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Semi-permanent continuous monitoring of a focal region along an interplate boundary by seismic ACROSS & multi-receivers

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We are showing a preliminary result of a trial for detecting a time-variant earthquake focal region along an interplate boundary by means of a new imaging method through a numerical simulation.

Remarkable seismic reflections from the interplate boundaries of a subducting oceanic plate have been observed in Japan Trench (Fujie {¥i}et al{¥i}., 2002; Mochizuki {¥i}et al{¥i}., 2005) and in Nankai Trough (Iidaka {¥i}et al{¥i}., 2002). Those strong seismic reflections existing in the current aseismic zones suggest the existence of fluid along the subduction boundary, and it is considered that they closely relate to a future huge earthquake. Seismic ACROSS is the time-lapse measurement technology to monitor the changes of transfer function along the propagating ray paths, by transmitting an accurately-controlled steady continuous signal and repeatedly receiving the steady continuous signals (Kumazawa {¥i}et al{¥i}., 2000). If physical state in a focal region along the interplate was changed enough in the time and space, for instance, by increasing or decreasing the fluid flow, we could detect some differences of amplitude and/or travel-time of the particular reflection phases from the time-variant target zone.

In this study, we first investigated the seismic characteristics of seismograms and their differences before and after the change of a target zone through a numerical simulation. Then, as one of the trials, we attempted to make an image of such time-variant target zone by applying a finite-difference back-propagation technique in the time and space to the differences of waveforms (Kasahara {¥i}et al{¥i}., 2010).

We here used a 2-D seismic velocity model in the central Japan (Tsuruga {¥i}et al{¥i}., 2005), assuming a time-variant target zone with a 200-m thickness along a subducting Philippine Sea plate at 30 km in depth. Virtual seismic sources were located at the surface assuming the position of the ACROSS sources around Hamana lake, Shizuoka, and at Toki city, Gifu. Vertical and horizontal seismograms were calculated at a 500-m interval in 260-km long by using FDM software (Larsen, 2000). We assumed that P- and S-wave velocities ({¥i}V{¥i}p and {¥i}V{¥i}s) in the target zone decreased about 30 % during the change ({¥i}e.g.{¥i}, {¥i}V{¥i}p=3.5 km/s to 2.5 km/s) by an effect of fluid flow. Remarkable P-to-P reflections from the plate boundary were observed at the epicentral distance around 25- 60 km and at the travel time around 10 - 13 sec from the virtual Toki source. After applying the new imaging method to the differences between both seismograms at each receiver, it is clear that the remarkable signals related with the target change were focused around the target zone during a particular back-propagation time. In case the velocity decreases by a 10 % in the surface layer (from {¥i}V{¥i}p=3.5-4.5 to 3.15-4.05 km/s) possibly due to rain falls and/or seasonal variation, the target waveform-differences were mostly focused near the surface layer but some of them expanded downwards. However, since the target reflection phases from the plate boundary are observed in a limited offset-distance region, it is possible to distinguish between the effects of the change in the surface layer and the effects of the change in the deep target zone by using these limited seismic records.

As a preliminary result, it is still not easy to identify exactly the geometry of the target zone and the velocity change distribution. However, we can conclude that it is almost possible to decide the location of the target zone by means of an optimized receiver array together with the seismic source which can transmit the accurate and steady signals repeatedly like ACROSS even if we use a single source.

Keywords: ACROSS, continuous active monitoring, interplate boundary, time lapse, back-propagation time reversal