RIOMAR
2018 Annual Meeting

December 7, 2018
Research Presentations and Business Meeting
Location: SHERATON HOUSTON WEST
11191 Clay Rd., Houston, TX 77041
## Schedule

**December 7, 2018**

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## RESEARCH TALKS

**Oral session 1, Rivers, Lakes, and their Deposits**

*9:15 AM – 11:00 AM (Chair: Cornel Olariu)*

1. Stratigraphic anatomy of a fluvial channel belt: Cedar Mtn Fm. (Ben Cardenas and David Mohrig)
2. Flood-prone river deposits Froude supercritical flow macroforms (bars) (Haipeng Li and Piret Plink-Bjorklund)
3. Tributary networks within distributary river channel networks: A missing link to understanding fluvial stratigraphy (John Swartz and Ben Cardenas)
4. Using time-lapse airborne lidar surveys from the Trinity River, TX, to build a realistic model for generating point-bar and scroll-bar stratigraphy (Jasmine Mason and David Mohrig)
5. Experimental investigation of temperature control on particle settling velocity (Ye Jin Lim)
6. Paradox of water-depth-dependent TOC in fine-grained lake deposits (Wonsuck Kim)

**Oral session 2, Aeolian Dunes and Deltas**

*11:30 AM – 12:00 PM (Chair: Piret Plink-Bjorklund)*

7. Grainflow thickness: Surface process to subsurface record (Undergrad: Xiafei Zhao)
8. Revisiting Paleocene Lower Wilcox Group, Gulf of Mexico: river-dominated or mixed-process deltas? (Jinyu Zhang)
Oral session 3, Deepwater Systems and Deposits
1:30 PM – 2:30 PM (Chair: David Mohrig)

9. Characteristic features of large antidunes on early slopes of Gulf of California (Logan West)

10. Supercritical flow experiments with a wide range of grain sizes I: Lessons learned (Kenya Ono and Piret Plink-Bjorklund)

11. Supercritical flow experiments with a wide range of grain sizes II: Implications for outcrop interpretation (Kenya Ono, Haipeng Li, Dessy Sapardina and Piret Plink-Bjorklund)

12. Revisiting the origins of Canyons on GOM Margin (Cornel Olariu)

RESEARCH POSTERS

1. The fate of the Mississippi River’s sediment during last phase of the last glacio-eustatic cycle: a volumetric quantification (Ryan Herring and Cornel Olariu)

2. Physical sedimentology of river levees: Connecting sedimentation to attributes of the producing floods (Hima Hassenruck-Gudipati and David Mohrig)

3. Flood-prone river deposits: Sediment mobility during major storms (Haipeng Li and Piret Plink-Bjorklund)

4. Revisiting Campanian-Maastrichtian stratigraphy, Western Interior Seaway (Keith Minor)

5. Connecting the patterns of subsidence and extensional faulting to continued turbidite loading (Chris Liu and David Mohrig)

6. Supercritical flow signatures and erosional features in Juncal Fm basin floor fans (Dessy Sapardina and Piret Plink-Bjorklund)

7. The production of combined-flow turbidity currents: Reassessing the interpretation of wave base using sedimentary structures (Max Daniller-Varghese and David Mohrig)

8. La Jolla Group slope channels: Challenges of identifying channels vs supercritical flow bedforms (Kenya Ono and P. Plink-Bjorklund)

9. Maastrichtian slope channels of Washakie Basin: does the slope-break trajectory change during 1.9My affect channel geometries? (Yuqian Philomena Gan)

10. Comparison of outcrop data of basin floor fans: How common is Froude supercritical flow and outer fan erosion? (Dessy Sapardina and Piret Plink-Bjorklund)

11. Recognition of ancient compound deltaic clinothem and how they are clothed by tide-, wave-, and river-generated facies (Yang Peng)

12. Shelfal sediment transport in the South China Sea, a case study of large oblique accretion on the continental margin of Qiongdongnan Basin (R. Zhao)

13. Tidal sand ridges generated during transgressive backstep on a M. Jurassic Margin (Neuquen Basin) (Eunsil Jung)
RIOMAR Plans for 2018-2019

WONSUCK KIM AND STUDENT GROUP: Experimental Morphodynamics and Stratigraphy

1. How do river meanders change with sea level rise and fall?
Morphology and stratigraphy

Preliminary experiments with crashed walnut sediment reproduced self-organized meandering rivers over base level change. Different regions from the downstream base level show different responses in sinuosity to base level rise and fall. Greater sinuosity change occurs not in the most downstream part of the river but mid stream (upstream of the backwater region). In this year, we will focus on investigating point bar evolutions and lateral accretion over different places along a river over sea level fall and rise. We will collect time-lapse images, high-resolution topographic scans, and depositional sections.

2. Thermodynamic sediment transport: Temperature control on grain settling velocity.

We propose to make direct measurements of particle settling velocity over a range of temperature and compare the results to theoretical calculations. In theory, a given grain-size clast under colder condition has shorter advection length due to faster settling velocity. We are also planning to conduct delta experiments at a near freezing temperature to investigate morphological and stratigraphic imprints of cold temperature in Arctic deltas compared to template deltas. Literature and natural data search will be performed to compare with experimental results.
3. Temperature controls on Arctic delta morphology and stratigraphy: Ice cover thickness
The previous experiment with a delta that progrades in an ice-covered basin showed clear interaction between ice-cover and under-ice channel, which produced elongated subaqueous topset and increased in topographic roughness in the shallow water depth. We will continue this investigation with a range of different ice-cover thicknesses to examine the effects of global warming on delta front morphology and stratigraphy.

4. Control of flood intermittency on bifurcation length and time of deltas
Experiment on river mouth bifurcation will continue to further analyze bifurcation length and time over a range of intermittencies and collect more natural measurements to scale the experimental results. The experimental mouth bar formation and channel bifurcation is achieved by producing two characteristic advection lengths using intermittent flood and interflood discharges and corresponding deposit types: One is associated with interflood
bedload transport and the other is with flood-suspended transport, which develops proximal low-angle deposits and distal steep deposits, respectively. Frequent flooding causes shorter bifurcations with shorter bifurcation incidence time, whereas infrequent flooding causes longer bifurcations with longer incidence time.

![Elevation scan time series of an experiment with a flood every 10 min (I = 0.28).](image)

**Figure 4** Elevation scan time series of an experiment with a flood every 10 min (I = 0.28).

5. **Linking delta shoreline and foreset-bottomset transition trajectories: Experiment and theory**

Shoreline response to base level change has been studied extensively. However, the foreset-bottomset break has not been thoroughly investigated. We propose to study how the trajectory of this moving boundary responds to base level change. In this year, using flume experiments and theoretical work we will provide a unifying theory for foreset-bottomset break migration, similar with the autoretreat and fluvial grade theories. Especially, we will focus on investigating the linkage between shoreline and foreset-bottomset break during base level rise in this project year.
6. Turbidity currents over a fault: Subaqueous tectonic geomorphology

Preliminary turbidity-current experiments indicated different morphodynamic response of turbidity-current channel over a fault compared to a river in response to fault topography. When turbidity current flows over a fault i.e., flows from upstream shallow surface to a steep fault scarp, the velocity increases downhill. The maximum acceleration occurred not at the slope break but some distance away from it. This simple difference gives a feedback to topographic change over the fault scarp and potentially generates different landscape evolution underwater compared to subaerial case. We will investigate the subaqueous topographic evolution in 2D and 3D experiments.

Figure 6 Turbidity current over a fault scarp.
CORNEL OLARIU, RON STEEL AND STUDENT GROUP: Problems in outcrop & subsurface stratigraphy & sedimentology

7. Documentation of supercritical bedforms in outcrops of early-stage continental slope
Supercritical bedforms - is a continuation of the project in Valecito-Fish Creek Basin by PhD Student Logan West. The project will focus on the three dimensional reconstruction of the slope/basin floor supercritical bedforms; (1) reconstruction the large scale (hundreds of meters) bedding geometries and facies variabilities; (2) documenting and understanding the overall aggradation progradation pattern of the slope deposits over a distance of kilometers (how it varies between different canyons).

Figure 7 Top: Google Earth image of the Lycium Wash (center) and the orientation and location of observed paleoflow indicators. Bottom: Large, tens of meters thick cliffs oriented strike-oblique to the paleoflow. Note that bedforms are an alteration of sandstone and mudstone.
8. How do we recognize backwater zones in ancient strata?

