Depositional systems and facies models

Introduction

Overview

- In the second part of the course we will look at the main modern sedimentary depositional environments and the models (facies models) that describe their sedimentological and geomorphic characteristics
  - Then, we will look at how facies models are used to study past environments from ancient sedimentary records
    - The ones with modern analogues and those that don't have a modern analogue
- So, first, we need to introduce the facies analysis approach to the interpretation of sedimentary successions…

What is a facies?

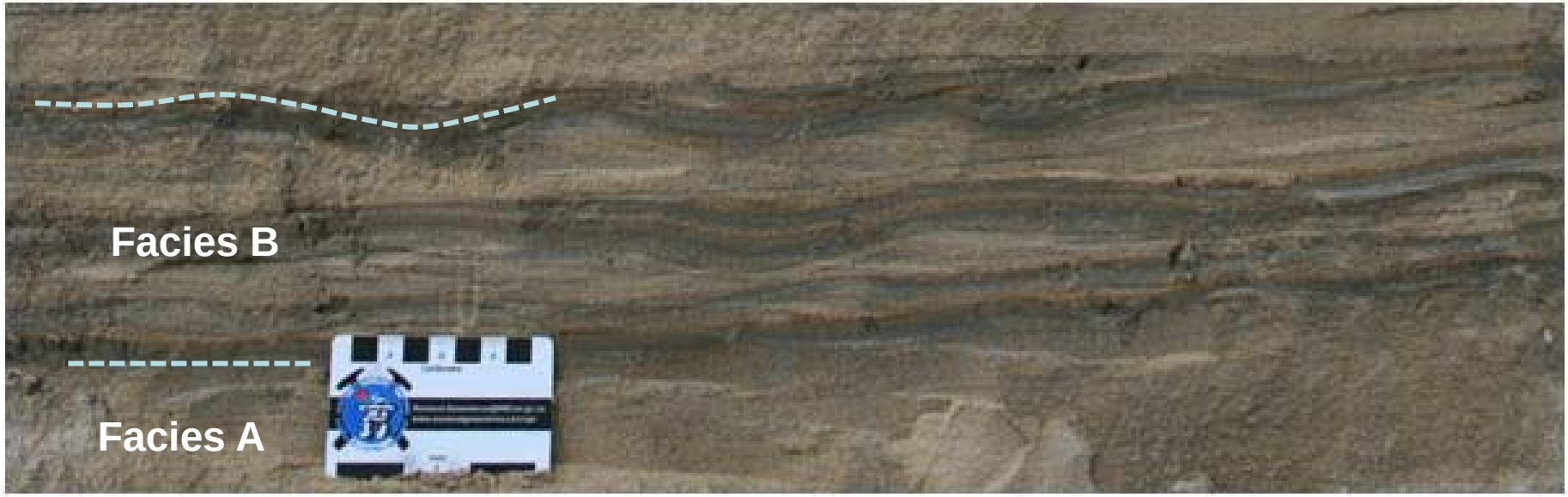
- In sedimentology, a ***facies*** is a particular combination of textural characteristics and sedimentary structures that bestow an aspect ("facies") that is different from the sediments above, below and laterally adjacent

Typical characteristics used to define a facies

- grain size, sorting, rounding
- lithology
- sedimentary structures
- bedding type (e.g. cross-beds)
- fossil assemblages

The term can be used in a purely descriptive manner (e.g. mudstone facies), and also in an interpretative sense (e.g. fluvial facies)

Example of a facies



Facies B: Fine sand (asymmetric ripples) and mud (draping laminations) Indicative of unidirectional flow events which transported sand along the bed (traction load) followed by settling of mud (draping the ripples)

