DEEP SEISMIC EXPLORATION OF THE SOUTH CASPIAN BASIN: LITHOSPHERE-SCALE IMAGING OF THE WORLD'S DEEPEST BASIN

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The Caspian Sea basins of central Eurasia constitute one of the major petroleum provinces of the world. The tectonic setting and geological evolution of the South Caspian Basin remains enigmatic, particularly with respect to the generation of such significant hydrocarbon resources. Situated within the Alpine-Himalayan collisional zone, the Caspian Sea separates the locus of young continental collision in the Caucasus to the west from large-scale strike-slip faulting in the Kopeh-Dagh system to the east. Although the basin is thought to have originated in Mesozoic time, as much as 8-10 km of Plio-Pleistocene strata have accumulated, representing average depositional rates of >1.5 km/my for the last 5 million years. The presence of numerous gas-driven mud volcanoes and active oil and gas seeps suggests that hydrocarbons are forming and migrating within the basin today. Furthermore, active seismicity in the region attests that structures and associated hydrocarbon traps in the shallow section are forming now.

New deep normal-incidence seismic reflection data from the South Caspian Basin provide the first full crustal and upper mantle image of this basin. Collected as part of a 1998 acquisition program directed by Chevron Overseas Petroleum Inc., two roughly perpendicular deep seismic reflection profiles were acquired offshore Azerbaijan (Fig. 1). These profiles, in the vicinity of the Absheron Ridge, are each ~70 km in length and recorded to 20 s, in a key area for understanding the regional tectonics of the enigmatic Caspian Basin system.The main aim of collecting deep seismic data in this important petroliferous basin was to: (1) reveal the deep structure and tectonics of the Alpian-Himalayan continent-continent collisional zone beneath the South to Central Caspian Sea, (2) portray the full Mesozoic (?)-Quaternary section of the Sedimentary basin that is inferred to be, in places, thicker than 20 km, and (3) elucidate the thickness and nature of the crust, providing critical information for subsidence and thermal modeling with implication for source rock maturation. These new reflection data provide a pseudo 3-D architecture of the South Caspian Basin in the vicinity of the Absheron Ridge. Althouth recorded with standard industry parameters (airgun source of 3180 cm^3 at 1900 psi, 25 m hydrophone spacing, 5400 m streamer length, 4 ms sample rate), the two deep seismic lines provide an image of the basin down to upper mantle depths.

Preliminary processing of these profiles reveals the following significant features: (1) a series of high-amplitude folds, developed within the thick Tertiary-Quaternary portion of the section, (2) a prominent, strongly reflective horizon at –26 km (12,8 s) on the southern part of the profile, (3) an underlying layered interval down to –34-38 km (16-16.5 s) with discernible lower frequency reflections, and (4) a noticeable decrease in reflectivity below –34 km (-16 s). As has been observed on numerous deep seismic reflection profiles, we interpret the bright reflection at –26-28 km depth as the basement/cover contact. Although laterally discontinuous, this bright reflector can be traced toward the Absheron Ridge, exhibiting a gentle northward dip. This geometry suggests deepening of the crust from south to north, which could be interpreted as evidence for northward subduction of the South Caspian lithosphere beneath the Absheron Ridge. If correct, these observations imply that the sedimentary fill of the South Caspian in the vicinity

of the Absheron Ridge is –26-28 km in thickness, making this the deepest sedimentary basin in the world, to our knowledge. The more highly reflective portion of the section below –28 km is interpreted as the crystalline basement. Downward termination of reflectivity is thought to respresent the Moho, despite the absence of a clearly reflective horizon, making for a composite crustal thicness in this portion of the basin of –34-38 km. The apparent 8 km thickness of the crystalline crust is consistent with an oceanic affinity for this part of the basin. The overlying section is dominated by large, S-vergent fault-propagation(?) folds that root into a relatively "shallow" detachment, dipping northward from ~14 to 20 km (8.5-9 s).

This survey constitutes a compelling pilot study for the utility of deep seismic reflection profiling in the Caspian Sea. A program of regional deep seismic exploration of the Caspian region, Project CASPIANSEIS, is designed to (1) address the crustal and upper mantle architecture of the basins, (2) provide first-order constraints on the subsidence and thermal history of the source intervals, (3) relate shallow prospective structures to the deep geology of the basin, and (4) place the history of the Caspian Basins in the context of the regional tectonic setting (Fig. 1).

