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TRAVEL TIMES FOR A CRUSTAL MODEL IN FINLAND

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In this paper some travel time combinations have been calculated for refracted, converted refracted and reflected converted refracted waves for a crustal model consisting of two parallel homogeneous isotropic layers overlying a homogeneous isotropic half space.

The model used is based upon explosion studies made in Finland during the years 1959—1961 by Vesanen and Penttilä (VESANEN *et al.*, [2]). In Table 1, H_1 and H_2 are the thicknesses of the first and second layers, and v_{P1}, v_{S1}, v_{P2}, v_{S2}, v_{P3}, and v_{S3} are the velocities of longitudinal and transverse waves in the first and second layers and in the half space.

In travel time calculations ray theory approximations have been used which are equivalent to normal mode theory solutions (JEANS, [1]). Ray theory is valid with the following assumptions:

1. Seismic waves are propagated from a point source in a homogeneous isotropic half space in the direction normal to the wave front.
2. Fermat's principle of stationary time applies.

Table 1.

$H_1 = 20$ km	$v_{P1} = 6.10$ km/sec	$v_{S1} = 3.50$ km/sec
$H_2 = 13$ km	$v_{P2} = 6.65$ km/sec	$v_{S2} = 3.75$ km/sec
	$v_{P3} = 8.20$ km/sec	$v_{S3} = 4.60$ km/sec

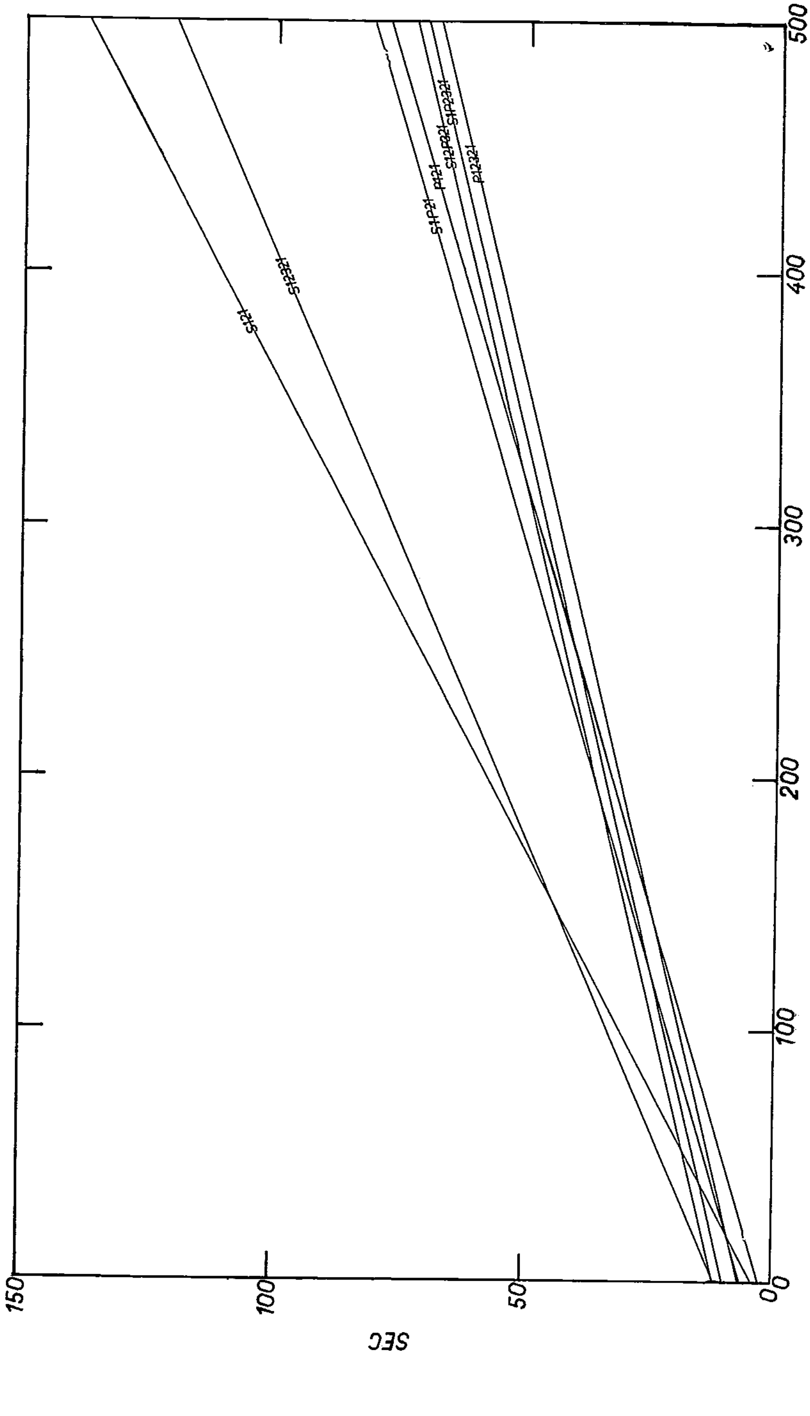
S121
S12321
S1P21
P121
S12P321
S1P2321
P12321
KM
SEC
0
100
200
300
400
500
0
50
100
150

Fig. 1a.

