Building a Facies Model - Shoreface Systems Example

William W. Little

Purpose:

The purpose of this exercise is to guide students through the process of constructing facies models based on understanding relationships between physical features (sedimentary texture and structures) and the processes (medium, energy) that form them and to be able to apply this understanding to concepts of facies and facies associations and how they correspond to depositional environments and systems.

Objective:

The ultimate goal is, before reviewing published facies models, students will be able to design reasonable (not perfect) models of their own.

Methods:

Step 1: Each facies model is introduced through an in-class discussion, during which the instructor guides students toward an understanding of basic concepts, such as energy regimes and the nature of boundaries (surfaces) between these regimes, as well as likely sediment characteristics, structures, and transport processes and directions. These items are outlined on a black- or white board as they are discussed. Though the shoreface system is used as an example in this document, a similar approach can be applied to any depositional system.

Step 2: Students work in groups of three or four to draft a reasonable facies model consisting of a plan view and both depositional strike and dip cross-sectional views. Though they compare and contrast their models in groups, each student is, ultimately, responsible for his/her own final model.

Step 3: Students compare and contrast their models to those from published sources to try to understand differences between interpretations. Part of this is to emphasize that there is a range of correct interpretations and to not become locked into thinking there is a single “correct” solution.

Step 4: Students prepare a final draft of their model, along with a written outline of how they would present/explain the model to others. This is submitted for a grade.

Step 5: Three models (two clastic and one carbonate) are chosen from the nine discussed in class for inclusion on an exam. Students reproduce their models and, in narrative form, flesh out their outlines. To avoid rushing them on the exam, I make it available over a three day time frame and allow them to come to my office when ready.

Position within Course:

The exercise should be conducted after students are familiar with rock classification, identification of sedimentary structures, and basic concepts of sedimentology, such as base level, accommodation space, and Walther's Law. For me, it is the middle third of the course, following Sedimentary Rock Properties and Classification and prior to Principles of Stratigraphy.

Step 1: In-class Discussion

What is a shoreface?

A surface along a coast over which sediment moves parallel to the shoreline.

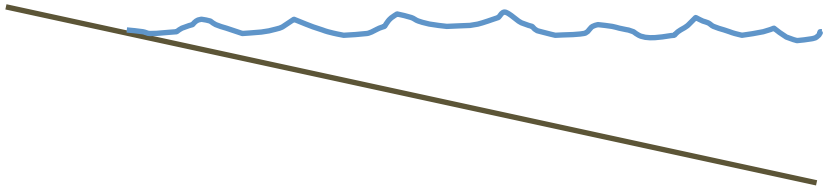
What elements are needed to construct a prograding beach system?

A basinward-sloping depositional surface

What is the significance this surface?

It is a platform over which sediment can accumulate, forms the base of a sedimentary deposit, and represents the boundary between depositional events.

An intersecting base-level surface



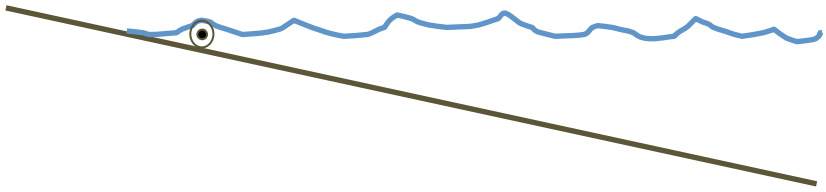
What is the significance this surface?

It limits the elevation to which sediment can accumulate.

Sediment

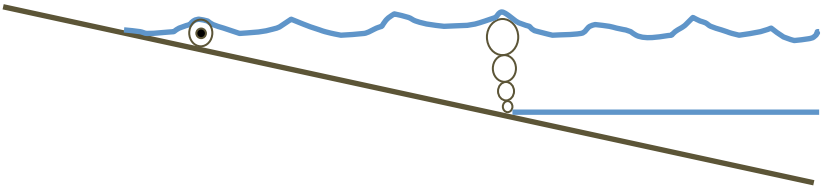
What is the sediment source?

Rivers deliver sediment to the shore, where it is then transported along the coast by waves.



