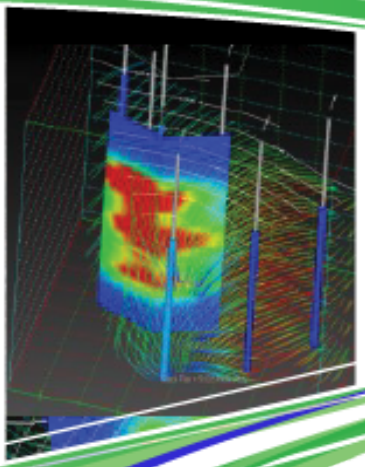

NARPM Presents…
Focus on Geology
Depositional Environments

Herb Levine
Hydrogeologist, EPA Region 9

EPA United States Environmental Protection Agency

26th NARPM Training Program

July 30, 2019

Depositional Environments Introduction

- Why is this important or relevant?
- Impacts to identification of flowpaths and contaminant transport
- Decrease uncertainty and increase potential for a successful remedy
- Applications and case study will be presented at NARPM 2019.

Depositional Environments

- 90% of mass flux contaminant transport at Superfund sites has been shown to be through 10% of aquifer material.
- A site conceptual model that accurately reflects the geologic plumbing is essential for remedy selection and implementation.
- selection/design and unnecessarily lengthy cleanups. Site conceptual models that do not consider depositional environment tend to incorrectly interpret the geologic plumbing which leads to faulty remedy

Depositional Environments

- Identify groundwater flow paths and preferential contaminant migration pathways
- Map and predict contaminant mass transport (high permeability) zones and matrix diffusion-related storage (low permeability) zones
- Identify data gaps and determine a focused HRSC program, if needed
- Optimize groundwater monitoring program
- Improve efficiency and timeliness of remediating contaminated groundwater
- Reduce cost of remediation

EPA/600/R-17/293
September 2017

EPA United States Environmental Protection Agency **Groundwater Issue**

Best Practices for Environmental Site Management:

A Practical Guide for Applying Environmental Sequence Stratigraphy to Improve Conceptual Site Models

Michael R. Shultz[1], Richard S. Cramer[1], Colin Plank[1], Herb Levine[2], Kenneth D. Ehman[3]

CONTENTS

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[1]Burns & McDonnell
[2]U.S. EPA
[3]Chevron Energy Technology Company

BACKGROUND

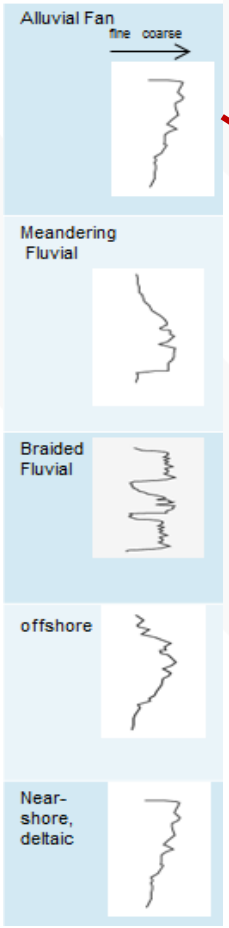
This issue paper was prepared at the request of the Environmental Protection Agency (EPA) Ground Water Forum. The Ground Water, Federal Facilities, and Engineering Forums were established by professionals from the United States Environmental Protection Agency (USEPA) in the ten Regional Offices. The Forums are committed to the identification and resolution of scientific, technical, and engineering issues impacting the remediation of Superfund and RCRA sites. The Forums are supported by and advise Office of Solid Waste and Emergency Response's (OSWER) Technical Support Project, which has established Technical Support Centers in laboratories operated by the Office of Research and Development (ORD), Office of Radiation Programs, and the Environmental Response Team. The Centers work closely with the Forums providing state-of-the-science technical assistance to USEPA project managers. A compilation of issue papers on other topics may be found here:

