RESERVOIR FLUID COMPLEXITY IN THE SOUTH CASPIAN BASIN

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Introduction

The South Caspian Basin (SCB) hosts more than 600 oil and gas onshore and offshore fields. Hydrocarbons are essentially accumulated in Pliocene sandstone reservoirs, referred to in the literature as the Productive Series or Red Series, interbedded with mudstones. The Productive Series overlays the Oligocene-Miocene Maikopian Formation, which is believed to be the main source rock in the SCB (Abrams and Narimanov, 1999; Torres, 2007).

Fluid properties in two adjacent anticline fields located offshore in the SCB show significant variations both laterally and with depth (from 26 to 53 degree API gravity, GOR from 350 scf/bbl to > 20,000 scf/bbl). However, the processes controlling these variations remain poorly understood, thereby limiting the ability to predict fluid properties across the fields. To achieve better predictive capability, it was desired to underpin the observed fluid property variations by the geochemical variations arising from oil generation and in-reservoir alterations. In this regard, this study presents the results of fluid property and geochemical analyses performed on fluids from 35 wells (25 stock tank oil samples, 19 pressurized bottomhole samples, 1 pressurized surface sample) and 8 distinct producing intervals from two fields. The fluids physical properties, gas chromatography, gas chromatography-mass spectrometry and gas chromatography-isotope ratio mass spectrometry (bulk & molecular) analysis data were measured, the lateral and vertical variations in fluid composition were evaluated and subsequently, the potential impact of hydrocarbon source, charge history and in-reservoir alteration processes are discussed in the geological context of the SCB.

Main Results

The results of the extensive physical property and geochemical suite of analyses, including the first comprehensive record of gas isotopes in the SCB, suggest that the Oligocene-Lower Miocene Maikopian Formation initially generated hydrocarbons which accumulated in the deeper sandstone horizons and possibly in the shallower horizons. Subsequently, the Middle to Upper Miocene Maikopian Formation also generated hydrocarbons, which migrated to the shallower sandstone reservoirs. There are no dramatic change in facies from the Oligocene-Lower Miocene to the Middle-Upper Miocene Maikopian deposits, but a possible change in organic matter input is reflected mainly in the bulk and molecular carbon isotope values (>2‰ shift) and hopane versus sterane ratios (e.g. C_{29}–C_{35} hopanes/C_{27}–C_{29} steranes ratio varies from 1.3 to 3.1).

Compared to the facies described in the literature for the Maikopian Formation, biomarker distributions show a less reducing environment but are mixed with compounds indicative of a highly reducing environment. This is likely related to slight lateral facies changes in the Maikopian source rock, wherein organic matter derived from a marine anoxic depositional environment was mixed with organic matter deposited under less anoxic conditions, including terrigenous input. Other source rocks in the SCB—Jurassic and Cretaceous carbonates, Eocene

shales and Lower Pliocene mudstones—might also contribute to the hydrocarbons accumulated in the Pliocene sandstone reservoirs, possibly indicating a more complex petroleum system than previously reported for the SCB. The presence of H_2S, reported for the first time in the SCB, in a clastic reservoir further suggests a possible contribution from deeper carbonate source rocks.

Evidence of slight biodegradation observed in the shallower reservoirs in the southwestern part of one field possibly related to the proximity to the oil-water contact in this area. However, other in-reservoir processes, including water washing and evaporative fractionation, were found to be active agents altering hydrocarbon distributions in most samples. Co-occurrence of biodegraded and non-biodegraded fluids and of hydrocarbons showing various stages of thermal maturity (from early oil window < 0.8% vitrinite reflectance (VReq) to ~1% VReq) in some samples indicate that several reservoirs have received more than one charge of hydrocarbons. Migration of lighter fluids might be the dominant process affecting the fluid behaviour in localized areas in the shallower reservoirs, highlighting the potential key role of the fault network.

Conclusions

Variations in fluid properties in the two studied SCB fields are mainly related to the mixing of hydrocarbons generated by slightly different source rock facies within the Oligocene-Miocene Maikopian Formation, at different maturity levels (light-hydrocarbon charging might still be in progress) and the in-reservoir alteration processes, affecting hydrocarbons to various degrees across the fields. Lack of fluid homogeneity and the localized nature of various alteration processes supports a model of hydrocarbon migration through faults that acted in succession as seals or conduits throughout the life of the basin.

Further work is ongoing to integrate the results of more than 50 PVT studies performed on fluids collected from both fields with the geochemical characterization of the oil and gas samples to provide additional insight on the dynamic behaviour of the fluids.

References

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