Monday, January 18, 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.

Lawrence D. Meckel, III
Chief Geologist
Woodside Energy (USA), Inc.

Sand-Prone Submarine Mass-Transport Deposits: Reservoir Characteristics and Classification of an Underappreciated Deepwater Facies

Sand-prone submarine mass-transport deposits (Figure 1) are deepwater deposits that have been underappreciated by geoscientists as reservoirs and as drilling hazards. Recent studies confirm that sand-prone mass-transport deposits are common in the deepwater stratigraphic record (Figures 2 & 3), and that they act as significant oil and gas reservoirs in major global hydrocarbon provinces such as the Gulf of Mexico, West Africa, and the North Sea (Figure 4). Furthermore, sand-prone mass-transport deposits filled with locally overpressured gas or water in the shallow subsurface represent a shallow drilling hazard that warrants significant consideration in deepwater drilling programs.

Mass-transport deposits are defined as sedimentary stratigraphic successions that were remobilized after initial deposition but prior to substantial lithification, and transported downslope by gravitational processes as non-Newtonian rheological units

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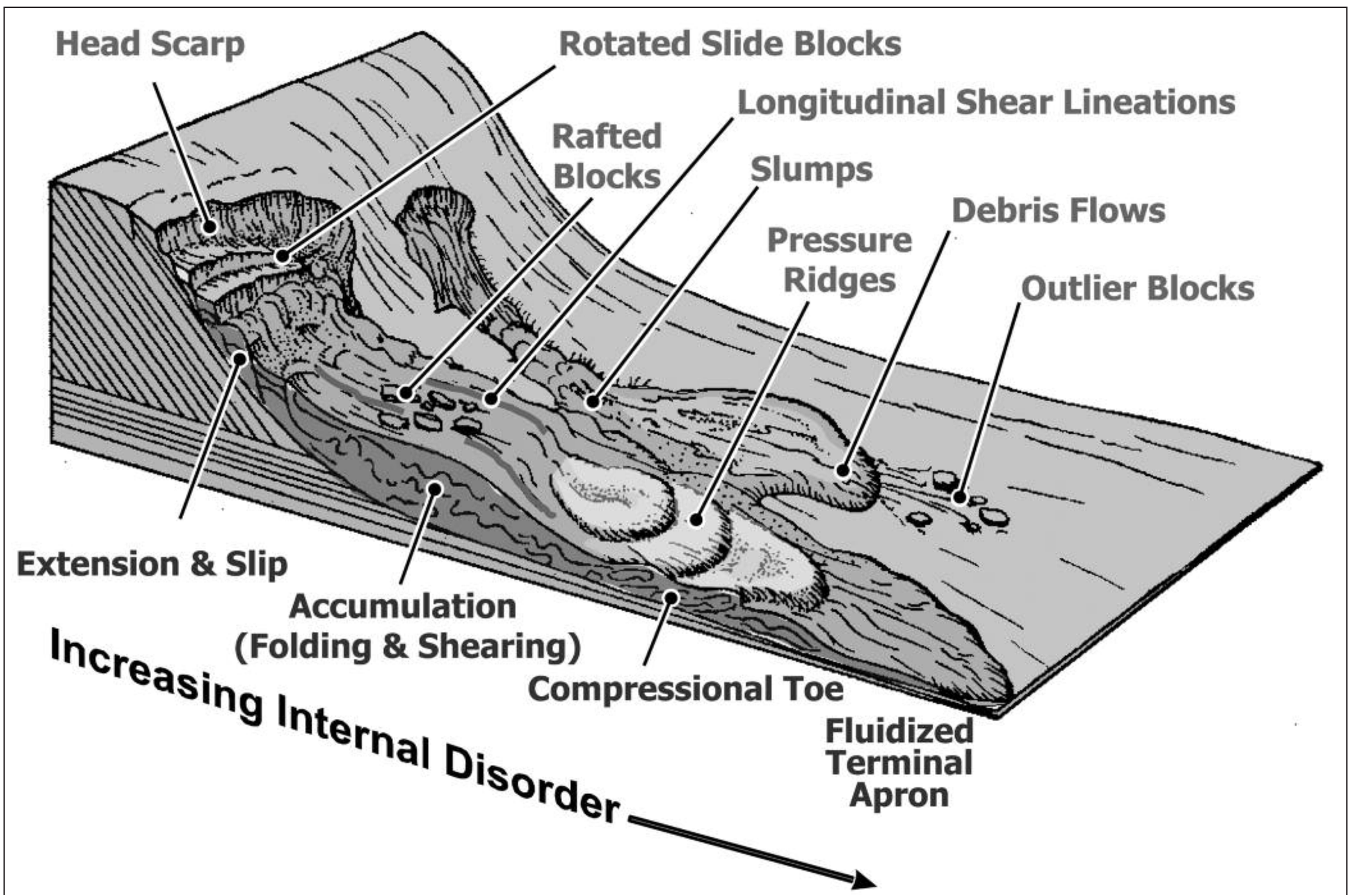

