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Vibration structure and radiation waves of active fault
活断層の振動構造と放射波

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1 Introduction

Elucidation of earthquake source structure is important from the viewpoint of disaster prevention and earthquake prediction. We have elucidated the vibration structure of an epicenter based on acoustic knowledge[2-7]. First, the dynamic model of source radiation from the source to the main observation point has proposed based on source radiation data. In geological exploration, a sound source is usually placed above a fault, such as the ground or the sea. However, the source of earthquake vibration exists inside the fault. When the position of a signal source changes from the top to the inside of the fault, the propagation phenomena changes greatly. In this paper, we clarify the relationship between the structure of the duct and the radiation pulses.

2. Propagation in duct

2.1 Lateral wave

A part of the sound wave that enters the boundary between two media at a critical angle propagates as a lateral wave on the boundary. The lateral wave at far distance from a sound source is given by [1)],

$$p_\ell = 2\mathrm{i}n\exp\left[\mathrm{i}k\left(L_1+L_2+nL\right)\right]\left[km\left(1-n^2\right)r^{1/2}L^{3/2}\right]^{-1} \quad (1)$$

where $|SC| = L_1$, $|DP| = L_2$, $|CD| = L$,
$R_1 \equiv \left[(z+z_0)^2 + r^2\right]^{1/2}$, $n = \rho_1/\rho_2$, $m = c_1/c_2$
$|kR_1| \approx 1$.

See Ref.1, 7 for more details.

2.2 Processing methods and results

Figure 1 shows the schematic diagram of the duct structure that models an active fault. Constituent factors of the duct that contribute to the radiation waves from the duct are a gap and an internal velocity distribution. As shown in the figure on the left, velocity distribution used for the study are a flat type and a V-shaped type.

A sound source installed at the left end of the duct is excited by a single periodic pulse of 6 Hz. The single periodic pulse excites the lateral waves on the upper and lower boundary of the duct. The radiated waves from the duct are the combination of the above two lateral waves. Lateral waves depend on the speed of two media forming a boundary.

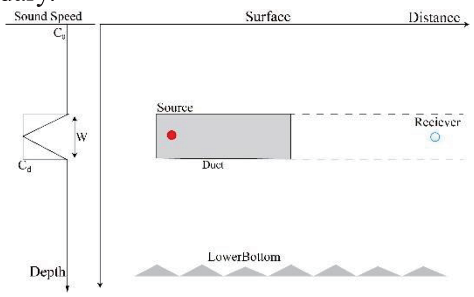

Fig.1 Schematic diagram of an active fault model.

However, the formation mechanism of the lateral wave that occurs on the boundary with the V-shaped velocity distribution is not known. Therefore, we investigate the generation of lateral waves as a function of the duct structure while keeping the speed of the surrounding medium constant. The velocity structure of the verified duct is flat type and V-shaped type as shown on the left of Fig.1. **Figure 2** shows the radiated wave when the speed Cd in the duct is changed in the flat duct with the gap of 400 m. The reception depth is 20 km, the same as the sound source depth, and the horizontal distance from the sound source is 40 km. The PE method was used for this treatment. The speeds Cd in each figure are 5400, 4400, 3000 m/s from the upper figure.

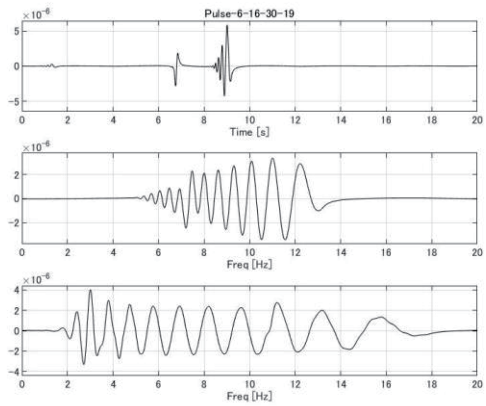

Fig.2 Radiation waves from the duct corresponding to the flat velocity structure shown in Fig.1. upper: Cd:5400, middle: Cd:4400, bottom: Cd:3000 m/s.

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In the upper figure, the speed difference with the peripheral speed of 6000 m/s is slight. This figure shows that the interference between the two lateral waves is small. These interference waves increase as the Cd decreases. As shown in the bottom figure, when the speed difference to the surrounding medium is large, pulse stretching and large dispersion occur.

