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STRUCTURAL-GEODYNAMIC AND HYDROCARBON SYSTEMS IN THE BLACK SEA-CASPIAN REGION

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Summary. The purpose of these studies is to tackle a scientific problem of identifying patterns in the origination and evolution of structural-geodynamic and hydrocarbon systems in the Black Sea-Caspian region (BCR) and to determine conditions conducive to the formation and distribution of hydrocarbon fields using basin analysis, numerical geologic modeling, paleotectonic and paleogeographic reconstructions, geochemical studies, etc. Research findings and their scientific merit consist in a comprehensive analysis of patterns behind the formation and evolution of structural-geodynamic and hydrocarbon systems in the BCR.

Introduction

Structural-geodynamic systems (SGS) can be defined as the totality of elements within the framework of the basement and sedimentary cover unified by a common reaction to geodynamic impacts from the external or internal (in relation to the system) source of tectonic energy during one or several phases of tectonic genesis. The framework of different tectonic zones is given in details in the map of the main structural elements (Figure 1).

The conducted studies allow producing the models of structural-geodynamic systems in the BCR determining the key features of the present-day tectonic zonation in the region. We built 3D structural models of the sedimentary cover for this purpose (Figure 2).

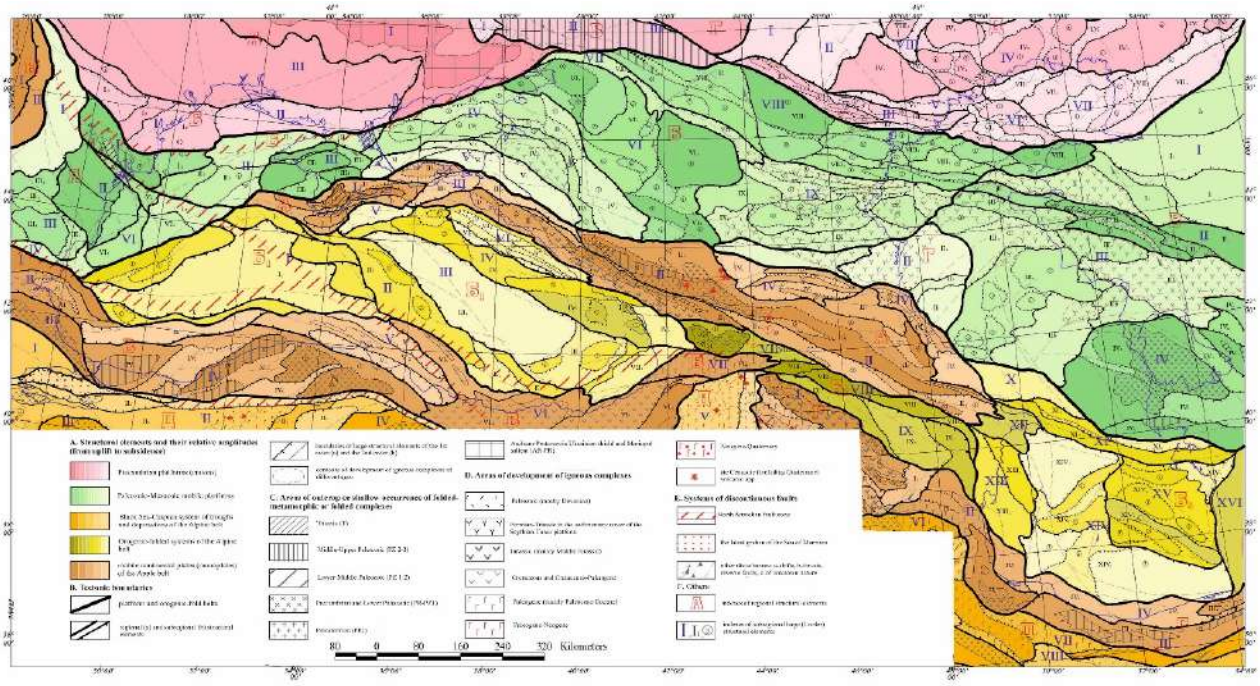

Fig. 1. Map of the main structural elements of the Black Sea-Caspian region

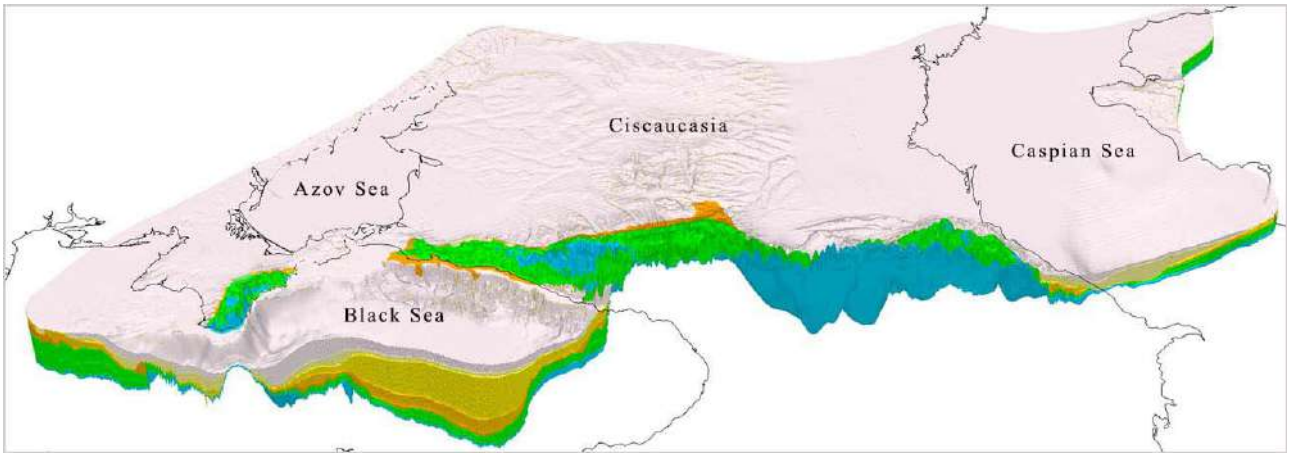

Fig. 2. Model of the sedimentary cover of the Black Sea-Caspian region

Sizeable zones of interblock interaction at the basement of mobile platforms are studying with great interest from a practical standpoint. This interaction results in the deformations in the overlapping plate cover and has an impact on the settings in which sediment deposition and fluid exchange occur during its formation. These studies can facilitate the search for and localization of potential oil and gas targets of anticlinal and depositional origin, in particular, at the level of deep horizons in the plate cover.

Results

The main results are presented in scientific publications and conferences (Guliev et al., 2021; Guliyev et al., 2017; Kerimov et al., 2021, 2022; Lavrenova et al., 2021; Mustaev et al., 2021, 2022; Senin et al. 2022).