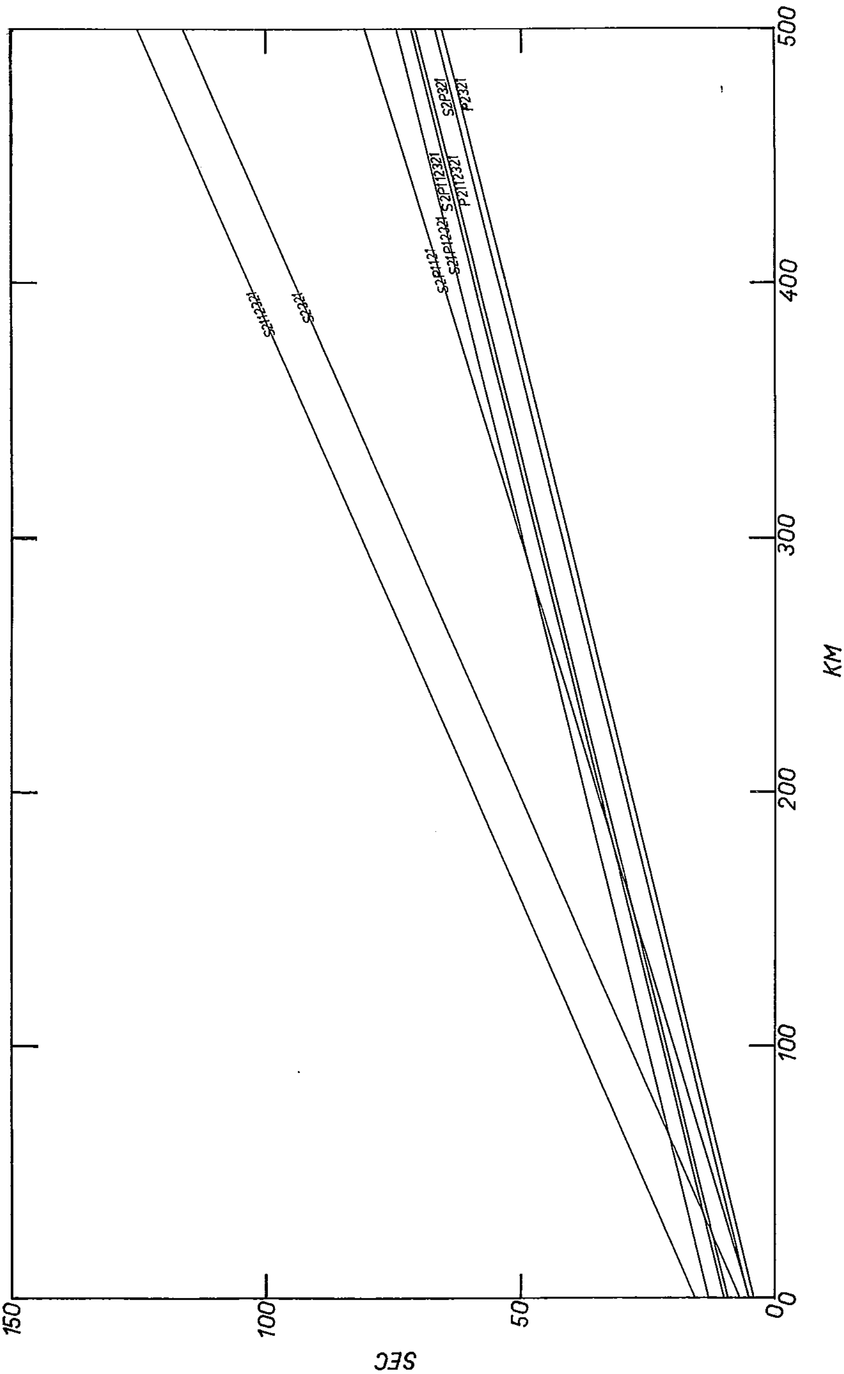
S2P321
P2321
S2P112321
P2112321
S2P1121
S21P12321
S2112321
S2321
0
100
200
300
400
500
KM
0
50
100
150
SEC

Fig. 1b.

