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Self-development and Renewal of Hydrocarbon Resources and Reserves in the Caspian and Black Sea Region

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Abstract. The results of aerospace, seismic and geochemical studies along with monitoring of the Earth degassing at the geophysical laboratories in the region of research are considered. They allow making a conclusion that the hydrocarbons are self-developing and renewable resources. Abundant seepages of oil and gas, dynamics and the mode of natural discharge of the hydrocarbons in the territory of the Caspian and Black Sea Region (CBSR) and in the waters of the Caspian Sea and Black Sea evidence for availability in their depths of the hydrocarbon systems, within which current active fluid dynamic processes providing for the self-development of the hydrocarbon resources and reserves are occurring. Self-development of the hydrocarbons is correlated with the periods of activation of the present-day geodynamic processes accompanied by the solar activity, solar and lunar tides, earthquakes, mud volcanism, sea level fluctuations, and correspondent variations of the electromagnetic fields as well as by the spatial and temporal variations of the gravitational field of the Earth. Therefore, a formed in a natural way continuous “natural process line” engaged in transformation of the subsoil matter into the energetic and chemical raw material is functioning in the territory of the geodynamically active regions, and the oil and gas deposits are generated as the product of functioning of the above line.

1. Introduction

The most important particular feature of the structure of the Caspian and Black Sea Region (CBSR) is represented by the tense state of its subsoil, high and variable geodynamic activity, which is expressly revealed in its explosive variations – seismicity, earthquakes and “sedimentary” volcanism: mud, oil and gas, mixed etc., which, in their turn, determine the intensity of the geofluid dynamic processes.

By now, we have accumulated large factual evidence confirming the existence of the process of self-development of the hydrocarbon resources and reserves. Main peculiarities and facts confirming the assumption about the possibility of renewal of the hydrocarbon raw material are the following:

- Detection on the bottoms of the Caspian Sea and the Black Sea, as well as in the mainland of a huge number of natural and operating during a long period of time gas seepages in the form of macro- and micro seepages, pockmarks and mud volcanoes in Azerbaijan and other [1].
- Periodic eruptions of the mud volcanoes discharging dozens and hundreds million cubic meters of gas during the recent hundreds of years [2]-[4]. Total number of the eruptions calculated on the basis of the volume of breccia attains several thousand. Historical data related to the eruptions



show that about several dozen trillion m³ of gas were emitted into the atmosphere in the process of eruptions during the most recent period of the mud volcanoes activity.

- Lengthy subvertical channels and intermediary chambers composed of the loose rock masses connecting the surface with the zones of generation of the hydrocarbons are revealed under the mud volcanoes.

Multiple facts of self-development of the hydrocarbon resources in the oil and gas fields exist in addition to the foregoing. There are determined the facts of the long-term functioning of the producing wells in the oil and gas fields of the old producing areas in Azerbaijan and Ciscaucasia, the assumed (calculated) reserves of which have been extracted long time ago [5], [6]. Estimation of the rate of self-development of the hydrocarbons was performed in certain fields. Thus, for 29 producing horizons of the Bibi-Heybat oil field the rate of natural inflow of the oil varies within the range of 0.32...1.4 tons/day comprising on average 0.76 tons/day or about 277 tons/year. The rate of oil accumulation in the traps comprises from 12 to 700 tons/day and the term of formation of the oil deposits amounts to 1...12 million years. For various sections of the Garadag gas condensate field the values of the coefficient of natural recovery of the wells amount on average to 5.2 thousand m³/day of gas and 0.9 tons/day of gas condensate [7].

2. Research methods

The centers of current discharge of the hydrocarbons in the territory of the mainland and within the sea waters of the CBSR were studied by means of combining the aerospace, seismic and geochemical methods, as well as by monitoring of the Earth degassing on the basis of the geophysical observatories in order to estimate the process of self-development of the hydrocarbons.

3. Results of the research

The obtained results provide the evidence that the Caspian and Black Sea Region and the waters of the Caspian Sea and Black Sea included therein represent the venue of active present-day fluid dynamic processes activated by the elastic-deformation processes running in the depths thereof. Abundant seepages of oil and gas, dynamics and mode of the natural discharge of the hydrocarbons in the near-Absheron waters of the Caspian Sea including the Baku Bay, and in the central – deep water part of the Black Sea and adjacent to the sea shore Kerch-Taman territory prove availability in its depths of the hydrocarbon systems providing for self-development of the hydrocarbon resources and reserves.