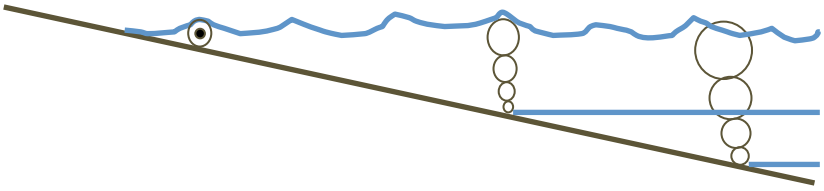
Does a wave impact the entire depositional slope? If not, why?

No. Waves die out with depth. This is called "wave base."



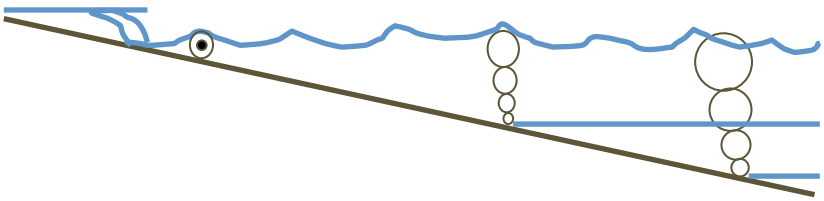
Are there times when wave base might be deeper than others?

Yes. During storms. This is called storm wave base, to distinguish it from fairweather wave base.



What happens when waves arrive at the beach?

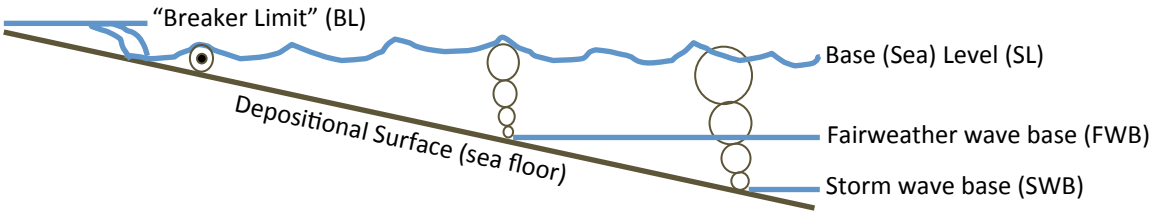
They break, lose their form, and flow across the beach surface.



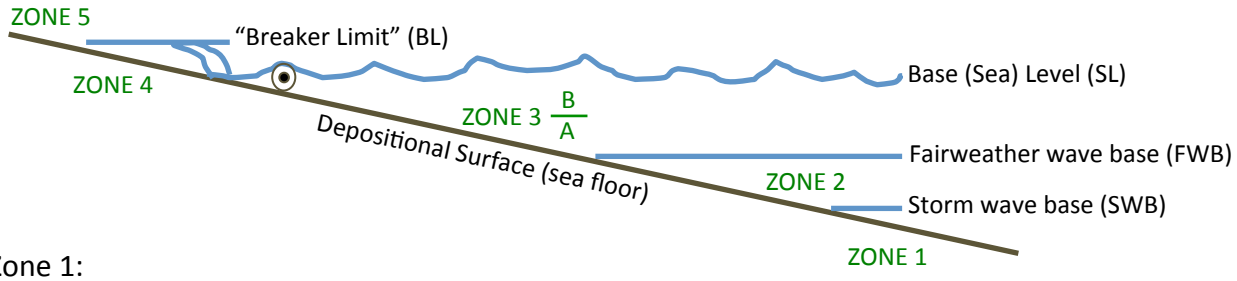
Notice that, to this point, a shoreface system is represented by a number of horizontal surfaces that intersect the depositional surface at varying elevations. What is the significance of these surfaces?

They separate the system into a number of zones (environments) based on energy conditions.

Let's label (name) the surfaces.



For now, let's number the zones separated by these surfaces. Describe likely energy conditions, sediment grain size(s), direction(s) of sediment movement, depositional processes, and likely preserved sedimentary structures for each.



