Example

Introduction. With the oil price falling for large and small oil Company's by rather urgent problem becomes the acceleration and optimization of the prospecting and exploration process for industrial oil and gas accumulations in the reservoirs of traditional and non-traditional type. A more active and purposeful use in the prospecting process of mobile methods and technologies of "direct" searching for oil and gas accumulations may contribute for solving the problems of the exploration optimization and acceleration and the success rate of drilling increasing.
In the Azov and Black Sea region a significant volume of research's to find commercial hydrocarbon accumulations has been conducted with using the direct-prospecting methods of forming the short-pulsed electromagnetic field (FSPEF) and vertical electric-resonance sounding (VERS), as well as the frequency-resonance method of remote sensing processing and decoding. The prospecting investigations have been conducted as within offshore, so on onshore areas. The report presents and analyzes the results of the direct-prospecting methods use on the Burgas prospecting area in Bulgaria.

Methods of investigation. Prospecting investigation by mobile method of frequency-resonance processing of remote sensing data and ground-based geoelectric methods FSPEF (SCIP) and VERS may be conducted in three main phases: 1) frequency-resonance analysis of satellite images of the major search areas and blocks in a relatively small scale (*the study of regional character*); 2) a detailed frequency-resonance analysis of satellite images of individual areas (sites) of anomalous zones, allocated at the first stage (*work of detailed character*); 3) field geoelectric works on the most promising local areas, identified at the second phase of the work (*ground-based studies*).

Initial and geological data. Administratively the Burgas search area belongs to the Burgas community and is situated in the south-eastern coastal part of Bulgaria. In tectonic plan, this area is situated in the northern slope of the folded Burgas Synclinorium, located south of the Stara Planina anticlinorium. It is part of Srednegorskaya tectonic zone, on which the Bourgas trough is imposed, which is stretching at the south along the mountain folded structures of Strandja anticlinorium. In the geological structure of this depression take part the rocks of sedimentary-volcanogenic formations of the Upper Cretaceous age and terrigenous-carbonate deposits of the Paleogene. The first are presented by the trachyte-andesite, andesites, andesite-basalt tuffs, tuffites, tuff-sandstone and other rocks of volcanic-sedimentary type. Column of Paleogene is folded by the limestones, dolomites and Paleocene-Eocene marls (1-p Provadia well), as well as argillites, sandstones, conglomerates and breccias of top Eocene (Karadeniz-sea well).Prospects for oil and gas potential in the Bourgas trough (both on onshore and at offshore) are linked mainly with volcanogenic-sedimentary strata of rocks, formed in the fissure cavities (pushing) and in the areas of crushing of inter-block faults. In this region the inter-block faults control the transverse bloc zoning with a general tendency of the folded basement dipping by step in an easterly direction, towards the Black Sea. Some search interest has the Paleogene sediments, where you can expect the availability of natural gas deposits. Oil shows, related to intrusions and covers of igneous rocks, are known in many countries. It was also found a significant number of industrial deposits (Mexico, Cuba, Texas, California, Japan, New Zealand, and others). The presence of hydrocarbons in igneous rocks suggests that these volcanic rocks are natural ways for the migration of oil and gas to the surface through the sedimentary sequence (Kudryavtsev, 1959). The cover igneous rocks, their tuffs and agglomerates, lying among the sediments, in some cases, serve as reservoirs for oil deposits. Oil and gas shows in the sequences of volcanic rocks are usually characteristic for basic and ultra basic rocks. This is due to the fact that these rocks are often the final phase of the magmatic cycle. Their breakthroughs in the upper layers of the earth's crust and the surface open the ways for the deep hydrocarbons lifting, after the termination of the intrusion of molten magma. Intense volcanic activity promotes active tectonic-genesis. The volcanic formations are accumulated together with sediments, forming a volcanic-sedimentary formations (rhythmic alternation of sedimentary rocks with effusions). In connection with the magma intrusion along the numerous cracks stretching there is a hydrocarbons migration and their accumulation in favorable structural and litho logical conditions (Kudryavtsev, 1959).