4. Results of the geophysical research

The Caspian and Black Sea Region is characterized by high seismicity and mud volcanic activity. About 1000 earthquakes of various intensities are registered in the region every year. Analysis of the data about the earthquakes and the recorded eruptions of mud volcanoes allowed detecting the relationship between the seismicity and activation of the mud volcanic activity. Only during the late 2000 – early 2001 there were recorded 16 eruptions of mud volcanoes, and also a series of powerful earthquakes with the magnitude of up to 6.8 took place in the southern Caspian region. It is determined that the earthquakes play the role of a “triggering mechanism” in the mud volcanic process. The magnitudes of the earthquake, depths of the center, energy class and the distances between the center of the earthquake and the volcano play an important role in this case. The eruption of the volcano either matches in time with the earthquake or follows it with a certain time delay [8].

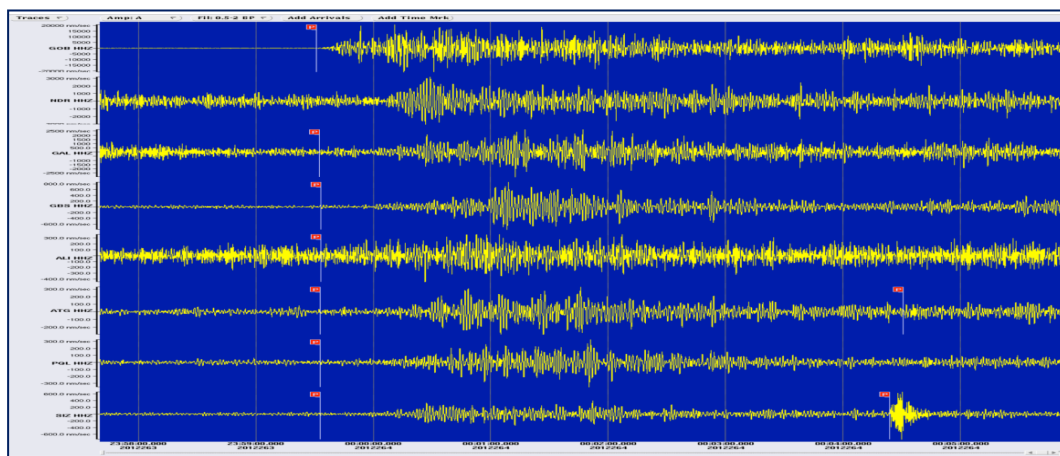


Figure 1. Digital waveform records taken from the stations in Gobu, Nardaran, Gala, Gobustan, Shirvan, Altyagach, Pargulu and Siyazan.

Seismic monitoring in the real time scale was used in order to map the spatial position of the centers of disturbance. For that purpose, digital recording of the waveforms from the mud volcanoes was performed at the stations (Figure 1). The images of underwater mud volcanoes are obtained using the advanced seismic technologies.

5. Results of monitoring from the geophysical observatories

Estimation of the gas mode and degassing was performed on the basis of the geophysical observatory installed on the Dashgil, Perekishkuel and other mud volcanoes in the real time scale during the period of time from 2003 till 2018 (Figure 2.).

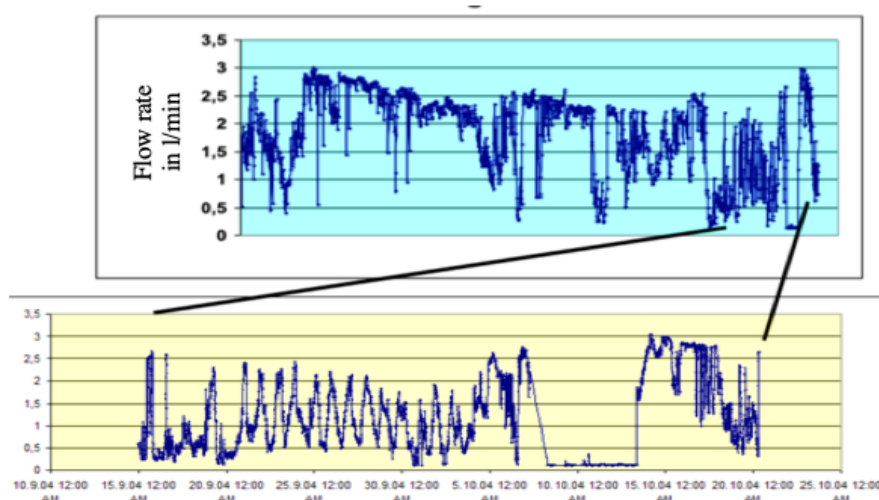


Figure 2. Record of the flow made at the degassing monitoring station operating in the continuous mode at the Dashgil mud volcano (June-October 2004).