The following work was completed as part of our studies within the conditions conducive to the formation of sedimentary basins in the BCR and regularities behind their distribution: we performed basin analysis, summarized the results from earlier studies, constructed lithologic-paleogeographic schematic maps, paleogeographic maps and maps showing the extent of sedimentary basins. Basin analysis involved generating depth structure maps and thickness maps based on the reviewed G&G data. These maps allowed tracing a shift in the depocenters, identifying particular aspects related to the formation of sedimentary basins, define their boundaries, and distinguish sizeable areas of persistent downwarping

The geologic-geochemical data on the material composition of deposits in the sedimentary cover and geochemical characteristics of the section provided a basis for identifying the elements of generation-accumulation hydrocarbon systems (GAHS), including regional Middle Jurassic, Cretaceous (Aptian), Paleogene (Kuma formation), and Maikopian oil and gas source rock intervals as well as a potential oil and gas source rock interval in the Miocene deposits. To identify reservoir intervals we reviewed the available data on oil and gas saturation in the sedimentary section, i.e. oil and gas shows and fields. For this purpose, we created a relevant database on the indicators of oil and gas occurrence. According to this data and taking into account paleogeographic reconstructions completed for each sedimentary basin, we determined the most important permeable rock intervals and impermeable seals. We estimated present-day maturity to reconstruct the processes of hydrocarbon generation based on the numerical modeling of the GAHS (Figure 3).

The modeling of hydrocarbon systems resulted in the reconstruction of hydrocarbon migration and accumulation processes in the Meso-Cenozoic complex of the BCR. Due to the persistent subsidence of the studied basins, migration of hydrocarbons proceeds towards their flanks.

Consequently, flank and near-flank zones represent areas where hydrocarbon accumulation is most likely to occur (Figure 4). Due to the specific aspects of the tectonic framework and the presence of squeezing folds in the Mesozoic complex, hydrocarbon migration processes in the Terek-Caspian Basin are currently not unidirectional. The flow of fluids from the main oil kitchen areas located in the downwarped part of the foredeep is mainly directed towards the platform flank and the southern flank. Thus, the main hydrocarbon pools formed in anticlinal structures of the central north-south trending foredeep. All the modeled GAHS are marked by crossflows (to a greater or lesser extent) due to the particular aspects of the evolution of depositional processes in the setting of alternating transgressions and regressions. The crossflows are also linked with the active tectonic regime in the studied region. The presence of stacked pools validates the conclusion on widespread processes of HC crossflows.

