Basin Analysis and Petroleum System Characterization and Modeling, Interior Salt Basins, Central and Eastern Gulf of Mexico

DE-FC26-03NT15395

Goal

The project goal is to develop, through basin analysis, the concept that petroleum systems acting in a basin can be identified through basin modeling. The specific objective is to demonstrate that the information and analysis resulting from the characterization and modeling of petroleum systems in the North Louisiana Salt Basin and the Mississippi Interior Salt Basin can be used to provide a reliable and advanced approach for targeting stratigraphic traps and specific facies associated with a geologic system and providing a refined assessment of undiscovered and underdeveloped reservoirs and associated resources.

Performers

University of Alabama, Tuscaloosa, AL
Louisiana State University, Baton Rouge, LA

Results

Existing information on the North Louisiana Salt Basin has been evaluated, an electronic database has been developed, regional cross sections have been prepared, structure and isopach maps have been constructed and burial history, thermal maturation history, and hydrocarbon expulsion profiles have been prepared. Seismic data, cross sections, subsurface maps, and related profiles have been used to evaluate the tectonic, depositional, burial, and thermal maturation histories of the basin. Basin geohistory modeling and petroleum system identification and selection have been completed. A comparative study of the geohistories of the North Louisiana and Mississippi Interior salt basins has been made. An assessment of the undiscovered and underdeveloped reservoirs in the North Louisiana Salt Basin has been completed.

The researchers have concluded that:

Oil and gas reservoirs are associated with salt-supported anticlinal and domal features. Normal faulting is associated with the northern margin of the basin, with combination structural and stratigraphic features and with monoclinal features having lithologic variations.

Petroleum reservoirs are mainly Upper Jurassic and Cretaceous fluvial-deltaic sandstone facies; shoreline, marine bar, and shallow shelf sandstone facies; and carbonate shoal, shelf, and reef facies.

The chief petroleum source rock is Upper Jurassic Smackover lime mudstone beds.

Generation of hydrocarbons from Smackover lime mudstone was initiated during the Early Cretaceous and continued into the Tertiary.

Hydrocarbon expulsion commenced during the Early Cretaceous and continued into the Tertiary with peak expulsion occurring during the Early to Late Cretaceous.

The geohistory of the North Louisiana Salt Basin is comparable to that of the Mississippi Interior Salt Basin, with the major difference being the elevated heat flow that the strata in the North Louisiana Salt Basin experienced in the Cretaceous.

Potential undiscovered reservoirs in the North Louisiana Salt Basin are subsalt Triassic Eagle Mills sandstone and deeply buried Upper Jurassic sandstone and limestone.

Potential underdeveloped reservoirs include Lower Cretaceous sandstone and limestone and Upper Cretaceous sandstone.

Petroleum system characterization and modeling of these geologic systems is in progress in Phase 2 of the project. This work should result in a refined assessment of the undiscovered and underdeveloped reservoirs and associated hydrocarbons in this basin and in the targeting of stratigraphic traps and specific reservoir facies in these geologic systems. This refinement should improve industry's oil and gas exploration techniques.

Benefits

A major part of the proposed research project is stratigraphic analysis, particularly the interpretation of sequence stratigraphy and transgressive-regressive cycles. This aspect of the project has excellent potential to result in a scientific and technical breakthrough similar to the contribution that the advent of the concept of sequence stratigraphy made to geoscience and petroleum exploration in the 1980s.

Currently, stratigraphic analysis and resulting seismic stratigraphy is based upon sequence stratigraphy. At the time of its inception, sequence stratigraphy represented a revolutionary advance in geoscience, because it provided a means for the regional correlation and mapping of marine facies through the use of stratigraphic sequences, which are bounded by unconformities or correlative conformities. This concept provided a reliable means to perform stratigraphic analysis and correlate ancient marine facies that were deposited in shelf environments (highstand systems tract deposits) with those that accumulated in slope and abyssal plain environments (lowstand systems tract deposits). The development of this concept resulted in the design of new exploration strategies and advanced seismic detection techniques for deepwater sandstone reservoirs. These exploration strategies and techniques have been highly successful in the discovery of new hydrocarbon resources

Background

The north-central and northeastern Gulf of Mexico area remains an underexplored region containing sedimentary basins with a host of formations having a high potential for hydrocarbon accumulations in intermediate underdeveloped and deep (below 15,000 feet) undiscovered oil and gas reservoirs.

In the U.S. Geological Survey (USGS) study of the world's oil and gas provinces, the North Louisiana Salt Basin and Mississippi Interior Salt Basin hydrocarbon volume ranked in the top 8 percent (33rd out of 406) of the most petroliferous basins in the world. Based on USGS resource estimates and production in these basins, 2-3 billion barrels of oil and 5-6 trillion cubic feet of gas remain to be recovered.

The assessment of these undiscovered and underdeveloped resources and the design of effective exploration strategies to reduce the risks and costs associated with finding them require comprehensive basin analysis and advanced petroleum system characterization and modeling. Presently, a high percentage of the hydrocarbon production in the Mississippi Interior Salt Basin is from deep reservoirs. However, to date, there is no production in the North Louisiana Salt Basin for reservoirs below 15,000 feet.

