550. 341 : 551. 14

PRELIMINARY RESULTS OF A SEISMIC REFRACTION STUDY OF THE EARTH'S CRUST IN S.W. FINLAND

by

U. Luosto

Institute of Seismology, University of Helsinki

Abstract

In summer and autumn 1965, an explosion seismic investigation of crustal structure was carried out in S. W. Finland. Three layers were found in the crust. Of the two crustal models calculated, the following was accepted:

H_1	= 12.2 km	V_1	= 6.07 km/sec
H_2	= 18.0 »	V_2	= 6.51 »
H_3	= 11.8 »	V_3	= 6.64 »
Depth to Moho	= 42.0 »	V_n	= 8.03 »

1. *Introduction*

In summer and autumn 1965, the Institute of Seismology and the Geological Survey carried out a seismic study of the structure of the Earth's crust in S.W. Finland. In all, 150 underwater explosions were blasted in the Gulf of Bothnia on a line which exceeded 170 km.

In this work an analysis has been made of the records from seven stations located on land on the line Rauma to Porvoo, the shortest distance to the explosions being 17 km and the farthest 411 km. The records of the 49 greatest expolosions are included in the investigation. The refraction line A—A and the recording stations are represented in Fig. 1. The recording stations are denoted by numbers 1, 2, 3, etc. No list of observations or explosions is included in this short preliminary paper. A list of explosions with charges of at least 50 kg was published by the

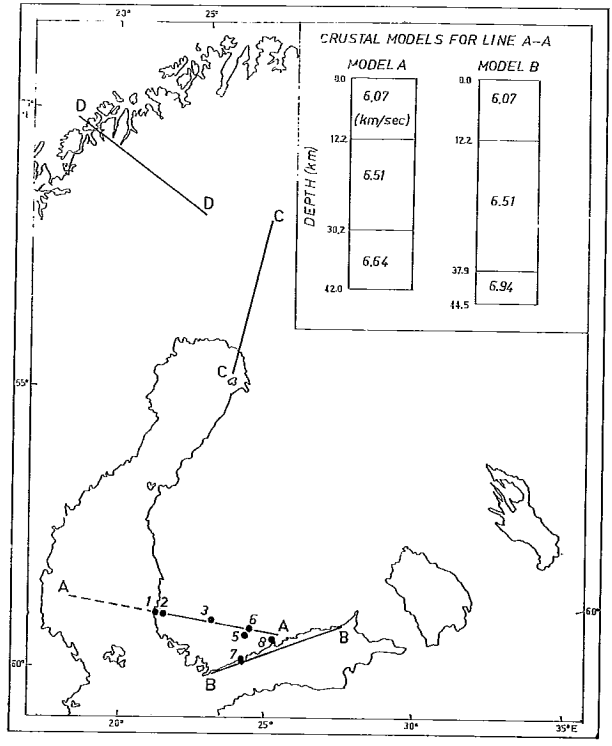

Fig. 1. The refraction lines and the two alternative crustal models for line A—A.

Institute of Seismology in the Preliminary Seismological Bulletin of September 1965. The recording instruments were Willmore seismometers with periods of 0.5 to 0.7 seconds and with visual records. At Nurmijärvi station (5), however, there were standard instruments with photographic records.

The travel time lines of P waves have been calculated by least square method to fit the equation:

$$T_k = T_{k0} + D/V_k \,,$$

where $k = 1, 2 \ldots$, T_k is the travel time, T_{k0} the intercept time and D the distance from shot point to recording point. V_k is P wave velocity in the k:th layer. After finding the parameters T_{k0} and V_k, refraction layers are computed from the usual equations.

Table 1

Layer	Phase	V_k (km/sec)	T_{k0} (sec)	No. of observations
1	P_1	6.07	0.07	56
2	P_2	6.51	1.52	61
3	P_3	6.64	2.75	37
3	P_3'	6.94	3.66	18
4	P_4	8.03	7.92	91

2. *Results*

The values found for the constants T_{k0} and V_k are represented in Table 1. The observed travel times reduced to $T - D/7$ ordinate are given in Figure 2 as a function of distance. The calculated travel time curves are also represented there.