During the first phase of the studies the gas monitoring station included the sensor meters used to measure the methane flow, radon emission, gas composition and atmospheric pressure and the temperature. The device used for recording of the obtained data transformed the information into the digital data format, stored it and transmitted to the database computer using the transmitter antenna [9].

6. Results of the geochemical research

These results allowed obtaining the information about the sources of current self-development of the hydrocarbons – the sources of generation of the hydrocarbons and the residual generation potential of the oil and gas producing rocks (OGPR) in the CBSR evidencing that the currently available processes of generation and migration of the hydrocarbons represent one of the main reasons for the process of self-development of the hydrocarbons [10]. It is known that the oil and gas producing rocks generate the hydrocarbons not within the entire distribution area, but primarily in the hydrocarbon generation centers. As it is shown by the results of modeling, the sedimentary basins in the CBSR represent the multi-center basins; and generation of hydrocarbons in different centers and in various parts occurs with a different intensity. Hence it follows the difference in the residual generation potential in various parts of the basin [11]. As it is shown by the results of the geochemical research and modeling of the hydrocarbon systems (Figure 3) within the boundaries of the Tersky-Caspian trough, the Middle and Upper Jurassic OGPR have currently developed their potential completely.

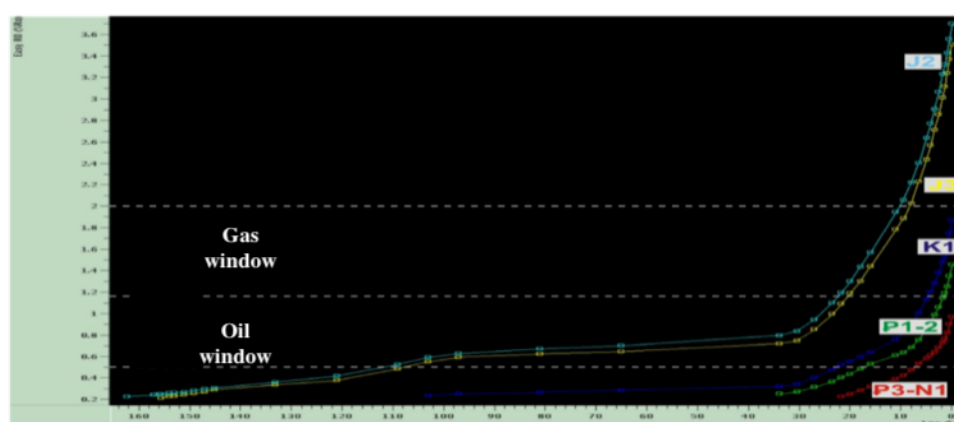


Figure 3. Graph of the catagenetic evolution of the OGPR in the Tersky-Caspian trough.

Generation of the hydrocarbons by them is possible solely within the boundaries of the Garadag structural zone, where they are at the gradation of the catagenesis of MC4 with preserving 20% of their generation potential [12]. The extent of development of the kerogen in the Apt-Alb OGPR is decreased from 90% in the depocenter of the Chechen trough to 40...70% at its boundaries. It comprises 30...10% in the Sunzha and Tersky zones. The potential of the deposits is preserved practically completely in the elevated Garadag zone. A similar trend can be also traced for the deposits of the Kum formation. The argillaceous rocks of the Maikop series have preserved their potential practically completely within the boundaries of the trough. The extent of development amounts to 40...50% only in the depocenter of the Chechen trough. Therefore, based on the specific features of the organic matter and the extent of the catagenetic transformation of the defined OGPR, main sources of self-development of the oil fluids within the Tersky-Caspian trough can be currently represented by the sediments of the Maikop series everywhere, and of the Lower Cretaceous and Kum formations – within the boundaries of the elevated sections. Self-development of the gaseous hydrocarbons is provided by the OGPR of the Apt-Alb and Kum formations within the limits of the submerged sections. The Jurassic oil producing rocks do not make any significant contribution to forming of the oil content in the Tersky-Caspian trough starting from the Late Miocene.

7. Discussion of the obtained results

The present-day hydrocarbon degassing occurs due to the generation and migration of the hydrocarbons at the later stages of the basin evolution and is accompanied by substantial geodynamic effects, which are registered in the form of earthquakes and can be mapped in the real time scale using the modern telemetric systems. This process is correlated with the periods of activation of the present-day geodynamic processes accompanied by the solar activity, solar and lunar tides, earthquakes, mud

volcanism, sea level fluctuations, and correspondent variations of the electromagnetic fields as well as by the spatial and temporal variations of the gravitational field of the Earth; and can be mapped in the real time scale using the modern telemetric systems [13].