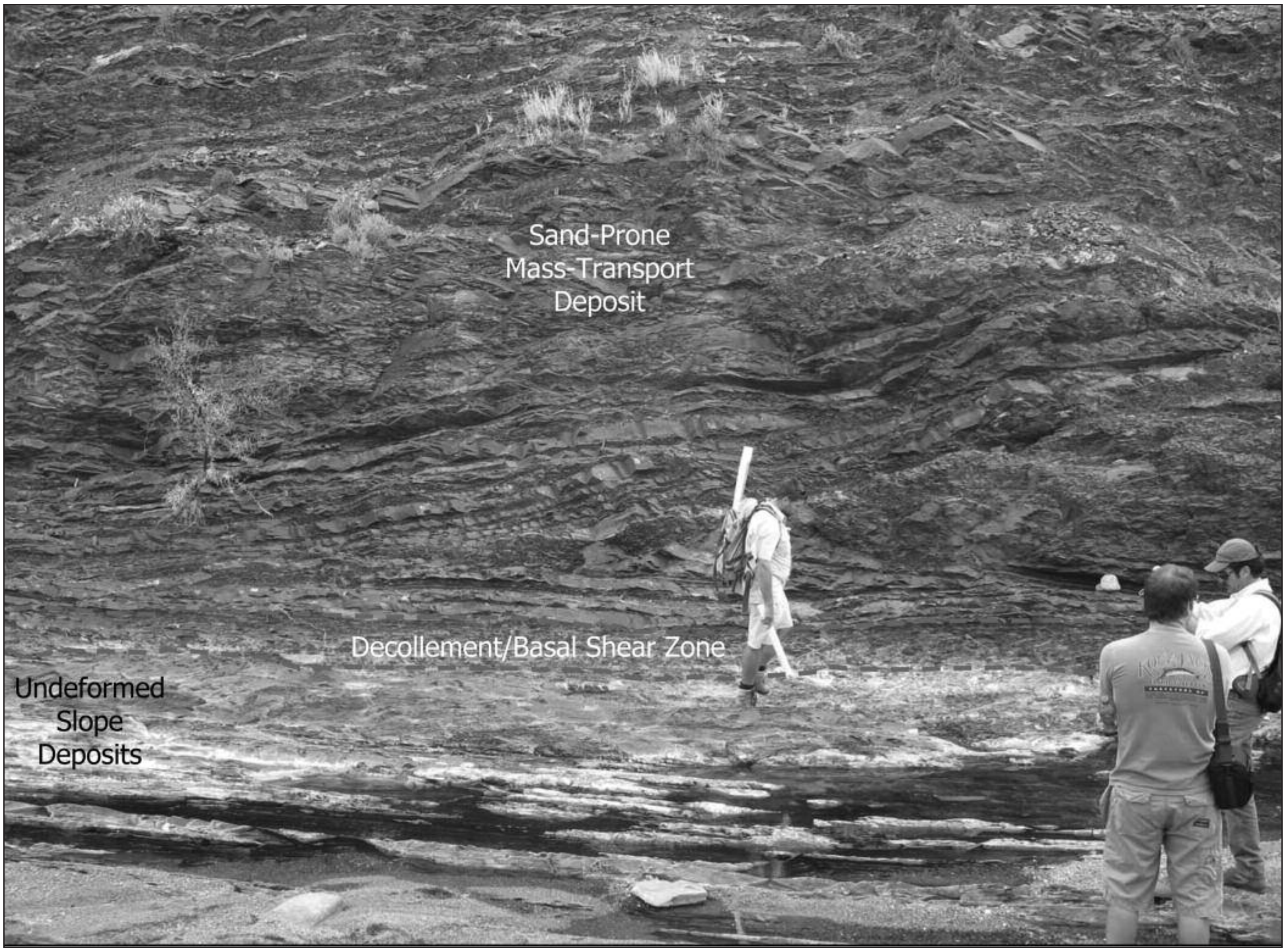

(non-turbulent, Bingham plastics or dilatant fluids). Individual mass-transport deposits may consist of one bed or many, and, depending on the pre-existing stratigraphy that has been remobilized, mass-transport deposits may be sand-prone or mud-prone.

