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Exploring Unconventional Hydrocarbons in the Makó Trough, Pannonian basin, Hungary: Results and Challenges

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The latest phase exploration in the Makó Trough, which commenced a few years ago, has focused on the utilization of unconventional hydrocarbons. Accumulations are regarded as "unconventional" when they cannot be produced economically except by means of some sort of stimulation, usually hydraulic fracturing. The model we have developed for the evaluation of the hydrocarbon potential indicates a significant gas accumulation in the area of the Makó Trough. The tally of the distinctive attributes of the hydrocarbon system and the combined analysis of the available geological data led to the conclusion that the Makó Trough represents an area of active basin-centered gas accumulation (BCGA), with very significant perspective reserves.

In a BCGA, hydrocarbons do not accumulate conventionally, in structural or stratigraphic traps, but rather in cells. Due to the geological setting of the Makó Trough, the hydrocarbon cell here forms a relatively continuous zone marked by considerable internal lithological and petrophysical variability. The most prolific parts, called sweet spots, possess a reservoir potential higher than the average. The identification of these sweet spots constitutes one of the most important, and quite possibly the most challenging task of the entire exploration project.

The hemipelagic Endrőd Formation, which acts as the source rock, contains organic-rich marls in a depth delimited by the 170-230 °C isotherms. These marls constitute the still active hydrocarbon "kitchen" of the BCGA in the Makó Trough. The top and bottom boundaries of the cell essentially coincide with the turbidites of the Szolnok Formation and the top of the pre-Neogene basement, respectively. In light of the fact that pressure, temperature, and maturity tests have produced rather similar results in a number of wells in the area, we have reason to believe that the extension of the Makó Trough's BCGA is of regional dimensions (>1000 km2). The thickness and lateral extension of the potential reservoirs yield a cell volume as great as several hundred km3 – the largest single prospective gas occurrence in Hungary to date.

Due to its novelty and complexity, the exploration of this unconventional resource demands the concurrent application of a wider range of geological and geophysical methods. In this presentation, we use selected examples to give an idea of where we stand on the way toward understanding the Makó Trough, particularly in terms of the geometric and structural features of the basin, the depositional (basin-fill) processes, and of the maturation history and accumulation properties of hydrocarbons.

The geophysical surveys were purpose-designed to enable the mapping of the deep sedimentary trough and the sediments deposited in it. The data acquired to date suggest that the basin-centered gas accumulation occurred in the Lower Pannonian strata (11-6? Ma). Interpreting the 3D seismic data, the structural features and sedimentology of the basin can be studied in excellent resolution, while the integration of the seismic information with the geological data obtained from the wells allows us to interpret local well information extensively to gain a deeper, three-dimensional understanding of the basin.

The sedimentary sequence filling up the Makó Trough displays distinct stratigraphic units separated by unconformities. Mapping the top of the pre-Neogene basement provides valuable insight into the nature of the paleo-geomorphological elements and the sedimentary environment at the onset of rifting. Paleontological information dates the syn-rift sediments of the trough to the Late Miocene (Early Pannonian), suggesting that the most intensive phase of basin evolution here was delayed by a few million years compared to adjacent areas. For the environmental reconstruction of the post-rift sedimentary sequence, we start with the assumption that initially a starved basin existed here, where sedimentation could not keep up with the rate of subsidence (Endrőd Formation). The basin was then almost completely filled by the turbidites of a prograding delta system (Szolnok Formation), followed by the sediments from the pro-delta (Algyő Formation) and the delta plain (Újfalu Formation). During

the Plio- and Pleistocene, the area continued to subside at a decreased rate, providing a limited accumulation space filled by a thick sequence of alluvial deposits similar to the paleo-environment of the Tisza River and its tributaries prior to regulation.

Our modeling of basin evolution in terms of subsidence, thermal and maturation history based on the results of geochemical, petrophysical, and paleontological investigations reveals that the organic matter accumulated in the trough underwent exceptionally rapid maturation during the last 5 to 7 million years. In fact, source rocks continue to mature at present time, and the hydrocarbons they generate continue to migrate and trap. The rather young age of the Pannonian Basin and its hydrocarbon system makes it quite different from the other examples of basin-centered gas accumulation, such as the classic Rocky Mountains in the U.S., or the Karoo Basin in South Africa, the Beetaloo Basin in Australia, making up the exploration portfolio of Falcon.