Criteria for recognizing backwater - The project (with a new student) will identify and understand the sedimentary deposits in the backwater zone along parts of the western side of the Cretaceous Interior Seaway, and so develop criteria to characterize backwater zone in other stratigraphic data. The project will use integrated outcrop and subsurface well-log data to reconstruct linkage between river and shoreline zones along two long transects through Campanian deposits of Wyoming/W Colorado and Utah. The hypotheses are that (1) backwater zone is recognizable in the stratigraphy as a distinct sedimentary zone (with narrow, deep and muddy-heterolithic channels), located between sandy fluvial deposits and their coeval shoreline, and (2) the backwater depositional belt is narrower during regression rather than during transgression. The Wyoming transect will focus on the fluvial Trail Member of Ericson Fm. (Mesaverde Group) that is the updip equivalent of the Iles Fm. shorelines in NW Colorado. The outcrops of Rock Springs Uplift, Vermillion Creek and Craig/Hayden areas as well as intervening well data will be used. The Utah transect will focus on the Bluecastle and Neslen fms in NE Utah and downstream coeval Sego Sandstone shorelines- north-central Utah and east-central Colorado.

Figure 8 Hypothesized backwater changes with base/sea level changes. A – Fluvial normal, transition and backwater facies belts behind the shoreline. B – During sea level fall backwater facies belt extends. C – During sea level rise the backwater facies belt narrows. D – Fluvial increase in the gradient with “normal” regression results in narrowing of the backwater area.
9. Characteristics & recognition of tide-dominated delta fronts
These are still the most poorly documented type of deltaic strata. Tidal currents can be enhanced or well preserved on shelf-edge areas, on embayed & protected (from waves) coastlines, on shelves with a critical width, in active-tectonic straits, or in other sites where waves are dampened, so that strong stratigraphic tidal signals may provide insight to these settings. We have established the first onshore to offshore correlated stratigraphy for the palae-Orinoco delta system (GSAB 2017). This shows segments of tide-domination, and we plan to focus on how this is expressed in the stratigraphy. We will also document the different ways in which the large fluid mud supply from the Amazon Delta and Guyana littoral current impacts the front of the Orinoco delta (current student Yang Peng and new external PhD student Ariana Osman are involved).

Figure 9 Tide-dominated delta fronts are poorly known. Do they have mouth bars? Do distributary channels extend far down the delta-front slope? What dampens the waves to allow preservation of tidal signals, given the short time scale of wave reworking.

10. What is the slope-channel architecture of medium-relief (<1km) shelf margins?
A project (by current PhD student Yuqian Gan) that will build on our outstanding subsurface well database in Washakie Basin. The large-scale stratigraphy of the basin fill has been mapped using 1000 wells and some of the topsets (fluvial-delta sequences) and
bottomsets (fans) have already been worked in detail. The current project will identify and characterize the deepwater slope channels (mapping their log character, thickness, “density” along the clinothems) and how they change with changing long-term shelf-edge trajectory, and changing fan system.

Figure 10 Note how the channelized upper reaches of the fans tend to migrate slopewards when the shelf-edge trajectory flattens

11. Canyon formation and evolution – is a new project that has arisen from the previous study of the Wilcox Yoakum canyon that seems to be part of an area with recurrent canyon incisions and not in front of river fairways. The project will test the hypothesis that shelf dissecting canyons are maintained and cut landward with the help of longshore currents cascading into the canyon rather than by rivers at the lowstand.
Figure 11 Sketch with the model of longshore drift forming and feeding the canyon head. The presence of a shoreline headland is enhancing the offshore directed flows that initiate and enhance erosion of the canyon headland.
DAVID MOHRIG AND STUDENT GROUP: Modern, experimental and subsurface stratigraphy & sedimentation

12. Experimental study of feedbacks between depositional turbidity currents and a mobile substrate that leads to initial minibasin development and continuing evolution. (Kim & Mohrig)
An appropriate polymer for subaqueous studies has finally been identified and methodologies for generating 3D acoustic volumes has been perfected.

![Image of dip-line acoustic profile through 6 stacked turbidites. Arrow points to interface between basal turbidite and mobile substrate.]

13. Source-to-sink analysis of the Quaternary Rio Grande delta and submarine system: Connecting sediment transport and environmental change to the production of stratigraphy
Recently released seismic and lidar data sets plus core from both the submarine and deltaic system are being used to reconstruct connections between the fluvial to coastal to submarine system and their controls on resultant stratigraphy.
14. Using time-lapse lidar and bathymetric data to further understand the generation of coastal river channel-belts.

Time-lapse data collected between 2010 and 2016 provides a full description of river channel deposition that lead to channel-belt formation on the coastal Trinity River, TX.

Figure 13 Thickness map for the Tarantian submarine ramp of the Rio Grande system. Dash line = 100-m isobaths and the shelf-slope break. Solid lines define network of submarine channels.

Figure 14 Lidar-defined evolution of Trinity River between 2011 and 2015. (A) Lidar-based DEM in 2011. (B) Lidar-based DEM in 2015. (C) Difference map between (A) and (B); red = sediment deposition, blue = erosion. This subaerial data is merged with bathymetric data for a full description of channel-belt evolution.
15. Development of coastal barrier systems.
Pre- and post-storm airborne lidar surveys associated with hurricanes Ike and Harvey are being connected with targeted trenching and sediment analyses to better define the controls of storm surge, waves, and antecedent topography on the production of washover fans and fan stratigraphy.

Figure 15 Students sketching stratigraphy in trench of Hurricane Harvey washover fan. Inset: Trench wall revealing punctuated sedimentation history associated with construction of this fan.

16. Patterns and processes of floodplain sedimentation.

Figure 16 Levee deposit following river flood. Trenching and sampling define sedimentation processes building proximal floodplain.
17. Aliasing of detrital zircon records by sediment-transport processes: When, where and how heavy minerals move.

Our 12-m recirculating flume is being reconfigured so that trains of 1-m length dunes can be developed; these dunes will be composed of quartz sand. Magnetite will be introduced as the dense fraction and will be tracked through the bedforms as a function of sediment-transporting conditions. We will determine conditions associated with systematic sequestering of dense grains in dune troughs and other topographic lows versus efficient transport through a channel system.

PIRET PLINK-BJORKLUND AND CSM STUDENT GROUP:
Outcrop sedimentology, modern processes & experiments

18. Active margin slopes
Active margin slopes are highly channelized. Channels may occur in canyons or within slope fans. Our research indicates a large variety of channel fills that range from hard-clast conglomerates to sandstones to mudstones with thin lags (see below). All these channel fills display a large variety of Froude supercritical flow bedforms and are active channel fills with a multitude of bypass features. Thus some muddy channel fills recognized on seismic are likely to be active rather than abandonment fills and associated with basinward sediment transport.

19. Comparison of slope and basin-floor fan architecture: where are the large basin-floor lobes
New data indicates that our basin-floor fan models overestimate the size and sandiness of lobes and underestimate the amalgamated channel sandstones. This project aims to evaluate depositional and erosional architecture in basin-floor fans. Some of the same systems suggest significant deposition in Froude supercritical flow conditions (especially on slope). Thus the second aim is to evaluate the proportion of supercritical flow deposits in basin-floor fans. Field datasets: southern California (Juncal Fm), Ainsa (?), Annot (?), comparison to Spitsbergen and Karoo.
20. Linking Froude supercritical flow processes (experiments) and outcrop recognition
Our data from slope and basin-floor outcrops suggest a significant deposition from Froude supercritical flow. In order to link outcrop structures to processes we conducted experiments on supercritical flow using clay to gravel size sediments. Experimental sedimentary structures (see below) show similarity with dm to hundreds of m scale sedimentary structures documented in outcrops.

21. Towards a new framework on signal propagation into sedimentary record
Separating autogenic and allogenic controls on deposition is one of the key focuses of research. Yet we lack a rigorous process to estimate autogenic and allogenic processes or their effects on deposition, including a clear definition of autogenic processes. Progress has been made what concerns temporal and spatial scales of autogenic vs allogenic processes but not on other significant aspects, such as system sensitivity, connectivity and thresholds.
22. Crossing scales from modern to ancient tide-dominated and -influenced deltas
There is a large discrepancy between depositional models of modern and ancient tide-dominated and -influenced deltas. This project aims to cross that gap and compare data from modern and ancient deltas. Literature review, field data from Denver basin “isolated sandbodies”, modeling

23. River hydrology and climate types: predictive discharge analyses in S2S perspective
River hydrology is a significant control on river deposit types. Better understanding of the link of river hydrology to climate types improves river facies and architecture predictability, as well as flood hazard predictability. Global modern river discharge analyses, modeling.