Results of investigations. In 2006, the experimental study of reconnaissance character has been held in Bourgas trough with the mobile geoelectric methods FSPEF (SCIP) and VERS (Levashov et al., 2006; 2012) using. As a result of work, the Western geoelectric anomalous zone has been identified, which defines the dedicated hydrocarbon accumulation areas. The anomalous zone is oriented in sub-meridian direction, the zone has a serpentine character and isometric outlines (zone length is of 30 km and a width is of 2-5 km). On Figure 1 the discovered in 2006 anomalies are indicated by the red outlines. In this case, as the structure-forming can serve the "effusive flows", which is characterized by a considerable length and a small width. In 2010, the frequency-resonance processing (Levashov at al., 2010; 2012) of the satellite image of the area has been carried out in order to identify the promising areas for oil and gas. The obtained results (Figure 1) confirmed the data of ground-based geoelectric work and allowed to allocate a new Eastern geoelectric anomalous zone, perspective for the discovery of oil and natural gas deposits (the length of the anomalous zone is 14 km, the width – 4-6 km).It can be assumed that the hydrocarbon traps in the Burgas area are likely to have a zonal character: they may be of unconformity type, tectonically screened and of lithological replacement type. By the collector in a given area can be the tuff-sandstones, tuffites and fractured-porous rocks of cross-section. By the trap covers are the dense lava covering formation of basalts and andesites. The latter is important, since the volumes of hydrocarbon accumulations in reservoirs, overlain by basalt, may be significant. According to the data of studies the forecasted hydrocarbon resources in the surveyed area have been evaluated approximately. Resource calculations were carried out based on the information of the geological conditions of occurrence and material composition of sequences in the cross-sections, studied by vertical electric-resonance sounding (VERS) at two stations B5 and B2 within the contours of Western geoelectric anomalies (Figure 1). There were also used the materials from the drilled p-1 Pomorie well on the Black Sea coast near the town of Bourgas and the cross-section of the well near the Ravnets. Area of Western anomalous zone is 110 square km, of Eastern anomaly– 70 square km. By the VERS sounding the anomalous polarized layers (APL) of the "oil" and "gas" type were marked at the point B5 in the depth interval of 2400-3250 m, and at point B2 – 3200-5050 m. Number of APLof the "oil" and "gas" type in the cross-section is 6. The folded basement lies at a depth from5200 m to 6500 m.

