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Production characteristics of sheet and channelized turbidite reservoirs, Garden Banks 191, Gulf of Mexico, U.S.A.

Garden Banks 191 is 160 miles from Lafayette, Louisiana in 700 feet of water. Since 1993, Block 191 has produced over 210 BCF of dry gas from Pleistocene reservoirs. This paper will address the production characteristics of turbidite sheet (4500' sand) and channel (8500' sand) reservoirs. Understanding the distribution of shale breaks within both reservoir types is critical because the shales compartmentalize gas production and control water encroachment.

The 4500' sand interval is 1000 ft (305 m) of interbedded sandstones and shales typical of amalgamated and layered sheet sands (Mahaffie, 1994). The turbidite sands shale out rapidly to the south onto a salt-cored high that had topographic relief at the time of deposition. Three facies have been identified in cores and borehole images: thick-bedded sands, thin-bedded sands, and laminated shales. Electric log evaluations typically underestimate the effective porosity and overestimate the water saturation in the thin-bedded facies, leading to an underestimation of reserves.

Individual turbidite sand beds are 0.2 to 8.5 ft (6 cm to 2.6 m) thick, with most being less than 2 ft (0.6 m). Thin-bedded sheets are interrupted by a few relatively clean channel and lobe deposits, which occur randomly through the 4500' sand interval. These relatively minor channel sands are 10 to 60 ft (3-18 m) thick. A core from the interval in the adjacent Block 236 structure shows that the fine- to very fine-grained sands are massive or planar- to ripple-laminated, suggesting deposition mainly from low-density turbidity currents. The sand is subdivided into four producing members separated by thicker intervals of the laminated shale facies that extend across the reservoir but pinch-out downdip into the aquifer. The reservoir has a strong water drive and is connected to a fairly extensive aquifer. Water encroachment occurs individually in each member and is constrained by the shale breaks. Horizontal permeability is greater than vertical permeability in the reservoir interval. For example, in a dual completion (A-6 well), member 3 watered out before the underlying member 4.

The 8500' sand is an approximately 900 ft thick, fining-upward channel sand deposited in a slope mini-basin formed by salt withdrawal. Cores and borehole images show the lower part of the channel fill to be dominated by thick (3.0-12.0 ft) massive, fine- to medium-grained sands. Concentrations of rip-up clasts up to several feet thick are common both along the erosional bases of
individual flow events and suspended within the deposits. These facies were probably deposited by high-density, sandy turbidity currents and other high-density sediment gravity flows (Lowe, 1982; Stelting et al., 1998.) Lower-energy facies, such as laminated sandstone and/or siltstone, interlaminated siltstone and shale, and homogeneous to laminated shale are scattered throughout the interval. These finer-grain deposits were deposited by thin-bedded and muddy turbidites.

Electric log evaluations of thick sands with abundant shale rip-up clasts underestimated the reservoir quality of the facies. Having continuous core was critical to estimating reserves, selecting intervals to perforate, and designing a development strategy for the channel sand reservoir.

Sand character, initial pressure data, and production history

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show the 8500' sand to have good vertical connectivity but poorer lateral connectivity. The unit is divided informally into five members based on shale breaks and perched water contacts. Initial RFT pressures indicate the stacked channels of members 3, 4, and 5 are connected vertically within the reservoir body. Members 1 and 2 form an abandonment phase that is not connected to the lower members. Perched water contacts and the pattern of water influx indicate lateral barriers in member 3 and between the A1 and A7 wells in members 4 and 5. Bottomhole pressures taken over several years show members 4 and 5 are acting as a single tank. Although initial pressures indicated member 3 was connected to members 4 and 5, the shale break separating members 3 and 4 appears to have acted as a barrier during production.

The aquifer downdip to the 8500' sand is either small or poorly connected to the reservoir as the sand has produced by a combination pressure depletion/limited water-drive mechanism.

Recoveries have been excellent. If they were driven by the same limited water drive exhibited by 8000' reservoir, recovery efficiencies would be much lower.

