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Abstract

Full Text

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GEOPHYSICS

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STRUCTURE OF THE SEDIMENTARY SEQUENCE OF THE SEA OF JAPAN ACCORDING TO CONTINUOUS PROFILING BY THE REFLECTED-WAVE METHOD

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In 1966 the Sakhalin Integrated Scientific-Research Institute of the Siberian Branch of the USSR Academy of Sciences and the Department of Marine Geophysical Surveys of VNIIGeofizika carried out four profiles in the Sea of Japan: I, II, III, IV, by the reflected-wave method (MOB), with a total length of about 300 km. Profile IV is confined to the continental slope,

Fig. 1. Scheme of the location of the profiles. *a*—MOB seismic profiles, 1966; *b*—isobaths of the sea floor

II and III begin on the continental slope and continue into the basin; profile I is located entirely within the basin (Fig. 1).

A method of continuous profiling was used with a symmetrical array having one central shot point and a shot interval 420 m long. A 24-channel piezoseismograph streamer designed by VNIIGeofizika was used, towed by the vessel at a depth of 7-8 m. The blasting work was carried out with the aid of a floating explosive ma—

magistral line, the charge size was 10-20 kg when they were submerged to a depth of 1.5 m.

The material obtained, according to the character of the reflected waves, is divided into two groups.

Seismograms with the first group of waves were obtained in the central part of the deep-water basin, at sea depths of more than 3000 m. The reflected

Fig. 2. Seismic section along profile I. Reflecting boundaries: 1—reliable construction; 2—uncertain construction; 3—interpolation; 4—reference boundary corresponding to the basement of the sedimentary sequence

Figure 2: Fig. 2. Seismic section along profile I. Reflecting boundaries: 1—reliable construction; 2—uncertain construction; 3—interpolation; 4—reference boundary corresponding to the basement of the sedimentary sequence

Fig. 2. Seismic section along profile I. Reflecting boundaries: **1**—reliable construction; **2**—uncertain construction; **3**—interpolation; **4**—reference boundary corresponding to the basement of the sedimentary sequence

waves here are recorded at times from 4.6–4.7 to 6.1–6.3 sec. The clearest and most extended reflections stand out in the initial part of the seismograms, in the time interval 4.6–5.4 sec. Their number reaches 8–10. At times greater than 5.4 sec, the number of reflections decreases to 3–5, and their quality also deteriorates.

The wave field is closed by a reflection at times of 5.8–6.0 sec, which, with small breaks in correlation, is traced throughout the entire deep-water part of the Sea of Japan. By its character this reflection may be assigned to the reference ones. It has a form of record and an intensity different from those of the other reflected waves, and a greater intensity of adjacent waves. Usually three to four phases of this wave can be traced; however, their axes lack the regular hyperbolic form that is characteristic of waves in the initial part of seismograms. The apparent period of the wave ranges from 0.028 to 0.035 sec. The apparent periods of other waves are 0.022–0.028 sec. After the reference reflection, a further series of reflected waves is distinguished on the seismograms; their geological significance differs in different parts of the sea.

The second group of records includes seismograms recorded in the shallow-water part, where sea depths decrease to the first hundreds of meters. The quality of the material here generally deteriorates: the duration of the record decreases to 0.5–1.5 sec, the number of reflections to 2–5, the traceability of waves along the profile is reduced to 1.0–1.5 km, the record is complicated by side waves and multiple waves, the axes of in-phase correlation are often broken and discordant with one another, and the reference reflection that closes the first group of waves is practically not traceable.

Characteristic of both groups of records is the presence of an intense, multiphase reflection from the sea floor. In the transition zone from the deep-water part of the sea to shallow water, an intermediate group of waves is distinguished, combining the features of the first two.

In accordance with the character of the wave pattern, the sedimentary layer of the deep-water basin is divided into two sequences (Fig. 2). The upper of these contains 8–10 reflecting boundaries with an extent of 10 km or more and has a thickness on the order of 700 m. In the lower sequence, the number of reflecting boundaries decreases to 3–5; their extent remains the same as for the upper sequence, and the thickness of the second stage is 800–1000 m.

The division of the section of the sedimentary sequence of the deep-water basin into two sequences is apparently caused by different compaction of the sediments and by their different lithological composition. It appears that the upper sequence co-

consists of thin interbedding of weakly compacted sandy-clayey material; the lithological composition of the lower unit is more uniform, and the degree of compaction of the rocks is considerably greater than in the upper unit. The reflecting boundaries in the lower part of the section are characterized by weak acoustic properties; the intensity of the reflected waves is not great.

The thickness of the sedimentary layer in the central part of the deep-water basin is 1500–1600 m, decreasing in some places to 1000–1200 m. The boundaries lie predominantly horizontally and conformably with one another. However, there are exceptions to this rule, one of which is an anticlinal structure along the lower horizons in the area of picket 425 of profile I, with an amplitude of about 300 m (Fig. 2). The overlying horizons, unlike the latter, are not deformed and lie practically horizontally; in this connection the impression is created that the anticlinal bend under consideration is a structure of draping.