Comparison of river discharge according to climate types. The two extremes are arid climate rivers that transport all their sediment during high magnitude floods and have no sediment transport or reworking (channels are dry) during low-flow, and the rainforest rivers that have extremely little variation around their mean annual discharge.

24. Foreland basin systems with focus on back-bulge depozone
Although an accepted concept, the sedimentary succession of back-bulge depozone is not well understood despite the recent interest in back-bulge deposits of shale oil reservoirs. Literature review and field data from US Western Interior
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Oral Presentation: Abstracts
The stratigraphic anatomy of a fluvial channel belt: Cedar Mountain Formation, Utah, USA.

Benjamin T. Cardenas and David Mohrig

Physical and numerical experiments, as well as theory suggests that the clastic sedimentary rock record is primarily composed of a scour-and-fill architecture, where the deposits most likely to be preserved are those filling the deepest scours to move through a particular location. To test this hypothesis for fluvial channel belts, we use a rich dataset collected from the Cretaceous Cedar Mountain Formation, Utah, USA. Unmanned Aerial Vehicles were used to produce overhead photomosaics and structure-from-motion digital-elevation models. Sets of dune (n = 1,071) and bar (n = 107) strata exposed on the top surface of an exhumed channel belt were mapped onto its photomosaics, as were their measured transport directions. This data was complimented by fifty-nine stratigraphic sections and thirty-one lateral sections that were collected along the vertical exposures defining the channel belt margins. Together the vertical sections and planform mapping show that the studied belt is a compound structure composed of the stacked deposits of multiple, individual channel belts and representing 5 to 6 channel reoccupations. Lateral sections reveal bar strata made up of sets of dune cross-beds recording the frozen-in-place kinematics of bar forms (Figure 1). Locally, the paleo-topography of Cretaceous-age bar forms even define the upper surface of the outcrop. Comparison of the channel-belt centerline to local paleotransport directions indicate channel planform was preserved through multiple re-occupations. The preservation of these channel elements is not consistent with the null hypothesis of a scour-and-fill dominated stratigraphy. We interpret this departure to be a product of the kinematics of the depositional system. Rapid avulsions could preserve the final state of the active channel bed and its individual bar elements. Frequent avulsions with respect to lateral migration rates would also minimize lateral channel amalgamation, as we observe. A frequently avulsing river system would also favor multiple channel reoccupations, as the time available to completely fill and bury unoccupied channels with flood plain sediment would be minimized; this is consistent with the 5 to 6 stacked channel belts observed. This dune-to-bar-to-channel scale preservation of belt elements falsifies the scour-and-fill hypothesis and provides a foundation for future studies connecting properties of fluvial systems to the generation of channel-belt strata.
Figure 1. (A) Cross-sectional view of preserved strata from the lee and stoss sides of a bar form. Flow was from right to left. The black, dashed-line box marks the extent of the interpretation panel in B. (B) The truncation surface separating lee-side (underneath) from stoss-side (above) strata is marked as a red line. This line is interpreted to preserve the upstream-dipping, stoss-side slope for the bar of 6°. Sets of dune strata are marked by thick black lines and dune cross-strata by thinner black lines. Deposition on the stoss-side of the bar is best shown by the upward climbing dune sets at the right-side side of the panel. Beneath these stoss-side strata are steeply dipping beds recording the prior lee face of the bar. At the left-hand side of the exposure it is particularly clear that the bar form is composed of compound strata in which the bar shape evolved through deposition of dune cross-beds. At this same location the truncation surface separating stoss and lee strata becomes conformable. The package of thick dune sets at this position is interpreted to be associated with higher sedimentation rates on the lee face of the bar. The observed spatial change in the dip angles of dune sets and the truncation surface document change in bar shape through time.
Characteristics of flood-prone river deposits: Froude supercritical flow macroforms

Haipeng Li and Piret Plink-Bjorklund, Colorado School of Mines

Drone mapping of the early Eocene Green River Formation fluvial successions at Cottonwood Canyon reveals unusual meso- and macroforms. The mesoform-scale sedimentary structures are characterized by an abundance of dm- to m-scale scour-and-fill structures, low-angle convex-up cross strata, and low-angle to planar laminations. Such sedimentary structures have been suggested to indicate Froude supercritical flow conditions by comparison to experimentally-produced sedimentary structures. The abundance of these sedimentary structures, which also suggest high deposition rates, is consistent with deposition in variable discharge rivers during flood events with high water power. On macroform-scale, variable-discharge river flood deposits have been hypothesized to lack macroforms, or display low-angle downstream accretion sets. This drone dataset that documents a paleo-river reach across ca. 4 km, indicates a considerably larger variety of macroforms. Accretion sets in these macroforms are interpreted to scale to bankfull flow depth, similar to bars, and indicate channel depths of ca. 20 m. The macroform architecture changes in a downstream direction from upstream dipping to vertical aggradation to gently downstream dipping accretion sets. The 4-17° upstream-dipping accretion sets consist internally of upstream or downstream dipping strata, as well as low-angle convex- and concave-up strata (Fig. 1). The upstream dipping strata are conformable with accretion set boundaries, but the foresets dip at 5-24° in downstream direction with a laterally variable dip angle. These updip accretion sets transition downstream into flat to gently downstream dipping sets. Yet another type of architecture displays large-scale scour-and-fill-like structures (ca 7 m deep and 70 m wide) cutting into climbing-ripple dominated low-angle strata. The scour fill displays layers conforming to the scour and overspills the scour in downstream direction forming low-angle downstream accretion sets (Fig. 1). This dataset shows significant differences from the known bar types, such as braid bars or point bars, whereas comparison to Froude supercritical flow experimentally produced deposits indicates significant similarities. We thus hypothesize that we document a larger variety of flood deposit macroforms than previously recognized and show that there is a hierarchy of Froude supercritical flow structures what concerns their size.
Figure 1.
Examples of macroform architecture in flood-prone river deposits, deposited in Froude supercritical flow conditions.
O-3
Tributary networks within distributary river channel networks: A missing link to understanding fluvial stratigraphy

John M. Swartz

The location and behavior of river drainage networks is a primary control on landscape topography and fluvial stratigraphy. Drainage network characteristics are typically viewed as the product of erosional processes resulting from the interaction of climate and tectonics. In particular, drainage divide location and migration is often modeled by the relative erosional potential of competing streams. The Texas coastal plain is a strongly depositional landscape characterized by forms and deposits of large river systems that have been prograding into the Gulf of Mexico since the Mesozoic. The landscape surrounding these larger distributaries is dominated by low-relief floodplains and smaller stream networks commonly known as the Coastal River Basins. Using a compilation of lidar elevation datasets we systematically identify and map these coastal river networks across the coastal plain. We calculate for each basin a series of stream metrics and statistics such as length/contributing area, slope, and local relief. Additionally, our high-resolution elevation data allows for detailed analysis of the stream heads and drainage divides between basins. We find that the basin divide of these networks are older distributary alluvial channel belts formed by one of the larger coastal rivers. This indicates that the organization and geometry of the examined stream networks is initially set and controlled by depositional processes, but the resulting basin morphology statistics are nearly identical to those of drainage networks located in dominantly erosional settings. We explore how drainage networks can form in depositional settings as a consequence of sedimentary processes such as river avulsion and alluvial ridge formation, with important implications for understanding drivers of drainage network formation, the speed and scale of drainage reorganization in coastal settings, and fundamental controls on the creation and preservation of fluvial stratigraphy.
Using time-lapse airborne lidar surveys from the Trinity River, TX, to build a realistic model for generating point-bar and scroll-bar stratigraphy