For the above model we can use the even more simple Snell's law, $\sin \Theta_i = \frac{v_i}{v}$, where Θ_i is the angle of incidence at the i:th boundary, v_i is the velocity of the P-wave (or S-wave) and v is the velocity of the head wave. Making use of Snell's law and considering the geometrical paths, we can get for the different refraction arrivals the linear form (1)

$$t - t_0 = \tau + \frac{\triangle}{v}, \tag{1}$$

where

t is the arrival time of a wave at a station
t_0 is the origin time

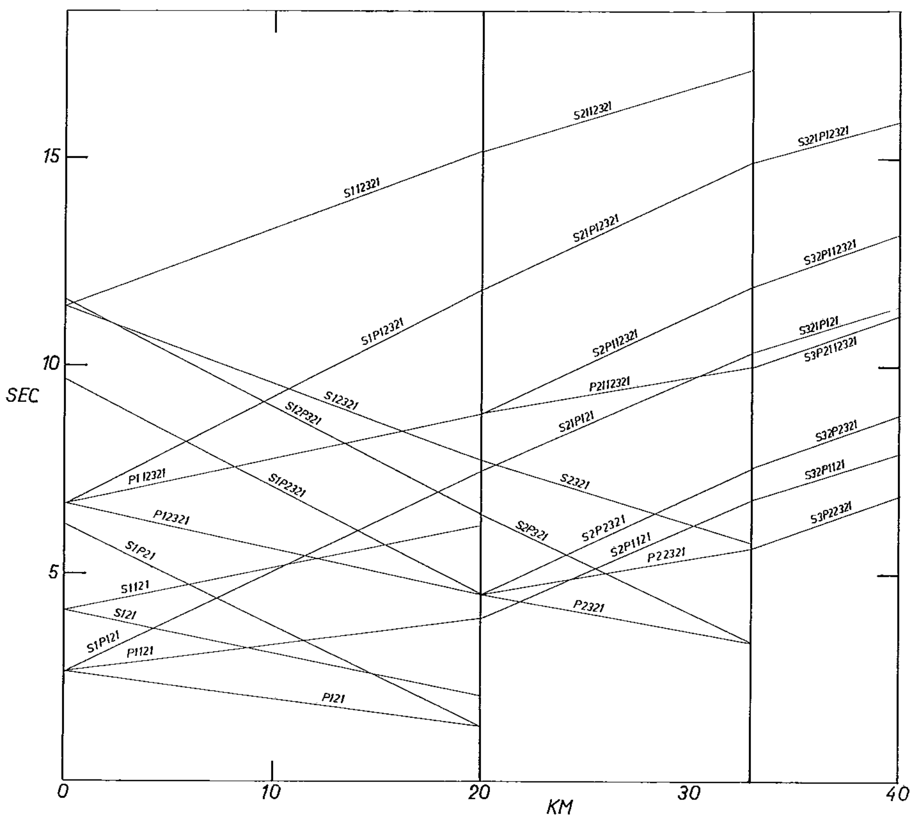

Fig. 2.

τ is the intercept time depending upon the thicknesses of the layers, the velocities and the depth of focus
$\triangle$ is the epicentral distance
v is the velocity of the head wave

In Figs. 1 a and 1 b some travel times are represented for depths of focus of 0 km and of 25 km with $t - t_0$ as ordinate and $\triangle$ as abscissa.

The function τ is represented as a function of the depth of focus in Fig. 2 with the depth of focus as abscissa. The heavy lines at the depths of 20 km and 33 km are the two discontinuities of the crustal model. Some explanation for the phase notation is given in Fig. 3, where the phase in question is $S_{11} P_{2321}$. The letters refer to either P or S and the numbers to the layer through which the phase is travelling.

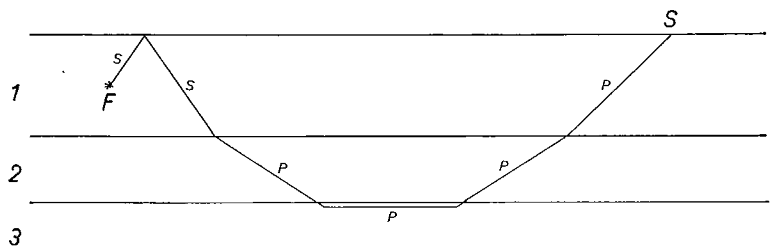

Fig. 3.

The results are valid only for the model used, provided that ray theory solutions are accurate enough to describe an actual focus.

No energy considerations have been taken into account. Hence there may be weak arrivals among the waves.

The results (Figs 1 a, 1 b and 2) have already been tested and the agreement between theory and practice seems to be reasonably good. Deviations indicate, however, that the model used is not in complete accordance with the true crustal structure in Finland. After several accurate crustal structure investigations have been carried out, a new modification of the model will be suggested.

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