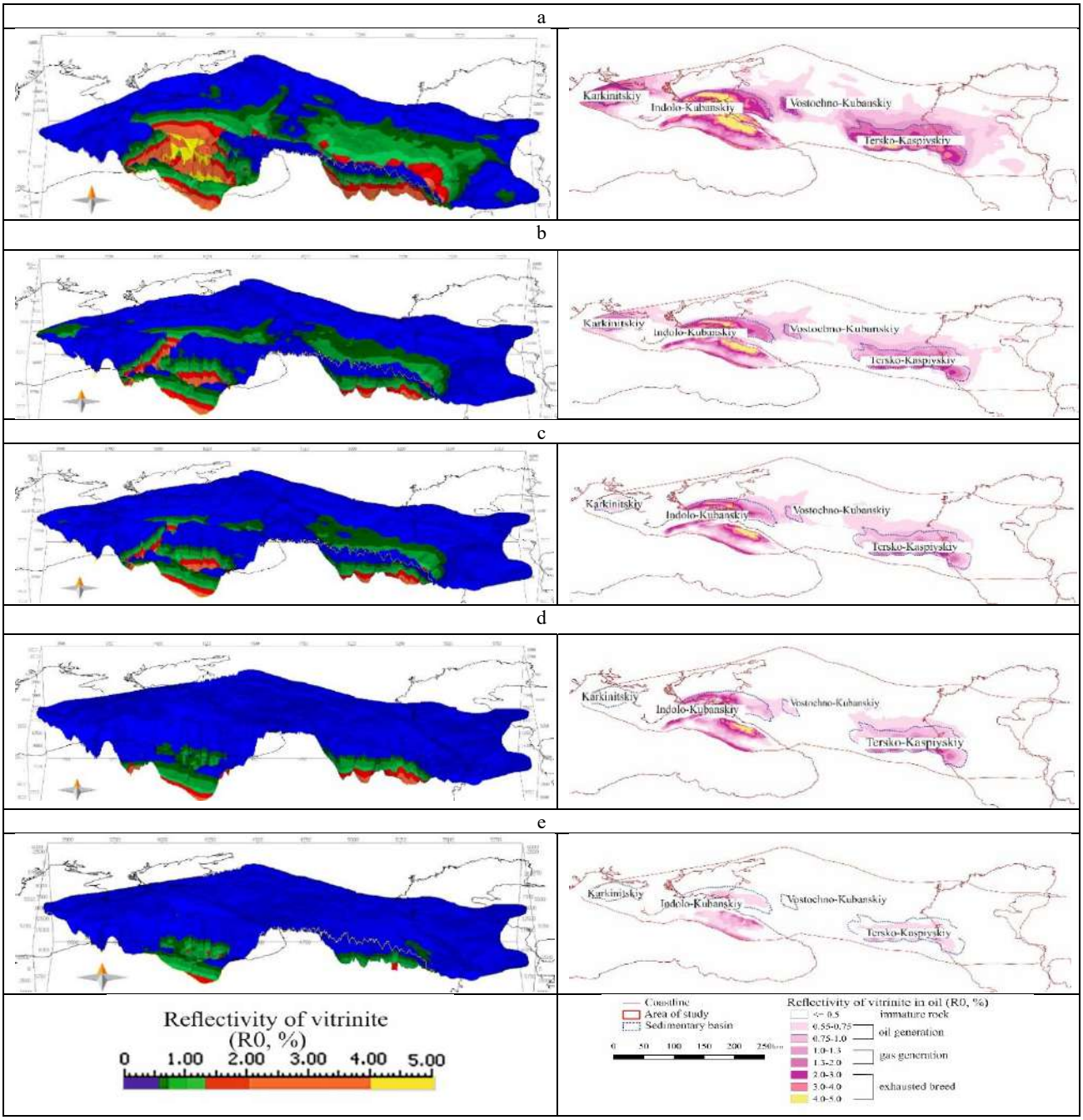

Fig. 3. Models and maps of modern maturity: the Middle Jurassic (a), the Lower Cretaceous (b), the Eocene (c), Maikop (d) and the Miocene (e) deposits

Conclusions

The conducted studies have produced the following results:

1. The following four areas of persistent subsidence, i.e. depositional basins, have been identified: the Karkinit, Indolo-Kuban, East Kuban, and the Terek-Caspian Basin.

2. We have defined the conditions conducive to the evolution of structural-geodynamic systems in the BCR from the Late Paleozoic to the Pleistocene with a trend towards the gradual attenuation of geodynamic activity.

3. It has been revealed that geodynamic processes have remained active in the Black Sea-Caspian region during a long span of geologic time up to the present day.

