

PS Facies Interpretation Based on Quantitative Analysis of Grain Size and Bed Thickness from Well Logs in Deepwater Turbidite Reservoirs*

Chicheng Xu¹, Carlos Torres-Verdín¹, and Ronald Steel²

Search and Discovery Article #50610 (2012)**

Posted June 11, 2012

*Adapted from poster presentation at AAPG Annual Convention and Exhibition, Long Beach, California, April 22-25, 2012

**AAPG©2012 Serial rights given by author. For all other rights contact author directly.

¹Petroleum & Geosystems Engineering, The University of Texas at Austin, Austin, TX (xuchicheng@gmail.com)

²Jackson School of Geosciences, The University of Texas at Austin, Austin, TX

Abstract

Grain size and bed thickness are critical properties for facies interpretation and petrophysical ranking in clastic reservoirs. Routine geological work infers grain size and bed thickness from sliced core samples which only cover a very limited segment of the reservoir. Well log-core integration is therefore necessary to extrapolate geological properties from cored depth intervals to remaining wells and into the reservoir. Grain size often controls reservoir quality and has a measurable impact on most well logs. Additionally, bed thickness affects well logs in various ways because of differences in vertical resolution. We aim to quantitatively classify rock and bed types based on well logs and use the classification for facies interpretation and stratigraphic reservoir modeling.

We numerically simulate theoretical well-log responses originating from clastic reservoirs with different grain sizes in the context of deepwater turbidite systems. The simulation takes into account fluid effects such as capillary transition and salty connate water. Petrophysical relationships are examined between grain size and pore geometry as inferred from the combined effects of initial connate-water saturation and reservoir capillary pressure. From the numerically simulated logs, we derive several quantitative log attributes, which highly correlate with grain size. Rock classification is then performed based on the relevant set of log attributes to detect and rank different rock types with specific grain sizes. A Thomas-Stieber plot is constructed to identify thinly bedded sections. We apply variance cutoff techniques to determine bed boundaries for medium and thick beds and for calculation of bed thickness.

The methods are applied to two field cases of deepwater turbidite reservoirs, one from the Gulf of Mexico and another from the Central North Sea. In both cases, we perform facies interpretation based on the vertical succession of rock types and the inferred variations of bed thickness. We show that these two geologic attributes significantly contribute to reducing uncertainty and non-uniqueness in the construction of reservoir stratigraphic models. Results indicate that the classified rock types and their petrophysical ranking agree very well with production measurements, thereby lending credence to the estimation procedure developed in this paper.

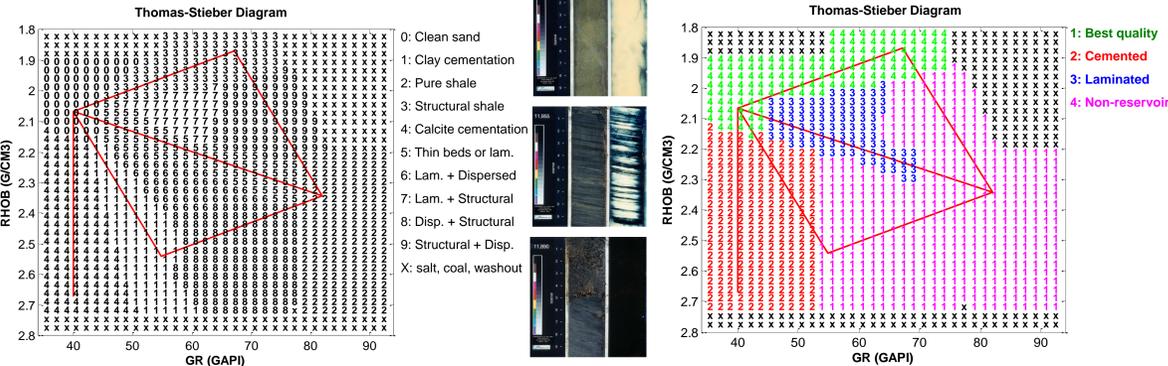
Facies Interpretation Based on Quantitative Analysis of Grain Size and Bed Thickness from Well Logs in Deepwater Turbidite Reservoirs

Chicheng Xu, Carlos Torres-Verdín, and Ronald Steel
The University of Texas at Austin