Jasmine Mason and David Mohrig

Comparison of three bare-earth airborne lidar data sets collected in 2011, 2015 and 2017 combined with trench data show that point- and scroll- bar growth and migration are not necessarily linked and represent markedly different depositional processes. Scroll bar crests were found to have similar elevations to those of outer bank levee crests, implying that they are constructional features that create positive topographic relief above the elevation of both the point bar and the floodplain. Scroll bar positions can move away from the channel centerline, even as point bars widen and laterally migrate towards their outer banks. Trenches dug along scroll bars show that they were built from reworked suspended sediment, with common ripple-scale cross stratification, planar laminations, and muddy bioturbated layers—characteristics that are often associated with levee sedimentation in other systems. Point bar deposits, however, are consistent with bed-material transport. Time-lapse maps created from the three lidar data sets show that point bar deformation occurs over short time scales and should be expected to dominate its accretional stratigraphy, producing numerous internal bounding surfaces. We also demonstrate how the misidentification of point-bar lateral-accretion surfaces as scroll-bar stratigraphy can lead to inaccurate reconstructions of channel properties due to systematic differences between point bar and scroll bar planform geometries.
Figure 1. Bare earth digital elevation models for a portion of a river bend at three times and the associated difference maps. For all maps, north is up, flow is from top to bottom, and the water surface is denoted by the hatched line. 1a) Elevation of the point bar and outer bank in 2011. 1b) Elevation of the point bar and outer bank in 2015. Notice the lateral extent of the point bar has increased and the position of the outer bank has moved. 1c) Elevation of the point bar and outer bank in 2017. Notice the movement of the outer bank. 1d) Difference map between 2011 and 2015 with areas of deposition denoted in red and areas of erosion in blue. Deposition dominates the entire surface of the point bar. 1e) Difference map between 2015 and 2017 with areas of deposition denoted in red and areas of erosion in blue. Notice the erosional surface on the top of the point bar. 1f) Difference map between the entire study period, 2011 and 2017, showing areas of deposition in red and areas of erosion in blue. The portion of the point bar with the highest aggradation is along the downstream, channel-ward edge of the bar.
Experimental Investigation of Temperature Control on Particle Settling Velocity

Ye Jin Lim and Wonsuck Kim

Water temperature exerts a control on sediment transport and influence settling velocity of moving particles through temperature-dependent fluid properties (i.e., viscosity and density). However, typical settling velocity calculations assume water temperature of 20°C and use estimated values of kinematic viscosity (1 × 10^{-6} m^2/s) and density (1 kg/m^3) of water at 20°C, neglecting possible variations of settling velocity due to changes in such properties. To directly assess the effects of temperature on particle settling velocity, we have performed laboratory experiments measuring settling velocities in a range of precisely controlled and monitored water temperatures. Sediments of various sizes were settled into a tube placed inside a water-filled tub, and illuminated within the fluid column to be analyzed using particle image velocimetry method. Preliminary experimental results show that for a given particle size, settling velocity increases with an increased temperature. The results suggest that temperature control on particle settling velocity may affect sediment transport capacity of rivers and results in transport mode change. This may be imperative to understand morphodynamic evolution especially for systems such as rivers and deltas in Arctic coasts under much cold environment. Thus, water temperature should be taken into consideration when calculating particle settling velocity, and should be incorporated into future sediment transport and landscape evolution modeling efforts to help improving our understanding landscape changes in different temperature regions and predictions of landscape response to global warming especially in vulnerable Arctic coasts.
O-6
Paradox of water-depth-dependent TOC in fine-grained lake deposit

Wonsuck Kim, Chuanmin Zhou, Zhijie Zhang, Jinyu Zhang, Cornel Olariu, and Ron Steel

Flocculation of fines is a major contributor for high total organic carbon (TOC) in deposit due to the capturing of organic material during the settling of flocs. As water depth increases, there are more captures of organic material while flocculated grains settle over longer vertical distances. The flocculation process increases its speed with salinity in the basin then that increase in salinity causes higher TOC in the deposit. However, an increase in salinity shortens the run-out distance of gravity flow and/or decreases the spreading of plumes. This is because fine sediment flocculates fast and settles within short lateral distances away from the source (i.e., delta). Qinghai Lake, the largest lake in China has three deep depositional centers; two are close to the major delta feeding sediment to the lake and the other is distal from the delta. Moreover, these two proximal basins show high TOC whereas the distal one shows relatively low TOC even though their surface grain sizes are similar. The lake salinity changes over time and causes different sediment transport distance. The flocculation in high saline condition concentrates TOC in the near two basins, but fine sediment spreads and settles uniformly across the lake when the lake salinity is low.

Figure 1: Flocculation, gravity flow experiment with 1-5% bentonite currents
Grainflows thickness: Surface process to subsurface record

XiaFei Zhao, Ben Cardenas, and Wonsuck Kim

Grainflows, or sand avalanches, on the slipfaces of Aeolian dunes, form via the relaxing of oversteepened lee slopes. Grainflows transport sediment from the upper slipface to the lower slipface of the dune. Prior work has focused on understanding grainflow geometry across the slipface. However, the stratigraphic record favors the preservation of the deposits at the bottommost parts of a lee face. Relationships between the geometry of the bottommost grainflow deposit, which is most likely to be preserved in ancient cross-sets, and its formative dune are not fully understood. Here, we explore how dune height controls the thickness of the bottommost grainflow deposits. Using LIDAR data from White Sands, New Mexico, USA, lee slope angles of 300 dunes were measured in order to obtain a range of lee face slopes for a mass balanced model. The model calculates bottommost grainflow thickness for a range of dune heights by relaxing the maximum slipface slope to the minimum slope. Slope relaxation is modeled as scour above a bypass point on the slipface, and balanced deposition below the bypass point. Slopes range from 28° to 35° with a mean of 30° and a standard deviation of 1°. Additionally, multiple simple growing sand pile experiments with a uniform quartz sand (D = 200 µm) as high as 5-6 cm showed grainflow-constructed lee slopes range from 30° to 35°. Results from both LIDAR data and the sand pile experiment show slopes fluctuate independently from slipface height, which indicate a linear increase in grainflow mass with dune height. Future work involves trenching recent deposits at White Sands to constrain the modeled relationship between variable dune heights, which will be known, and preserved grainflow base thickness. Slipface positions where grainflows transition from net-erosional to net-depositional will also be measured. When informed by experiments, modern observations, and recent deposits, the mathematical model will be useful in estimating dune heights from ancient Aeolian cross-strata and lead to a better overall interpretation of the Aeolian rock record.
It is important to accurately characterize the spatial and temporal changes in physical depositional processes of ancient shallow-marine deltas, not only for scientific reasons, but also because these changes affect facies distributions and therefore reservoir heterogeneities. We use a core database from Lower Wilcox Group in South Texas to describe and interpret the dominant process variations and depositional environments for one 4th-order sequence. The updated interpretation of this classical ancient ‘river-dominated’ delta suggests more significant process variations than previously suggested. Dominance of storm-wave process is indicated by wave-ripple laminae and possibly combined-flow ripple laminae in the fair-weather intervals and hummocky/swaley cross stratification and low-angle laminations in the storm beds. However, the relatively simple alternation of fair-weather beds and storm beds is complicated by the presence of: 1) normal and inversely graded siltstone to very fine grained sandstone beds, suggesting hyperpycnites generated during the river flooding season; 2) mud-dominated heterolithics with delicate mud rhythmites, suggesting tidal modulation between the storm events. The wave-dominated deposits are commonly truncated by fluvial-dominated, tide-influenced distributary channels. The interpreted mixed-process delta is linked to the last stage of Lower Wilcox Group with widest shelf and weakening sediment supply, resulting in a stronger wave and tide influences and relatively weaker fluvial influences. This work thus provides another example of the complicated interplay of fluvial, wave, and tidal currents in the shallow-marine deltaic environment, even though the same system has been previously interpreted as a classic river-dominated delta. Many existing interpretations of ancient deltas thought to have been only controlled by a single process may need to be revisited and possibly revised to take into account the natural spatial and temporal variability inherent to the shallow marine realm.
Figure 3. Overview of core descriptions with dominant process of each bed.
Characteristic features of large antidunes on early slopes of Gulf of California

Logan West

Hundreds-of-meters wavelength, long-lived, multi-event bedforms in outcrop are interpreted as deepwater antidunes and other supercritical bedforms, the first recognized for some of this nature. Deepwater sediment gravity flows commonly reach a Froude supercritical flow state, but interpretation of their deposits largely excludes antidunes, which are often assumed ephemeral. Well-exposed, extensive slope turbidites of the Fish Creek-Vallecito Basin of southern California are organized into 3-10 m-thick bedsets of 20-30 distinguishable lenticular backset beds that build undulating geometries and accrete opposite to paleoflow. Bedsets are differentiated by cyclic down-dip transitions from thin, subparallel fine-grained beds into thicker, inclined coarser-grained beds and back into thinner, flattening and, in cases, downflow-dipping finer-grained beds. Within bedsets, compensationally stacked waveforms have ~3-7 m amplitudes and ~75-215 m wavelengths that increase up section and are comparable to upstream migrating sediment waves. Bedform geometries and grain size data are used to make preliminary inferences about the depositing flows. Bioturbated fine-grained caps of each sand bed indicate antidune bedforms evolved across multiple flow events, underscoring an additional level of deepwater depositional organization that bridge bed and architectural element scales.
Supercritical flow experiments with a wide range of grain sizes I: Lessons learned

