GEOPHYSICAL EVALUATION AND EXPLORATION POTENTIAL OF THE HAYMANA-POLATLI AND CANKIRI BASINS, CENTRAL ANATOLIA, TURKEY

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The underexplored Haymana-Polatli and Cankiri basins are located in north-central Turkey within a 100 km radius of the capital city of Ankara (Figure 1). Only three wells have been drilled - two in the Cankiri basin and one in the Haymana-Polatli basin. The proximity of the basins to a ready gas market and to refining infrastructure, combined with favorable petroleum geology, makes them attractive targets for prospect generation.

Gustavson Associates acquired 18 exploration licenses encompassing some 8165 km2 within the two basins. The company entered into a joint venture agreement to explore the area with Carson Services, an international aerogravity-aeromagnetic surveying contractor. This paper presents the results of this phase of geological and geophysical reconnaissance of the basins.

These are Upper Cretaceous to Tertiary onshore sedimentary basins. They are superimposed on the Paleozoic to Mesozoic crystalline basement terrain of the Central Anatolia Massif, a continental-scale geologic province which encompasses most of central Turkey in an east-west direction. The basins lie immediately south of the North Anatolian Fault, a major right lateral wrench system that marks the boundary between the Pontid Fold Belt on the north and the Central Anatolia Massif on the south. Economic basement in the two basins consists of Upper Cretaceous ophiolites which are underlain by Upper Jurassic to Lower Cretaceous carbonates and Paleozoic metasediments.

The basins share a similar geologic history and contain similar sedimentary successions. Like the Tuz Golu basin (located immediately southeast of the Haymana-Polatli basin), these basins have been interpreted by some Turkish geoscientists to be structurally modified remnants of an Upper Cretaceous to middle Eocene accretionary forearc basin which developed at a complex collision zone between the Eurasian and African-Arabian plates. Thick sedimentary fills in these basins, consisting of both flysch and carbonate-evaporite sediments, include a number of potential oil and gas reservoir facies.

The Haymana-Polatli basin contains about 5800 m of Upper Cretaceous and younger sedimentary section, which overlies the ophiolite basement. The Eskipolatli well, drilled (by the state minerals agency, MTA) in 1978 in the western portion of the basin, bottomed at a depth of 3509 m in the uppermost portion of the Upper Cretaceous Haymana fm. The vast majority of that unit, which is approximately 2000 m thick, was not penetrated. The Haymana fm constitutes one of the three primary exploration targets in the basin. It consists of flysch sediments that contain potentially important turbidite sand units deposited in submarine fans. Oil-impregnated turbidite sands of the Haymana fm crop out in the eastern portion of the basin on the Caldag Anticline and point to a potential play for submarine fan traps in the subsurface. Fossiliferous limestones and sandstones of the overlying Upper Cretaceous Beyobasi fm and algal reefal carbonates of the Paleocene (Danian) Caldag fm are the other two primary exploration targets in the basin. The Caldag reef play is limited to the southeastern portion of the basin where that facies belt may be present in the subsurface.

Previous source rock studies suggest that shales within the Haymana fm may be effective gas source rocks in both basins. Other research suggests that the oils in the Haymana fm sands may be derived from an unidentified Mesozoic carbonate source.

The Haymana-Polatli basin is highly structured with a complex polyphase structural history. A limited amount of rather poor quality seismic data suggests that compressional structures (sharp folds and reverse faults), that have surface expression, also dominate the structural style of the upper half on the basin. The compressional structures formed in response to young transpressional wrench tectonic movement that overprinted the older structure of the basin. The deeper structural levels appear to contain buried remnants of extensional features (horsts, grabens and half grabens) which were formed during the initial extensional development of the forearc basin. Decoupling of the shallow compressional structures from the deeper extensional regime appears to occur within the thick package of fine-grained flysch sediments of the Haymana fm.