Next, using a V-shaped velocity type that is closer to an actual active fault structure, we verify the radiation of a duct with a finite-length. First, the effect of the termination of the duct is examined. **Figure 3** shows the received waveforms before and after the termination of the 20 km long duct with the V-shaped velocity structure with the gap of 440 m and the Cd is 3000 m/s. This sudden waveform change occurs because the two lateral waves are forcibly combined at the termination. On the other hand, a part of the lateral waves is reflected to the sound source direction at the terminal boundary.

Figure 4 shows a group of pulses received at the distance of 40 km from a sound source using the duct with the gap of 350 m, the duct bottom speed of 3000 m/s, and the length of 11 km. The pulse A is the pulse that has passed through the termination boundary. The pulse B is the pulse reflected from the ground surface. The shape is the same as the excitation pulse. The pulse C is the pulse reflected at the terminal boundary and the sound source boundary. Since the pulse C propagates back and forth in the duct, it is affected by the duct structure. Therefore, grasping the characteristics of the pulse C leads to grasping the structure of the duct.

Figure 5 shows the change in the amplitude of the pulse C with respect to the gap change using the duct with the bottom speed of 3000 m/s and the length of 10 km. As is clear from the figure, it can see that waves are trapped in the duct over a wide range of the gap from 120 m to 900 m.

Summary

We analyzed the radiation structure from an active fault with a sound source inside. Two lateral waves propagating along the boundary propagate to a long distance while gently interfering with each other. On the other hand, the termination of the duct forces two lateral waves to interfere. As a result, the radiated wave from the duct is a function of the gap and length of the duct.

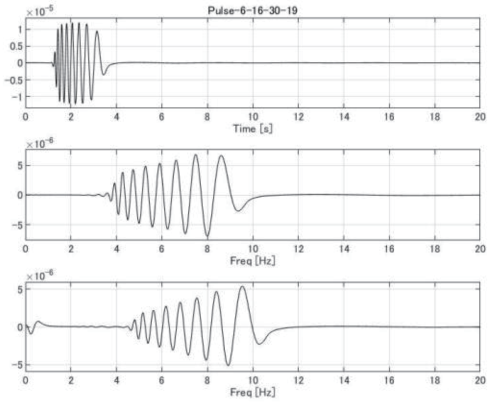

Fig.3 Waveforms received before and after the termination of 20 km. Upper:19 km, Middle;21 km, Bottom: 23km.

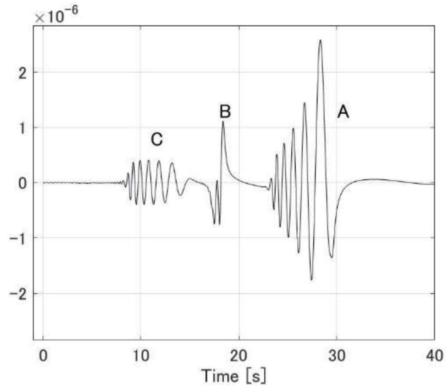

Fig.4 Pulses received at the distance of 40 km from a sound source using the duct with the gap of 350 m, the duct bottom speed of 3000 m/s, and the length of 11 km. A: direct pulse, B: Surface reflected pulse, C: Trapped pulse in the duct.

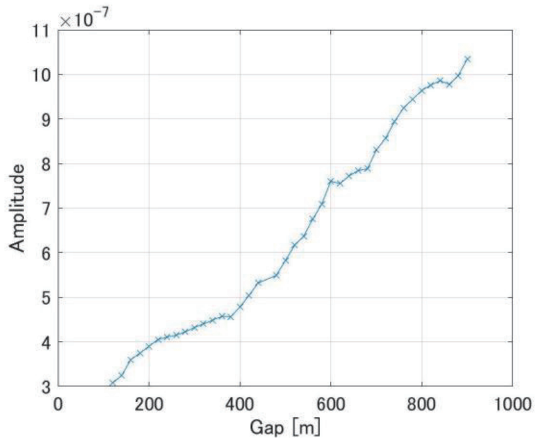

Fig.5 The change in the amplitude of pulse C with respect to the Gap change using the duct with the bottom speed of 3000 m/s and the length of 10 km.

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