Kenya Ono & Piret Plink-Bjorklund

Recognition of Froude supercritical flow deposits in environments that range from rivers to the ocean floor has triggered a surge of interest in their processes, bedforms and sedimentary structures. Experimental supercritical flow deposits are the key for interpreting the sedimentary record. So far, all experimentally produced supercritical flow deposits are of a narrow grain size range with fine to medium sand. In some cases (Cartigny et al., 2014) the grain size was so homogenous that it prevented the formation of visible stratifications and laminations that are encountered in natural deposits. This paper presents results of supercritical flow experiments that use clay to gravel size sediment. These experiments show that cyclic steps can produce more complex and a larger variety of laminations than the previously suggested backsets and scour-and-fill structures. Our experiments also produced irregular lenses, mounds and wedges with backsets and foresets, as well as undulating planar to low-angle upstream and downstream dipping laminae. Hydraulic jump size, migration rate, grain size segregation and substrate cohesion are observed as the key controls on sedimentary structures. We further demonstrate that Froude supercritical flow promotes suspension transport of all grain sizes, including coarse sands and gravels, and rapid local deposition at hydraulic jumps, including silt and clay. These results expand the range of dynamic mud deposition into supercritical flow conditions, where local transient energy reduction rather than overall flow waning conditions allow for deposition of fines.

Figure 1. Experimental run with fine sand, medium to coarse sand and gravel, 48 minutes after the start of feeding coarse sediment. Note the lateral variability of sedimentary structures and grain distribution, as well as the multitude of sedimentary structures produced without changing the water or sediment discharge.
Supercritical flow experiments with a wide range of grain sizes II: Implications for outcrop interpretation
Kenya Ono, Haipeng Li, Dessy Sapardina and Piret Plink-Bjorklund

Sedimentary structures produced in supercritical flow experiments that used clay to gravel size sediment bear close similarity with our field datasets of slope turbidite deposits from the Eocene Juncal Formation and La Jolla Group that contain grain sizes from cobbles to clay (Ono and Plink-Björklund, 2017), but also with other outcrop deepwater datasets that expose a large range of grain sizes (e.g. Lowe 1982; Massari 1984; Ito and Saito, 2006; Postma et al., 2009; Postma et al., 2014). These experimental sedimentary structures are also similar to Eocene Wasatch and Green River Formation river deposits in the Uinta Basin, despite their lower grain size range. Comparison of the experimental deposits to outcrop datasets highlights the role of supercritical flow internal transient instabilities, rather than overall flow condition changes, in producing lithologically and geometrically complex stratigraphy. Despite the stable discharge rate and the dominance of cyclic step regime, the experiments produced a wide range of sedimentary structures that range from low-angle undulating laminations to systematic backsets to scour and fill structures as well as to mounds and wedges. This is in contrast with some previous hypothesis that suggest a prevalence of systematic backsets with reworking into scour and fill structures to form from cyclic steps, or that low-angle undulating bedforms specifically indicate antidune deposition. Our results rather support that a large variety of sedimentary structures can be produced from upstream migration of cyclic steps, as a function of hydraulic jump size, migration rate and sediment caliber. The experiments show that plane beds and low-angle undulating beds form lateral to hydraulic jumps coeval with the accretion of backsets, sigmoidal mound strata or scour and fill laminae, rather than due to changes in overall flow conditions. These experiments thus caution against attempting to link specific outcrop sedimentary structures to specific supercritical flow bedform stability conditions, and support the notion that antidunes, unstable antidunes, chutes and pools and cyclic steps as mutually transitional bedforms. Furthermore, there is more than an order of magnitude difference between the size of the experimental hydraulic jumps and their consequent scours, despite the constant discharge rate. Similar, order of magnitude variability in scour size is observed in the field datasets with implications for interpreting channels vs scours. The experiments further demonstrate that a high degree of lateral and vertical lithological variability, such as transitions between conglomerates, sandstones and mudstones can be produced as a function of internal flow instabilities at constant discharge rates.
Figure 1. Comparison of outcrop and experimental results surest that heterolithic channel fills may be produced in stable discharge conditions from supercritical flow.
We propose that Wilcox canyons are formed by a combination of tectonic uplift and shelfal or longshore currents rather than during low stages of the sea level. It was proposed before, in northern Gulf of Mexico, a clustering in a 100-150 km wide area of six Late Cretaceous-Paleogene age incisions up to 1000 m deep and 100 km long suggest a structural rather than eustatic control. The incisions counterintuitively align with the basinward trend of the San Marcos Uplift instead of forming in front of large sediment fairways (rivers) that formed depocenters of the Rio Grande and Houston embayments. The Sabine Arch and LaSalle Arch also uplift regions around the Gulf of Mexico Basin align with large slope incisions that indicate a similar mechanism. Contemplating the interactions between the tectonic arches movements and river-delta behavior in relation to canyon incision, three mechanisms have been proposed (shelf edge bulge, high uplift rates/ shoreline bulge and low uplift rates/ river incision). We prefer the shoreline bulge model that seems to act in some of the modern canyons.

The “high uplift rate” (HUR) scenario suggests a relative fast vertical rise and extent of the uplift into the inner shelf area, diverted the river away from the area and protruded the shoreline as a headland. The headland diverted the longshore currents and river derived sediment transport toward the shelf margin and eventually cascading over the shelf edge triggering incision and formation of the canyons. There are modern systems with a similar morphology like Cap de Creus Canyon located in western Gulf of Lyons shelf in Mediterranean Sea is forming adjacent of a headland which redirection the longshore flows toward offshore and erode the shelf edge.

The Yoakum Canyon, largest in Wilcox, was likely active over multiple sea level cycles over millions of years rather than one single sea level cycle of 100,000 years. The stratigraphic log pattern of deltas on the shelf on the side of the canyon are different suggesting have been deposited while the canyon was active.

The relationship of Wilcox Group incisions with tectonics and long lived evolution of canyons provides insight into the large volume of clastic sediment and possible new mechanisms for sediment delivery to the deep water Gulf of Mexico.
Figure TOP: Regional overview of the Gulf of Mexico highlighting location of paleocanyons, regional tectonic features, shelf edge margins, and Wilcox Group Embayments (modified from Fisher and McGowen, 1967; Hutchinson, 1984; Laubach and Jackson, 1990; Lawless and Hart, 1990; Galloway, 2008). BOTTOM: Successive delta depocenters in relation with the canyons of Wilcox. Sequence 1 is oldest and sequence 12 is the youngest. Note that while canyon is incising the shelf is also building on the sides.
RIOMAR
2018 Annual Meeting

Poster Presentation: Abstracts
Paralic sedimentary deposits contain almost 40% of the hydrocarbon reservoirs and continue to be important for the industry, and even more so by its key link in understanding sediment fate into a source-to-sink perspective. In order to achieve a greater understanding of sediment dispersal during transgression and regression associated with river deltas, the last such cycle of the Mississippi River delta is studied herein. Previously published sediment thickness maps and borehole data of the Mississippi valley, delta, and shelf deposits have been compiled to discover how the Mississippi locus of deposition fluctuated since the Last Glacial Maximum (LGM). This investigation also compared calculated river derived sediment volumes during the last 20ky to deduce the volume and rate of sediment that bypassed the shelf onto the slope. At the LGM (19ka) when the sea level was 120 metres below present, the Mississippi River lay entrenched into the shelf and it built its deltas on the shelf margin. As the base level rose rapidly subsequent to the LGM, the river filled its valleys with sediment in the ensuing retrogradation and formed depocentres outside the valley. As the sea levelled, the river’s deltas prograded back outside of its valleys. Digitizing and employing previously published data showed that shelf depocentres migrated widely from the outer to the inner shelf following sea level rise and had thicknesses varying between 5–500 metres. This investigation seeks to test the various hypotheses concerning the locus of deposition during each of the stages of sea level rise. To this end, the sediment deposited in the valley and delta has been mapped and the volume quantified for each of these stages. Recently calculated values for the Mississippi River water discharge since the LGM, estimated to have fluctuated to as much as eight times (160,000 m3s⁻¹) that of the present, allowed for the enumeration of sediment discharge through time. Using the rate of sea level rise to plot the location of the shoreline with the inferred past river mouth and the delta through time, the rate of volumetric change of the mapped on shelf deposits was calculated with respect to time. By deducting this rate of volumetric change of mapped on shelf deposits from the computed sediment discharge through time, the rate and volume of off shelf deposition since the Last Glacial Maximum was quantified, displaying a higher rate of deposition before the retreat of the shelf margin deltas.
Figure: Late Wisconsin Unconformity
Delta-like deposition at the distal part of a natural levee: How is sand transported on natural levees?