Zone 1:

- Energy conditions: Low
- Grain size(s): Mud
- Transport direction(s): Insignificant
- Depositional processes: Grain settling from suspension, bioturbation
- Sedimentary structures: Horizontal mud laminations, burrows, possibly minor ripple bedding

Zone 2:

- Energy conditions: Alternating between low and high
- Grain size(s): Interbedded mud and sand
- Transport direction(s): Insignificant for mud; mostly offshore for sand
- Depositional processes: Grain settling from suspension for mud; grain settling from suspension combined with oscillatory current for sand, bioturbation for both
- Sedimentary structures: Muddy intervals same as Zone 1. Sandy intervals hummocky to trough cross-bedded, possibly climbing ripple bedded

Zone 3:

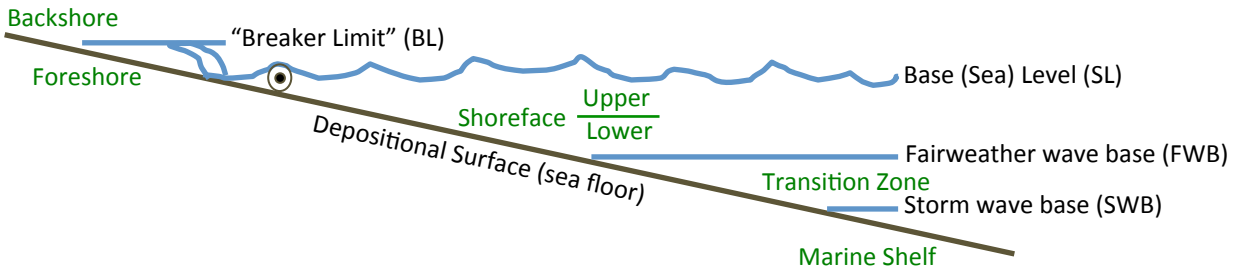
- Energy conditions: High
- Grain size(s): Sand
- Transport direction(s): Offshore in 3A transitioning to onshore and along shore in 3B
- Depositional processes: Same as sandy beds in Zone 2 for 3A to oscillatory current flow in 3B
- Sedimentary structures: Same as sandy beds in Zone 2 for 3A, becoming mostly trough cross-bedding in 3B

Zone 4:

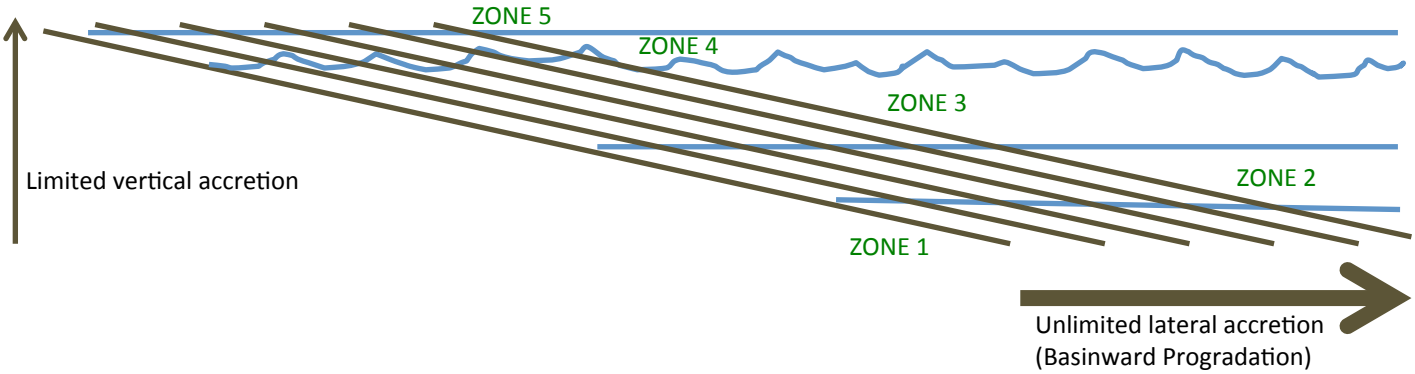
- Energy conditions: Very high
- Grain size(s): Sand
- Transport direction(s): Onshore to along shore
- Depositional processes: Sheet flow
- Sedimentary structures: Horizontal sand laminations to low-angle ripple bedding, possible small vugs, scours, and water escape structures

Zone 5: Highly variable, ranging from coastal dune to marsh or lagoon environments.

