A beam forming experiment of airgun array energy to acquire PS converted phase

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Seismic experiments with airguns, which are useful to understand the crustal structure, have been conducted many times these days. Multi-channel seismic reflection (MCS) using multi-channel hydrophone streamer is an effective method to figure out highly resolved geological structures. The MCS method is usually use a seismic vessel for airgun shooting and signal recording simultaneously. Generally, airgun reflection signals arrive the hydrophone streamer cable from reflection points almost under the vessel and have near vertical incident angles. This means that target depth of MCS surveys are limited in shallow depth less than 15 km, because of difficulty in velocity estimation by using reflections with near vertical incident angles.

Two-ship method is valid for the survey to reveal deeper target depth. The method uses two vessels for airgun shooting and signal recording individually, and enables us to record larger offset reflection phases. In this case, target depth is assumed as deep as 30 km. Amplitude of large offset signal decreases due to spherical divergence. As one of the trials to recover the amplitude decrease by the spherical divergence, we report here an MCS experiment using focused seismic energy source by beam-formed airgun-array.

Airgun-array generates P-wave signals only because of water, whereas S-wave signals are converted from P-wave at structural boundary. Acquiring PS converted waves are important to reveal the S-wave velocity structure, which is associated with physical property such as poisson's ratio. However, it is difficult to receive the PS converted waves in usual MCS survey, because the PS converted waves reflect back in larger offset than that of P-wave signals. To record the PS converted waves, two-ship method and wide-angle reflection survey with ocean bottom seismometers (OBS) or ocean bottom cable (OBC) are suitable.

In the viewpoint mentioned above, a beam forming experiment of airgun-array energy was conducted off Boso region in the Japan Trench in June 2001. R/V Kairei of Japan Marine Science and Technology Center (JAMSTEC) was used as a seismic vessel. Kairei has a 12000 cu. in. airgun array, composed by eight 1500 cu. in. airguns. Usually, the eight airguns are shooting simultaneously and resultant seismic waves travel just below the airguns with maximum energy. To change the beam direction of airgun shooting energy, towing way of airguns and shooting time of each airgun were changed. Four pairs of two airguns were towed in every 24-m interval. Each pair of airguns shot with beam delay, which was delay time from 0 to 14 milliseconds. Fifty shots were recorded in every beam delay. Whereas large amplitude of seafloor reflection was recorded by near traces in small beam delay, large amplitude was recorded by far traces in large beam delay. This means that the beam direction of airgun shooting energy is enable to change from just below the vessel to backward. In the next two-ship seismic survey in this summer, we are planning tol conduct the beam direction change and aim to acquire PS converted waves.