Hima J. Hassenruck-Gudipati, David Mohrig, Paola Passalacqua, Kyle Wright

A natural levee is the boundary between a river and its floodplain. Since levees are net depositional, sedimentary structures and textures can be used to better understand sediment transport across this boundary during floods. On the Trinity River in Texas, USA, we observe levee-channels (constructional channelized features) on natural levees. Natural levees are thought to be built by settling of suspended sediment during overbank flow with grain sizes decreasing away from the river. We hypothesize that levee-channels facilitate the transport of coarser grain sizes further landward than predicted by this simple model. To test this hypothesis, we trenches and sampled levee-channels on six different levee segments. Close to the river, common attributes of levee-channels include beds that are net-aggradational with occasional erosional surfaces and levees constructed from climbing-ripple deposits. At the distal ends of levee-channels, delta-like features with foresets record the focused deposition and progradation of sediment on to the floodplain or wetland. In the downstream reach of the study area, levee-channels can extend up to 1km away from the river, while in the upstream reach, the levee-channels extend no more than 200m. The delta-like features are observed at the distal ends of both the longer and shorter levee-channels. Levee-channels also vary in width (W) and depth (D) from the upstream to the downstream reach, increasing from 1m (W) by 0.1m (D) to 10m (W) by 1m (D). Additionally, we compared changes in grain size down a levee to predicted changes in flow velocity using a 2D hydrodynamic model in order to explore the importance of levee-channels to the overall levee growth. This study explores possible explanations for the morphological and grain size differences observed in levee-channels by examining downstream changes in Trinity River grain size, migration rate, hydraulics, and wetland occurrence.
Figure 1. (A) Four trenches of Trinity River levee deposits show both delta-like foresets at the distal end of levees and internal bounding surfaces associated with sediment bypass. (B) Levee grain sizes range from mud to medium sand. Grain size distributions correspond to the samples collected from the numbered trenches in A. There is no significant reduction in grain size from proximal to distal levee at both the upstream and downstream sites.
P-3
River responses to floods: Sediment mobility during major storms

Haipeng Li and Piret Plink-Bjorklund

The San Jacinto watershed provides the main water supply to the Lake Houston. A catastrophic flood (largest since 1951) occurred along the entire watershed in response to the excessive rainfall during Hurricane Harvey in 2017. As a result of this 500-year flood, the neighborhood along the river course suffered great economic loss and dramatic changes have been observed in river morphology. This ground and drone survey focuses on the morphological changes to bar top area during Harvey as well as post-Harvey reworking over the course of ca. nine months. Four new bars were also trenched to investigate the deposits. Planar lamination, low-angle (<20°) cross-stratification, scour-and-fill structures, and angle-of-repose cross-strata are most abundant sedimentary structures, and large scour surfaces occur. Sedimentary units without any obvious lamination have been interpreted as a result of rapid deposition from waning flood. Cross-strata migrating in an almost perpendicular direction to the main flow have been observed, which may indicate retreating flood water from bar top. Occasional climbing ripples are found on top of the bars. Bar top areal changes indicate a total of 2.38% increase in the bar area with a total of 84,886 m$^2$ net deposition during Harvey. This net change consists of both erosional and depositional changes and indicates a high sediment mobility, as the total areal loss for bars that experienced net erosion was 143,923 m$^2$, whereas the total areal gain for bars that experienced net deposition was 228,809 m$^2$. During the survey about nine months after Harvey, significant post-Harvey erosional and depositional changes were also observed. These results indicate that the San Jacinto river experiences significant sediment erosion and deposition during major floods as well as during lower magnitude flow conditions, and thus contrasts the extremely flood-prone Green River Formation river deposits that indicate that near 100% of geomorphological work occurred during major floods. The latter is also corroborated by the larger proportion of cross strata in the San Jacinto deposits. This survey further indicates that most of the sediment mobilized during the Harvey originates from natural sources, such as the river bed and bars, rather than from the sand mining operations as hypothesized in media. This conclusion is further corroborated by the mapping of Harvey satellite images that indicate main sediment input from a different tributary than where the mining operations are located.
Figure 1. New bar formed after Hurricane Harvey near the Kingwood neighborhood. Flow is away from the viewer.
Revisiting the offset-stacked Campanian stratigraphic sequences of S. Wyoming and NE. Utah

Keith Minor, Ronald Steel, Cornel Olariu

The Campanian-Maastrichtian succession in S. Wyoming and NE. Utah is comprised of offset, stacked series of transgressive-regressive stratigraphic sequences. The stratal succession records approximately five eastward-building clastic wedges or 3rd-order (>1 myr) sequences with strongly progradational to backstepping, stacked patterns into the middle of the fourth cycle during Canyon Creek/Pine Ridge formation time. One major transgression occurred at the beginning of the fifth (last) 3rd-order sequence during deposition of the Lewis Shale before the Western Interior seaway completely retreated from the area during Lance/Fox Hills formation time. Superimposed on these 3rd-order cycles are high-frequency (4th- and 5th-order) sequences (20-25 in the Chimney Rock, Rock Springs, Iles and Williams Fork clastic wedges) that appear to increase in frequency through the Campanian into the Maastrichtian (some 20 in the Lewis-Fox Hills clastic wedge). The high-frequency cycles are characterized by tens of meters thick fluvial and deltaic/shoreface tongues that prograded out for hundreds of km’s and intertongued with the marine mudstones. Two Campanian successions were revisited and measured, one relatively proximal section at Minnie’s Gap, WY-UT (total ~1,225 m), and a relatively distal section (total ~1,720 m) along the North Platte River in the Haystack Mts, WY. The succession shows an increase in thickness from the proximal to distal ends of the system, and the internal cyclical nature of the depositional pattern is best observed in the marginal marine deposits of the Chimney Rock, Rock Springs, Haystack Mts and Almond formations. The proximal, nonmarine to fluvio-tidal Ericson, Allen Ridge and Pine Ridge formations show isolated-to-amalgamated, channelized sandstone bodies with some brackish-water traces, as well as thinner-bedded sandstones. These are interpreted in terms of an alluvial plain to a coastal plain setting. The marine shoreline-to-shelf associations in both sections show upward-coarsening motifs some 20-60 m thick that reflect either mixed fluvial-tidal processes or mixed fluvial-wave processes. The former shoreline type is more common distally and the latter proximally. Paleoflow measurements indicate a southeast flow direction. Ongoing work is aimed at better understanding the tectonic and eustatic controls on sediment supply and accommodation.
P-5
Connecting patterns of subsidence and extensional faulting to continued turbidite loading of a deformable substrate

Chris Liu and David Mohrig

Exactly how sediment delivery systems co-evolve with a mobile substrate remains incompletely understood even though the nonlinear elements of this coupled system leads to the emergence of mini-basins. In a complex system, the emergent phenomena cannot be simply derived or predicted without parallel descriptions of the system at different levels of organization (Kwapien and Drozdz, 2012). Thus, we use physical modeling to investigate the coupling and to generate a data set that can be used to test numerical models. Seventeen strongly depositional turbidity currents composed of one percent silica mud by volume were released at an updip point source and flowed across an initially horizontal surface mobile substrate that was 50 mm thick. We measured the evolution of the upper deposit surface and the basal sediment-substrate interface using a distancing laser and an acoustic transceiver, respectively (Fig. 1, 2). Successive measurements of both define deformation of the substrate and resulting subsidence of the turbidites due to spatially variable loading. Results include: 1) maximum subsidence where the deposit was thickest; and 2) normal faulting that segmented the deposit. The localized strain expressed as normal faulting was one order of magnitude smaller than the maximum subsidence produced by lateral flow of substrate away from the maximum sediment load. The modification of surface topography by the spatially varying subsidence pattern and the horsts and grabens associated with active normal faulting was sufficient to alter the sediment routing and depositional patterns of the later turbidity currents. As a result, thicker deposits were laid down further away from the channel-lobe transition point. We hypothesize that segmentation of the initially unconfined turbidites by faulting must be combined with the larger-scale subsidence pattern in order to accurately characterize the emergence of minibasins.
Figure 1. (LEFT) Surface topography on deposits from 12 flows traversing a mobile substrate. Notice radial faulting associated with subsidence and extension of the turbidites. (RIGHT) Surface topography on deposits from 12 flows traversing a rigid substrate. Initial properties for all 24 currents were equal.

