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Internal vibration of active faults and lateral pulse generation mechanism
活断層の内部振動とラテラルパルスの発生機構

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1. Introduction

The radiation mechanism from an underground duct that models an active fault is described. Lateral waves propagating the boundary between two media have long been known. However, the behavior of duct structures with two close boundaries is unknown. First, a sound source is placed in a layered structure duct with the upper and lower boundaries sufficiently separated, and the lateral waves are generated on the upper and lower boundaries. Next, the two boundaries are gradually brought closer. Meanwhile, the behavior of the two lateral waves is investigated. As a result, it was found that two lateral waves coexist even in a duct sufficiently thinner than a wavelength and propagate while interfering with each other. As a result of their interference, the narrow ducts radiate impact and sustained pulses. These pulses vary with the width and length of the duct. Here, the change in the radiation pulse due to the increase in peripheral pressure when strain is applied around the duct is shown. Such duct propagation phenomenon is important for elucidating ground penetrating radar and seismic structure.

2. Propagation in duct
2.1 Lateral wave

It is known that a part of sound waves incident on a boundary where two mediums are in contact at a critical angle propagates as a lateral wave. The lateral wave at far distance from a sound source is given by [1)],

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

where $|SC| = L_1$, $|DP| = L_2$, $|CD| = L$,

$$R_1 \equiv \left[\left(z+z_0\right)^2+r^2\right]^{1/2}, \quad n=\rho_1/\rho_2, \quad m=c_1/c_2$$

On the other hand, the width of the active fault is not larger than the wavelength of propagating waves, and the adaptation condition is $|kR_1| \approx 1$.

That is, Application of Eq. (1) to the vibration analysis of the active fault is difficult.

2.2 Lateral waves in a duct

For active faults, it is necessary to consider the lateral waves on the two boundaries that approach each other. Therefore, we investigate how lateral waves are generated and propagated in so-called duct structures where two boundaries are adjacent. A sound source is

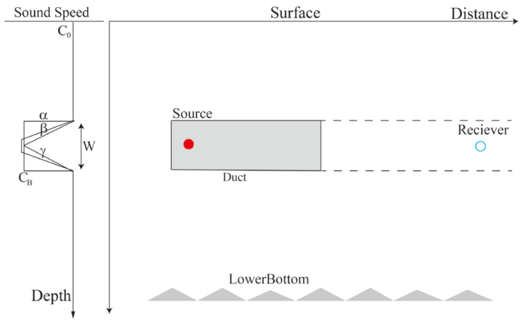

Fig.1 Schematic diagram of a duct model

located near the lower boundary, and the upper boundary is well away from the lower boundary. Next, the depth of the lower boundary and the sound source fix to 21km and 20km, respectively, and the depth of the upper boundary is changed gradually. The wave emitted from the sound source is a single pulse of 6Hz, 1 cycle. The parabolic equation method is used for the calculation.

The depth of the observation point is fixed at 20 km, which is the same as the depth of the

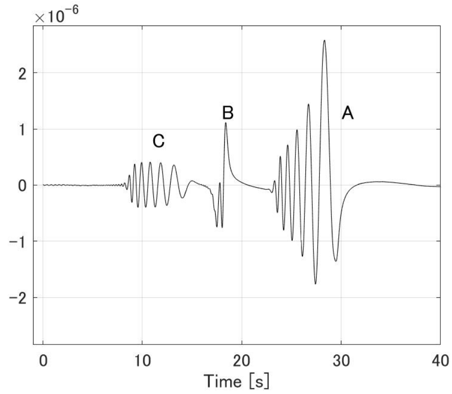

Fig.2 A group of pulses received at the distance of 40 km with respect to the pulses radiated from the duct model.

sound source, and the received waveform is observed with respect to the horizontal distance from the sound source. When the depth of the upper boundary is 9 km, the received waveform at a horizontal distance of 50 km is obtained.