Apply technical terminology.

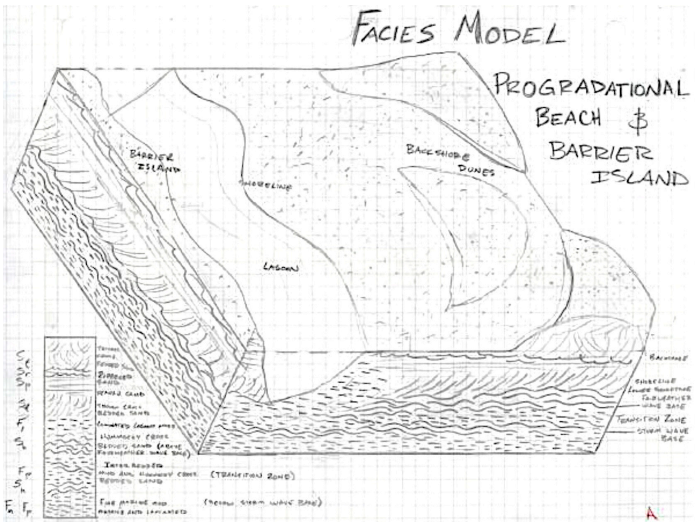


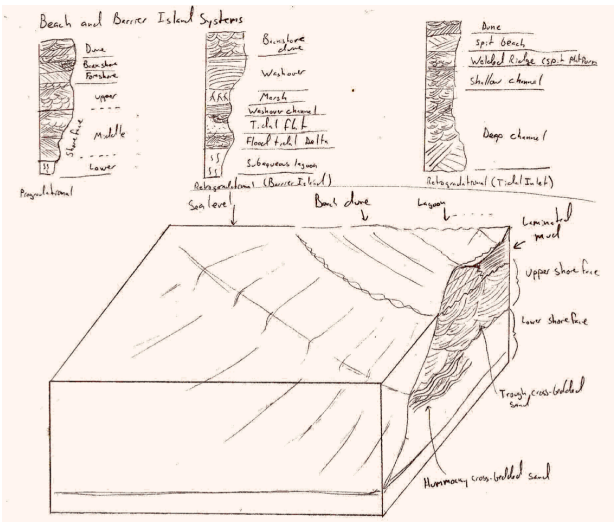
Considering that sediment collects only to a profile graded to base level and assuming a constant (non-fluctuating) base level, using Walther's law, show how sediment accumulates to form a progradational clastic "wedge."



Step 2: Work in Groups to Create a Model

Use this information to construct a three-dimensional block diagram and idealized vertical profile for a shoreface system.





Examples of student work – not perfect, but their catching the concepts.

Step 3: Compare to Published Models

I have several facies model books students can examine and also encourage them to use online sources.

Step 4: Graded Project

Description and Interpretation of Sedimentary Rock Bodies and Successions

Diagram an idealized facies model (map and cross-sections) to show the major environments associated with the following depositional systems. Include an idealized vertical profile and outline the lithofacies and processes associated with each environment. Models and vertical profiles should be hand drawn. Outlines should be typed. You will flesh out your outlines as sentences and paragraphs during the exam. You are encouraged to work in groups of three or four, but turn in your own final project. Several helpful reference books have been set aside in the department conference room. Please do not remove them without permission.

Clastic:
Braided stream system
Meandering Stream system
Deltaic system
Beach and barrier island systems
Clastic shelf system
Deep-sea fan system
Eolian system

Carbonate:
Carbonate ramp system
Carbonate reef system

Tentatively to be turned in at the beginning of class Wednesday, 16 November, prior to the exam. This date can change, depending upon when we finish the material. This information will make up part of the notebook due at the end of the semester.

Step 5: Exam

Geology 370 Exam 2
Description and Interpretation of Sedimentary Rock Bodies and Successions

Diagram an idealized facies model (map and cross-sections) to show the major environments associated with the following depositional systems. Include an idealized vertical profile and describe the lithofacies, facies associations, and processes associated with each environment.

Clastic:
Braided stream system or
Meandering stream system

Prograding beach system or
barrier island system

Carbonate:
Carbonate ramp system or
Carbonate reef system