Facies analysis

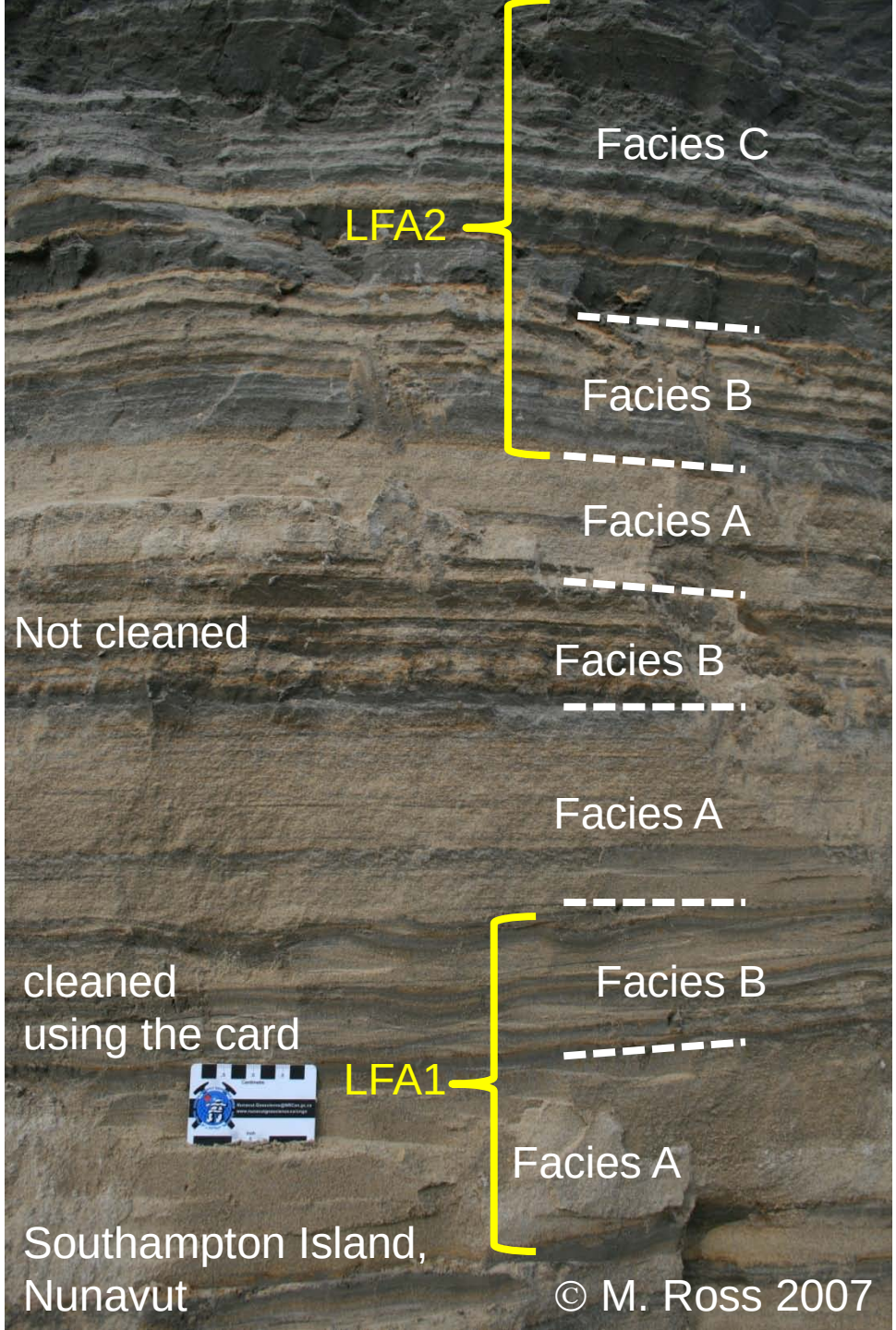
- It is understood that facies “units” will ultimately be given an environmental interpretation
  - The key to the interpretation is to compare observations with those from well-studied examples, and particularly from studies of modern ***depositional environments***

Depositional environment

- Geographic and geomorphologic area characterized by a distinct assemblage of depositional processes
  - e.g. A river valley, a tidal flat
- Many facies defined descriptively might suggest no particular environmental interpretation
  - The key to interpretation is to first combine closely related facies into ***facies associations***

Facies associations and successions

- ***Facies association***: Groups of genetically related facies which have some environmental significance
- ***Facies successions***: The concept of succession implies that facies associations change in a specific direction
  - Vertical: change over time
  - Lateral: spatial change; ex.: proximal to distal
  - The change is more often structured (cyclic) than random



