 components to some degree. The principal stacked energy peaks put forth in recent work (e.g., Weber et al., 2011) persist, but their amplitude (which maps into reflector impedance contrast) and timing (which maps into reflector depth) depend on factors that are not well constrained – most notably, the velocity structure of the overlying lunar interior. Thus, while evidence for the lunar core remains strong, the depths of imaged reflectors have associated uncertainties that will require new seismic data and observations to constrain. These results strongly advocate further investigations on the Moon to better resolve the interior (e.g., Selene missions), for the Moon apparently has a rich history of construction and evolution that is inextricably tied to that of Earth.

References:

1.Garcia, R.F., Gagnepain-Beyneix, J., Chevrot, S. & Lognonné, P. Very preliminary reference Moon model. Physics of the Earth and Planetary Interiors (2011).doi:10.1016/j.pepi.2011.06.015
2.Weber, R.C., Lin, P.-Y., Garnero, E.J., Williams, Q. & Lognonné, P. Seismic detection of the lunar core. Science (New York, N.Y.) 331, 309-12 (2011).