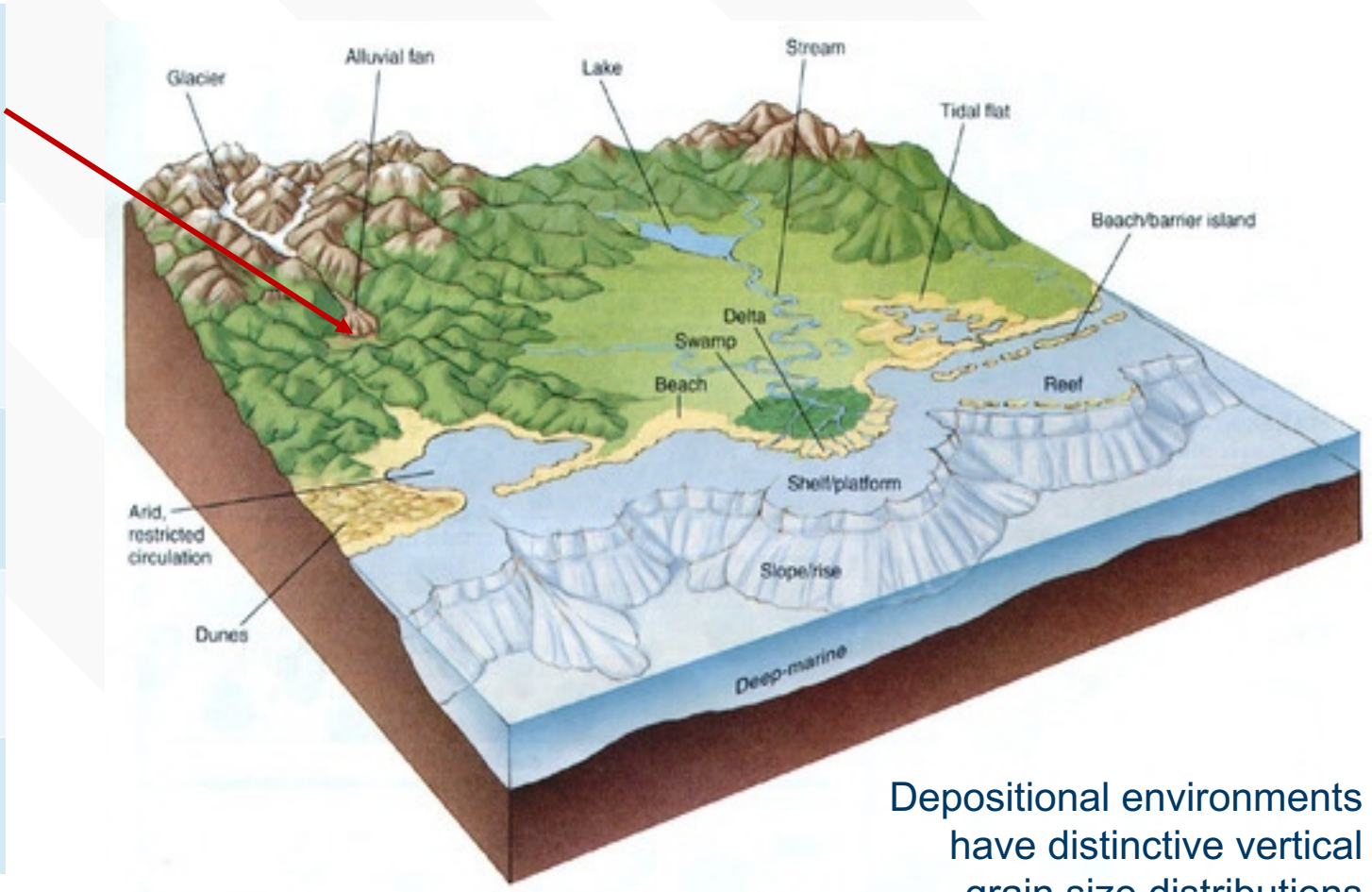
http://www.epa.gov/superfund/remedytech/tsp/issue.htm

The purpose of this issue paper is to provide a practical guide on the application of the geologic principles of sequence stratigraphy and facies models (see "Definitions" text box, page 2) to the characterization of stratigraphic heterogeneity at hazardous waste sites.

Application of the principles and methods presented in this issue paper will improve Conceptual Site Models (CSM) and provide a basis for understanding stratigraphic flux and associated contaminant transport. This is fundamental to designing monitoring programs as well as selecting and implementing remedies at contaminated groundwater sites. EPA recommends re-evaluating the CSM while completing the site characterization and whenever new data are collected. Updating the CSM can be a critical component of a 5 year review or a remedy optimization effort.