Figure 2. Unprocessed acoustic data corresponding to the two strike lines marked on Figure 1. The upper panel is relatively proximal and the lower panel relatively distal.
Supercritical flow signatures and erosional features in Juncal Fm basin floor fans

Dessy Sapardina and Piret Plink-Bjorklund

This drone photography survey of the Middle Eocene Juncal Formation in Alyson Canyon in Los Padres National Forest, Santa Barbara and in Ojala, California, was motivated by a previous RioMAR study of approximately coeval slope succession in the Frazier Park area. Previous studies interpreted the Alyson Canyon area as proximal depositional lobe complexes in a basin-floor fan (Thompson, 1987), and the Ojala area along Highway 33 as outer-fan setting of depositional lobes (Obligado, 2003).

In the Alyson Canyon area the facies are sandstone dominated and the sandstone facies occur as amalgamated, erosional bound lenticular deposits. Only minor thinner-bedded and more tabular facies occur at the base of the outcrop. Sedimentary facies are dominated by scour and fill structures with upward flattening laminae, low-angle convex-up structures and backsets. The Ojai outcrops are also sandstone prone but the small size of the outcrop does not allow to observe larger bounding erosion surfaces. A few m to dm scale erosional scours are common and scour and fill structures and backsets are common sedimentary structures. In the Ojala area a proportion of heterolithic facies is larger and some heterolithic facies have a tabular architecture suggesting deposition in sheets or lobes, whereas sandstone-prone facies occur as erosional bound lenticular deposits. Scour and fill structures and backsets are common sedimentary structures.

Comparison to Froude supercritical flow experimentally produced data suggest that Froude supercritical flow deposits are common in the Juncal Formation basin floor fans. The erosion surfaces and the association of sandstone prone facies with the erosional bound deposits suggest that the proportion of channelized deposits is high, and present even in outer-fan setting.
Figure 1. Preliminary line drawings on the Alyson Canyon drone dataset.
Detrital Zircon Transport Lag in Fluvial Bedload: An experimental and numerical investigation

Max Daniller-Varghese and David Mohrig

The difference in transport rates and times of different density particles, such as detrital zircons in quartz sand, is critically important to accurately assessing sediment provenance. Because zircons are typically twice as dense as their surrounding sediment, and because transport rate scales with grain density, zircon transport rate as bedload will be smaller than that of quartz sand. Moreover, intermittent transport conditions, sediment segregation into floodplains, or preferential sequestration in deep pools can add substantial time lag.

We experimentally modeled fluvial bedload containing detrital zircons using a 5m x 0.6 m domain in a flume. Using magnetite sand as a proxy---it has a similar density as zircons---we developed mature, three-dimensional bedforms with variable scour depths that transported multiple bedform lengths. We measured magnetic particle concentration by separating them from bed samples with a magnet and then related change in concentration directly to transport rate. Our experimental results suggest that detrital zircon transport is substantially slower than bulk sediment transport because denser particles segregated to bedform troughs. The ratio of transport rates will be integrated into a simple hydrodynamic transport model, in order to constrain a minimum transport lag for dense particles from source to sink.
Figure 17. The evolution of 3d bedforms in a 5.2m x 0.6m sub-domain of the Basement Flume in the Experimental Sedimentology Lab at the University of Texas at Austin. Bedload transport of quartz + magnetite sand was allowed until the sediment had moved past its initial position, ensuring that every grain had been transported. Note: all measurements, including the topography scale bar are in mm.
La Jolla Group slope channels: Challenges of identifying channels vs supercritical flow bedforms

Kenya Ono and Piret Plink-Bjorklund

Submarine canyons on the shelf-edge and upper slope are known as regions of repeated deposition and erosion, and locations where slope channels initiate. Recent modern seafloor studies suggest that active depositional and erosional bedforms commonly demonstrate upslope-migration at the base of canyons. Modern studies also show that tributary channels at the shelf-edge transform downslope into large canyons and form stable conduits. Outcrop record is essential to complement this morphological understanding and the dynamics of flow process in order to understand the long-term canyon evolution.

This presentation focuses on submarine canyon outcrops of the Eocene La Jolla Group in southern California that exhibit a 100 m thick and 5 km long exposure in a paleoflow oblique direction. This study aims to describe three orders of bypass and erosive architectures and structures. The first-order scale can be correlated with the seismic scale. Individual channels, 20-100 m deep and 150-750 m wide, indicate complex cross-cutting channel margin relationships. The second-order within the channel fills are 10-20 m thick scour and fill structures with upward flattening laminae. The third-order is are tens of cm to multiple m thick sedimentary structures that include backsets and foresets, scour-and-fill structures, and gradational low-angle to planar lamination. At all these hierarchical levels there is a large lateral and vertical variability in grain size distribution that ranges from cobble conglomerates, to sandstones and mudstones.

Comparison to experimental results and modern datasets illustrate the scaling between the channel and scour size and provide hypothesis for interpretation that include high channel avulsion rates and supercritical flow internal instabilities.
Figure 1. A: Complex cross-cutting relationships at heterolithic channel margins and 10m scale scour and fill structures. B: Complex grain-size distribution in conglomeratic channels at multi-meter scale.
A current work-in-progress project is to evaluate architecture of slope channels in clinothem sets with different shelf-edge trajectories. The activity of slope channel is linked to the amount of sediment available at shelf edge, which is a function of sediment supply from upstream fluvial systems, rate of sea level change, and sediment transport processes on the shelf such as tidal currents and wave-generated longshore drift. The combination of those factors give distinct shelf-edge trajectories: prograding if sediment supply dominates, aggrading if accommodation dominates. I propose that in an aggradation dominant shelf trajectory, the majority of sediments are trapped on the shelf, and slope channels only develop immediately below shelf-edge delta with ready sediment supply and upper slope over-steepeening, and the position of the slope channel entry on the upper slope is relatively fixed for that reason. Slope channels shut off when base level rises and the delta is no longer connected to the shelf edge. This shows up in basin floor record where the deepwater fan no longer aggrades. In prograding shoreline trajectories, a slight base level change and high sediment supply is able to strongly drive delta transit across the shelf. Greater number of shelf-edge deltas means greater number of slope channels, but they can be short lived as the associated shelf-edge deltas switch position with changing sea level, and overall produce a larger number of smaller fans.

One location to test these hypotheses is the Maastrichtian Washakie-Great Divide Basin, a Laramide syn-tectonic basin that contains 16 southward basin-filling clinothems 230-430m in height, each of ca.100 kyr duration. The system is supply dominated, with an aggrading dominant first stage (C1-C9) and a progradation dominant second stage (C10-C16). C9 and C10 are chosen to represent the two clinoform growth stages, respectively, in the study of slope channel behaviour in two different shelf-edge trajectories. Channel elements are recognised by blocky gamma ray motif. For both C9 and C10, the thickest channel element can be 40m, while the thinner ones are just few meters. The width of each individual fairway is ~3-5km, and are found only upstream of basin floor fans. The sediment fairways are linked to a shelf-edge delta, especially in C10, where a slight sea level fall promoted shelf edge incision at the eastern end of the basin up to 60m deep. Dispersal of fluvial and shelf sand down into slope channels is aided by wave action, which by itself is only able to trigger unconfined flows that deposit thin sand sheets on the upper slope. Future study will map the net-to-gross ratio of slope channels on the slope to deltas on the shelf, and calculate shelf-slope-basin floor sediment partitioning for different shelf-edge trajectories.
(A) Geologic map of southern Wyoming showing the distribution of well logs in the basin. (B) Cross section (position shown in (A)) showing the well-developed topset, slope, and deep-water basin floor and the correlated 16 clinoths. The studied slope channels are in clinoths 9 and 10. (C) (D) Isopach maps of sandstone thickness within C9 & C10, respectively. Slope channel concentration are highlighted in circles in (E). (E) Cross section through the eastern half of the basin, position shown in (A). Slope channel clusters feeding basin floor fans in C9 and C10 are encircled. Two logs from C9 and C10 slope channels, respectively, are shown in (F) & (G), highlighting the amalgamated and blocky character of slope channel log relief. Compiled from Love and Christiansen 1985 and Blackstone 1991, Carvajal et al 2009, Koo et al 2015.
Comparison of outcrop data of basin floor fans: How common is Froude supercritical flow and outer fan erosion?

