Research Prospectus:

Quantitative Sedimentology Research Consortium

Dr. Janok P. Bhattacharya
Robert E. Sheriff Professor of Sequence Stratigraphy
Geosciences Department
SR1 Rm 312, University of Houston
4800 Calhoun Rd., Houston, Texas 77204-5007
e-mail: jpbhattacharya@uh.edu
Wk: (713)743-4720

Introduction

The quantitative sedimentology research program at the University of Houston is focused on investigating the sequence stratigraphy and 3D facies architecture of shallow marine, paralic, and fluvial depositional systems. Although much industry exploration effort is currently focused on deepwater depositional systems, about 50% of global oil production is currently from shallow marine, paralic and fluvial strata. Despite the continued importance of these reservoir types, ours is one of the only research programs devoted to this important area.

I am also investigating the interrelationships between structure and stratigraphy as a paired process. Specific projects are aimed at examining the effects of meso-scale tectonic structure on high-frequency sequence stratigraphic architecture in foreland basins and the relationship between sedimentation processes and formation of growth faults associated with deltaic depositional systems.

This memo lists the results of our ongoing research program as well as listing some of the projects that we would like to complete using additional consortium funds. Consortium members are also free to suggest possible additional research topics and we encourage collaboration, especially in applying our analog studies to actual subsurface reservoirs.

Through your sponsorship of our research programs, we will be in a position to continue to provide you with a new generation of keen and well-trained integrative petroleum geoscientists, who will be required to satisfy your future hiring needs.

General research interests

My general research areas include:

♦ Clastic facies models with an emphasis on 3D facies architecture.
♦ Sequence stratigraphy of shallow marine to non-marine systems.
♦ The effects of structure and tectonics on facies architecture and stratigraphy.
♦ Depositional processes and formation of growth faults in deltas.
♦ Quantitative description and modeling of modern and ancient deltas
♦ Seismic Geomorphology of shelf margin deltas.
♦ Origin of shelf mud belts.
Previous consortium studies have been directly applicable to reservoir characterization and fluid-flow modeling of shallow-marine and fluvial-deltaic depositional systems. The work on structural control on facies distribution has value in predicting reservoir distribution as a consequence of underlying or synsedimentary tectonics and structure. The growth fault work has been used to address reservoir compartmentalization in analog reservoirs.

Specific Projects:

1. Sequence stratigraphy across the marine to non-marine transition of the Cretaceous Notom Delta complex, Ferron Sandstone, Utah.
2. Facies architecture of wide valley systems, Cretaceous Notom Delta complex, Ferron Sandstone, Utah.
5. Facies architecture of asymmetric, wave-influenced deltas, Gallup Sandstone, New Mexico.
6. Facies architecture and clay distribution of asymmetric, wave-influenced deltas, Modern Brazos Delta, Texas Gulf Coast.
7. Facies architecture, structural style and fault properties of non-salt related synsedimentary growth faults in deltas.
8. Seismic geomorphology of shelf margin deltas and mass transport complexes in GOM mini-basins.

More details of these projects can be found on the following website:

http://www.qsc.uh

Project summaries of these new projects are provided below.

Costs and benefits

The consortium funding fee of $35,000K is structured to cover all of the costs associated with supporting one graduate student for a year. Consortium funding is also used to provide summer salary for PI's and other infrastructure needs. In return for your support, I will send a yearly report of activities to the sponsoring company. More extensive reports (pre-prints), oral presentations (Powerpoint) and Posters are all provided via a proprietary web-based format (primarily as pdf files) that can be printed or used internally at your own convenience and discretion. Membership immediately allows you access to the already built websites. These proprietary websites are password protected for the sole use of consortium members. We also run a yearly field trip to illustrate the outcrop examples that we are conducting research on. These field trips are marvelous training opportunities for your staff, and also provide an intimate view of the latest research that we are conducting. Many of our outcrop studies have re-examined classic outcrops used in industry training, and have included the Ferron sandstone,
Blackhawk-Castlegate sandstones and Panther Tongue sandstone in central Utah, as well as the Frontier sandstones in Wyoming.