The Cankiri basin contains a similar package of Upper Cretaceous and lower Tertiary flysch sediments. In addition, Middle Eocene algal carbonates were penetrated in TPAO's Topuzsaray #1 drilled in 1992 in the northwestern portion of the basin. These algal carbonates are considered to be prospective reservoir facies in the basin. This well bottomed in Upper Cretaceous sediments at 3689 m. TPAO's Sagpazari #1 was drilled in the eastern portion of the Cankiri basin in 1997. It unexpectedly found a very thick lower Tertiary salt sequence consisting of over 2000 m of bedded salt and interlayered organic shales. The Sagpazari well bottomed in salt at a depth of 3700 m. This newly discovered basin-center evaporite package of uncertain Tertiary age (Middle Eocene to Oligocene?) includes at least 31 salt cycles separated by clastic zones consisting of organic shales and anhydrite. Some of the shales carried slight oil shows suggesting that these clastic zones may be important oil source rocks in the Cankiri basin in addition to the shales of the flysch sequences which have been previously identified as possible gas source rocks.

Seismic data show that the Sagpazari #1 well was drilled into the crest of a major salt diapir. Of course, many prolifically hydrocarbon-bearing salt basins (including the Gulf of Mexico) produce from structural and combination traps associated with salt diapirs, ranging from salt-cored anticlines to salt piercement ridges and salt domes.

In addition, if the basin-center salt of the Cankiri basin is laterally equivalent to the Middle Eocene algal carbonates, then this basin may be analogous to other important hydrocarbon-bearing carbonate-evaporite basins of the world. For example, the Upper Carboniferous Paradox evaporite basin in the western United States has yielded in excess of 400 MMBO from basin-margin algal-carbonate reservoirs sourced from basin-wide black shales which separate the individual carbonate-salt cycles. The Sagpazari well log bears remarkable resemblance to well logs from the Paradox basin.

The Cankiri basin is also a highly structured basin consisting of a variety of structures from compressional folds to the above-mentioned salt diapiric structures. Reverse-faulted, transpressional anticlines dominate the structural grain in the northern part of the basin. They are related to intense wrench tectonics associated with the basin's proximity to the North Anatolian Fault. Numerous structural traps are possible within this basin as in the Haymana-Polatli basin.

Potential may also exist for sub-salt plays beneath the Tertiary salt in underlying Upper Cretaceous sediments.

With these play concepts in mind, the recently completed aerogravity and aeromagnetic surveys of the basins have identified both deep structure and faulting with considerable success. The surveys were flown at 1500 m above sea level with 1 second sampling resulting in an average station spacing of 43 m. Acquisition was with the patented Carson GFM System; 8 channel differential GPS positioning and Carson modified LaCoste Romberg gravimeter. The data were acquired in a specially modified DeHavilland DHC-6 Twin Otter aircraft. A high-resolution cesium vapor magnetometer was employed to collect simultaneous magnetic data. More than 10,000 line km of gravity and 11,500 line km of magnetic were acquired along 1.5 km and 9 km flight grids. Calibration lines were also flown over key wells and seismic sections. In total more than 233,000 gravity and 268,000 magnetic measurements were obtained with a relative positional accuracy of 1-3 cm.

Automated Euler and Werner deconvolution algorithms were applied to the magnetic data to provide a depth map to magnetic basement and to shallower magnetic sources. Localized Neogene basalt flows occur at the surface in various portions of the Haymana-Polatli basin, including an area not far from the oil impregnated sandstone outcrops of the Haymana fm on the Caldag Anticline. These surface flows, which to varying degrees mask the underlying geology, are well defined on the magnetic data.

The free air gravity data collected were reduced to a Bouguer data set utilizing a 3-D terrain correction algorithm. These data were residualized with a variety of techniques to aid in the identification of Upper Cretaceous to Lower Tertiary accretionary forearc basin depocenters and Lower Tertiary carbonate buildups. In the Cankiri basin, the gravity data were calibrated at the Sagpazari #1 and were of great value in salt diapir and salt basin definition.

Field sampling of rock magnetic susceptibility and density has permitted a more rigorous quantitative characterization of the properties of the geologic column. This in turn has improved the integrated modeling of anomalies throughout the basins.

The integration of the existing seismic data with the gravity data has provided a better understanding of interval velocities and densities. The gravity data integrated with the rest of the geological and geophysical database clearly indicate the location and extent of several major sedimentary prisms in both basins. Wrench faults, which typically fail to map well in regional 2-D seismic grids, are very well expressed in the airborne geophysical data.

The acquisition of these data has greatly enhanced the interpretation of the overall stratigraphic and structural architecture of the basins. It has provided important new continuous geophysical data in areas which fall outside the limits of existing seismic data. The results of these geophysical surveys, combined with other geological studies, provide the basis for generation of several promising seismic leads and drilling prospects.