Dessy Sapardina and Piret Plink-Bjorklund

The drone dataset from the Juncal Formation basin floor fans in California suggests significant deposition from Froude supercritical flow turbidites, and a large degree of channelization even in on the outer fan. Bedforms and structures originating from supercritical flow conditions have been identified in other ancient as well as in modern submarine fans (Fildani et al., 2006; Lamb et al., 2008, Nomark et al., 2009, Gong et al., 2012; Covault et al., 2014., Postma et al., 2014; Lang et al., 2017; Postma and Kleverlaan., 2017). Outer fan channels and a lower volumetric proportion of lobes has been suggested from some modern systems (e.g. Picot et al., 2016; Carvajal et al., 2017). These data arise questions whether Froude supercritical flow and a high degree of channelization are common features in basin floor fans or just occur in specific conditions and fan types. To explore this question we initiate a literature study of well documented outcrop examples of basin floor fans and compare their sedimentary structures and architecture. This poster presents results of preliminary comparison to Ainsa, Sorbas, Tabernas, and Sandino basin floor fans that display erosionally bound deposits with low-angle bedforms, scour and fill and backsets, similar to the Juncal Formation fans.
Figure 1. Complex architecture with many internal truncations (A) Oblique areal photograph showing major bounding surfaces in a lobe sequence in Mizala Fans, Sorbas Basin. (B). White lines are indicating erosional bounding surfaces. Paleo-flow direction is to the right. Fan lobe beds are underlain by thick mud interval. (C) Backset stratification. From Postma and Kleverlaan, 2017.

Figure 2. Complex architecture with erosion surfaces in Ainsa 1 Fan. (A) Basal erosion surface and draping above the mounded topography created by the underlying cohesive pebbly mudstones. Solemarks at the base of this sandy bedset suggest backsets. (B). Gravelly sandstones with mounded and scour topography.
From Pickering et al., 2014.
Recognition of ancient compound deltaic clinothem and how they are clothed by tide-, wave-, and river-generated facies

Yang Peng, Cornel Olariu, and Ronald J. Steel

Many modern deltas exhibit a compound character that consists of a shoreline clinothem and a subaqueous clinothem connected through a subaqueous platform. Despite the ubiquity of compound clinoforms in modern deltas very few examples have been documented from the ancient rock record.

This study presents recognition criteria of the compound clinoform systems in both tide- and wave-dominated delta based mainly on the Pliocene Orinoco Delta but also conditioned by other modern and ancient cases. We suggest that the deltaic compound clinothem can be identified using a combination of: (1) the 3-D configuration identified in bathymetry or seismic data, (2) stacked muddy coarsening-to-fining upward or coarsening-upward units (30-70 m thick) and overlying coarser and sandier coarsening-upward units (20-30 m thick) that represent the subaqueous and shoreline clinoform pair, and (3) distinct facies recognized in the rock record. Both types of delta have highly bioturbated mudstones and/or siltstones in the bottomset. Tide-dominated subaqueous deltas have muddy foreset with tidal scours containing tidal rhythmites or inclined heterolithics and occasional storm-wave deposits (e.g., wave-enhanced sediment-gravity-flow beds, thin hummocky/swaley cross beds (HCS/SCS), or fluid-mud deposits). The subaqueous platform tends to change from storm-wave-influenced strata to tidal-dominated signals (e.g., bidirectional current-ripped/cross-stratified sandstones, spring and neap tidal bundles, tidal rhythmites). The overlying shoreline clinothem comprise stacked sets of river and tidal deposits. In contrast, wave-dominated subaqueous delta comprises mainly mudstones interbedded with thin normally-graded and HCS/SCS beds in the foreset. The subaqueous platform to the shoreline clinothem show upward-thickening HCS/SCS and trough/tabular crossbedded sandstones interbedded with siltstones.

Recognition of the compound clinothem in the rock record is important as some subaqueous clinthem may be misinterpreted as shorelines in conventional sequence stratigraphic models, and this can lead to a wrong estimate of sea-level history. In addition, significant amounts of river-derived sediment are likely trapped in the subaqueous clinothem.
Figure. 3-D block diagrams of tide- vs. wave-dominated deltaic compound clinoforms with facies for each position.
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Shelfal sediment transport in the South China Sea, a case study of large oblique accretion on the continental margin of Qiongdongnan Basin

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The paleo-sediment flux on the northwestern continental shelf of the South China Sea from the late Miocene to the present was calculated based on 2-D seismic data. A large difference (about 5 times larger) between the sediment volume preserved on the shelf of Qiongdongnan Basin and the amount of discharge from the apparent source area, the Hainan Island, it has been observed. This huge mismatch between the potential source and sediment preserved along the basin margin suggests that sediments on the shelf of Qiongdongnan Basin were not just from Hainan Island but rather from a larger drainage area. The fine-grained lithology of the cored deposits on the shelf, and the strong southward migration of western shelf edge break caused by large sediment supply to that area suggest the Red River as a possible source. We suggest that the sediments on the shelf of Qiongdongnan Basin were mainly derived from the Red River since the late Miocene and were transported eastward from the Yinggehai Basin by shelf currents similar to modern currents circulation. Part of the sediment was probably dispersed on the shelf as fluid muds and most likely accumulated during the highstand, falling stage and transgression periods. During the low sea level stand most of the river derived sediments was probably delivered to the slope or flowed into the central canyon.

Schematic three-dimensional block diagrams illustrating shore-parallel transport of mud along the shelf of YGHB-QDNB (modified from He et al., 2015; Peng et al., 2018) during the lowstand periods in the Pleistocene (A1) and Miocene (B1), compared with highstand periods as A2, B2, respectively.
Coarse, Well-sorted, and Cross-bedded Sandbodies Associated with Shelf Transgression, Jurassic Lajas Formation, Neuquén Basin

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Seismic data in Lower-Middle Jurassic, southern Neuquén Basin show that the Lajas-Los Molles system (the shelf and associated slope to basin floor) prograded and aggraded more than 120 km. The interpreted shelf-edge trajectory shows that it was generally rising north-westwards as the shelf-margin sedimentary prism built out during a period of 18 Ma (Pleinsbachian to early Callovian). However, at times significant transgression across the pre-existing shelf lead to flooding of the shelf break and the river continued with another regression at a higher and younger level, as deltas continued to prograde. The abrupt rise and backstep of the shorelines are of special interest and focus here.

A few km wide and over 100 m thick Lajas outcrop in southern Neuquén Basin was used to correlate flooding surfaces and mapped shelf sandstone architecture using digital elevation models, satellite imagery and drone photography. Multiple vertical sections describe the facies, i.e. lithology, sedimentary structures, ichnology, and paleocurrents. The outer-shelf Lajas transgressive deposits in the outcrops have been identified in the outbuilding margin clinoforms within the La Jardinera outcrop and medium-grained sandstones indicate there was an enhancement of tidal currents along the shelf edge. Tidal environment is interpreted from the development of the very clean and well sorted, thoroughly cross-bedded marine sandbodies (up to 12 m thick) enveloped within transgressive thick mudstone. The orderly stacking of crossbedded sets, bi-directionality of paleo-flow indicators and occasional marine trace fossils suggest that the interval was generated by marine, subaqueous 2-D and 3-D dunes that were driven by tidal currents. Further, the 10 to 12 m thick units laterally continuous for a few hundred m to km, with 3 to 6 m composed cross-bedded sets that thicken and coarsen slightly upward suggest that the smaller simple dunes constructed compound dunes, large bedforms common in both estuaries and on tidal shelves. These sandstone bodies near the shelf break appear to have migrated along the shoreline under strong tidal currents on the outermost shelf during transgression. The well sorted, cross-bedded sandstone bodies arise from sand eroded by the landward migrating transgressive ravinement and reworking of the underlying deposits of the regressive units. The sediment transport by tidal currents on the outer shelf also suggest strong sediment bypass off the shelf edge into deep water. This study is one of the few which try to understand outer shelf reservoirs developed in Lajas Formation and their link with sediment transport to deep water Los Molles slope and fan deposits.
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