I. Summary - "Well logs have 80% subsurface information". How much do you get?

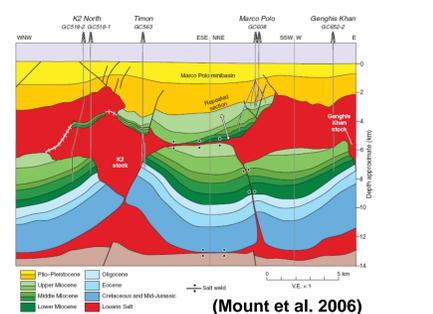
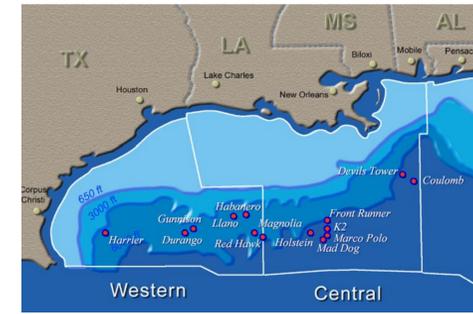
1. Grain size and bed thickness are the two basic attributes for turbidite facies interpretation.
2. Grain sizes determine pore throat sizes which relate to reservoir saturation-height behavior.
3. Bed thickness is revealed by log variability analysis and Thomas-Stieber diagram.
4. Both grain size and bed thickness are quantitatively derived from conventional well logs only.
5. Logs, core, seismic data, and analogues are integrated for a holistic reservoir characterization.

II. Methods

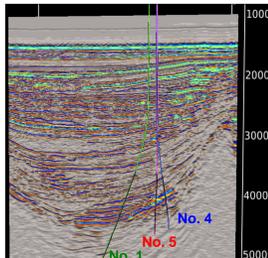
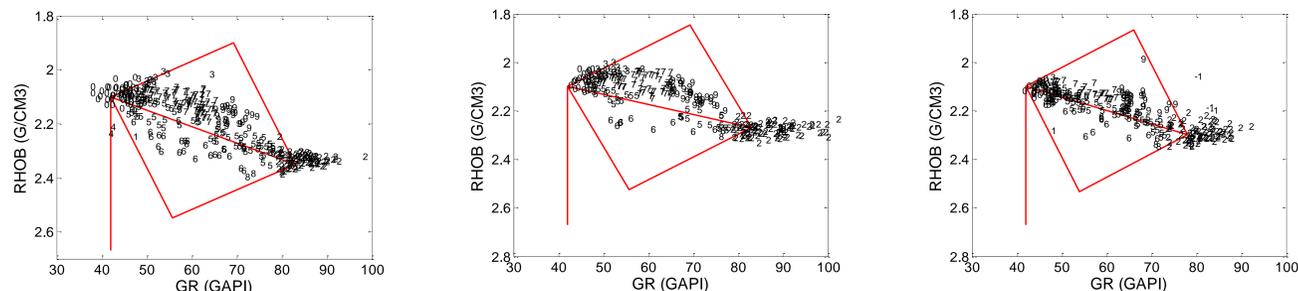