Pattern Recognition

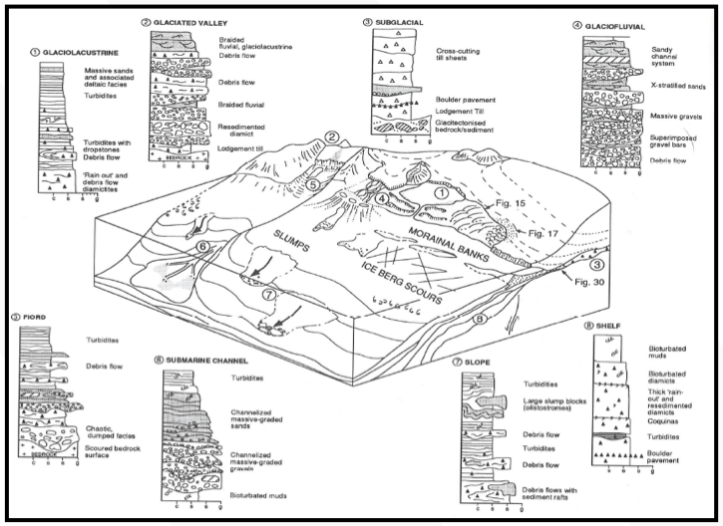




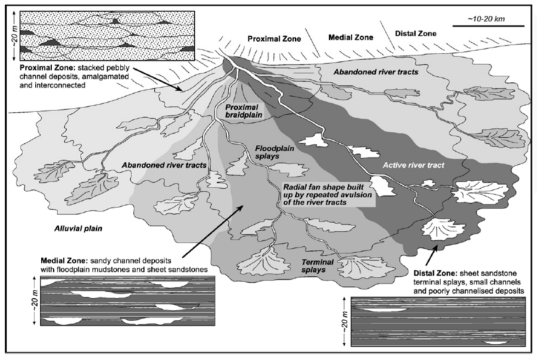
Depositional environments have distinctive vertical grain size distributions

Pattern Recognition

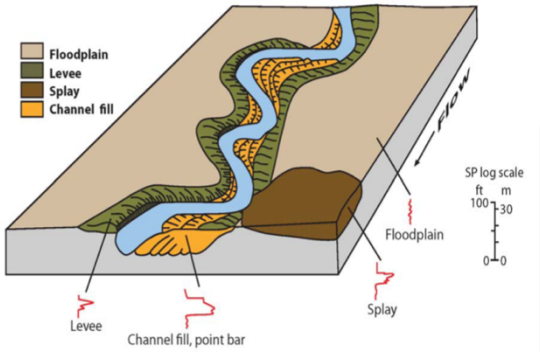
Glacial depositional systems



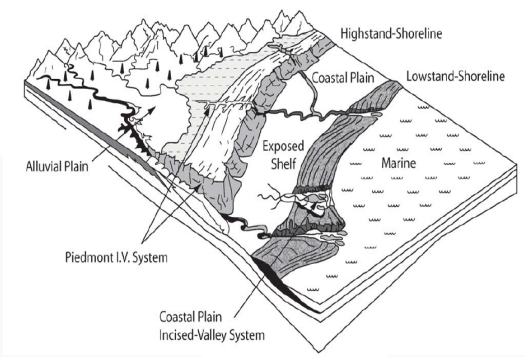
Alluvial fan facies model



Meandering river facies model

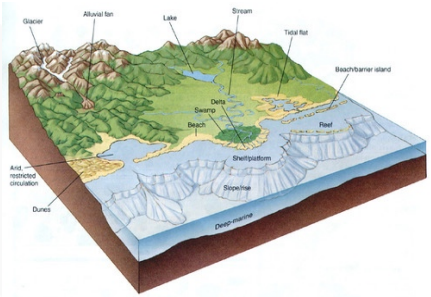


Coastal depositional systems



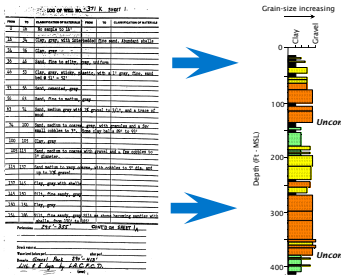
The Environmental Sequence Stratigraphy (ESS) Process

