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Abstract

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GEOPHYSICS

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SEISMIC INVESTIGATIONS OF THE EARTH' S CRUST IN THE BUKHARA REGION OF THE UZBEK SSR

Studies by deep seismic sounding in the Bukhara-Khiva region in 1959 were a direct continuation of similar work carried out in 1958 in southeastern Turkmenia and the Fergana region ([2]).* The principal task of the work was to determine the regional deep geological structure of the territory along the Amu Darya (Karabekaul)—Nuratau profile, with the aim of evaluating the relief and depth of occurrence of the Paleozoic basement, the behavior of the principal boundaries of the Earth' s crustal section, and the interpretation of the nature of gravitational and magnetic anomalies. The investigations were carried out in a low-frequency modification of the correlation method of refracted waves, using a complete system of correlationally linked hodographs of refracted waves with simultaneous recording of deep reflections. Shot points were located at intervals of 12-17 km for tracing waves from horizons in the sedimentary sequence and from the surface of the Paleozoic basement, and at intervals of 40-70 km for tracing waves from the principal boundaries of the Earth' s crustal section. This system of observations made it possible to obtain continuous hodographs of waves of considerable length (up to 50-80 km) and to approach the question of their nature more objectively.

The main methodological questions of regional investigations have been considered in works ([2-4]). The present article gives the character of the wave pattern and the principal results of the work.

Character of the wave pattern. On the seismograms obtained during investigations of the Earth' s crust in the Bukhara-Khiva region, a large number of waves were recorded which, on the basis of a number of kinematic and dynamic features, may be divided into three main groups:

1. Longitudinal refracted (head) waves, recorded both in the first and in subsequent arrivals.

2. Waves reflected from deep boundaries of the Earth' s crustal section, recorded in the initial part of the record and, at large distances from the shot points, beyond the critical angle.

3. Waves classed as multiple, reflected-refracted, and converted waves of various types, associated with deep boundaries of the section, as well as waves with small values of apparent velocities ($V^* = 4000$ m/sec), among which the presence of weakly refracted single and multiple waves is possible.

Among the first group of waves the following were identified and interpreted:
a) refracted waves corresponding to boundaries in the sequence of sedimentary rocks, P_{kmz};

* The investigations were carried out jointly with the Uzbek Geophysical Trust and the All-Union Scientific Research Institute of Geophysical Prospecting Methods. In addition to the authors of the article, V. Z. Ryaboi, A. E. Starobinets, F. A. Galkin, B. B. Tal-Virskii, and others took part in the work.

b) refracted waves corresponding to the Paleozoic surface, P_z;

c) refracted waves corresponding to a boundary in the granite layer, P^0;

d) refracted waves corresponding to the surface of the subcrustal layer (the Mohorovičić boundary), P_{pr}.

The waves P_{kmz} are traced in the initial part of the record in the interval 0-40 km from the shot point and are characterized by: a wave with $V^* = 4500$ m/sec –deposits of Cretaceous age (P_{Cr}); a wave with $V^* = 4800$ m/sec–the surface of Jurassic deposits (P_J). The first group of waves has short tracing intervals (1-4 km), while the waves P_{Cr} and P_J have intervals of 20-30 km. The mean apparent frequencies of these waves are 25-14 Hz. The waves P_z, corresponding to the surface of the Paleozoic basement, are traced to 100 km from the shot point in the form of intense, complex, multiphase oscillations.

Table 1

Group of waves	V^*, km/sec	V_g, km/sec	V, km/sec
P_z	5.8-6.2	6.0-6.2	1.8-3.5
P^0	6.3-7.8	6.4-6.75	5.2
P_{pr}	8.0-9.5	8.1-8.3	6.2
P_{otr}	18-6.5		6.2

The apparent velocities of the waves P_z vary from 5800 to 6200 m/sec. The apparent frequencies are from 16-14 to 12-10 Hz; the predominant frequencies in the spectra, determined at the frequency-analysis station, are 10-16 Hz.

The waves of the granite group P^0 are traced mainly in the subsequent part of the record at distances of 70-120 km from the shot point. They have low intensity and short intervals of continuous tracing. The apparent velocities

of the waves P^0 vary within very wide limits, from 6300 to 7800 m/sec; the apparent frequencies are 12–15 Hz.

