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The Effects of Salt Withdrawal of Trap Evolution and Hydrocarbon Systems in the Gulf of Mexico Basin

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The northern Gulf of Mexico basin margin exhibits a large variety of structural trap styles that resulted from, or were influenced by, salt withdrawal. In the past decade, improved seismic data quality and geological concepts have led to a fundamentally new regional understanding of the distribution of these structural styles and their evolution in the context of allochthonous, laterally moving salt sheets. High quality offshore seismic data, recent onshore deeper seismic, and key deep well penetrations have contributed to the recognition of important similarities between offshore and onshore structures. Concepts developed for offshore exploration using high-quality seismic data are applicable in the onshore where data quality is poorer. Continued exploration success and efficient exploitation of hydrocarbon traps in the environment require an even more in-depth understanding of their geometry, evolution, and structural integrity than has been achieved in the past. Particularly important needs include better methods for predicting fault and trap geometries, evaluating fault seal, and a clearer appreciation for the mechanics of salt movement. Finding and producing economic accumulations in a mature area will depend on applying technology based on an integrated knowledge of the hydrocarbon system. A key piece of this technology is an understanding of the relationship of trap evolution to other play elements and their associated risks.

Extensive normal growth fault detachment systems have been documented in the onshore and on the inner continental shelf and appear to have been variously influenced by salt movements. Perhaps the most important advance in understanding these detachment systems is the notion that some of them originated as allochthonous salt sheets fed from the Jurassic Louann salt onto the ancient continental slope. Their subsequent evolution as growth fault provinces resulted from sediment influx and accommodation provided by salt withdrawal, the end product being a detached normal fault system with distinctive structural attributes, including remnant salt of the detachment surface. These types of detachment systems can be distinguished from more conventional detached styles through palinspastic restorations and geohistory analysis. Examples exist in the Frio and Miocene detachment provinces of south Louisiana and have striking analogs in the Plio-Pleistocene trend.

Increased emphasis on the dynamics of salt movement in environments like the Gulf of Mexico has led to a significant advance in understanding the form, emplacement history, and deformation of allochthonous salt sheets. Geomechanical modeling is potentially useful for testing qualitative models of salt sheet evolution based on purely geometrical structural restorations. Specific aspects include base salt configuration, formation of mini-basins on tabular salt bodies, and identification of potential migration pathways. Intraslope mini-basins formed during the withdrawal of tabular salt sheets. Depositional models developed to predict the lateral and vertical distribution of reservoir types in these basins indicate that the fill evolved from older basin- floor fans to younger shelf-margin sequences, with sediment progradation and progressive salt withdrawal. In many cases, the basins have ponded high-quality deep water reservoir sands accounting for a large fraction of recently discovered hydrocarbon reserves in the Gulf. Improved knowledge of the salt withdrawal process coupled with higher quality seismic data give rise to concepts with implications for new hydrocarbon plays beneath salt, higher confidence models of trap geometry where data are poor, prediction of secondary migration pathways, and perhaps the prediction of controls on subtle trap formation or favorable reservoir distribution.

Biographical Sketch

Cliff Ando received his B.A. in geology from Occidental College in 1973 and his Ph.D. from the University of Southern California in 1979. His dissertation work involved research into the structural geology and regional tectonics of the Klamath Mountains in northern California. In 1979, he joined the Cornell University COCORP project as a research associate, where he spent three years doing research on the deep continental seismic reflection profiling of the United States. Beginning in 1982, he worked on the extensional evolution of the Basin and Range province and the Gulf of Mexico basin margin for Shell Development Company. Cliff joined Exxon in 1989 and has worked in the Structural Analysis Section evaluating the potential of West Africa, the Far East, and South America.

Carlos Dengo received a B.S. in geology in 1976 from Syracuse University and an M.S. and Ph.D. in geology from Texas A&M University. He joined Exxon Production Research in 1982 and worked for eight years in the basin analysis and structural interpretation groups. He transferred to Exxon Exploration in 1992 as a supervisor in the Gulf of Mexico Group. He is currently the Frontiers Coordinator in the Americas Business Unit at Exxon reviewing new exploration plays in Latin America.

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