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As a practical limit, sand-prone mass-transport deposits are defined as having an effectively porous and permeable sand-to-shale ratio of at least 20 per cent. Exceptional cases of reservoir-prone mass-transport deposits include otherwise mud-prone mass-transport deposits with a single sand or sands in excess of 10 m thick, regardless of the sand-shale ratio of the overall mass-transport deposit. Porosities in these sands can be in excess of 30%, and permeabilities can be on the order of several darcies. Outstanding production rates and ultimate recoveries are possible (Figure 4). However, production rates and ultimate recoveries are typically not as spectacular as in the best examples because reservoir quality can be degraded by significant amounts of detrital or diagenetic clay and compartmentalization can impact continuity of reservoirs.

Shallow water flow is not exclusive to mass-transport deposits. However, a review of the literature suggests it occurs far more frequently in mass-transport deposits than turbidites. In a significant number of cases, mass-transport deposits represent drilling hazards that can potentially pose significant health and safety risks, and also have the potential to require expensive sidetracks or casing programs to be implemented during drilling. In the most extreme cases, devastating damage to infrastructure or drilling operations may result from inattention to these features, such as catastrophic well failure while drilling, or even destruction of subsea drilling templates.

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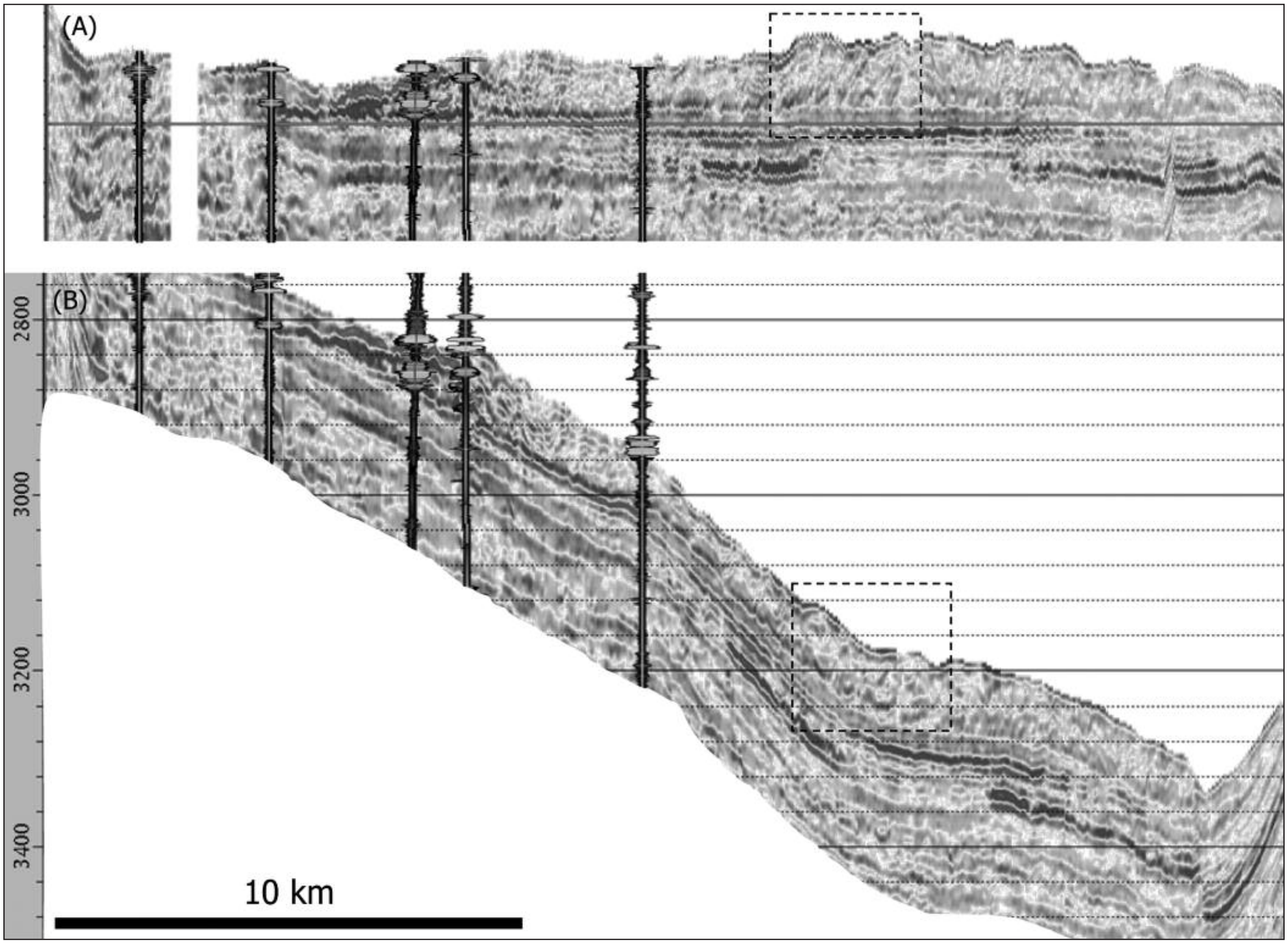