The velocity V_1 has been calculated from the records of stations 1 and 2. The observations are from the distance interval from 17 to 140 km, where the first onset is that of P_1. From a large number of observations a good result for the velocity of this wave has been attained.

The second wave, P_2, is the first to arrive between 140 and 220 km. Unfortunately, only a limited number of good records were available for this interval. Most of the observations are from distances greater than 220 km. Identification of this wave, however, was relatively sure.

At a distance interval of about 210 to 260 km a very strong impulse arrives about one second after the P_2 onset. For the interpretation of these impulses a third crustal layer has been postulated in which the velocity of the P wave is 6.64 km/sec. However, after 240 km some impulses occur before the P_2 onset which correspond to a velocity of 6.94 km/sec.

Table 2

Layer	MODEL A		MODEL B	
	H (km)	V (km/sec)	H (km)	V (km/sec)
1	12.2	6.07	12.2	6.07
2	18.0	6.51	15.7	6.51
3	11.8	6.64	16.6	6.94
Depth to Moho	42.0	8.03	44.5	8.03

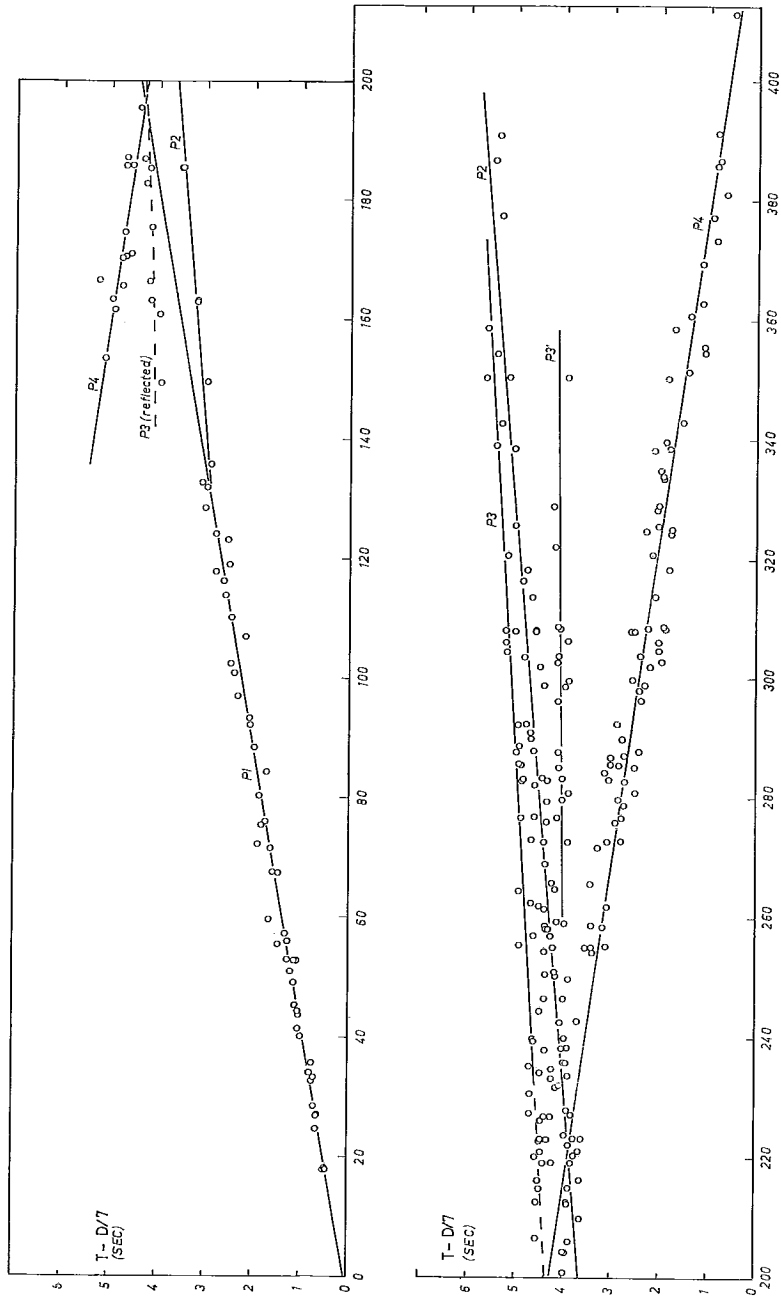

Fig. 2. Observed travel times reduced to $T - D/7$ ordinate and travel time curves.

The P_4 or P_n wave is the first to arrive after 220 km and its velocity was easy to compute, owing to the great number of observations. Of the waves P_3 and P_3' only one is possible. For this reason the results led to two alternative structure models, which are presented in Table 2 and Figure 1. Because of the greater number of observations and better agreement with the previous investigations of crustal thickness in Finland, Model A has been preferred. A minimum for the average crustal thickness is obtained by assuming that the crust consists of only one layer in which the velocity is 6.07 km/sec. This yields the result 36.5 km.

3. *Discussion*

The investigation suggests a relatively great crustal thickness for such a low-lying region. But if the third layer is neglected, it is not possible to explain the predominant impulses at about 240 km as reflections from any remaining discontinuity. Because of the third layer it is difficult to compare the present result with previous