Facies successions and fining-upward trend

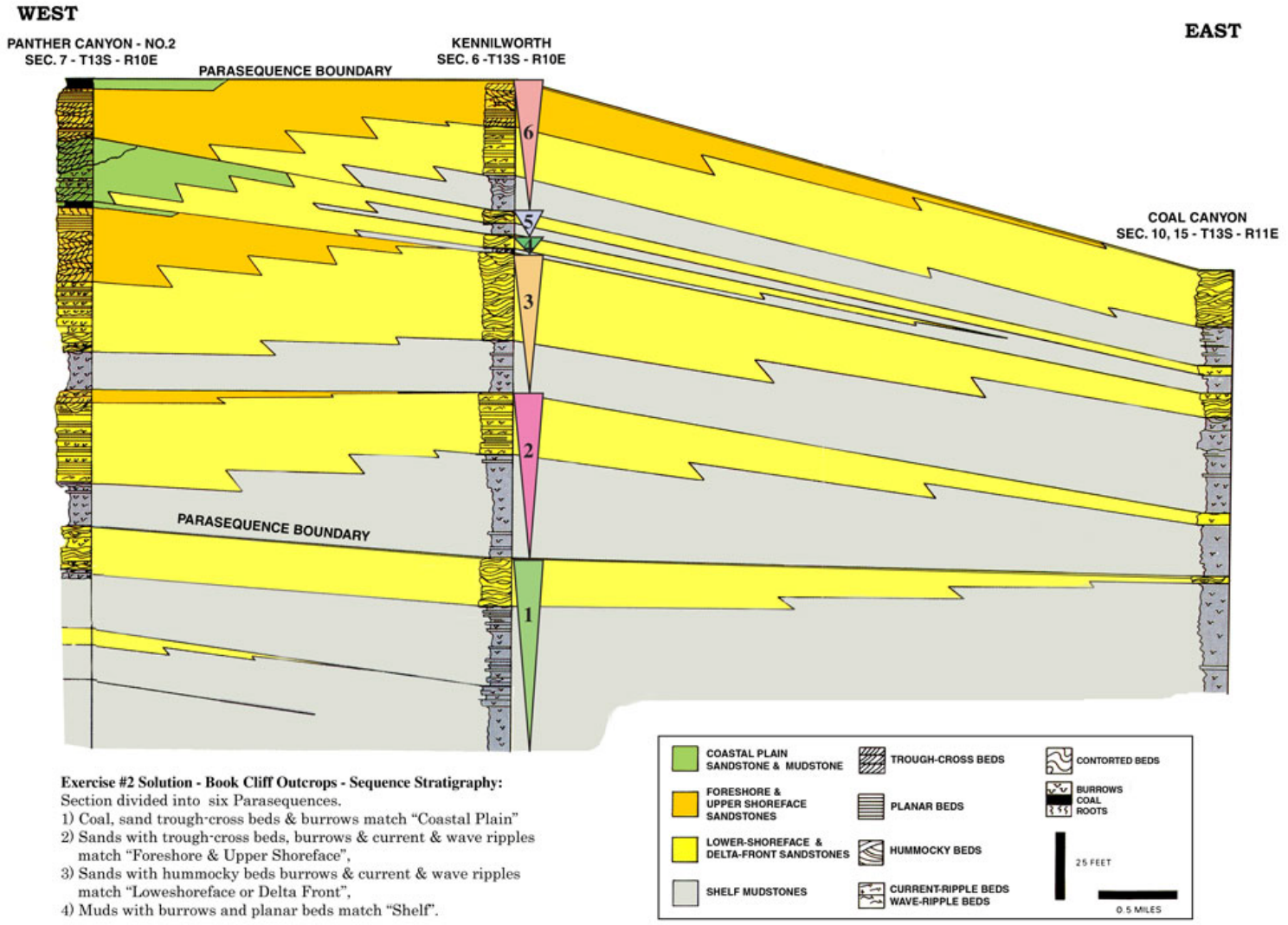
Facies C: Very fine sand, silt and mud; microfossil assemblage indicative of hyposaline conditions

Facies B: Fine sand and mud, ripples (traction transport; lower flow regime) and draping laminations (wavy grey laminae; particle settling)

Facies A: Fine and medium sand, massive or laminated (upper plane beds; upper flow regime)

Interpretation:
Glacimarine subaqueous fan showing seasonal cycles in terrigenous sediment input and glacier retreat/marine transgression

Facies Successions



Exercise #2 Solution - Book Cliff Outcrops - Sequence Stratigraphy:
Section divided into six Parasequences.
1) Coal, sand trough-cross beds & burrows match "Coastal Plain"
2) Sands with trough-cross beds, burrows & current & wave ripples match "Foreshore & Upper Shoreface",
3) Sands with hummocky beds burrows & current & wave ripples match "Loweshoreface or Delta Front",
4) Muds with burrows and planar beds match "Shelf".