III. Marco Polo Field Background

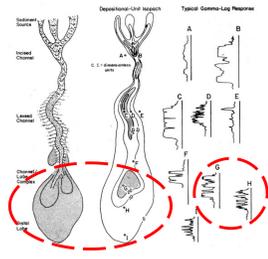
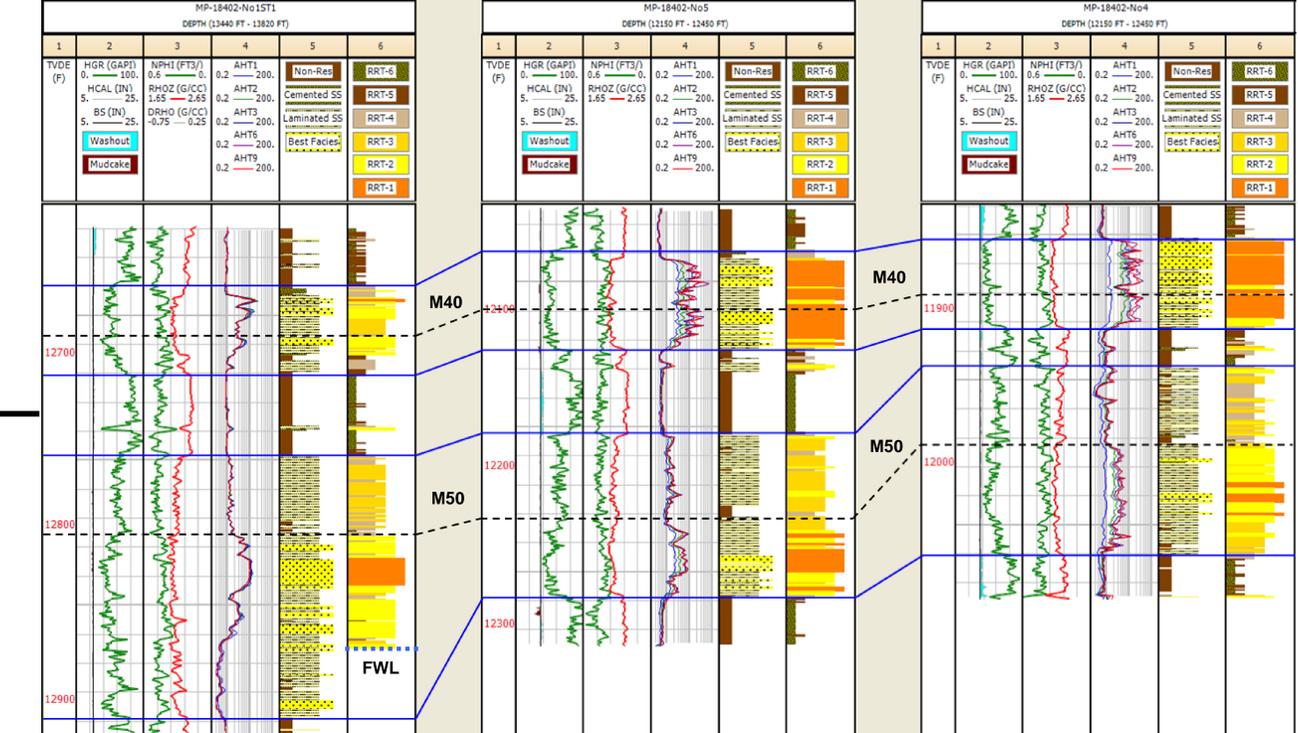
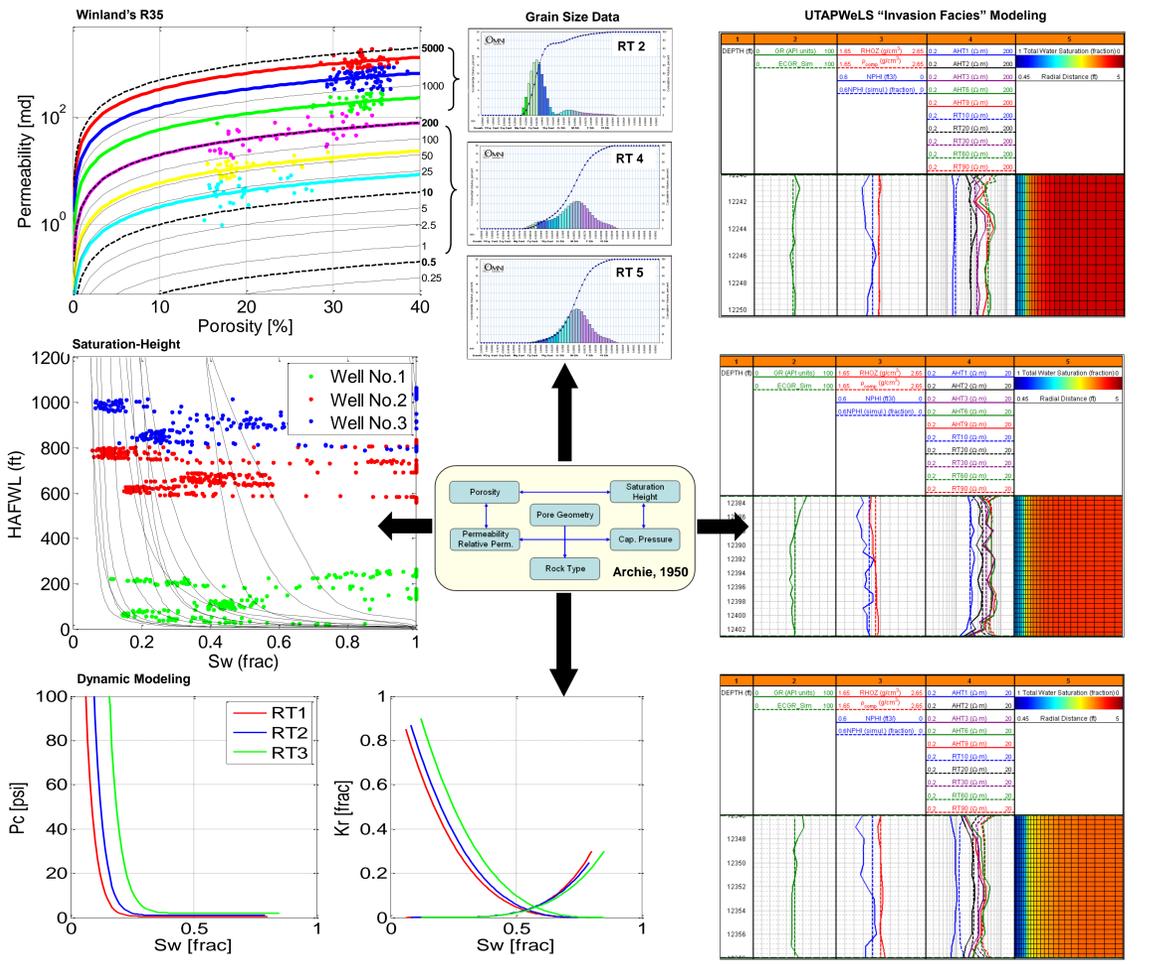
1. Central Gulf of Mexico, 5000 ft water depth.
2. Miocene, unconsolidated sandstone.
3. Prograding submarine fan complex.
4. Medium, fine, to silty grain sizes.
5. Significant presence of thin laminated shaly sand.
6. Porosity ~ 30%; Permeability: [100, 2000] md.



