BPM06

Sensitivity Analysis of Controlling Factors in Biogenically Charged Petroleum Systems - A Case Study from the Levantine Basin

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SUMMARY

The Levantine Basin in the Eastern Mediterranean has become an attractive area for oil and gas exploration due to recent discoveries of major gas fields in the pre-salt sequences. Information on whether the gas in these new discoveries is of thermogenic or biogenic origin was restricted for a while, as the strategic implications are clear: if the gas is thermogenic, then deeper thermogenic oil potential could be lower or even excluded. However, if the gas is biogenic, an opportunity could exist for deeper thermogenic systems which could include oil. It is now known that the gas is predominantly of biogenic origin in Tamar, Leviathan and Aphrodite, with possible minor thermogenic contributions. As a result, exploration for deeper thermogenic systems and especially for oil is now planned in the Levantine. This shows the importance of understanding the processes which resulted in the formation of the newly discovered gas fields.

Gas fields of biogenic origin have been producing from depths of up to 4500m for more than 30 years in Northern Italy, and many commercially important deeper biogenic gas discoveries have been added in the last few years, in many cases opening completely new plays. However, biogenic gas discoveries at very shallow depths have also been made, such as the Peon field in Norway (at 160m below the sediment surface!), and these show that the timing and depth of generation of biogenic gas generation is not the only issue that needs to be understood. Migration and trap/seal mechanisms of biogenic gas fields also need to be considered, especially as 'conventional' seals are not expected to have adequate sealing properties at the shallow depths at which biogenic gas is assumed to be generated. Both generation and seal quality evolution need to be considered as closely coupled processes in these plays.

The Levantine Basin offers a particularly interesting 'laboratory' to test the variables that control the evolution of biogenic gas fields. It is a sub-salt play with regionally extensive salt coverage of Messinian age, however the gas is not trapped and sealed directly below the salt but within Oligocene-Miocene silty/sandy turbidite sequences which are assumed to be both the gas source and reservoir. The most unusual feature is that the area was subjected to a geologically extreme event during the Messinian Salinity Crisis (MSC) between 5.99 and 5.32 Mabp when the water depths in the entire Mediterranean Sea were reduced by up to 2000+m followed by salt deposition of up to 1500m in a very short time span of less than 50,000 years. This caused rapid changes in the depositional environments and sediment surface conditions, as well as in the pressures and temperatures in the subsurface. As the timing and the conditions induced by the event are reasonably well defined, it offers a unique opportunity to test and possibly constrain some of the controlling factors in both deep and shallow gas plays. A 230 km long regional 2D type section which connects the three major discoveries was interpreted and reconstructed (Fig.1), and this petroleum systems model was then used to investigate the sequence of events in the study area and their possible effects on the proven biogenic and assumed thermogenic petroleum systems.

Figure 1 Regional type section in the Levantine Basin with a) original uninterpreted seismic data, b) interpreted seismic data for this study with well control from Eratosthenes seamount and Levant margin, and c) 2D seismic based petroleum systems model used for the study with lithology overlay. Section length is 230 km.

We will present a sensitivity analysis of the basic elements of the petroleum system based on the data that is publicly available at the time of the presentation. Only limited thermal calibration data is currently publicly available, but uncertainties related to this will be shown where applicable. The regional type-section will be used to show the data and interpretations related to the construction and calibration of the model, as well as the underlying assumptions that were used to constrain the model properties and boundary conditions. We will then investigate the properties and processes related to the formation of the currently known biogenic system within these constraints. Special emphasis will be placed on the topic of biogenic gas generation, and we will test and present various generation concepts from simple thermally controlled biogenic gas generation to more complex approaches which, for example, enable deep gas generation to be explained. We will then be able to assess gas migration and accumulation timing and additional controlling factors such as gas migration volumes and rates, the significance of gas exsolution during pressure release, as well as seal quality evolution and potential entrapment processes through geologic time.

This will enable us to illustrate sensitivities in the system and how well it can be constrained, and also to assess the timing relative to the Messinian Salinity Crisis. In the final part, we then assess the assumed deeper thermogenic petroleum systems which are at the moment speculative in the study area, and show which range of conditions could lead to the co-existence of biogenic and thermogenic petroleum occurrences and the possible contributions from the different potential thermogenic source units.