SEISMOSTRATIGRAPHY AND PREDICTION OF GEOLOGICAL SECTION OF AZERBAIJAN

The paper describes evolution history of the methods of seismostratigraphic analysis and geological section prediction, and provides a brief methodology for these studies supported by the seismic data. Based on the interpretation results of the Sovetler-Kalamadin regional profile, the possibility of identification of structural evolution stages, seismic complexes and seismic facies in the Meso-Cenozoic succession is demonstrated. Several exploration wells drilled on the prospects in the Jafarli field (##1, 5, 21, 22) produced oil, thereby confirming our forecasts.

Keywords: seismic stratigraphy, prediction of geological section, seismic facies, seismic prospecting, wave dynamics, interpretation, "bright spot", "dark spot", oil accumulation

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It is interesting to see how some scientific terms change their original meaning over time. So it was, for example, with the term "facies", by which the Gressly, the scientist who had introduced the term in 1839, understood horizontal changes in the petrographic and paleontological features of synchronous deposits. Later, initial meaning of the term had significantly changed, and at present, it has more than 10 different explanations.

It was also rather ambiguous how the researchers, especially paleontologists and stratigraphers had accepted the term "seismostratigraphy", introduced in the early 1970s by American geophysicists P. Weil and others. Even the authors of the Russian geological and geophysical studies proposed using alternative terms such as "seismic facies" (perhaps more realistically reflecting the essence of the matter), structural-formational complexes, etc. Nevertheless, despite the expressed objections, seismostratigraphy had managed to rank itself in the scientific glossary. Nowadays, seismostratigraphic methods are successfully used in geophysical oil-gas prospecting studies, together with structural-formational studies, prediction of geological section, AVO analysis, etc.

Well, how did these methods come about?

Until the early 1970s, although there were separate attempts of individual geophysicists, in particular, K.A.Mustafaev who locally predicted oil and gas potential based on refracted seismic waves, almost all geophysical methods (gravity, electrical and seismic exploration) engaged in study of structural features of the earth's crust and its individual components, had not include any interpretation of the material composition of the component rocks and saturating fluids.

Since the 1970s, as the seismic surveys started to be implemented using common depth point method (CDPM), and, most importantly, as seismic data recording and processing took a digital form, the accuracy and reliability of seismic surveys has sharply increased.

Since this period, along with solving strictly structural tasks, this innovation has also allowed implementing kinematics and wave dynamics based assessment of the material composition of section building sediments, and, in favorable geological environment, to predict their oil and gas content[1].

[1] During the same period, i.e. from the beginning of the 1970s, oil and gas saturation forecast of the new areas began to be carried out using other geophysical methods, in particular, detailed gravimetric and electrical surveys. The greatest success in this field was achieved by the prospectors of Western Siberia, where several dozen hydrocarbon deposits were discovered based on the electrical exploration data.

The next levels of these studies were reached with the possibility of mapping thin-layered geological bodies, studying lithological-facies changes in synchronous formations with the identification of lithological-stratigraphic traps, and, most recently, monitoring the deposit development processes (Gogonenkov, 1987, Mammadov, 2009, Kunin, 1990, Schlesinger, 1998).

It should be noted that the solution these complex problems is achieved in combination with the data of borehole geophysical and petrophysical investigations. Interpretation methods of seismostratigraphic studies include tracing seismic complexes (cyclites) or sequences in time sections, conditioned by the sea level changes and the presence of large breaks in sedimentation. The next step in the seismic data interpretation is to analyze the main wave pattern parameters of each seismic complex (form, amplitude and frequency of reflections, etc.) and identify the seismic facies, which are considered as analogues of geological facies. In complex with borehole data, it is possible to identify lower rank units in a seismostratigraphic complex, including seismic horizons, layers, etc., and to restore the historical sedimentation conditions.

In Azerbaijan, seismostratigraphic studies were started in the early 1980s, more precisely in 1982–1983, when the trust "Azneftegofizika" carried out interpretation of Sovetler-Muradkhanli-Jarli-Kalamadin regional geophysical profile. According to these data, the following structural stages were identified in the Yevlakh-Agjabedi trough in the section of Meso-Cenozoic deposits: 1) the most intensively dislocated Cretaceous stage, 2) enveloping Paleogene-Miocene stage; and 3) Pliocene-Anthropogenic stage not involved in folding.

According to the character of the seismogram, individual stratigraphic intervals of these stages correspond to a complex of nappe sedimentation (Lower Pliocene pay section, lower sections Maikopian and Paleogene – until the Cretaceous) and lateral accretion (Absheron-Akchagyl and Miocene deposits).