1



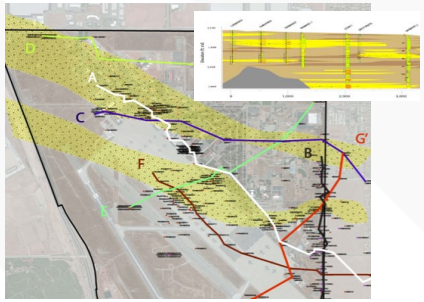
Determine depositional environment, which is the foundation of the ESS evaluation

2



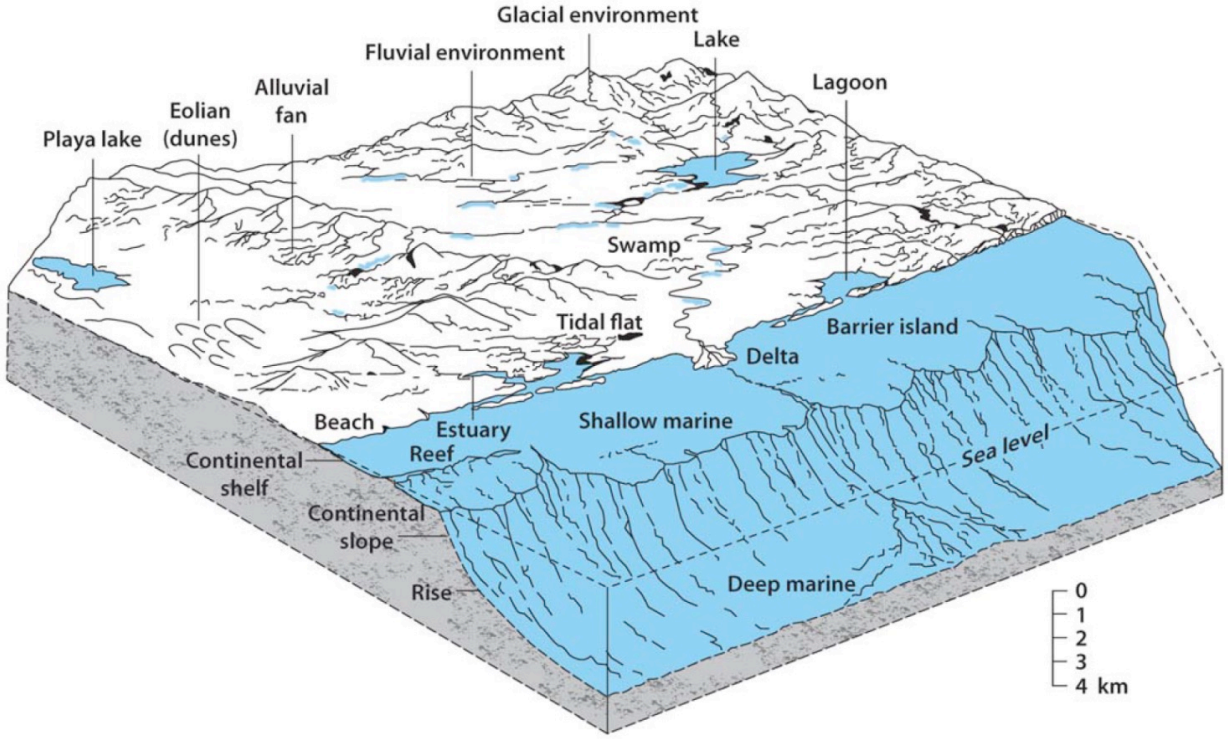
Leverage existing lithology data: format to emphasize vertical grainsize distribution