Independent companies, which account for 50% of domestic oil production and 65% of gas production, have developed into major players in drilling new exploration wells, particularly in the onshore north-central and northeastern Gulf of Mexico. These companies do not have the research staffs or financial resources to conduct long-term, fundamental research, such as basin analysis and petroleum system modeling in support of their exploration efforts. They realize, however, that the information and analysis resulting from these studies is beneficial in the design of effective exploration strategies. In addition, prior to 1996, no comprehensive basin analysis or petroleum system modeling studies had been performed on any of the basins in this region.

Summary

Based on basin modeling and petroleum source rock characterization, the Upper Jurassic Smackover lime mudstone beds have been identified for detailed petroleum system characterization and modeling study in Phase 2 (concept demonstration) of the project because these beds are the major petroleum source rock in the North Louisiana Salt Basin. Other potential source rocks identified are also Mesozoic beds, including uppermost Jurassic, Lower Cretaceous, and Upper Cretaceous shale beds. These beds also will be studied in Phase 2 of the project to further assess their petroleum source rock potential.

Project researchers have:

- Evaluated and organized existing information on the North Louisiana Basin into a database.
- Assessed the tectonic history of the basin.

Evaluated the depositional and tectonic history of the basin strata.

Characterized the burial history of the basin strata.

Described the thermal maturation history of the basin strata.

Completed basin geohistory modeling and petroleum system identification.

Completed comparing the geohistory of the North Louisiana Salt Basin to that of the Mississippi Interior Salt Basin.

Completed a first assessment of the undiscovered and underdeveloped reservoirs in the North Louisiana Salt Basin.

The final report for Phase 1(concept development) of the project has been submitted.

Work on Phase 2 (concept demonstration) of the project is in progress.

Current Status (July 2007)

The project work is on schedule. The work accomplished in Phase 1 (Years 1-3) of the project includes data compilation; determination of the basin's tectonic, depositional, burial, and thermal maturation histories; basin modeling; petroleum system identification and selection of the North Louisiana Salt Basin; comparison of the geohistory of the North Louisiana Salt Basin to that of the Mississippi Interior Salt Basin; and the first assessment of the undiscovered and underdeveloped reservoirs of the North Louisiana Salt Basin. All tasks in Phase 1 have been successfully concluded. The lime mudstone facies of the Upper Jurassic Smackover Formation has been identified as the main petroleum source beds in the North Louisiana Salt Basin. Lime mudstone and shale facies of the uppermost Jurassic and Lower Cretaceous strata may have potential as petroleum source rocks in this basin. Therefore, Smackover and other Mesozoic facies have been identified for petroleum system characterization and modeling in Phase 2 (Years 4-5) of this project. Work to characterize and model the Smackover petroleum system in the North Louisiana Salt Basin is in progress in Phase 2 of the study.

Funding

This project was selected in response to DOE's Oil Exploration and Production solicitation DE-PS 26-O1NT15375 on May 7, 2002, as part of the Public

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Project End: April 30, 2008

Anticipated DOE Contribution: $999,959
Performer Contribution: $359,094 (26 percent of total)

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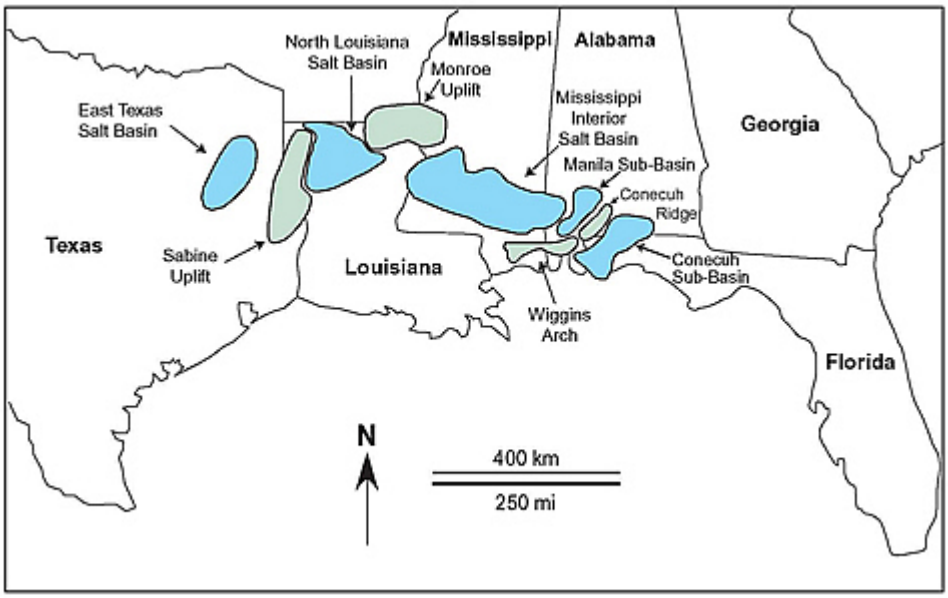
Publications

Basin Analysis and Petroleum System Characterization and Modeling, Interior Salt Basins, Central and Eastern Gulf of Mexico, 2004 DOE Topical Technical Report, Year 1, 89 pp.

Basin Analysis and Petroleum System Characterization and Modeling, Interior Salt Basins, Central and Eastern Gulf of Mexico, 2005 DOE Topical Technical Report, Year 2, 195 pp.

Basin Analysis and Petroleum System Characterization and Modeling, Interior Salt Basins, Central and Eastern Gulf of Mexico, 2006 DOE Topical Technical Report, Year 3 and Final Report for Phase 1, 422 pp.



Location of North Louisiana Salt Basin.