Also, I would be interested to discuss the opportunities of specific projects, cores, or data sets that you have that I could have a student work on as part of their MS or Ph.D. research project. Such “gifts in kind” would also be encouraged and would give students valuable interaction with industry.

Your funds may be leveraged against significant sums from the various funding agencies that have supported my work in the past (e.g. PRF/ACS; DOE). You have access to new ideas and concepts, research breakthroughs, data, powerpoint visuals, and posters, as they are completed, versus the larger community that only has access to the final published papers, which routinely appear several years after work has been completed. You also have access to myself and students via in house visits and the annual field trip.

**Current Research Team: Theses and Dissertation Topics**

**PhD Candidates**
- Weiguo Li – Incised Valleys in the Cretaceous Ferron Notom Delta, Utah.
- Felipe Lozano – Sesimic geomorphology of shelf edge deltas, GOM.
- Yijie Zhu - Sequence stratigraphy of the Cretaceous Notom delta, Utah.
- Tianguang Xu – Detrital Zircon analyses and provenance of the sediments within the Cretaceous Notom delta, Utah.
- Oluwaseyi Fatoke – Sequence stratigraphy and structural control on shelf margin deltas, Niger Delta.
- Donald Barker – Sequence stratigraphy and sea-level history of Mars.

**MS Candidates:**
- Milly Wright – Chemostratigraphy of the Cretaceous Ferron Notom delta, Utah.
- Chris Campbell – Facies architecture of incised valley fills, Ferron Notom delta, Utah.
- Eric Blankenship – Sedimentology and structure of Growth Faults in the the Cretaceous Ferron Notom Delta, Utah.
- Daniel Garza – Facies architecture of delta front sandstones, Cretaceous Ferron Notom Delta, Utah.
- Michael Loparco – Sequence stratigraphy of an asymmetric delta, Cretaceous Gallup sandstone, Ship Rock New Mexico.
- Ryan Krueger – Reconstruction of wave field in an ancient asymmetric, wave-influenced delta, Gallup Sandstone, New Mexico.
- Derek Rice – Origin and distribution of clay minerals in the Modern Brazos Delta, an asymmetric wave-influenced delta on the Texas Gulf Coast.

**2005-2008 Publications**

*Refereed papers submitted or in press:*


**Recent Published Articles in Refereed Books and Journals:**


Chapters or Papers in Books:

Field Guides, Unpublished Reports and Short Course Notes:
Proprietary

University of Houston Quantitative Sedimentology Research Consortium Field Trip, Sunday August 12th – Friday August 17th. 128p.


Examples of Individual Projects:

Project 1. Sequence Stratigraphy and Facies Architecture of the Cretaceous Notom Delta Complex, Ferron Sandstone, Hanksville, Utah

The Last Chance delta complex of the Cretaceous Ferron sandstone in central Utah has been extensively studied both from the facies architectural and sequence stratigraphic perspective, and is widely used as a field training ground by industry. The Notom delta complex, superbly exposed farther to the south and east along the Burr Trail, and around Hanksville, Utah, has received far less attention. This area of Utah is even more arid than the classic Ferron exposures around the San Rafael Swell resulting in even better continuous cliff exposures, which are perfectly suited to 3D reservoir characterization studies (Fig. 1 and 2).

Figure 1. General view of Ferron sandstone exposures near Hanksville Utah. Note the almost complete lack of vegetation and the extensive and continuous quality of the outcrops.
Figure 2. Base map showing outcrop belt, measured sections and location of preliminary cross-section shown in Fig. 5, below.
Preliminary scouting, conducted in the Summer of 2004 and data collected in the summer of 2005, shows a wide variety of complex facies and syndepositional features, including fluvial, wave- and storm-dominated delta fronts overlain by possible incised valley feeder systems to the delta. We propose an initial field study to begin a detailed sequence stratigraphic analysis of this unit.

Outcrops just west of Hanksville show upward-coarsening delta fronts that internally consist of a complex series of lens-shapes, scoured HCS storm beds interbedded with lightly burrowed mudstones, suggesting a strong storm-fluvial influence (Fig. 3). The relationship of these fluvial-storm influenced facies to adjacent wave-dominated and more homogenous shorefaces will be tested using the recently developed asymmetric model for wave-influence deltas.