Conservative estimates indicate that at least $200 million US had been spent through 2002 (when costs were substantially lower than at present) in mitigating and remediating shallow water flow issues in deepwater wells in the Gulf of Mexico alone. Cost estimates for remediation and mitigation since 2002 have not been published, but are likely to be much higher. To some degree, this statement is tempered by the fact that most companies now employ dedicated shallow water flow teams to address this issue.

These observations suggest that these remobilized sands may be a more significant component of deepwater hydrocarbon systems than has been generally acknowledged. However, the term 'mass-transport deposit' has a disparate, and often confusing, usage in peer-reviewed literature, and no criteria exist to help differentiate sand-prone mass-transport deposits from superficially similar turbidite systems. The purposes of this presentation are therefore twofold:

(1) To propose a classification of mass-transport deposits that focuses specifically on depositional process, and that explicitly includes the potential for mass-transport deposits to contain sands, as observed in numerous cases.

(2) To provide quantitative and qualitative criteria to aid practitioners in differentiating sand-prone mass-transport deposits from mud-prone mass-transport deposits and sand-prone turbidite systems at regional to reservoir scales. The criteria for differentiation, which are based in large part on the author's personal experience and observations, are necessary because a comprehensive summary of recognition criteria for reservoir-prone mass transport deposits has not been published previously.

Differentiation is important in the case of sand-prone systems because turbidites and mass-transport deposits have fundamentally different reservoir properties and require very different exploration, appraisal, and development strategies. Key differences between the two types of deposits are useful, but not foolproof, predictors of reservoir properties (i.e., petrophysical character, spatial distribution, and lithologic nature) away from well control, especially if 3D seismic data are available to help constrain lateral variations in facies. Furthermore, identifying and characterizing sand-prone mass-transport deposits accurately in the subsurface allows better prediction of reservoir

