by Dag Nummedal
Unocal E&PT
Sugar Land, Texas

The Paleo-Volga Delta and Lacustrine Sequence Stratigraphy of the South Caspian Basin

The Productive Series of the South Caspian basin consists primarily of Pliocene delta deposits of the Volga River. GCA reservoirs at the Apsheron Sill and numerous old fields in the transition and onshore areas of Azerbaijan contain Productive Series beds. Outcrops on the Apsheron Peninsula north of Baku, extensive seismic data, and cores in the GCA field provide the data base to determine age, depositional systems, stratigraphic architecture, and reservoir properties of the Productive Series.

SOCAR (State Oil Company of Azerbaijan) invited five companies (Agip, BP Amoco, Conoco, Tpao, Unocal) to undertake a joint study of the sedimentology and stratigraphy of much of the Productive Series. The 13 investigators involved in the study *(see Project Team)* emphasized the highly productive Pereriva and Balakhany suites and outcrops of the Kirmaku, Nkp, and Nkg suites. Related projects by other Unocal personnel added valuable insights into the sedimentology, with some being presented as posters in conjunction with this talk.

Age of the Productive Series was determined by a combination of Ar^{39}/Ar^{40} dates of ash deposits bracketing the Productive Series, graphic correlation of micropaleontological data and event beds, and adjustments based on the global oxygen isotope curve for the Pliocene and latest Miocene. The Miocene-Pliocene boundary (5.3 Ma) lies at or near the base of the Pereriva Sandstone, and the top of the Productive Series (top Surakhany) is about 3.0 Ma.

Lake levels in the Caspian repeatedly rose and fell during deposition of the Productive Series. Climatic cycles responsible for the changes in lake level dramatically affected the sediment yield from the Volga drainage basin. At lowstands of lake level, the climate was hot, evaporation from the lake was high, and there was little to no flow of water or sediment into the lake. Extensive lake-margin exposure surfaces characterize the lowstands.

As cooler and wetter climate replaced the hot and dry periods, lake levels rose. During early, slow rises in lake level, major sandstone packages of braided fluvial deposits grading lakeward into thin mid-channel bars and braid-delta fronts accumulated.

During late transgressions and highstands, the deltas were well north of the Apsheron region and only distal prodelta mudstones accumulated in the study area. With no sandstones deposited between the transgressive and highstand muds and the next overlying exposure surface, the Volga delta apparently did not prograde back south during the subsequent fall in lake level. Return to a hot, dry climate probably left the river dried out as lake level fell. This is very different from marine systems where major delta complexes generally prograde as sea level falls.

Changes in lake level occurred on time scales ranging from about 10^6 to 10^4 years, with some or all perhaps driven by Milankovitch cycles. Longer cycles may include a tectonic component unrelated to climatic variations. Because of the strong climatic influence on lake level change and stratigraphic architecture, there is more "order" (predictive cyclicity) in the paleo-Volga deposits than in any documented marine deltaic succession.

Understanding how climate/lake level cycles control the timing of sand delivery into the Caspian basin has clear exploration significance. At the development scale, the systematic vertical change in depositional systems within nested sequences of different thicknesses exerts the dominant control on heterogeneity and connectivity of reservoirs and seals. ⇒

Project Team

[1] Project team: V. Abreu (Unocal), Z. Batı (Tpao), H. E. Clifton (Conoco),), T. D. Demchuk (Conoco), M. Fornaciari (Agip), A. A. Narimanov (Socar), D. Nummedal (Unocal), G. W. Riley (BP Amoco), A. Sayilli (Tpao), J. A. Stein (BP Amoco), V. E. Williams (Unocal), R. J. Witmer (Unocal), D. S. Van Nieuwenhiuse (Amoco).

Biographical Sketch

Dag Nummedal is manager of geology in the exploration and production technology division of the Unocal Corporation, Sugar Land, Texas. He was a professor in the Department of Geology and Geophysics at Louisiana State University in Baton Rouge from 1978 to 1996. His Ph.D. is from the University of Illinois and his M.S. and B.S. degrees are from the University of Oslo, Norway.

Nummedal's research and teaching have covered stratigraphy, petroleum geology, coastal and shallow marine sedimentation, coastal engineering, and planetary geology. Current research is focused on sedimentation and sequence stratigraphy of the Pliocene paleo-Volga delta in the Caspian basin, Azerbaijan, sequence stratigraphy of Cretaceous shallow marine deposits of the U.S. western interior, and rift basin tectonics and stratigraphy in basins along the SE Asian margin and the Gulf of Suez. Of increasing interest is the practice and theory of management of industrial R&D organizations.

Nummedal has published 80 refereed papers and numerous technical reports, taught short courses and seminars on sequence stratigraphy and related subjects worldwide. He is the current Councilor of Research at SEPM (Society of Sedimentary Geology). □