Tuesday, November 13, 2007

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Social 11:15 a.m., Luncheon 11:30 a.m.

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by ***Ursula Hammes, Hongliu Zeng, Robert Loucks and Frank Brown, Jr.***
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All Fill—No Spill: Slope-Fan Sand Bodies in Growth-Faulted Sub-basins: Oligocene Frio Formation, South Texas Gulf Coast

Growth-faulted sub-basins in the Oligocene Frio Formation are major exploration targets along the South Texas Gulf Coast (Fig. 1). Historically, exploration has targeted on-shelf highstand and transgressive systems tracts and lowstand prograding-wedge systems tracts with great success. Companies have recently become interested in exploring for slope-fan sandstone reservoirs in lowstand growth-faulted sub-basins. However, the distribution, thickness and pathways of these gravity-transported slope-fan sandstones are not well understood and are more complex than highstand transgressive systems tracts or lowstand prograding-wedge systems tracts (Hammes et al., 2005, 2007a).

Correlating "first sands" likely leads to an erroneous interpretation.

Slope fans are prolific reservoirs in the deep waters of the Gulf of Mexico and other types of continental margin settings (e.g., Mitchum et al., 1993; Straccia and Prather, 2000). The typical slope and basin-floor-fan models in Pliocene and Pleistocene deepwater Gulf of Mexico basins are interpreted to exhibit a fill-and-spill sequence within one 3rd/4th-order minibasin (e.g., Pirmez et al., 2000; Hooper et al., 2002).

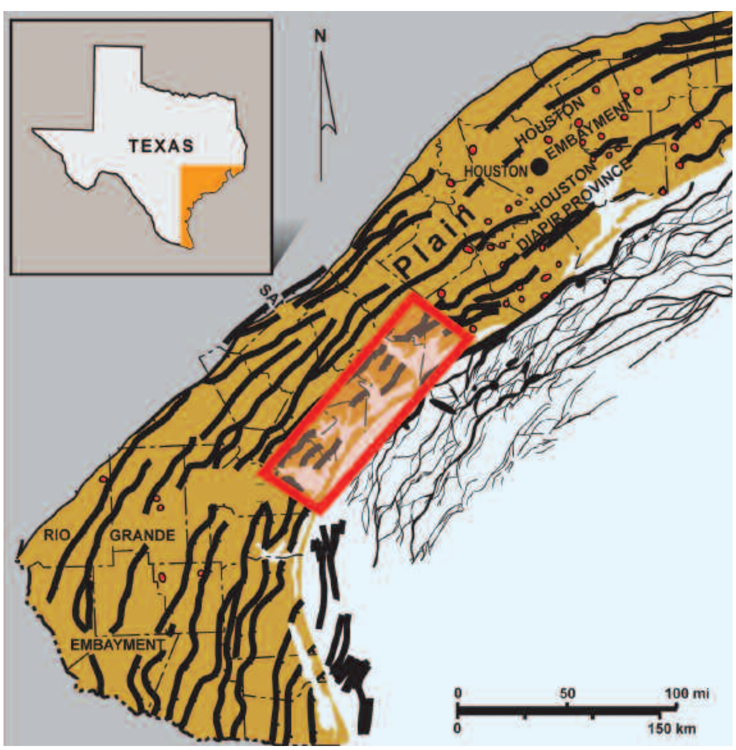

Figure 1. South Texas regional tectonic map and study area. Displayed are the growth faults that parallel the coastline. Note the absence of salt domes in the study area (indicated by the box). This area is dominated by mobile shale. The study is based on data from South Texas Bay areas. (Modified from Ewing, 1991)

In contrast, Frio slope fans in growth-faulted sub-basins fill the present accommodation space but rarely spill into the next sub-basin within a 3rd-order sequence because of an evolving sediment ridge. interpreted The growth-faulted Frio Formation sub-basins resulted from early slope-fan sediments overloading a ductile substrate (basinal shale or salt) above a detachment surface (Brown et al., 2004; Hammes et al., 2005, 2007a). This led to mobilization and fold development of a sediment ridge during one 3rd-order lowstand of sea level (Fig. 2). Slope-fan systems with amalgamated channels and levees formed along the slope and terminated as lobe-shaped fan deposits. This produced downslope sediment ridges which ponded slope-fan sediments and kept them from spilling farther downslope onto the deeper basin floor (Fig. 3). Consequently, after a sediment ridge formed, all gravity-flow sedimentation was contained within its attendant sub-basin.

Overall, slope fans have limited lateral continuity because of avulsion of lobes in the slope-fan system (Brown et al., 2004). When correlating more proximal sub-basin slope-fan bodies to more distal slope-fan bodies, time stratigraphic rather than lithostratigraphic correlations