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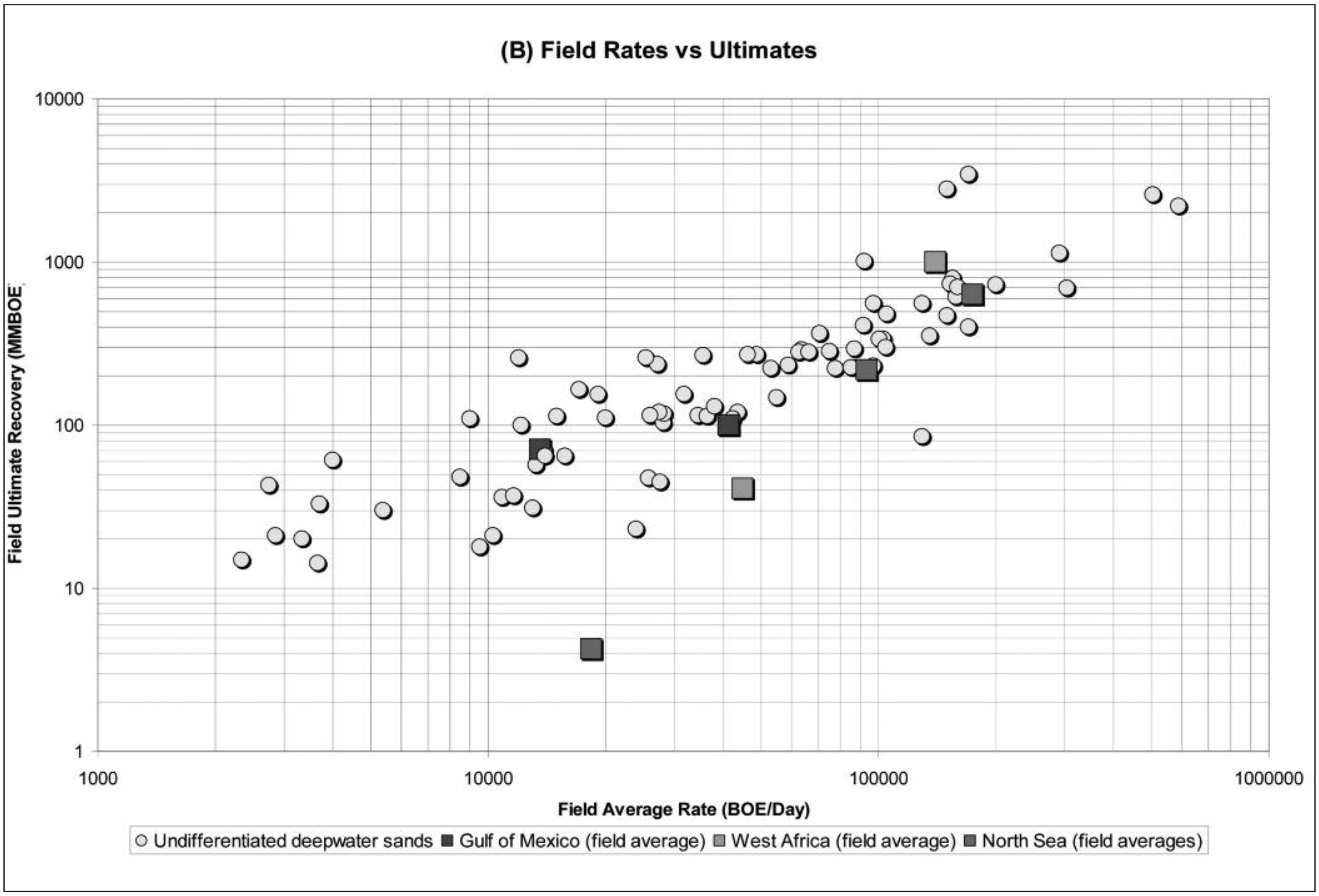

performance, which in turn facilitates better hydrocarbon field development plans. These implications are especially important given ever-increasing costs associated with the development of deepwater fields.

This presentation uses personal observations, as well as published examples from producing fields, the seafloor and shallow subsurface, outcrops, and flume tank experiments to illustrate specific criteria that aid in the recognition of sand-prone mass-transport deposits in the subsurface. Many of the criteria used to identify sand-prone mass-transport deposits are also valid for identifying deepwater channels and/or injected sands. None of these criteria is sufficient by itself to distinguish between a mass-transport deposit and a turbidite system. However, in aggregate, the criteria are sufficiently diagnostic to identify mass-transport deposits that are likely to be reservoir-prone, and have a reasonable probability of discriminating them from other genetic units.

Biographical Sketch

Dr. Lawrence D. Meckel, III (Trey) is the Chief Geologist of Woodside Energy (USA), Inc. Previously, he was the Coordinator of Reservoir Modelling and Geoscience Technology at Woodside Energy Ltd. in Perth, Australia. He specializes in integrated depositional systems analysis, sequence stratigraphy, risk assessment, reservoir characterization, and compartmentalization issues.

With Woodside, and previously with Shell International E&P, Dr. Meckel has been involved in research, exploration, development, and production projects in the Gulf of Mexico, West Africa, Australia, New Zealand, Malaysia, West of Shetlands, and South America, as well as onshore developments on the Texas Gulf Coast and the Anadarko Basin.

Dr. Meckel received a Ph.D. in Earth Sciences from the Swiss Federal Institute of Technology (ETH-Zürich), an M.A. in Geology from The University of Texas at Austin, and a B.A. with Honors in Geology from Williams College in Massachusetts.

Among his numerous papers and presentations, he won the New Orleans Geological Society's 2002-2003 Best Paper Award. He was the convenor of a 2009 AAPG Hedberg Research Conference on deepwater foldbelts, and is chairing a session on unstable continental margins at the 2010 AAPG Annual Conference in New Orleans.