Research of the extent of degassing was performed both with the mud volcanoes and within the focused sources of the hydrocarbons. Indirect estimation can be performed on the basis of the balance of the discharged gases and fluids emitted from the deposits of the hydrocarbons, mud volcanoes and focused effluxes. Frequency analysis of the degassing parameters recorded by the monitoring station characterizes the strength of the shallow-focus earthquakes and mud volcanoes that reflects the energy and power of the fluid generating processes running within the center. There are determined two basic categories of the geological sources of supplying CH₄ to the atmosphere – the process of formation of the hydrocarbons within the sedimentary basins and geothermal or volcanic discharges.

Comparative intensity of the fluid dynamic processes is determined based on intensity of occurrence of the discharges of fluids and geochemical and temperature anomalies on the surface of the mainland and on the sea bottom [14]. Numerous mud volcanoes located in this zone can be considered as possible channels of discharging the flow of fluids to the surface. Based on the data provided by the space radars, natural discharges of oil from the depths of the south-western part of the Caspian Sea are estimated from 2 to 16 thousand tons per year.

Calculation of the numbers of eruptions of the mud volcanoes for the entire term of their existence shows that the Big Kyanizadag mud volcano erupted 7350 times, Toragay – 6860 times, Dashmardan – 1250 times, Dashgil – 550 times and so on that allows performing, in its turn, calculation of the approximate volumes of the gas emitted to the atmosphere.

The calculations performed by F.G. Dadashev et al. showed that billions cubic meters of gas and several million tons of oil are released every year to the daylight surface in the area of the Absheron Peninsula [15]. The structural analysis shows that the centers of underwater discharge of the offshore mud volcanoes provide a direct proof of the fact of availability of the hydrocarbon systems in the depths of the crust and transit channels.

The centers of disturbance detected within the sedimentary mantle, their morphology and the depths of their origination can be defined using specific observations with application of the method for high-resolution seismic survey. Generation in the “centers of disturbance” is accompanied by a spontaneous loosening of the sedimentary rocks, and, as it is shown on the basis of the seismic research, such centers are distributed discretely, not within the entire volume, and are characterized by an essential spatial and temporal variability.

Instable and variable with time tectonically tense state of the crust is an active force for driving of the migration processes [16]. It results in various deformations and exerts the influence on structural behavior of the rocks. Studying of active geodynamic phenomena allows providing reasoning for availability within the sedimentary basins of the specific “centers of disturbance” – certain volumes of the sedimentary mantle, in which the processes of generation of the hydrocarbons occur at high rates and are accompanied with significant dynamic effects. Realization of the conditions created for the phase transitions is the basic factor for generation of the hydrocarbons in the “centers of disturbance”.

8. Conclusion

The aforementioned results of the studies allow suggesting the following concept of self-development and renewal of the hydrocarbon resources and reserves.

Generation, migration and accumulation of hydrocarbons form an integral part of the processes of transformation/redistribution of the matter running within the entire volume of the sedimentary filling and at all the stages of evolution of the sedimentary basins. The centers of phase transitions – the “centers of disturbance”, in which the transition of a part of the sedimentary material from the structured and stratified state of a specific mixture into the amorphous breccia mass occurs within the limits of the above volumes of the sedimentary filling. Just these “centers of disturbance” represent the place of generation and emigration of the hydrocarbons at the later stages of the basin evolution that is exactly *the main reason for self-development and renewal of the hydrocarbons*. Generation and

migration of the hydrocarbons occur periodically and at high rates during the periods of the disturbance phases correlated in terms of the time and extent of occurrence with the periods of activation of the present-day geodynamic processes – seismicity, earthquakes and the “sedimentary” volcanism: mud, oil and gas, mixed etc., which are also related to the solar activity, solar and lunar tides, sea level fluctuations and variations of the electromagnetic fields as well as by the variations of the gravitational field. Therefore, studying of the processes of self-development of the hydrocarbon resources and reserves and estimation of their amounts and flow rates shows that a formed in a natural way continuous “*natural process line*” engaged in transformation of the subsoil matter into the energetic and chemical raw material is functioning in the territory of the geodynamically active regions. As the result of functioning of such “natural process lines” discharge of the hydrocarbons occurs in the porous environment saturated with the hydrocarbon raw material and characterized by metastability, capability of phase transitions and special sensitive zones – the centers of disturbance. Generally speaking, oil and gas fields can be regarded as the product of functioning of such “natural process lines”.

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