Systematic study of S-wave motions from deep moonquakes

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Based on the study of the S-wave motions with a technique of deconvolution between the east-west and north-south components of the Apollo long-period seismic data, Vinnik et al. (2001) suggested that at the station AP12, the S wave motions from any of the 13 source groups of deep moonquakes are nearly parallel to the north-south direction. The uniform polarization of the S waves may imply that some local structure under the station biases the S-wave motions. The study of Vinnik et al. (2001) is, however, not complete because they did not examine the source group A1 including the largest number of deep moonquakes. In this study, we reexamined the S-wave motions recorded at the four Apollo stations for several source groups of deep moonquakes, using various methods including deconvolution.

The data used in this study are the long-period records in the special event tape (Nakamura, 1982) of the Apollo missions. Since direct S waves from deep moonquakes incident nearly vertically to the stations, we expect they predominantly oscillate along the horizontal plane. The arrival times of those S waves were determined by exploring the time when the motions along the horizontal plane became much more significant than those in the vertical direction, also considering eye-measurement and difference of the arrival times between the stations in a traditional manner (Nakamura, 1983). Exploring the time was done by calculating the covariance matrixes for three components of seismograms and obtaining the eigenvalues and eigenvectors as the functions of time (Matsumura, 1981). This procedure was not applied to the data recorded at the station AP14 in lack of the vertical component.

We examined the orientations of the S-wave motions in the three methods with (1) deconvolution between the east-west and north-south components, (2) direct observation of particle motions just after the S wave arrivals, and (3) calculation of covariance matrixes, respectively. The results from the three methods agree with each other, showing that the S-wave motions at the station AP12 varied from source group to group. We did not always see that the S wave motions were nearly parallel to the north-south direction. The S wave motions from the source group A1 were parallel to the directions between about 5 and 45 degrees measured clockwise from the east, while those from the source group A14, which is located near the source group A1, were in a range between about 70 and 85 degrees. Our results are consistent with the observations in the amplitude ratios of the unprocessed waveforms and spectrum. The S wave motions recorded at the other three stations also varied from source group to group. Therefore, we suggest that the S-wave motions recorded at the four Apollo seismic stations are not notably biased around the stations.

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