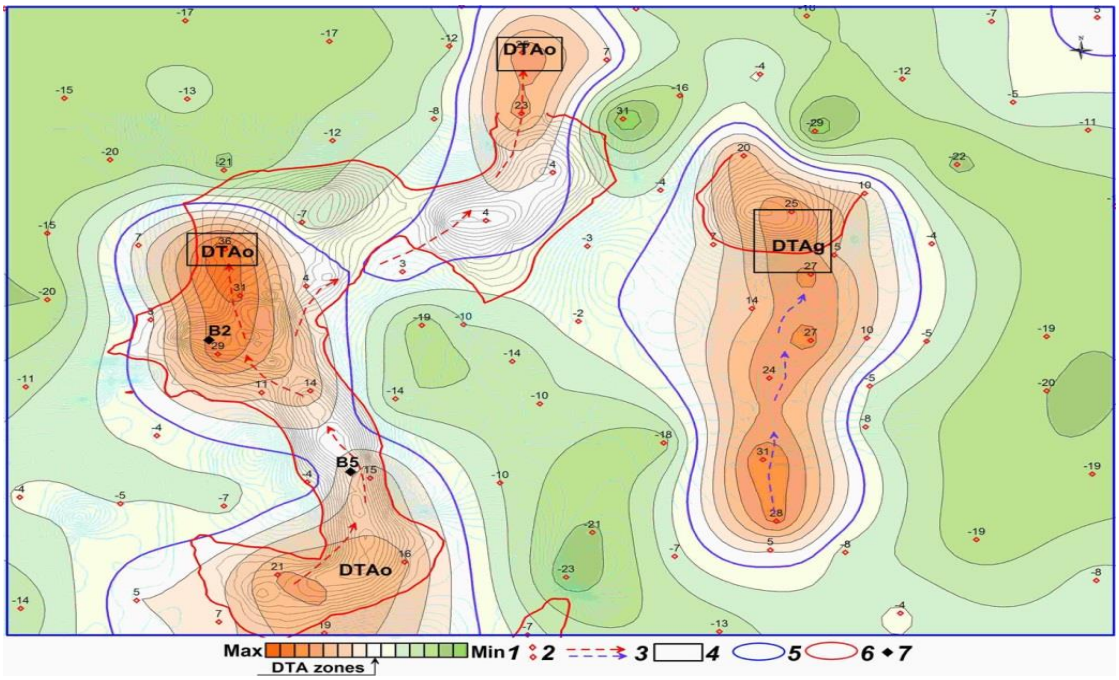

Figure1 Schematic map of the results of the satellite image frequency-resonance processing of search area in the Black Sea region. *1*– scale of the anomalous response intensity; *2*– points of the anomalous response determining; *3*– projected directions of HC migration; *4*– areas recommended for detailed study and drilling; *5*– outlines of the anomalies according to satellite image processing; *6*– outlines of the anomalies according to the ground-based geoelectric survey by FSPEF method; *7*– points of VERS sounding

The available data of electric-resonance sounding of geological section at stations B2 and B5 in Bourgas trough are very important from the point of view of search criteria's. They indicate the presence, in the range of the projected productive volcanic-sedimentary rocks, of natural hydrodynamic systems, ensuring the autonomy of oil and gas reservoirs. Here, in the six identified APL of the "oil" and "gas" type, the presence of plantar formation waters (residual waters) are predicted, which were formed in the reservoir since the hydrocarbon deposits formation. The presence of formation water in the frozen lava flows and weathered intrusive igneous rocks indicates at the good permeability of these rocks. The height of the column of gas-oil deposits determines the effective volume of oil and gas reservoir (Kudryavtsev, 1959). Approximate estimates of probable hydrocarbons resources in Western anomalous zone are following: natural gas – 28.0 billion m^3, oil – 35.0 million tons. In the Eastern anomalous zone the VERS sounding of geological cross-section was not conducted and the volume of hydrocarbon resources has not been assessed. We also add that in September 2016 the frequency-resonance processing of Burgas area satellite image has been conducted with using the technology of fluids pressure in reservoir assessment (Levashov et al., 2011). After processing a map of anomalous zones in isolines (values) of reservoir pressure has been constructed. Within the Eastern and Western anomalous zones the most promising areas for detailed survey by ground-based methods FSPEF and VERS have been isolated (localized).

Recommendations and conclusions. At the initial stage of geological and geophysical study of the Burgas area it is recommended to conduct the areal geoelectric survey with a rational number of VERS sounding stations to assess the total volume of the expected hydrocarbon resources within the Western and Eastern anomalous zones. The results of detailed geoelectric work will permit to simulate the type of hydrocarbon traps in volcanic strata and select the optimal location for the first exploration well laying within the Burgas prospecting area. There is an opinion that the large oil and gas deposits in Bulgaria may be found only in the Black Sea deep water. We do not think so, and offer to pay attention to the poorly studied for the oil and gas prospects Burgas area on the Bulgaria onshore. Given that the prospecting and exploration of commercial oil and gas accumulations on the onshore and the development of discovered resources is significantly cheaper than within offshore, the discovered and mapped anomalous zones deserve a detailed study as by mobile direct-prospecting methods, so and traditional geophysical (seismic, primarily).To this we can add a quote from the article (Rusakov and Kutas, 2014, p. 3), which states:"In the last three years in Turkish, Bulgarian and Romanian exclusive economic zones of the Black Sea 11 exploratory wells were drilled on the shelf, in the transition zone and the deep basin, 10 of which have been deemed lacking. To assess the potential of Domino-1 well (Romania), there is need to spend several billion dollars within 5-6 years". The traditional geophysical methods are not direct methods of oil and gas exploration. In this regard, there are low success rate of drilling - many wells do not provide commercial inflow or are dry. According to (Zapivalov, 2013, p. 3) "the success of exploration in the world is kept at an average of 30%".A more active and purposeful use in the prospecting process of mobile methods and technology of "direct" searching for oil and gas accumulations may contribute for solving the problems of the success rate of drilling increasing.

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