C.G.St.C.Kendall 2003 [X-Section from Van Wagoner et al 1990]

Architectural elements

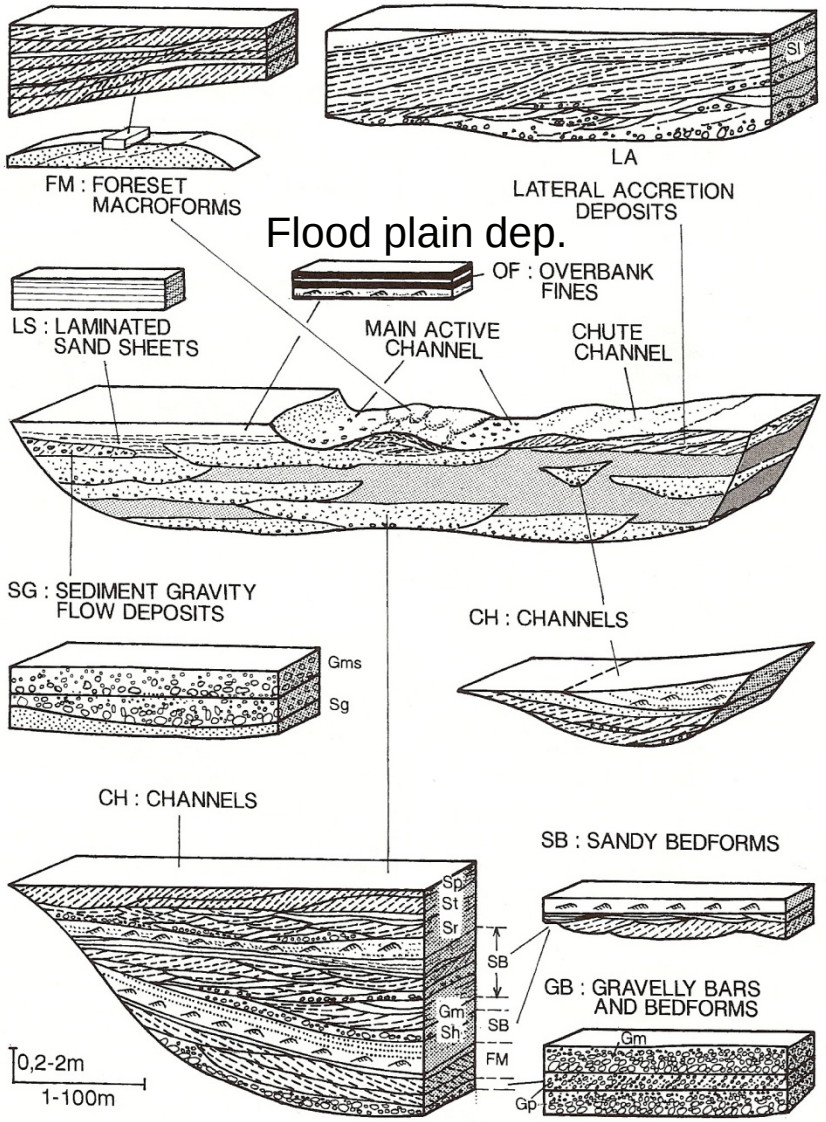
- Architectural elements are related to the geometry of the deposits
  - Distinguished on the basis of bedding geometry
    - Bounding surfaces (contacts) separating facies associations are described and classified according to their geometry and lateral extent (leads to a hierarchy of surfaces)
    - This allows the reconstruction of the geomorphology of a depositional body (e.g. a channel)

Architectural elements

Point bar deposits

Flood plain dep.