refraction results in Fennoscandia. By comparing the travel times of the P_n wave with the observations of some previous investigations, however, it has been found that the travel time of this wave decreases towards the north, as can be seen from Table 3. The refraction lines in question are shown in Fig. 1. We find that on the line B—B the travel time of the P_n wave at the distance 231.8 km agrees with the travel time of the present line within the limits of distribution. On the line C—C at a distance of 292.6 km the travel time is 1.8 sec shorter and on the line D—D at a distance of 305.9 km 2.8 sec shorter than on the present line. Whether the last two remarkable differences mean that crustal thickness decreases towards the north, is not possible to say with certainty at present.

Table 3. P_n travel times on the lines B—B, C—C and D—D compared with the travel times at the same distances on the line A—A.

Line	Shot point	Record point	Distance (km)	Travel time (sec)	Reference	Corresponding travel time on line A—A
B—B	Kotka	Hanko	231.8	36.45	[1]	36.80
C—C	Hailuoto	Sodankylä	292.6	42.5	[1]	44.3
D—D	Tromsö	Muonio	305.9	43.3	[2]	46.1

The theoretical group and phase velocity curves of the surface waves are calculated for the crustal model A in [3]. With suitable choice of the lacking S-velocities quite good agreement between the calculated and observed surface wave velocities in Finland has been achieved.

Acknowledgments. The author expresses his gratitude to M. T. PORKKA' Ph.Lic. and E. PENTTILÄ, Ph.Lic. for many fruitful discussions. The financial support received from the National Research Council for Sciences (Valtion Luonnontieteellinen Toimikunta) is gratefully acknowledged.

REFERENCES

1. PENTTILÄ, E., 1963: Report on the 1960 and 1961 explosion seismic investigations of the Earth's crust in Finland. *Geoph.*, **7**, 209—220.
2. SELLEVOLL, M. A., and E. PENTTILÄ, 1964: Seismic refraction measurements of crustal structure in Northern Scandinavia. *Årbok, Universitetet i Bergen*, **9**, 3—10.
3. NOPONEN, I., M. T. PORKKA, S. E. PIRHONEN, and U. LUOSTO: Structure of the crust and Upper Mantle in Finland. Communication C 33, ESC Copenhagen Meeting 1966 (to be published).