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Figure shows pulses that move separately on the path of the upper and lower boundaries. (See Ref.2 Fig.3)

The above procedure is repeated further to examine propagation in ducts with narrower widths. As a result, the two lateral waves coexist while interfering with each other even in a duct with a very narrow width. Based on the result, the duct model shown in **Fig.1** was formed. The emission of the pulse from the obtained narrow duct is shown below.

The depth of the active fault is 20km, the width is 440m and the length is 20km. The epicenter is applied to the left end of the active fault. **Figure** 2 shows the waveform observed at the receiving point at the horizontal distance of 40 km from the epicenter. Pulse A is a pulse that has passed the end of the duct. Pulse B is a pulse reflected at the surface of the earth. Its shape is the same as the vibration pulse. Pulse C is a pulse reflected at the terminal boundary and the sound source boundary. Since this pulse C propagates back and forth in the duct, it is affected by the structure of the duct. Therefore, understanding the characteristics of pulse C leads to understanding the structure of the duct.

2.3 Impact of ambient pressure

Lateral waves are a function of boundary velocity. The increase in strain on a crust leads to an increase in the velocity of the peripheral medium. It is considered that the pulse radiated from the active fault changes accordingly. **Figure** 3 shows the change in the pulse C with the sound velocity of the peripheral medium as a parameter. The highest pulse has a peripheral medium velocity of 6000 m/s. The following pulses are pulses when the speed is increased by 100 m/s, and the bottom figure is the pulse for the speed of 7000 m/s. There was a difference of about 1.3 seconds between the top and bottom pulses, but the waveform also changed. Therefore, the power spectrum of each pulse is taken and shown in **Fig.4**. Each spectrum corresponds to the velocity of the ambient medium as in Fig.3. The results show that the pulse velocity increases and the power spectrum changes as the velocity around the duct increases. These are considered to change depending on the structure of the active fault [4].

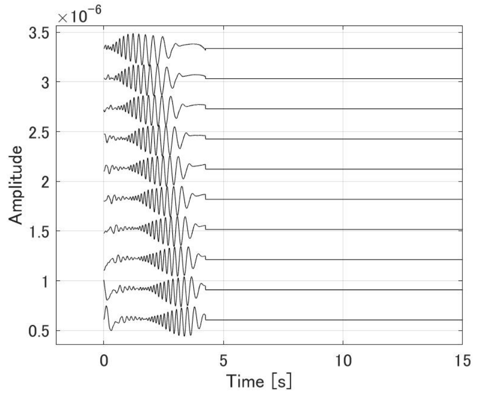

Fig.3 Changes due to ambient sound velocity with respect to pulse C in Fig. 2.
Top pulse: For ambient velocity of 6000 m/s.
Bottom pulse: For ambient velocity of 7000 m/s.

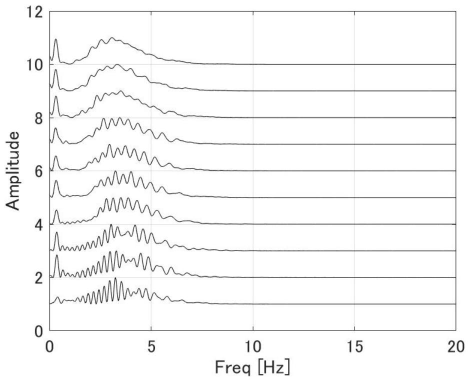

Fig.4 Power spectrum Changes for pulses in Fig. 3.
Top pulse: For ambient velocity of 6000 m/s.
Bottom pulse: For ambient velocity of 7000 m/s.

3. Summary

We simulated the occurrence and propagation of the lateral waves in the duct structure modeling active faults. As a function of the width of the duct, the generation and propagation of the pulse was investigated. As a result, even if the duct width is smaller than the wavelength, the lateral waves are generated on the two boundaries, and it was clarified that they propagate together while interfering. These are important results for propagation of shock waves in the active faults. When strain accumulates in the crust around the active fault and the stress increases accordingly, the velocity of the pulse generated inside the active fault increases and the waveform changes. These are important results for the observation of the active faults.

References

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