

Change in Rayleigh wave phase velocity due to decrease of P -wave velocity before an earthquake

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ABSTRACT. 20 per cent decrease of P -wave velocity has often been noted by many workers before an earthquake. Change in Rayleigh wave phase velocity due to such a decrease is studied so as to note the possibility of using the phase velocity change as one of the methods to predict earthquake. For this purpose theoretical phase velocity and its change due to the decrease of P -wave velocity have been obtained for a two-layered crustal model over a homogeneous mantle. 20 per cent decrease of P -wave velocity in the first layer gives a decrease of phase velocity by 4 per cent over a wide range of period with a maximum decrease of 4.8 per cent. While 20 per cent decrease of P -wave velocity in the both first and second layers of the crust gives a phase velocity decrease of 5 per cent over a wide range of period with a maximum decrease of 7.0 per cent.

Decrease of P -wave velocity in a region before an earthquake is wellknown now. Kondrotenko and Nersesov (1962) from travel time curves noted that P -wave velocity was 5.3 km/s before a strong earthquake and became 6.3 km/s after the earthquake. Whitcomb *et al.* (1973) noted decrease of P -wave velocity by 20 per cent about 11,000 days prior to the 1971 San Fernando earthquake. Stewart (1973) observed a 20 per cent decrease of P -wave velocity 380 days prior to the 1973 Pt. Mugu earthquake, California. This decrease by 18 per cent was also observed by Feng *et al.* (1974) about 300 days prior to the 1970 Sich earthquake in China. In the present work we note theoretical change in Rayleigh wave phase velocity due to such a decrease of P wave velocity in the crust and thus investigate the possibility of using the phase velocity change as one of the methods to predict earthquakes.

It is known that phase velocity of Rayleigh waves decreases with decrease of P -wave velocity of the medium. To note the exact nature of such a decrease due to decrease of P -wave velocity prior to an earthquake we consider a two-layered crust over a homogeneous mantle (half space) as shown in Table 1 (model IP-O). There, α denotes P -wave velocity, β denotes S -wave velocity, ρ denotes density and d denotes thickness of a layer; H is the total thickness of the first two layers; suffix 3 denotes the corresponding quantities in the third layer (half space). The model IP-O is same as IP-I obtained earlier (Bhattacharya 1971) but with dimensionless parameters.

Using the partial derivatives of phase velocity with respect to the P -wave velocity for the model

IP-O the percentage of phase velocity decrease due to 20 per cent decrease of P -wave velocity in the crust has been noted. In Fig. 1 phase velocity of Rayleigh waves for the model IP-O has been shown. Fig. 2 shows the phase velocity changes in per cent due to 20 per cent changes of P -wave velocity in the first layer of the crust as well as due to 20 per cent changes of P -wave velocity in both first and second layers of the crust in the model IP-O. In Fig. 2, T denotes period.

If we consider the P -wave velocity change only in the first layer we note that phase velocity changes by more than 4 per cent over a wide range from $T\beta_3/H = 0.7$ to 2.8; taking $\beta_3 = 4.73$ km/s and $H = 41$ km this is approximately phase velocity change of 0.14 km/s over a period range 6 to 24 sec. The maximum phase velocity change is 4.8 per cent at $T\beta_3/H = 1.3$. It may be seen that thickness of the first layer is only 0.305 part of total crustal thickness; obviously the phase velocity change will increase with increase of thickness of the first layer.

Considering P -wave velocity changes both in first and second layers of the crust Fig. 2 shows that phase velocity changes by more than 5 per cent over a period range $T\beta_3/H = 1.2$ to 5.5. With earlier mentioned values of β_3 and H this is approximately a phase velocity change of 0.18 km/s over a period range 11 to 48 sec. Maximum phase velocity change is 7.0 per cent at $T\beta_3/H = 3.0$.

Tolet and Panza (1976) have shown that error in phase velocity due to data processing method is of the order of 1 per cent with realistic number of array stations. Thus the decrease of phase velocity can be used to predict an earthquake.

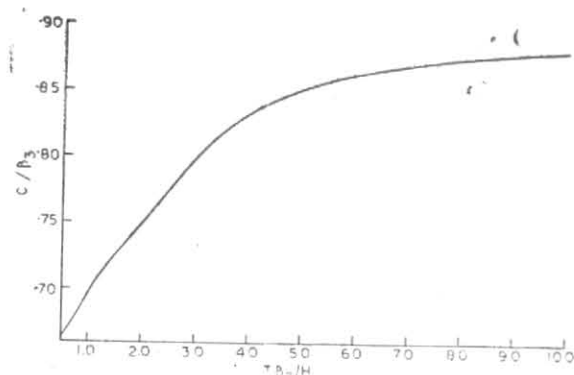


Fig. 1. Phase velocity (c) of Rayleigh waves for the model IP-O (Table 1)

TABLE 1
Model IP-O

d/H	α/β_3	β/β_3	ρ/ρ_3
0.305	1.199	0.723	0.818
0.695	1.362	0.825	0.912
∞	1.742	1.000	1.000

The decrease of S -wave velocity is also known to precede an earthquake. Although the decrease is smaller than P -wave velocity, but partial derivative of phase velocity with respect to S -wave velocity is much larger than that with respect to P -wave velocity. Hence a small change in S -wave velocity will also significantly affect the phase velocity. Thus prior to an earthquake in addition

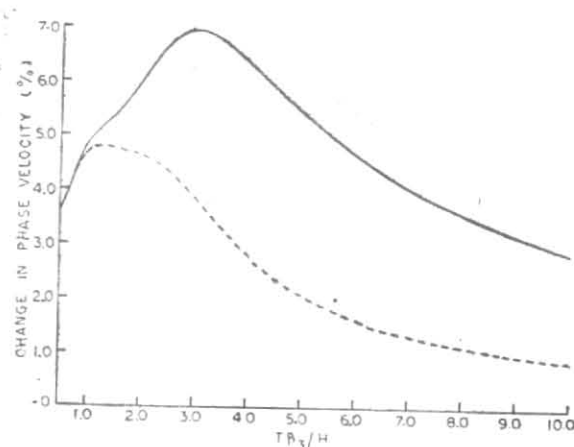


Fig. 2. Change in phase velocity due to 20 per cent change in P -wave velocity in the first layer (dashed curve) and in the both first and second layers (solid curve) of the model IP-O.

to P -wave velocity decrease if we also consider a small decrease in S -wave velocity the change in phase velocity will be more than shown in Fig. 2.

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