Structural interpretation of the section clearly showed main regional and local elements of the region, in particular, the Yevlakh-Agjabedi trough, Saatli-Goychay uplift zone with corresponding local structures. In addition to this interpretation, structural-formational analysis of the section was carried out. The studies resulted in the identification of more than 8 seismic complexes in the section of the Meso-Cenozoic deposits. These complexes are separated by large unconformities in the P horizon type sedimentation (unconformity between surfaces of the Upper Cretaceous and Cenozoic deposits), or small unconformities and horizons with high dynamic expressiveness.

As the seismogram character differed significantly in each of the seismic complexes, preliminary judgements were made about the sedimentation conditions, geological evolution and the potential for identifying lithological-stratigraphic and other types of non-anticlinal traps in the region.

Later, these studies were replicated in the other on- and offshore regions of the country.

With the successful change of seismogeological surveys in favorable conditions, it is also possible to solve the problems of predicting the geological section (PGR), which includes the study of the lithological-stratigraphic section, the identification of the zones with abnormally high formation pressures and understanding the nature of oil and gas saturation of reservoirs.

Interpretation of CDPM data using the AVO analysis method is also based on correlations between the physical properties of rocks that make up the geological section of the study area with the seismic wave field parameters of the (velocity of longitudinal waves, amplitude, etc.).

Depending on change in the physical properties of deposits in the sedimentary complex, it is expected to register an anomalous increase in the intensity of reflections (“bright spot”) from the Pliocene rocks from one side, and an anomalous weakening of the intensity of reflections (“dark spot”) of the Miocene-Oligocene and Eocene rocks from the other (Kocharli, Polonsky et al., 1989). Based on these criteria, more than twenty deposit-type anomalies (DTA) have been identified for various stratigraphic complexes in the Yevlakh-Agjabedi trough. Distribution of these anomalies is shown in the Figure 1.

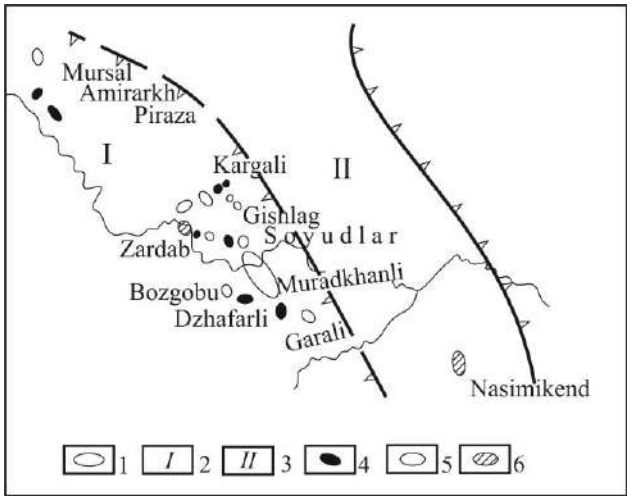

Figure 1. Distribution scheme of the deposit-type anomalies

1 – oil (gas condensate) deposits; **2** – Yevlakh-Agjabedi trough; **3** – Saatli-Goychay zone of uplifts; **4** – DTAs in the Lower Maikopian – Upper Cretaceous deposits, identified and prepared for deep exploration drilling based on CDPM seismic survey data; **5** – DTAs detected in Oligocene deposits; **4** – DTAs detected and prepared in Oligocene deposits

By the areas and stratigraphic complexes, the DTAs are distributed as follows:

1. Dark spot localized in the Pliocene-Miocene deposits on Zardab (2 objects) and Nasimikend (1 object) fields;
2. Dark spot corresponding to the Eocene deposits on Muradkhanli (2 objects), Garali (1 object), Mursal (1 object), Gishlag (1 object), Eastern Shikhbaghi (1 object), Zardab (4 objects), Garghali (2 objects) fields;
3. Dark spot covering the Upper Jurassic-Chokrakian deposits on Amirarkh (3 objects), Zardab (1 object), Jafarli (1 object), Bozgobu (1 object) and Soyudlar (1 object) fields.

Later, some of the cited objects were investigated by drilling. The drilling produced positive results, particularly for the Jafarli field. This field, located southeast of the Muradkhanli field, was prepared for seismic exploration drilling in 1982. Moreover, in addition to the structural interpretation of the seismic survey data, geological section prediction studies were carried out which confirmed the presence of a DTA here.

Curators from Moscow had argued that the Jafarli field is located on the southeastern periclinal of the Muradkhanli field. However, the objection proved to be incorrect as the results of velocity tests and other materials clearly indicated standalone character of the Jafarli field.

In 1983–84 wells No. 1, 5, 21, and 22 were drilled in the field. Having reached the Middle Eocene deposits, all of these wells produced oil with a flow rate of 100–200 m^3/s. This achievement has proven the reliability of forecasts developed based on geological section prediction (Figure 2).