The sedimentary sequence has a complex structure at the eastern end of profile I, near the island of Hokkaido. Here two anticlinal bends are distinguished. One of them, in the area of picket 100, affects the upper part of the section, has an amplitude of 150–200 m, and is reflected in the sea-floor surface. In its axial part it is complicated by two local structures. The second anticlinal uplift was detected in the area of picket 40. Analogously to the bend at picket 425, it affects only the lower horizons of the section. Its amplitude is 300 m. In the area of picket 60, discordant bedding of the boundaries is noted, formed by the adjacent limbs of the uplifts. The dislocation of the layers of the sedimentary sequence in this part of the profile should evidently be related to the Cenozoic folding of the island of Hokkaido.

At the base of the sedimentary sequence lies a boundary designated in the sections by the index . It corresponds to the supporting reflection described above and, with small interruptions, is traced on all profiles in the central part of the basin. Unlike the boundaries within the sedimentary sequence, it lies at angles of 5–7°. In some cases this surface forms gentle, extensive bends with an amplitude of 500–600 m; in other cases the horizontal and vertical dimensions of the structures are considerably smaller. It is possible that the bend in the area of picket 425 of profile I, described above as a structure of the sedimentary sequence, is in fact a complication of the reference surface, although the available materials do not allow this to be asserted unequivocally. Judging from comparison with DSS materials, the reference boundary is the surface of the basalt layer, characterized by boundary velocities of 6.4–6.6 km/sec.

Seismic DSS and CRW investigations carried out by the Institute of Oceanology

Fig. 3. Seismic section along profile II. Symbols are the same as in Fig. 2

Figure 3: Fig. 3. Seismic section along profile II. Symbols are the same as in Fig. 2

of the USSR Academy of Sciences in the Sea of Japan in 1957, 1962, and 1963 (1-3), using a system of point observations, showed that the Earth' s crust in the deep-water basin consists of two layers: a sedimentary one 0.7-2 km thick and a "basalt" one (thickness 8-12 km, $V_\Gamma = 6.6$ km/sec). On areas of flat bottom the sediments are subdivided into two layers: the upper one—horizontally layered, and the lower one—seismically homogeneous; on submarine elevations the thickness of the sediments is reduced to 200-300 m. However, this latter conclusion should be treated with greater caution, since the continuous-profiling materials indicate the possibility of sharp changes in the acoustic properties of boundaries in the sedimentary sequence and, correspondingly, in the characteristics of reflected waves, as a result of which correlation of waves solely by dynamic features may be erroneous.

Near the continental slope, the numerous reflecting horizons that were distinguished in the central part of the basin cease to be traceable. In some areas they disappear very abruptly. Such a case occurs at the northeastern end of profile II, where a sedimentary sequence about 2 km thick pinches out over a distance of 3 km (Fig. 3).

In other areas the layers of the sedimentary sequence disappear gradually. A similar picture is observed at the northern end of profile III. In both cases, however, the wedging-out of the sedimentary sequence occurs at sea depths of 3000-3200 m.

The question of the behavior of the reference boundary near the continental slope is of interest. In the central part of the basin the basalt layer, whose surface it represents, plays the role of the basement of the sedimentary deposits. In the intermontane basins of Primorye, the role of basement is played by Meso-Cenozoic rocks assigned to the granite layer. However, neither the materials of profiles III and IV nor the materials of profile II, illustrated in Fig. 3, lead to the conclusion that the reference boundary rises. The behavior of the reflecting boundaries at depths of 5000 m at the northeastern end of profile II suggests that it plunges toward the continent.

Fig. 3. Seismic section along profile II. Symbols are the same as in Fig. 2

In place of the extended reflecting boundaries of the sedimentary sequence in the deep-water basin, near the seashore there appear disconnected reflecting platforms, some of which dip toward the continent.

The materials obtained near the continental slope may be interpreted as follows. The sedimentary layer filling the floor of the deep-water basin adjoins the continental slope. Farther toward the continent it is replaced by Meso-Paleozoic and older rocks forming part of the granite layer, which, as indicated, performs the role of basement on the continent. The reference boundary—the Conrad surface, which in the deep-water basin plays the role of basement—and, together with it, the basalt layer, dip northward and westward beneath the granite layer.

The work described has yielded new data on the structure of the sedimentary sequence of the deep-water basin and on the character of its behavior as it approaches the continental slopes of Primorye, the Tatar Strait, and Hokkaido. The materials obtained also made it possible to identify certain features in the behavior of the granite layer and the Conrad surface.

It may be asserted that the sedimentary sequence in the deep-water basin has not yet been affected by folding. Processes of subsidence and sediment accumulation continue here, associated with the present stage of geosynclinal development of the Sea of Japan. At the same time, the sedimentary cover in areas adjacent to the Japanese Islands has been involved in folding that occurred in the Cenozoic at a later time.

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