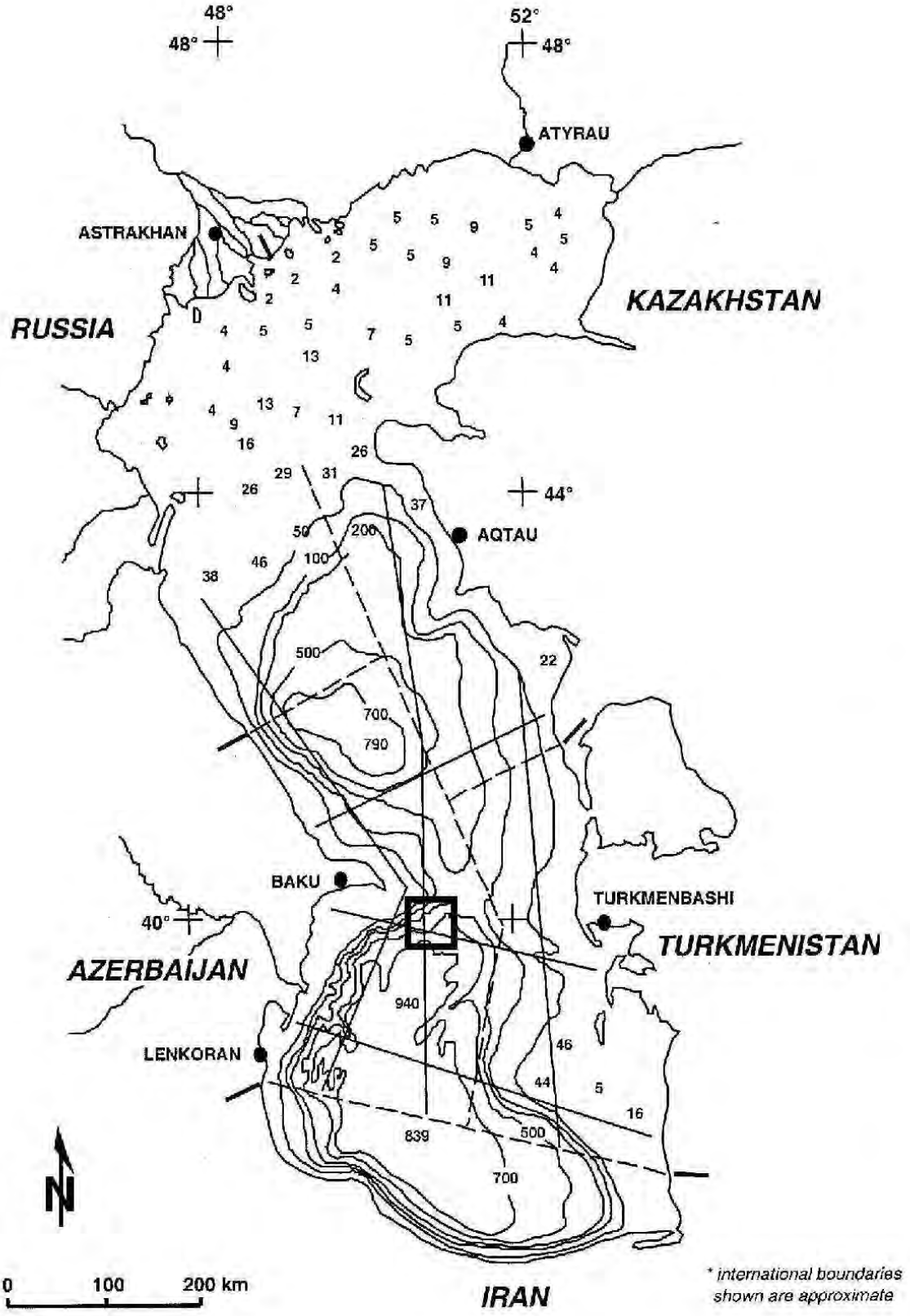
48°
48°
52°
48°
ATYRAU
ASTRAKHAN
KAZAKHSTAN
RUSSIA
44°
AQTAU
BAKU
TURKMENBASHI
40°
TURKMENISTAN
AZERBAIJAN
LENKORAN
IRAN
0
100
200 km
* international boundaries shown are approximate

Figure 1