4. We have defined favorable conditions for the evolution of hydrocarbon systems in the region's basins that include, on the one hand, the maturation of organic matter of oil and gas source rocks as a result of successive subsidence of sedimentary complexes, and, on the other hand, the regime that facilitates a regular flow of hydrocarbons towards the marginal zones of the basin and adjacent zones occupying an uplifted position throughout the evolution of the basins.

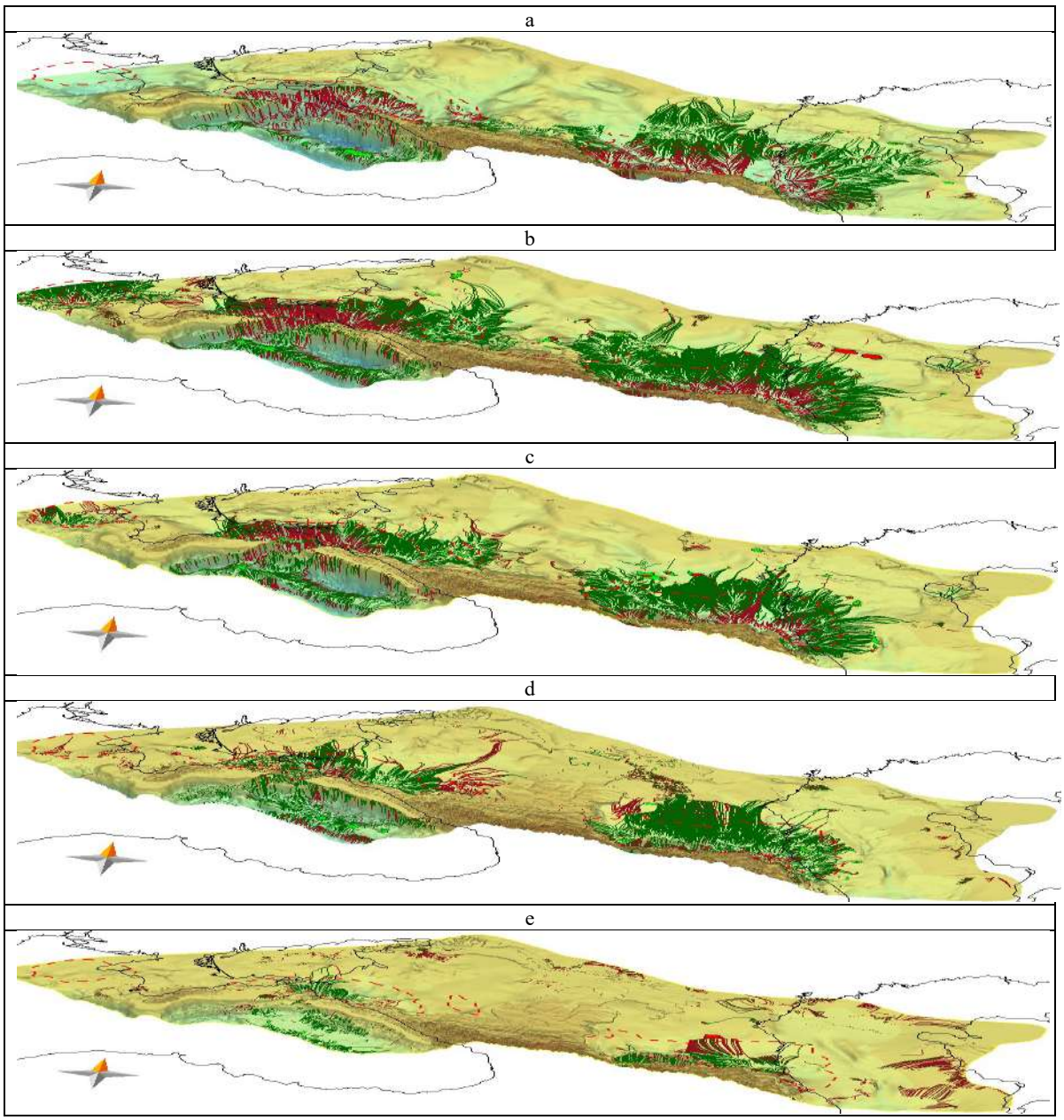

Fig. 4. Models of hydrocarbon migration from the Upper Jurassic (a), Cretaceous (b), Eocene (c), Maikop (d) and Miocene (e) deposits (green lines show the migration paths of liquid hydrocarbons, red - gaseous)

5. It has been demonstrated that variations in basin subsidence rates at different stages of their evolution had a critical impact on the realization of hydrocarbon-generating potential by oil and gas source rock intervals.

6. It has been found that from the latest Paleogene onward intermittent tectonic revival within the studied territory of the BCR has created an environment for vertical hydrocarbon crossflows and the appearance of stacked accumulations.

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