Flash floods



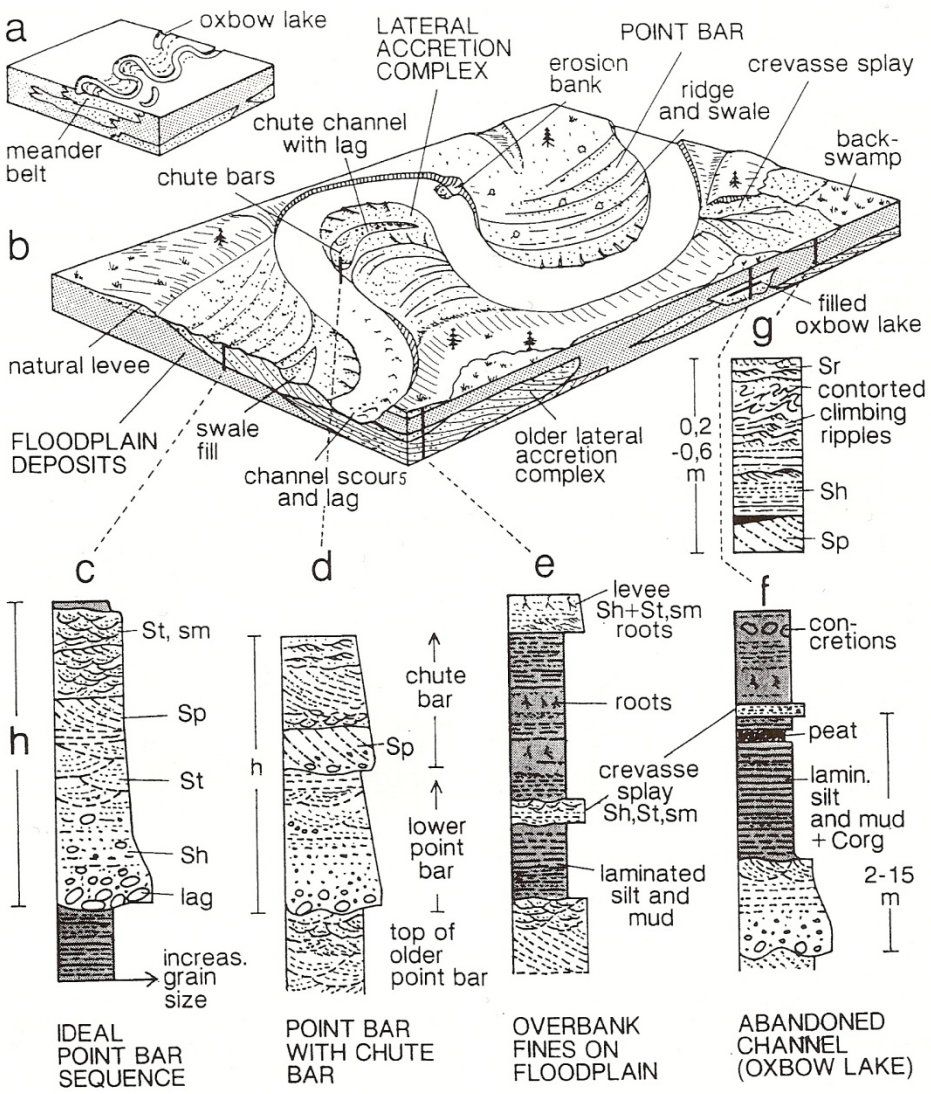
Facies models

- Despite the complexity and randomness of processes on the Earth's surface, there is a high degree of predictability in nature
  - Remember when we looked at combinations of water depth, current velocity, and grain size and how we were able to predict bedforms (e.g. ripples, dunes or upper flow regime plane beds)
- There is a tendency for a given depositional setting to lead to predictable facies associations and successions

Facies models

- A ***facies model*** is a general summary of a particular ***depositional system***, based on many individual examples from recent sediments and ancient rocks.
- A ***depositional system*** is an environment in which a deposit is formed by genetically linked active or inferred processes
  - ex. tidal depositional system, glacial depositional system, eolian depositional system

