Use of Seismic Surveying with the Method of Regulated Directional Reception in Exploration for Reefs in the Southern Cis-Urals

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Reefs of Assel’sko-Sakmaro-Artinsk age have been objectives for oil-gas exploration in the south part of the Cis-Ural downwarp (Bashkirsko-Orenburg Cis-Urals) for thirty years. Interest in them has increased in recent years due to the discovery of gas condensate fields in the reefs (5).

The reef masses are distributed along a flexural plunge of the Assel’sko-Sakmaro-Artinsk sediments of the western border of the foreland downwarp in a narrow belt of transition from shallow-water (platform) facies on the west to deep-water (depression) facies on the east (8). Characteristic of the reef masses of the South Cis-Urals is a sharp discordance in the structure between the underlying and overlying sediments. The sub-reef sediments of the Carboniferous and Devonian form the flanks of very gentle platform structures or monoclines (8), whereas in the super-reef halogen formations of the Kungur and clastic Permo-Triassic sediments there are disharmonic structures complicated by salt tectonics. Therefore, exploration of the reef masses which occur at great depth (1500-2500 m) is difficult and expensive. Such exploration is carried out by combined geophysical methods consisting of gravity surveying, electrical surveying, and in recent years also seismic surveying—these in combination with structural-exploration and prospecting drilling (5).

At the present time the method of exploration for reefs consists of determining from geophysical data the position of the belt and favorable areas within it for probable occurrence of reefs. This is followed by drilling.

In many favorable areas in the Bashkirsko-Orenburg Cis-Ural, oil-bearing and gas-oil-bearing reef masses have been found. However, their discovery was accomplished by the drilling of a large number of wells, because the geophysical methods had not located the exact position and configuration of the reefs. In order to solve this task, experimental work in the use of the seismic method of reef exploration was undertaken.

The complex structure of the reef masses and of the overlying halogen Kungur and clastic Permo-Triassic formations, which are complicated by salt tectonics, requires the use of the RNP (regulated directional reception) method, which under such seismogeologic conditions has several advantages over other modifications of seismic surveying (3, 4, 6).

Under such conditions the RNP method has considerably greater resolving capacity, permitting in many cases the recognition of superposed (interfering) waves, separation of useful waves, and construction of reflecting surfaces. At the same time experiments in the use of the usual modification of reflected waves did not yield positive results (3).

Comparison of the results of RNP with KMPV (refraction) data also shows the advantage of the RNP method. Construction of composite traveltime curves of refracted waves from horizons with steep angles of dip (more than 20°) is not possible due to the fact that in observations along the dip of such refracting surfaces, waves moving along them cannot be recorded. Quantitative interpretation of refraction data is carried out in many cases according to separate traveltime curves and is insufficiently reliable. Deep refracting horizons, which are traced in such a manner, cannot be correlated at depth, and even their approximate stratigraphic position remains unclear. As a consequence of this, the seismic sections, as the main resulting materials of the RNP method, are of secondary importance in the refraction method, but the preference is given to qualitative features of anomalous records of diffracted waves on seismograms (2). However, the latter do not yield unique information on their sources. As a consequence of this, in spite of considerable difficult and cost of the refraction method, up until now no reliable information has been obtained on the possible presence and position of reefs.

During 1959-61 the Bashneftegeofizika Trust carried out experimental work with the RNP method on seven areas favorable for reefs: Kanchurin, Kumertau, Yermolayev, Mayach, Molokanov, Kazlair, and Yakupov. See Fig. 1. The work was carried out and the material interpreted by G. K. Abdakínov, V. I. Beloshihtskiy, Z. I. Borschchenko, Yu. N. Voskresenskiy, L. N. GavriloV, A. D. KaptSan, A. A. Nikolayevskiy, E. R. Orazov, D. A. Samnikov, O. V. Ponomarenko, Ya. I. Shul’ts, and others. The methods and some results of these investigations are presented in several works (3, 4, 6).

Analysis of RNP results and of drilling data in the above areas permits several conclusions on possible uses of the RNP method in exploration for reefs.

In many cases the RNP method can be used to construct sufficiently extensive correlating reflecting horizons in the clastic Ufim and evaporite Kungur formations and also in the deeper Sakmaro-Artinsk and Carboniferous sediments (3). The reliability of constructing