The waves P_{pr} are traced from distances of 160–180 km from the shot point, mainly in the first arrivals. They are recorded at times of 28–30 sec; the duration of the group record is 0.3–2.0 sec. Individual axes of phase correlation have a short extent (4–10 km). The intensity of the recording of the waves P_{pr} is insignificant; with increasing distance from the shot point, the number of waves in the group decreases owing to the rather sharp attenuation of the first waves of the group. The apparent velocities vary within the limits from 8000 to 9500 m/sec, and the apparent frequencies from 10 to 16 Hz. With increasing distance from the shot point, some decrease in frequency is observed; sometimes their anomalous increase is noted.

The reflected waves recorded in the initial part of the record are represented, as a rule, by very short axes of phase correlation (1–3 km, rarely 5–10 km), which are sometimes strongly distorted by the superposition of intense interfering waves ($V^* < 4000$ m/sec) recorded in the same time range (from 5–8 to 20 sec) and distance range (20–80 km). The apparent velocities of the reflected waves, with increasing distance from the shot point, change from 18,000–20,000 m/sec to the values of the velocities of the corresponding refracted waves in the region of their initial point; the apparent frequencies lie within the limits of 10–16 Hz.

The waves P_{otr} are traced on seismograms from distances of 30–40 km from the shot point and are recorded in subsequent arrivals over the entire observation interval up to 250–300 km. The continuous tracing intervals of the waves P_{otr} are 10–50 km. The values of the apparent velocities decrease with increasing distance from the shot point from 9000 m/sec at distances of 80–90 km to 6500–7000 m/sec at the end of the traveltime curve (250–300 km). These waves are the most intense of all the recorded waves; the attenuation coefficient is very small. The apparent frequencies are 15–16 Hz near the shot point and 10–11 Hz at the end of the traveltime curve. The maxima of the frequency spectra obtained by the laboratory method at the frequency-analysis station are 12–16 Hz.

Sections. Seismic sections were constructed by the method of time fields from the traveltime curves of the waves P_z, P^0, and P_{pr}, with a constant mean velocity, and by the method of circles from the traveltime curves of the reflected waves P_{otr}, taking into account the horizontal gradient of the mean velocity. The values of the boundary velocities were deter-

were determined from hodographs of sliding waves for boundary segments constructed from two time fields, and from reciprocal hodographs by the method of the difference hodograph.

Table 1 gives the values of the apparent, boundary, and average velocities adopted in constructing the sections.

Fig. 1. Composite schematic hodographs (A) and a section of the Earth' s

Figure 1

Figure 1: Figure 1

crust (B) along the Amu-Darya (Karabekaul)–Nuratau profile. Hodographs: **1** –waves P_{kmz}, **2** –P_z, **3** –P_0, **4** –T, **5** –P_{pr}, **6** –P_{otr}. Seismic boundaries: **7** –constructed from hodographs of P_z waves and the corresponding Paleozoic surface (V_{g} = 6.0-6.2 km/sec); **8** –constructed from hodographs of P_0 waves and the corresponding boundary in the granite layer (V_{gr} = 6.4-7.0 km/sec); **9** –constructed from hodographs of supercritical reflections P^*_{otr} and the corresponding surfaces of the basalt layer; **10** –constructed from hodographs of P_{otr} waves and the corresponding surfaces of the subcrustal layer (the Mohorovičić boundary).

The refracting horizon corresponding to the surface of the folded basement characterizes a sharp stepwise subsidence, in the southwest direction, of the Paleozoic substratum from the belt of Paleozoic massifs of Nuratau to the Amu-Darya (Fig. 1). The amplitude of subsidence ranges from zero values in the eastern part of the profile to 5000-5500 m in the near-Amu-Darya zone. The refracting and reflecting horizons characterizing the principal discontinuities of the Earth' s crust have a comparatively calm bedding-

the basement, somewhat complicated only in the east of the profile, in the zone of a sharply complicated Paleozoic structure. The thickness of the earth' s crust averages 45 km, varying from 40 km in the east of the profile to 48 km in the Amu-Darya area. The thicknesses of the granitic and basaltic layers are fairly consistent and may be estimated approximately at 15-17 and 18-20 km.

Considering the results obtained from the investigations and the character of the structure of the earth' s crust in the Fergana intermontane depression, it may be stated that, on approaching the system of ranges of the Western Tien Shan (the Turkestan and Kuramin ranges), the thickness of the earth' s crust decreases sharply and, evidently, in the very center of the mountain system (along the line of the profile) will not exceed 40 km.

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