Example of a facies model



Example of a facies model

More “dynamic” or process-based model

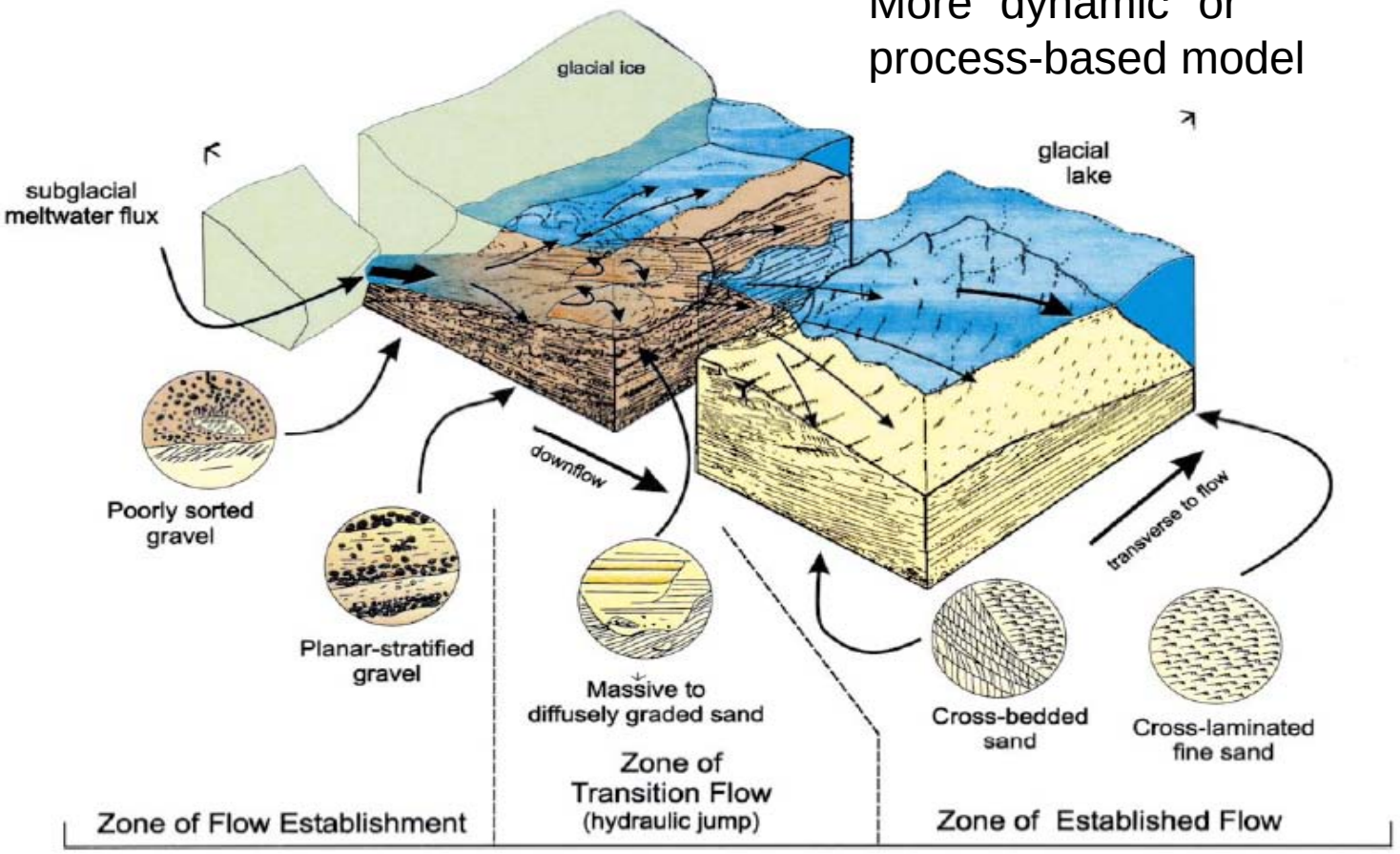


FIG. 17.—Schematic block diagram of proximal subaqueous fan model showing lithofacies and zones of jet-efflux development. Drawing by John Glew.

