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Abstract

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STRUCTURE OF THE EARTH'S CRUST AND SEDIMENTARY SEQUENCE OF THE SEA OF JAPAN FROM SEISMIC DATA

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In 1963, the Institute of Oceanology of the USSR Academy of Sciences, jointly with the Pacific Branch of the Institute, carried out seismic investigations in the Sea of Japan along a profile more than 500 km long, located in the central and southern parts of the Sea of Japan. Along it, 9 DSS stations were occupied, and CDP measurements were conducted over the entire length, with an interval of 3–5 km between stations. The layout of the profiles is shown in Fig. 1; the profiles on which the Institute had carried out investigations in preceding years are also plotted there ([1],[2]).

In DSS, the method used was that of fixed recording stations and shot points moving along the profile. The source of elastic oscillations consisted of explosions of TNT charges weighing 130 kg at depths of 90–150 m. Seismic signals were received by wide-band hydrophones, from which the signals were fed to the amplifiers of the DSS station. Two low-frequency amplifiers were used (pass band 5–10 Hz). Sound oscillations were recorded with the aid of a bottom-reflection analyzer. Records of the received signals were made on plume oscillographs H-700 on photographic paper. To determine the depth of the sea and to obtain additional data on the structure of the sedimentary sequence, reflected waves were recorded while underway. These waves were received by a hydrophone installed in the underwater part of the ship' s hull.

At all DSS stations, several principal types of waves can be distinguished: refracted, refracted-reflected, and reflected-refracted waves in the earth' s crust and sedimentary sequence; and direct, refracted, and multiply reflected waves in the water column.

Deep refracted waves of two types, P^* and P^m, are distinguished. The waves P^* are traced in the first arrivals in the interval 10–43 km. The apparent frequency of the record on the low-frequency amplifiers is 7–8 Hz. The apparent velocity is 6.0–6.6 km/sec. The refracted waves P^m are well traced in the first arrivals at all stations in the interval 37–81 km and have an apparent velocity of 8.0–8.8 km/sec. These waves are also clearly recorded on the low-frequency amplifiers

Fig. 1. Layout of seismic stations and profiles.

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Figure 2. Hodographs and bottom relief of profile 2

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(apparent frequency 8 Hz). At all stations, groups of waves were recorded that arrive after the waves P^* and P^m. Analysis of the kinematic and dynamic features of these waves shows that, in all probability, they are additionally reflected in the water column and in the layers overlying the refracting boundaries.

Refracted and multiply reflected waves in the water layer are well recorded over the entire frequency range, but especially clearly on the high-frequency channels of the bottom-reflection analyzer. These waves were used to determine the distances between the shooting and recording vessels, and also to calculate the velocity of sound in the upper part of the sedimentary sequence.

After identification of the waves at all stations, hodographs and a seismic section were constructed (Figs. 2 and 3). On the profile, the structure···

of boundary B, corresponding to P^* waves, by the time-field method was possible in the segment between stations 11-13. In other parts of the profile, construction of the boundary by this method could not be carried out because of the absence of intersecting time fields. After corrections for the water layer had been introduced into the hodographs, construction of the refracting boundary was carried out from the sea floor.

Fig. 1. Layout of seismic stations and profiles. **1**—DSS stations; **2**—profiles on which RWM studies were carried out; **3**—DSS profiles run from the expedition vessel *Vityaz*; **4**—RWM profiles; **5**—DSS stations occupied by Japanese researchers; **6**—RWM stations occupied from the *Vityaz*. In 1963 the studies were carried out on profile 2.

