Seismic Array Observation by ACROSS

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We are developing an active seismic monitoring methodology (ACROSS) to detect any small change of physical characteristics of the Earth's interiors, particularly in the earthquake-generating zones. To deal with this problem we have been developing technology as a system consisting of all the components: signal transmission, observations, analyses and so on. Our target is to maximize S/N (ratio of signal (information) to noise) and S/B (ratio of signal to bias). In this paper we review our seismic array observation system by ACROSS and its specifications, and report the latest result of array observation made towards our target.

Generally speaking, any observation data include noise and bias from various sources not only in time but also in space. The ACROSS is the best way to reduce the observation noise in time and the array, either of signal sources or signal receivers, is the best way to reduce the observation noise in space due to the heterogeneous subsurface layers and the different conditions of receiver sites in addition to acquirement of aperture with larger solid angle. The combination of ACROSS and array, or ACROSS array, allows us to obtain the data with high S/N and S/B with more than 10^3 easily by data-stacking in time domain and also in space domain and also by careful managements on all the technology components involved in the observation systems. As a consequence, we could achieve an overall reliability up to 10^3.

Next, we introduce a seismic array observation conducted in Mizunami since 2003, and show the latest results of analyses of transfer functions which reflect the characteristics of the structures in this area between the source (transmitter) and receiver. We installed 36 moving-coil type 3 component seismometers below the surface with a spacing of 5 m in the area of 25 m by 25 m. All the data were recorded at the sampling rate of 1 kHz referring to a GPS clock. We can obtain a transfer function between the source and the receiver by following three steps: (1) Evaluating a single force (N) as source characteristics from the measurement of the rotary motion of ACROSS transmitter. (2) Correcting/calibrating any biases of instruments on the observed data, converting the physical unit to displacement (m) and separating ACROSS signals and their noise. (3) Representing the transfer functions together with the estimated level of their error. Since the present ACROSS transmitter generates a rotating single force in a horizontal plane with alternation of clockwise and anti-clockwise rotations, and also the received signals are recorded as a vector (displacement or velocity) at one sensor, we have 6 components of tensor transfer function at each discrete frequency. We could obtain the good quality data with S/N ratio of 10^2 by a 1-hour stacked data and more than 10^3 by 600-hours. The data obtained so far are subjected to the SOMPI event analysis (SEA) and also to a beam-forming frequency-wavenumber analysis (FKA). We analyzed the transfer function corresponding to the vibrating modes of P, SV and SH waves. Several arrivals were resolved within the time window of 0.6 to 1.5 sec by SEA whereas a dominant peak on the F-K plot in a time window of 0 to 2 sec at the frequencies of 18.57 Hz and 20.57 Hz had lead to one dominant peak indicating an apparent slowness of 0.005 s/m. We have recognized that the propagating direction, amplitude and an apparent slowness vary with frequency range, surely due to the small-scale heterogeneities of subsurface. This effect revealed by the ACROSS array observation provides us with a new source of information on the underground structures, if the effect can be decoded by some means.

Consequently we came to face with the important and challenging problems: (1) optimum designing of ACROSS array to acquire the better data and (2) development of new theoretical method of analyzing the newly acquired type of data as above.