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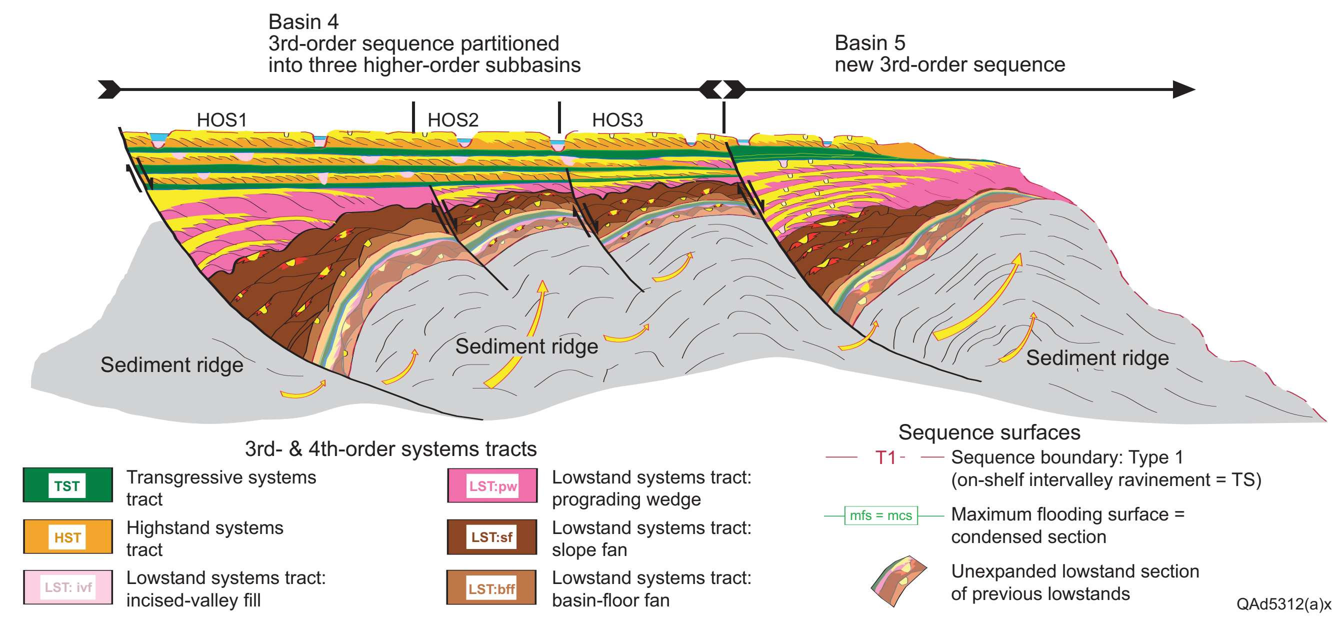

Figure 2. Conceptual model of slope-fan deposition in growth-faulted su-basins (from Hammes et al., 2007b). Lowstand systems tract commences with basin-floor-fan deposition onto fine-grained basinal sediments. Slope failure along incipient growth fault creates a depression that serves as ponding basin for subsequent lowstand deposits. Slope fans are being deposited into the sub-basin, mobilizing the unconsolidated shaley basinal sediments. Growth fault initiates movement and slope fans develop growth and rollover into fault. Depositional systems prograde over the slope-fans, establishing a prograding wedge. Sediment ridge and growth-fault movement cease. Transgressive and highstand systems tracts complete sub-basin deposition until a new sea-level lowstand occurs.

must be performed (Brown et al., 2004, their Fig. 9). Correlating "first sands" likely leads to an erroneous interpretation. As the prograding-wedge system prograded over these slope fans later during the lowstand, sediment-ridge and growth-fault movement ceased. Transgressive and highstand systems tracts completed the sub-basin depositional sequence. A new sequence will then begin with the next sea-level lowstand.

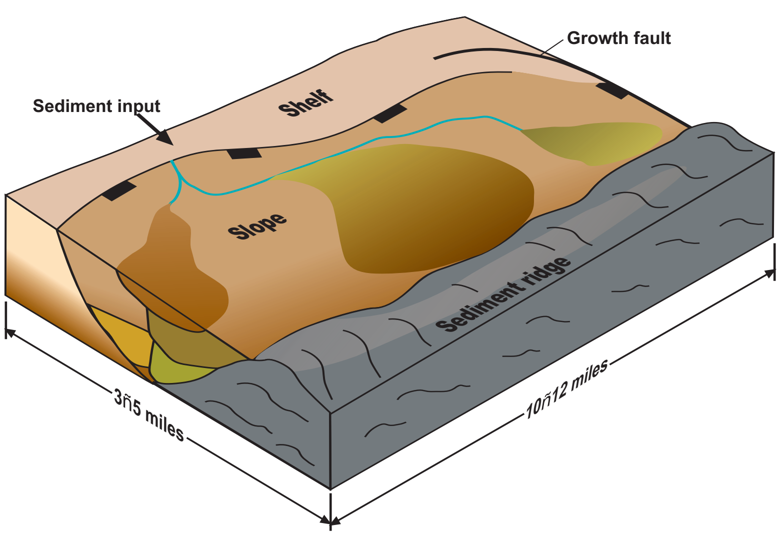

Figure 3. Frio growth-faulted sub-basin model showing slope-fans being trapped behind sediment ridge and slope channels aligning parallel to slope (from Hammes et al., 2007a). Slope-fans pond behind the sediment ridge that rose owing to loading of coarser-grained sediment onto fine-grained, muddy sediments. Note that no spill occurs beyond the sediment ridge into a subsequent sub-basin.

Production from slope fans in the south Texas Gulf Coast has been uncommon except in a few wells. Cumulative production ranges between 132 MMCF and 3.3 BCF and 5-130 thousand barrels of condensate. Porosities are typically between 10 and 25%, permeabilities range from <0.001 to 10 mD, and resistivities of productive intervals are generally between 2 and 3 and up to 10 ohms. Individual sands are 1 to 30 feet thick. The best production is associated with the absence of a water leg in association with a structural trap and located more proximally to the growth fault.

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Biographical Sketch

Ursula Hammes obtained her diploma in geology from the University of Erlangen in Germany in 1987 and her PhD from the University of Colorado at Boulder in 1992. She spent 10 years working as consultant, performing postdoctoral research at the Bureau of Economic Geology and as an exploration geologist in industry. Dr. Hammes joined the Bureau of Economic Geology in 2001 as a Research Associate. Her main research focus is clastic and carbonate sequence stratigraphy, depositional systems, and carbonate and clastic diagenesis.