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References cited

Lowe, D. R., 1982, Sediment gravity flows: II. Depositional models with special reference to the deposits of high-density turbidity currents: J. Sed. Petrol., v. 52, p. 279-297.

Mahaffie, M. J., 1994, Reservoir classification for turbidite intervals at the Mars discovery, Mississippi Canyon 807, Gulf of Mexico, in Weimer, P., Bouma, A. H., and Perkins, B. F. eds., *Submarine fans and turbidite systems: sequence stratigraphy, reservoir architecture, and production characteristics:* GCSSEPM 15th annual research conf. (Houston), p. 233-244.

Stelting, C. E., W. J. Schweller, J. E Florstedt, D. S. Fugitt, G. J. Herricks, and M. R. Wise, Production characteristics of sheet and channelized turbidite reservoirs, Garden Banks 236 Field, Gulf of Mexico: EAGE/AAPG Third Research Symposium (Almeria, Spain), paper #A006.

References not cited

Clark, J. D., and K. T. Pickering, 1996, *Submarine channel processes and architecture:* Vallis Press (London), 231 p.

Cook, T. W., A. H. Bouma, and M. A. Chapin, 1994, Facies architecture and reservoir characterization of a submarine fan channel complex, Jackfork Formation Arkansas, in Weimer, P., Bouma, A. H., and Perkins, B. F. eds., *Submarine fans and turbidite systems: sequence stratigraphy, reservoir architecture, and production characteristics:* GCSSEPM 15th annual research conf. (Houston), p.69-81.

Fugitt, D. S., C. E. Stelting, W. J. Schweller, J. E. Florstedt, G. J. Herricks, and M. R. Wise, 1999, Production characteristics of sheet and channelized turbidite reservoirs, Garden Banks 191, Gulf of Mexico, U.S.A.: Gulf Coast Association of Geological Societies, Transactions, v. 49, p. 254-265.

Biographical sketches

David Fugitt is a staff geologist with Chevron in Lafayette, Louisiana. He joined Chevron in New Orleans in 1978 where he worked both exploration and geophysical assignments in the Gulf Coast. In 1985, he moved to Lafayette where he has worked in field development and in the building of integrated subsurface and reservoir models. David received a BS in geology from Ohio State University in 1976, and an MS from Texas A&M University in 1978. He is a member of AAPG, Lafayette Geological Society, New Orleans Geological Society, and SPWLA.

Charles Stelting has been a regional and reservoir stratigrapher/sedimentologist specializing in deepwater depositional systems in various Chevron companies since 1982. He currently works in the New Orleans office. Charles provides stratigraphic assistance in Chevron's operations in North America and overseas. He teaches several corporate courses emphasizing the stratigraphic and reservoir character of deepwater, deltaic, and fluvial reservoirs. Prior to joining Gulf and Chevron, he worked 7 years with the USGS Office of Marine Geology. Charles participated on the Deep Sea Drilling Project (DSDP) Leg 96 on the Mississippi Fan in 1983. He received his BS in geology from Texas A&M University—Kingsville in 1980 and his MS from University of California - Riverside in 1989.

William Schweller has worked in petroleum research with Gulf and Chevron since 1982. His principal interests are in turbidite reservoirs and sequence stratigraphy of deepwater systems.

Gary Herricks has worked primarily in reservoir engineering during his 20 years in industry. He received his BS in petroleum engineering from Texas Tech University in 1979. Gary started with Tenneco Oil Company in the Rocky Mountain region where he was involved in several secondary and tertiary recovery projects. His last 15 years have been spent working reservoir engineering issues in the Gulf of Mexico. Since 1989, Gary has worked at Chevron in various capacities, including senior reservoir engineer, Garden Banks 191 project communication coordinator, petroleum engineering information technology coordinator, and most recently as reservoir engineering advisor.

Michael R. Wise is a senior petroleum engineer with Chevron U.S.A. Inc. and is currently working in the Gulf of Mexico business unit of the North American E&P Company. Wise has almost 22 years of combined experience with Gulf and Chevron and has worked in both the Gulf of Mexico and the Permian Basin, primarily in production and reservoir engineering. □