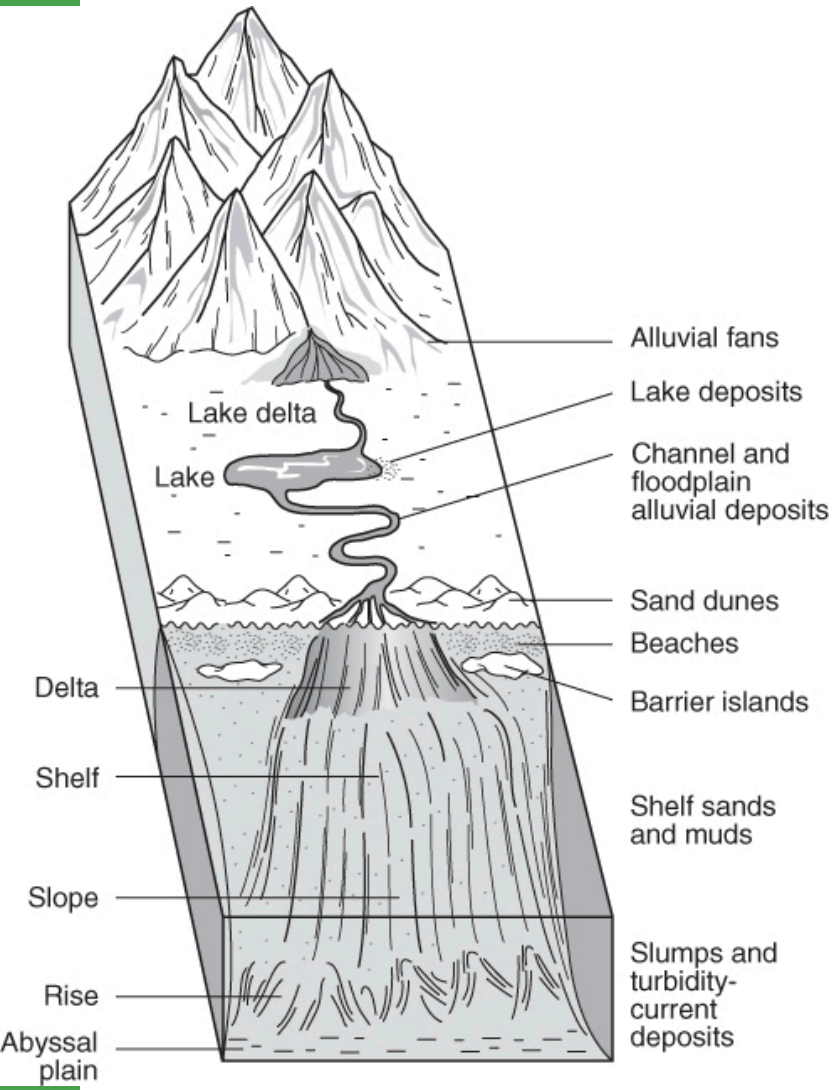
3



Map and predict in 3-D the subsurface conditions away from the data points

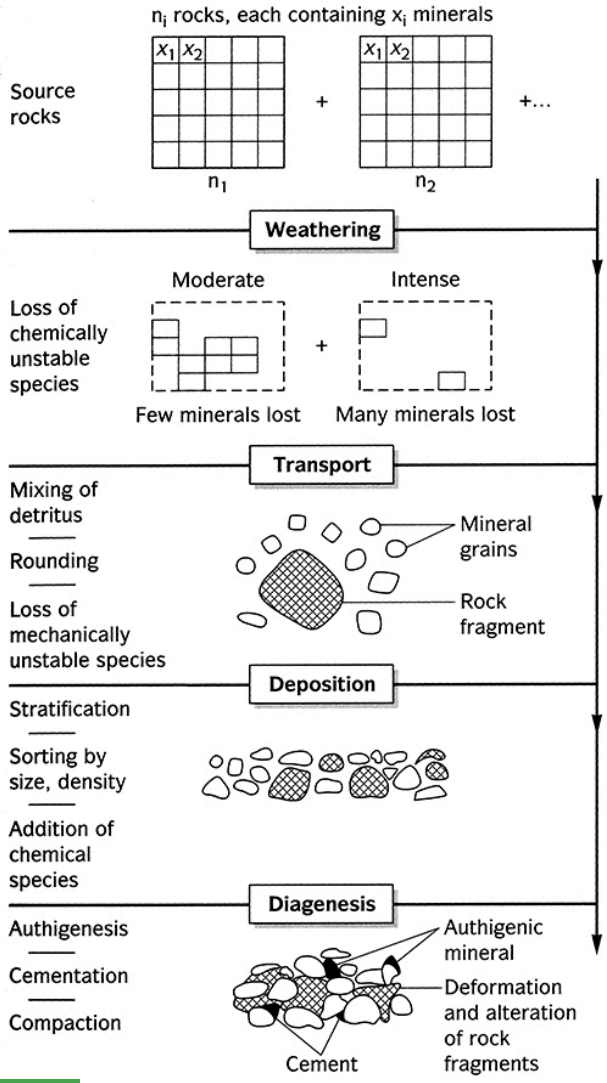
Focus on Depositional Environments





Sedimentary Environments control:

