HYDROCARBON SYSTEMS OF RESERVOIRED OILS IN THE SOUTH CASPIAN

Willam J. Devlin
Exxon Ventures (CIS) Inc., P.O., Box 4480, Houston, TX 77210-4480, USA

The South Caspian Basin comprises a unique set of geologic parameters that rank it among the most profilic hydrocarbon regions of the world. Surrounded by compressional orogens, the basin has accumulated up to 25 kilometers of sediment, with more than 10 kilometers of this fill deposited in the last 6 million years. The sedimentary fill of the South Caspian Basin, however, remains relatively undeformed compared to the adjacent Caucasus, Kopet Dag, and Elbruz fold and thrust belts. Deformation in the South Caspian is expressed as a series of large folds that are commonly pierced by mud diapirs and associated mud volcanoes, and which appear as linear physiographic features on the Caspian Sea floor. Late Miocene-Pliocene uplift of the surrounding region isolated the basin, and made it a depocenter for the enormous volumes of sediment that were shed from both the nearby orogens and the Russian Platform. The resulting, rapid burial rates led to such loe temperature gradients that hydrocarbons are still being actively generated at depths between 8 and 12+ kilometers.

In the Azeri sector of the South Caspian Basin, approximately 11 billion oil-equivalent barrels of cumulative production has been reported in the literature from onshore and nearsore fields, with an additional 10 billion oil-equivalent barrels of proven, but undeveloped reserves. Although estimates for undiscovered offshore potential vary widely, published have compared these volumes to total production in the North Sea. The combination of a prolific hydrocarbon system, large undrilled structures, and a favorable political climate for foreign investment has focused considerable industry attention on the potential of this basin.

The structural style of the offshore South Caspian structures is expressed as numerous elongate and typically symmetrical anticlines. These structures generally trend northwest, with a few marked deviations from this trend that suggest basement control on structural grain. Based on the structural analysis of regional 2-D seismic, the anticlines are interpreted to be large buckle folds overlying a ductile detachment zone at depth. The detachment zone for these buckle folds is interpreted to have deformed by ductile flow within a mobile, overpressured, shale-rich zone. Based on regional stratigraphic relationships, this interval is most likely within the Maikop shale, the primary source rock in the basin. The timing for the onset of folding can be clearly determined from seismic data. Across most structures, there is a relatively constant sedimentary thickness to the top of the Surakhany Formation. Above this interval the sedimentary section displays marked thinning by onlap onto the flanks of the growing structures. The stratal thinning begins with deposition of the Akchagyl Formation and isotopic age dates reported from ash beds in the lower part of this formation indicate a time for onset of approximately 3.4 Ma. Continued structural growth is indicated by stratal thinning onto the flanks of the structures to the sea floor. The ductilely deformed, overpressured Maikop shale is also the likely source for the ubiquitous mud diapirs in the basin. Within the context of the buckle fold mechanism discussed above, the mobile shale intrudes through the overlying sedimentary strata along zones of weakness, and the most common areas of weakness are associated with faults and fault zones within the anticlinal folds. This interpretation is consistent with the occurence of Oligo-Miocene shales collected from mud volcano ejecta from onshore localities.

Organic-rich rocks of the Oligocene to lower Miocen Maikopian Series and the middle-upper Miocene Diatomaceous Suite constitute the principal oil-prone source rocks in the basin. In the offshore South Caspian Basin, the Maikop source is interpreted to be present at depths between 10 and 12 kilometers. The ubiquitous nature of this source facies throughout much of the coastal and offshore regions of the South Caspian Basin is evidenced by prolific seepage of black oil. One-dimensional basin modelling techniques indicate that the Neogene-Quaternary sedimentary succession is thermally immature for kerogen to oil conversion down to 6 to 8 km, the top of the oil window is interpreted to be near a depth of approximately 8 km for Type II kerogens, and the base of the oil window and onset of gas generation is estimated at 13 to 14 km.
Reservoirs in the upper Miocene-Pliocene Productive Series contain the vast majority of discovered hydrocarbons in the South Caspian Basin. Based on outcrop studies, these strata are interpreted to have been deposited in nonmarine environments ranging from fluvial to lacustrine delta. In the late Miocene-Pliocene, the South Caspian Basin was a small, isolated lake. Sediments were transported into the basin from the north by the paleo-Volga, from the east by the paleo-Kura, and from the west by the paleo-Uzboy river systems. The most attractive reservoir targets occur in the lower Productive Series within amalgamated fluvial channel complexes of the Pereryva and lower Balakhany formations. These reservoirs are mapped at depths between 4 and 7 kilometers in undrilled offshore prospects.

The combination of unique geologic development, a prolific hydrocarbon system, and a benchmark chapter in the history of petroleum exploration characterizes the South Caspian Basin. Since the opening of the region to western investment, there has been steady industry interest and competition for exploration blocks. Consequntly, exploration activities that include the acquisition of 3-D seismic surveys and exploration drilling proceed apace. With all of this focused interest and resulting activity, the petroleum industry should know soon whether the South Caspian we will live up to its promise.