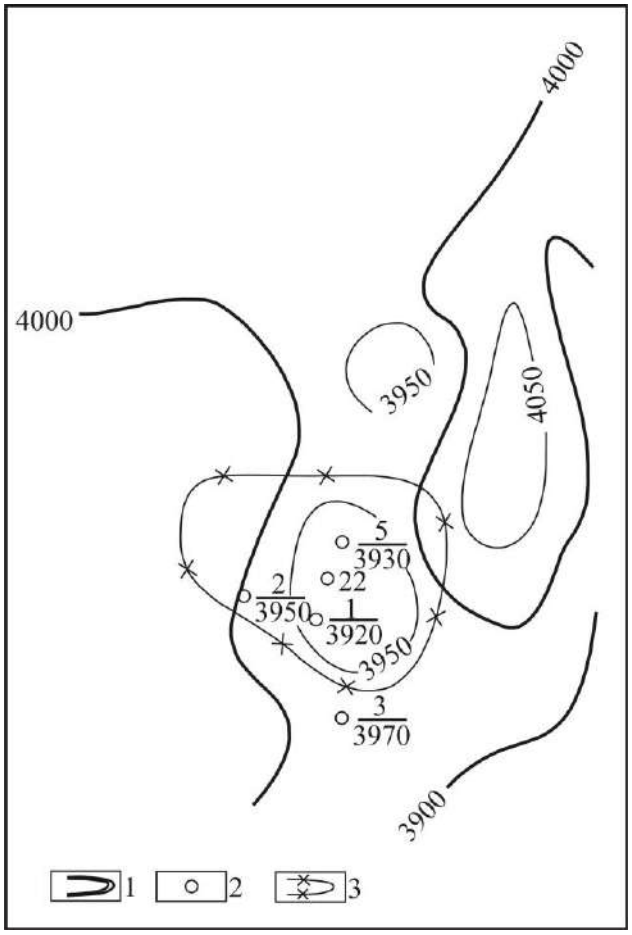

Figure 2. Structural map of Jafarli area:

1 – isolines of depths; **2** – deep wells; **3** – oil drainage boundary forecasted according to the data produced by CDPM seismic surveys implemented using GSP methods

Another area where the GSP is used, is the study of 4D in order to control the development of oil and gas fields. These studies gave positive geological results in the deposits of Kurovdagh, Kursanga, Garabaghli, Azeri-Guneshli, etc. With the help of these studies, additional hydrocarbon resources have been identified, and therefore, it is highly recommended to implement such studies in the other fields.

Later, popularity of the GSP studies has declined both in Azerbaijan and in the world's other oil and gas bearing regions. Apparently, it happened due to certain unconfirmed facts. Considering that the forecasts developed based on geological section prediction bear rather advisory than a mandatory character, obtaining additional information on the oil and gas saturation of the sections would always play a positive role, especially in the areas with favorable seismic conditions (Yevlakh-Agjabedi and Lower Kur troughs, Southern Kur Depression, etc.).

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AZƏRBAYCAN ŞƏRAİTİNDƏ APARILAN GEOLOJİ KƏSİLİŞİN STRATİQRAFİYA VƏ PROQNOZLAŞDIRILMASI

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Məqalədə seysmostratiqrafik analizin və geoloji kəsilişlərin proqnozlaşdırılması işlərinin inkişafı tarixinə dair məlumat təqdim olunmuş, bu növ tədqiqatların seysmik məlumatlar əsasında aparılması metodologiyasının xülasəsi verilmişdir. Məqalədə həmçinin Sovetlər-Qalamadın regional kəsilişin interpretasiyası nəticələrinin timsalında Mezo-Kaynozoy çöküntülərində struktur mərhələlərinin, seysmik komplekslərin və seysmik fasiyaların müəyyən edilməsinin mümkünlüyü əsaslandırılmışdır. Neft-qazlılığı proqnozlaşdırılan obyektlər sırasında Cəfərli sahəsində qazılmış bir neçə kəşfiyyat quyusundan (1, 5, 21, 22) neftin alınması həmin proqnozları təsdiqləməyə imkan yaratmışdır.

СЕЙСМОСТРАТИГРАФИЯ И ПРОГНОЗИРОВАНИЕ ГЕОЛОГИЧЕСКОГО РАЗРЕЗА В УСЛОВИЯХ АЗЕРБАЙДЖАНА

Ш.С. Кочарли

В статье, после рассмотрения истории образования сейсмостратиграфического анализа и прогнозирования геологического разреза, приводится краткая методика этих исследований по сейсмическим данным. На примере интепретации регионального профиля Советляр-Каламадын, обосновывается возможность выделения структурных этажей, сейсмокомплексов, сейсмофаций в разрезе мезокайнозойских отложений. Из прогнозируемых нефтеносных объектов, на площади Джафарлы было пробурено несколько разведочных скважин (1, 5, 21, 22), давших нефть, тем самым подтвердивших прогнозы.