Determining Oil and Gas Maturity and Mapping their "Deep" Stratigraphic Sources, South Caspian Basin: Possible Applications to SE Caribbean Basins

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Abstract

To determine the degree of oil maturity in the South Caspian basin, we used biomarker parameters such as the degree of sterane isomerization {*C29 (20S/S+R)*} and aromatization of monoaromatic sterane {C_{28}*triarom.sterane* / C_{28}*triarom.* + C_{29}*monoarom.sterane*}. Thermal maturity of hydrocarbon gases was defined by the ratios of hydrocarbon components, carbon isotopic composition (CIC) of methane, ethane, and other homologues. The close similarity between the geology of the South Caspian and the SE Caribbean basins suggests that by applying similar analyses in the SE Caribbean basins new insights into the depths and processes of oil and gas generation might be gotten there too.

In the South Caspian Pliocene deposits, which are the main production units, the degree of oil maturity varies widely (Ro=0.45 to 0.7%). The majority of Pliocene fields (the mean age of reservoirs) in the South Caspian basin (81.58%) has oil with average values of Ro 0= 0.53-0.63%, and testifies to a low degree of transformation of organic matter in the oil source rocks.

Calculations based on the experiments revealed dependence between CIC of gases and the degree of their catagenic maturity (Ro). For ethane in particular, Ro ($\delta^{13}CC_2H_6(^{o}/_{oo})$ =22.61g Ro(%) - 32.2 shows that the hydrocarbon gases' maturity in the South Caspian basin fields varies in very wide range (0.4 – 3.1 R_o (%)). The most frequently observed values of maturity lie in range of 1.3–1.6. This points to gas and condensate generation in a zone of thermocatagenesis and corresponds to the peak of the "gas window". Gases of very high maturity have been found in separate South Caspian fields, which correspond to the thermogenesis zone (R_o > 2.5– 3). Generally, the increase of gas maturity is associated with fields located in areas with shallowly underlying Mesozoic deposits.

In the northern part of the South Caspian basin (Absheron archipelago), vitrinite reflectance values were determined from core samples recovered from depths of 5.5 km, and then extrapolated to deeper sedimentary intervals. The gas "window" there is located at the hypsometric depths of 13–15 km. According to the seismic-geological data, this corresponds to the interval of Paleogene deposits. Based on similar estimations, the oil "window" corresponds to hypsometric depths of 5600-6700 m, and stratigraphically to the Miocene deposits. This determination is confirmed by the isotopic-geochemical studies of oil and kerogen. The interval of ethane generation in the western part of the South Caspian basin (Baku archipelago) extends from 9 – 10 km to 13 km. Conversely, the main production unit in the South Caspian basin (the Productive Series reservoir) occurs at relatively shallow depths of 2600–4700 m. Thus, the migration from source rocks to reservoirs took place for across a long distance, at least 1000-4000 m for oils and 9000-10000 m for gas. Most probably, this was a vertical migration.

The different degree of maturity of HC fluids within the South Caspian basin testifies to an extremely extended oil-gas “window” and at least two stratigraphically different sources: predominantly gas generating Mesozoic and oil-gas generating Paleogene-Miocene successions.

There are similarities between the South Caspian and SE Caribbean basins, especially the Barbados Accretionary Prism, the Columbus Shelf and Columbus basin. These are based on the age and thickness of the sedimentary infill, the wide occurrence of mud diapirism and volcanism, and the stratigraphic occurrence of the source rocks. They are confined to the Cretaceous, Eocene, Oligocene and Miocene complexes and are characterized by kerogene of II and II-III types. Different timing of these rocks’ entry into oil-gas “windows” is reflected in the wide component and phase composition and maturity of the hydrocarbon fluids. The processes of gas migration into reservoired oil and further remigration of oil and gas along vertical faults occur in the South Caspian and SE Caribbean basins.