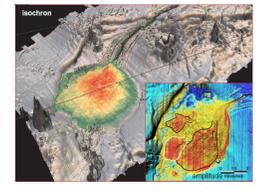
IV. Facies Interpretation and Validation



Cross Section - Well Locations



Dr. William Galloway's Depositional Model (From Galloway and Hobday, 1996)



(From Pirmez et al., 2000)

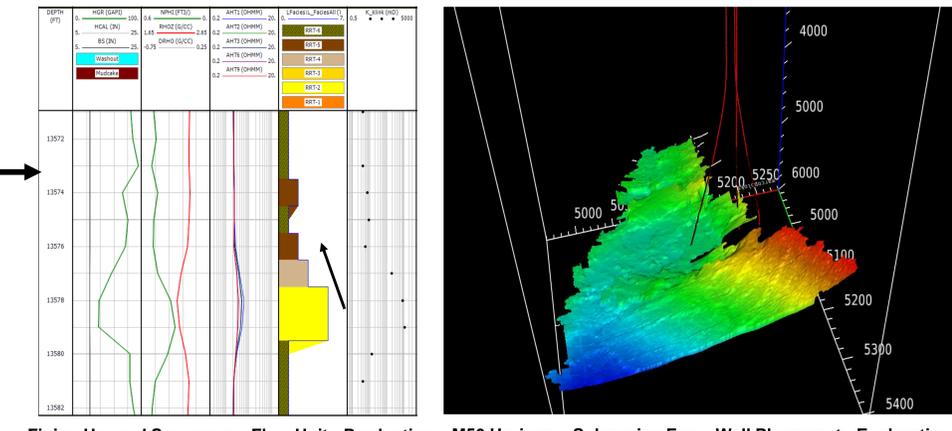
VI. Acknowledgements

Special thanks to Anadarko for providing the dataset for field study. The work reported in this poster was funded by The University of Texas at Austin's Research Consortium on Formation Evaluation, jointly sponsored by Anadarko, Apache, Aramco, Baker-Hughes, BG, BHP Billiton, BP, Chevron, ConocoPhillips, ENI, ExxonMobil, Halliburton, Hess, Maersk, Marathon Oil Corporation, Mexican Institute for Petroleum, Nexen, ONGC, Petrobras, Repsol, RWE, Schlumberger, Shell, Statoil, Total, and Weatherford.

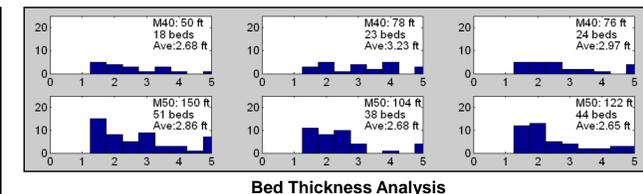


V. Conclusions

Well logs should be quantitatively integrated with core, seismic, and analogues for geologically-petrophysically consistent reservoir characterization in both exploration and production phases. This will become particularly important as drilling goes deeper into subsalt or pre-salt basins.



Fining Upward Sequence - Flow Unit - Production M50 Horizon - Submarine Fan - Well Placement - Exploration



Bed Thickness Analysis