Types of Depositional Systems

terrestrial → land

transitional → part land, part ocean

marine → ocean, sea

Facies models

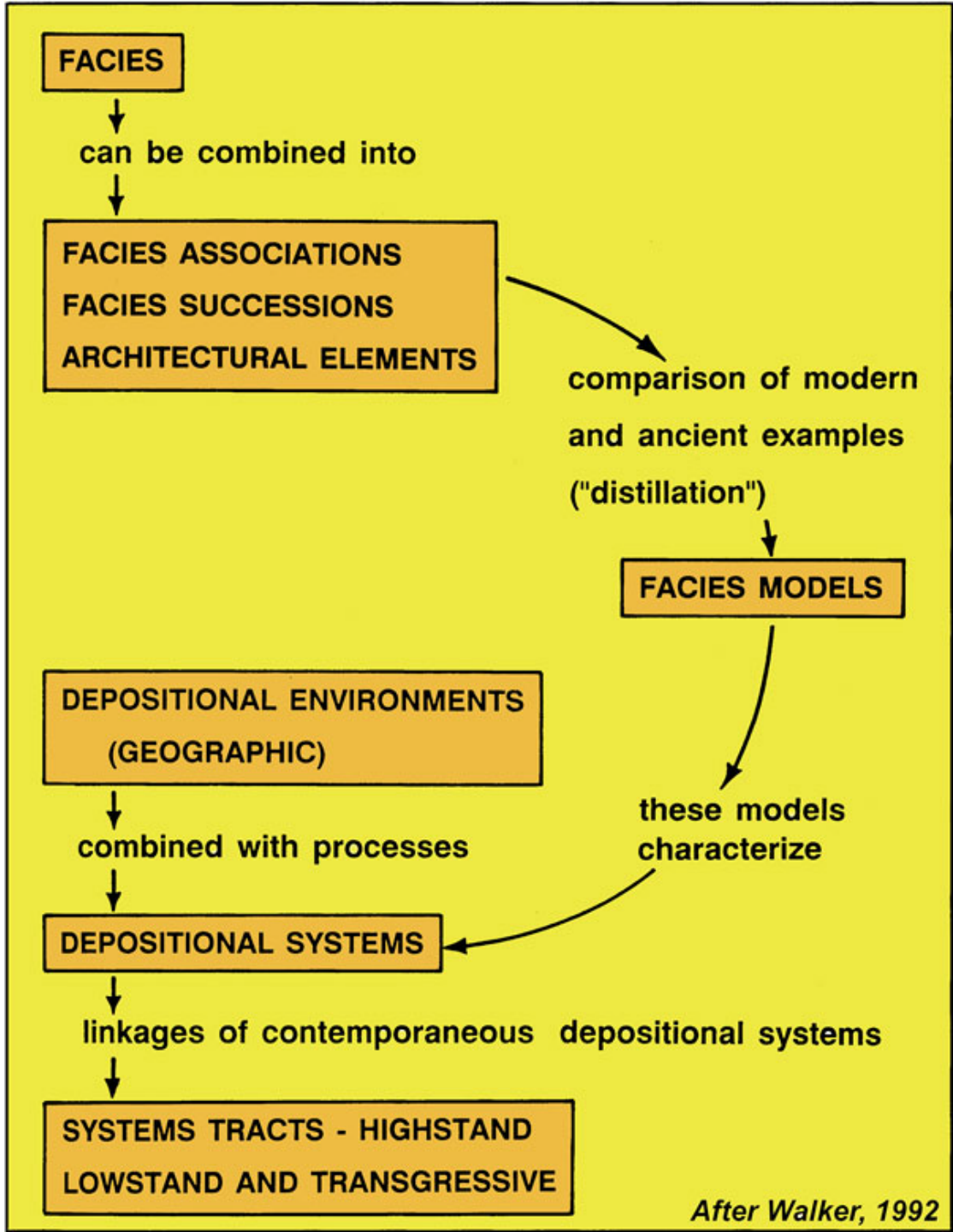
- The challenge is to determine which attributes are common to all examples and which ones are purely local nature
  - It is a subjective assessment because it involves experience, judgment, and arguments among sedimentologists
- Facies models are dynamic constructs that must be updated to reflect current understanding of an environment

Facies models

Relationship between:

- Facies
- Architectural elements
- Depositional settings
- Systems
- Systems tracts

Scheme used to characterize each depositional system



The five uses of facies models

- A facies model can act as
  - an integrated basis for interpretation for the system that it represents
  - a norm, for the purpose of comparison
  - a framework and guide for further observations (e.g. subsurface studies)
  - a predictor in new geological situations
  - an aid for teaching and learning…
    - Facies models are an essential element of a good sedimentary education