The average velocity in the overlying sequence was taken to be 2.0 km/sec. This value was chosen with allowance for determinations from waves multiply reflected in the water layer. The depth of boundary B in the interval of overlap of the time fields (stations 11-13) proved to be 0.8-1.0 km. The boundary velocity V_g = 6.6 km/sec. On both sides of this segment, boundary B was extended along single time fields with V_g = 6.6 km/sec. At other stations, the depth of this boundary was determined from t_0. Discrepancies in the determinations of the depth of boundary B

Fig. 2. Hodographs and bottom relief of profile 2

Fig. 3. Seismic section according to DSS and RWM data. **1** —boundary segments constructed from crossing time fields; **2** —boundary segments constructed from individual time fields; **3** —interpolation segments; **4** —depth determination

Figure 3. Seismic section according to DSS and RWM data

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from t_0.

by different methods (travel-time fields and t_0) are insignificant. Thus, the thickness of layer B along the profile varies from 0.7 to 1.7 km; below it lies a layer with a boundary velocity of 6.6 km/sec.

To construct boundary M by the travel-time-field method, hodographs of P^M waves at stations 10–13 were used. In the constructions, the layer velocity was taken as 6.5 km/sec. The depth of boundary M below the sea floor in the segment between stations 10–13 proved to be 12–13 km. The boundary velocity is 8.2 km/sec. On both sides of this segment, boundary M was extended using individual travel-time fields with $V_\mathrm{b} = 8.2$ km/sec. In other parts of the profile, the depth of this boundary was determined from t_0 at each station.

From the intersection points of the hodographs of P^* and P^M waves, the mean velocities in the earth' s crust were determined; they vary from 4.8 to 5.3 km/sec. For comparison with these values, mean velocities to boundary M beneath each station of the constructed section were also calculated, using layer velocities in the first layer $V_\mathrm{pl} = 2.0$ km/sec and in the second layer $V_\mathrm{pl} = 6.5$ km/sec. The discrepancies between $V_\mathrm{t.p}$ and V_r in most cases amount to 0.1 km/sec. Consequently, the model of a homogeneous layered medium adopted in interpreting the DSS materials is apparently sufficiently close to the real one.

Thus, the earth' s crust in the investigated area of the Sea of Japan consists of two principal layers. The upper layer, 0.7-1.7 km thick, may be assigned to sedimentary rocks. The second layer, 9–12 km thick, by the value of its boundary velocity belongs to the "basaltic" layer of the earth' s crust. The surface with $V_\mathrm{b} = 8.2$ km/sec is the Mohorovičić boundary.

The RWM investigations were carried out along the entire length of the profile worked by the DSS method and were undertaken for the purpose of a detailed study of the sedimentary sequence. The source of elastic vibrations was explosions of trotyl charges weighing 5 kg at a depth of 1-1.2 m. Reception of acoustic vibrations was performed with a four-channel piezoelectric streamer with a spacing of 100 m. Signals from the hydrophones were fed to the amplifiers of the SS-24-P seismic station and recorded on an N-700 oscillograph.

Correlation of waves from station to station was carried out according to kinematic and dynamic characteristics. In the sedimentary sequence one can distinguish 10–12 reflecting horizons. In the northern part of the profile the sedimentary sequence can be divided into two zones: upper and lower. The upper zone, 0.7-1.0 km thick, has a horizontally layered structure. In it 8–10 reflecting boundaries can be distinguished. The lower zone has a small number of reflecting surfaces. The thickness of this zone is from 0.5 to 1 km. The basement of the sedimentary sequence is characterized by intense reflected waves. The thickness of the sedimentary sequence down to the reference reflecting boundary varies from 0.1 to 1.7 km, with an adopted sound velocity of 2.0 km/sec. The maximum thickness of the sediments was determined in the northern part of the profile, and the minimum in the southern. Dome-shaped uplifts of the sediment basement in the southern part of the profile are noteworthy. Interestingly, above the second and third uplifts there are sharp steps in the bottom relief, with depth differences of 140 and 240 m. Comparison of the RWM data with the DSS data made it possible to identify the reference reflecting horizon with the surface of the "basaltic" layer.

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Note: Figure translations are in progress. See original paper for figures.