These storm-dominated delta fronts show striking similarities to Tertiary-age storm-dominated delta fronts in places such as offshore Trinidad, and these may represent excellent outcrop analogs.

Incised channelized systems overlying these delta fronts and shorefaces show complex internal geometry, associated with overlapping channel bars (Fig. 4). We are particularly interested in determining the relationship between storm-flood-dominated delta fronts and the associated feeder systems.
Figure 4. A. The undulating erosion surface likely represents a sequence boundary marking the base of a fluvially-cut valley. The valley is overlain by floodplain mudstones and channel-bar sandstones. B. This photo connects to the right of 4A., and shows the continuation of the basal erosion surface as well as laterally accreting bar deposits in the overlying valley fill. C. Close-up of the point bar deposits overlying the floodplain. More details of the bars are shown in figure 3.
During field work in the summer of 2005 I collected 6 vertical measured sections over a 180 square mile area (Figs. 2 and 5). I measured about 1,600 feet of section spaced 1.5 to 10 miles apart. The measured sections show that the Ferron is about 100 m (300 feet) thick and consists of up to 7 deltaic to shoreface marine parasequences passing upward into a fluvial succession characterized by sandy to conglomeratic fluvial channel belts and coaly floodplain mudstones. The proportion of non-marine versus marine facies increases to the south and west. Paleocurrents vary from northwest, north and northeast to southwest, suggesting the delta was fed by rivers flowing from the southwest.

Major, multistory channel deposits indicate valleys that cut into underlying shoreface and deltaic sediments. These are candidate sequence boundaries, which should allow detailed examination of the transition of sequence boundaries laterally and from proximal to distal location. There are opportunities for mapping valleys and documenting their internal architecture as well as examining strike variability of a major mixed-influence delta. The delta appears to be storm, wave, and flood influenced, although rare tidal cross stratification was observed, suggesting limited tidal influence.

I am supervising 6 students working on various aspects of these projects.

Figure 5. Regional cross section showing decreasing non-marine facies to the east and illustrating basic style of parasequence stacking.
Project 2. Facies Architecture of the shoreface to delta front transition, Gallup Sandstone, New Mexico

The Cretaceous Gallup sandstone of New Mexico has been interpreted as wave-dominated shorefaces associated with a barrier-island depositional setting. Scouting of these outcrops in the summer of 2004, around Rock Ridge, south of Ship Rock, shows a superb example of the transition between a fluvial, flood-dominated delta front laterally into a wave-dominated shoreface. Earlier work did not recognize the fluvial-nature of the parasequences along Rock Ridge (Fig. 6). Our scouting showed poorly-bioturbated mudstones interbedded with sharp-based, normally graded sandstone beds displaying Bouma sequences (Fig. 7). Not exactly the features typically associated with wave-dominated shorefaces.

These heterolithic parasequences pass laterally into homogenous and pervasively bioturbated to cross bedded sandstones interpreted as “classic” shorefaces (Fig. 8). These lateral facies relationships suggest a mixed river- and wave-influenced delta. We have recently developed a model for wave-influenced asymmetric deltas that predict specific relationships that link shorefaces and delta fronts (Bhattacharya and Giosan, 2003). Essentially, the fluvial-dominated delta fronts are predicted to lie downdrift of the
sandier, more homogenous and potentially better reservoir quality shoreface systems in the updrift region.

![Figure 7. Unbioturbated heterolithic strata (left) are associated with normally-graded sandstone beds displaying Bouma sequences (right) and interpreted as possible river-produced, hyperpycnal turbidites. These observation are not compatible with a wave-dominated shoreface interpretation and suggest far more fluvial influence.](image1)

![Figure 8. Thick sandy parasequence, about 1 mile east of the outcrops shown above show features more typical of a wave-dominated shoreface.](image2)

Our focus in the project will be to map the bedding relationships between the shoreface and delta front. Paleocurrent information and ichnological analysis will be critical to determine the detailed paleogeography and the orientation of the river plume versus the longshore drift system.

Two MS students will initiate field work on this unit this summer. Additional information on both proposed projects can be found by contacting Professor Bhattacharya as listed above.