Monday, November ??, 2010

Westchase Hilton • 9999 Westheimer Social Hour 5:30–6:30 p.m. Dinner 6:30–7:30 p.m.

Cost: \$28 Preregistered members; \$35 non-members & walk-ups

To guarantee a seat, you must pre-register on the HGS website and pre-pay with a credit card. Pre-registration without payment will not be accepted.

You may still walk up and pay at the door, if extra seats are available.

HGS General Dinner Meeting

Jim Mulligan and Bob Schellhorn Denbury Resources, Inc. Plano, Texas

Stratigraphic Details Illuminated Using Modern 3D Seismic Techniques in Upper Cretaceous Lenticular Reservoirs, Optimizing EOR Production in the Gulf Coast with CO₂

The five major Lower Tuscaloosa (Upper Cretaceous age) oil fields of southwest Mississippi were discovered in the 1940s and 1950s and were developed on 40-acre spacing to provide "apparently" abundant well control to delineate reservoir limits. However, upon closer inspection, via detailed subsurface work

utilizing existing well control and available whole core data, abrupt reservoir variations in these stacked fluvial and transitional marine sand sequences became evident. A review of these depositional processes revealed the limits of relying on

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"C" Channel Stratal Slice via Spectral Decomposition in GeoModeling

"apparently" high-density well control alone when implementing an EOR (tertiary) CO_2 project. Early recognition of flow units is critical to the success of a CO_2 flood. The CO_2 process is extremely sensitive to pressures and pressure variations, as viscous fingering and gravity segregation can have an adverse effect on flood performance. This realization drove Denbury Resources, Inc. to formulate a proprietary 3D seismic plan in an effort to optimize well locations by accurately defining reservoir limits (edges) while imaging multiple channels.

In 2001, Denbury Resources began to acquire proprietary 3D shoots for each of their five Lower Tuscaloosa CO_2 tertiary floods in southwest Mississippi. The sequence of 3D shoots beginning with the Little Creek complex in 2001, and followed by Mallalieu in 2005, the McComb area in 2006, and Brookhaven and Cranfield in 2007 depict the acquisition and processing advances realized in less than a decade. Full utilization of the geological well data set combined with the latest 3D interpretation software provides a visualization method to spatially depict these complex reservoirs and the future opportunity to monitor the CO_2 sweep efficiency via time-lapse 4D seismic^{*}.

Although each of Denbury's 3D surveys has resolvability issues due to limited bandwidth and frequency content, this does not impede the detection of channels and determining relative reservoir thicknesses. Channel detectability is readily accomplished by seismically "picking" a regional conformable stratigraphic event below the Lower Tuscaloosa reservoirs, flattening on that picked event, and then generating stratigraphically conformable (stratal) slices. These reservoir sands tune at certain frequenceies which correspond to a temporal thickness related to actual sand thickness and fluid content. We have combined four seismic attributes including up to three frequency volumes to detect these changes in reservoir thickness and/or fluid content. This combined image simultaneously displays spec decomp attributes in 3D space and the interpreter can animate through the slices in subsampled time increments to reveal increased stratigraphic detail.

Denbury Resources' latest generation of reservoir maps incorporate the results of the 3D spectral decomposition interpretation and has significantly enhanced the understanding and management of the five Lower Tuscaloosa EOR (tertiary) CO_2 floods.

*A companion two-year joint study now under way is utilizing Denbury's newest 3D control, which was shot in 2008 over a portion of Delhi Field (Tuscaloosa and Paluxy) in northeast Louisiana. The Reservoir Characterization Project – Phase XIII, via the Colorado School of Mines, includes a relevant time-lapse multi-component 9C4D seismic monitoring program to better image, depict, and manage a CO₂ flood in a highly heterogeneous series of multi-stacked lenticular bar and channel reservoirs.

Biographical Sketches

JIM MULLIGAN is the Regional Geological Manager – East Region for Denbury Resources Inc. Mr. Mulligan began his career processing marine 2D seismic data for Western Geophysical in Houston; he then spent four years with Sun Oil Co. as a production geologist in Midland and as an exploration geologist in Houston and Dallas. After two years with General American Oil Co. he joined



LaRue, Moore & Schafer as Vice-President of Exploration and represented their clients in the drilling of over 165 successful wells throughout the Gulf Coast of Texas and Louisiana in eleven years. His most notable discovery was the Gini-Wilcox field (named after his wife).

Denbury Resources Inc. employed Mr. Mulligan initially as a senior acquisition geologist, then as senior exploration geologist for Denbury's Gulf of Mexico properties and finally as senior production geologist mapping and developing properties in Mississippi (CO_2 fields) and Alabama (Black Warrior Basin). In 2007 he was promoted to Manager of Geology for Mississippi and then to Regional Geological Manager – East Region. He has a B.S. degree in Geology from Missouri School of Mines and was awarded a Professional degree in 1999. He is a member of AAPG, SEG, SPE, AGU, HGS, and DGS.

BOB SCHELLHORN is Regional Geological Manager—Western Region for Denbury Resources, Inc., in Plano, Texas. He earned a B.S. in geology at Southwest Missouri State University in 1982 and an M.S. in geophysics from the University of Texas at Dallas in 1987. In 1985 he joined Sun Oil Company (later Oryx Energy) and held various positions as a



seismic interpreter in exploration and development, both on shore and offshore. Despite his best efforts, he was assigned to numerous technical assignments in seismic data processing, new seismic technologies, hydrocarbon indicator group, and AVO group. After leaving Oryx in 1997, he worked for Chieftain International in Dallas and in 2001 began working for Denbury Offshore. During the last several years, he has been assigned to work Denbury's extensive portfolio of Mississippi, Louisiana, and south Texas oil and CO_2 fields. Mr. Schellhorn was Denbury's Manager of Geophysics before assuming his current position. He is a member of the Society of Exploration Geophysicists and the Dallas Geophysical Society.