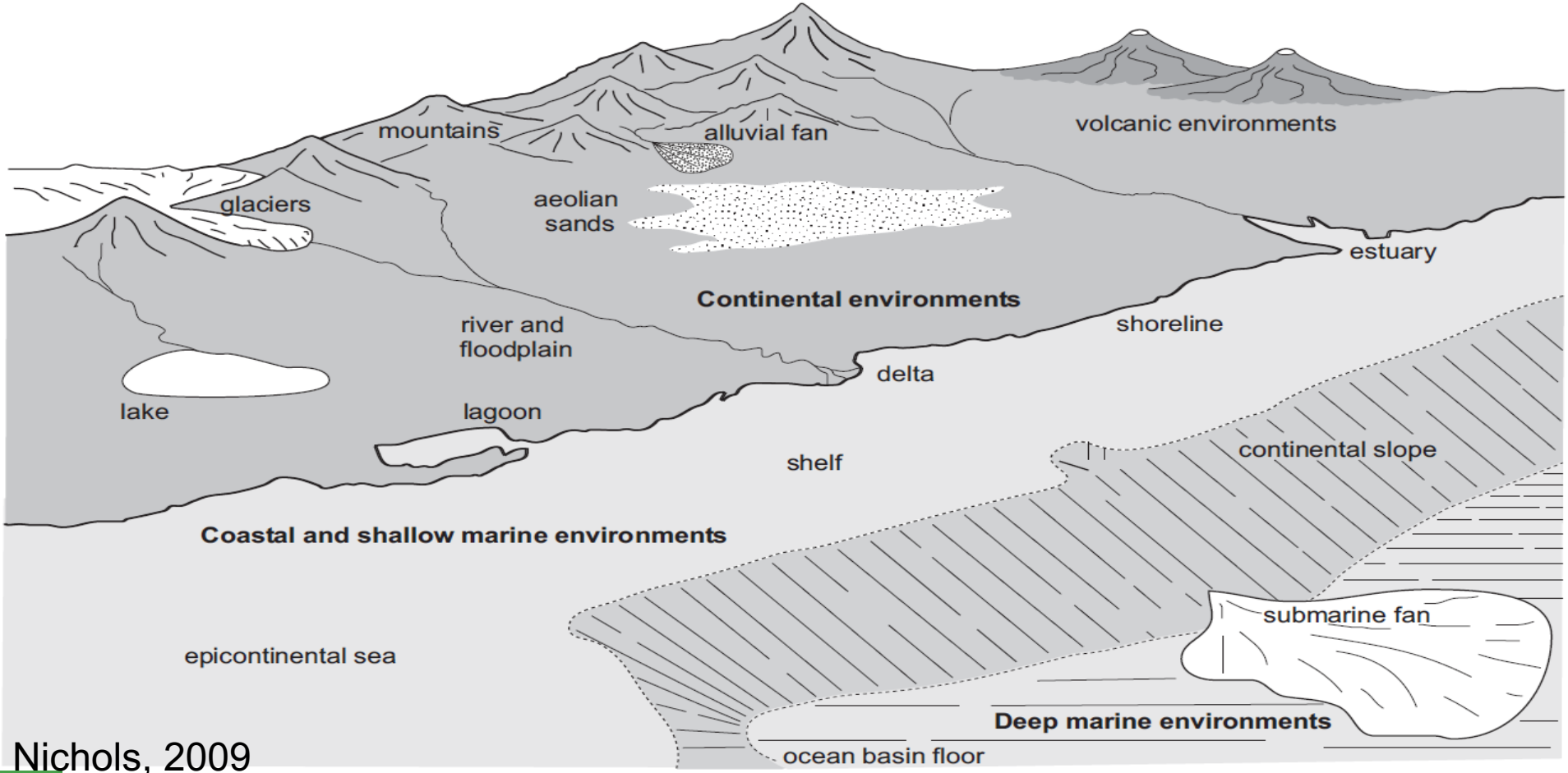
- The energy required to move the particle(s)
- The distance travelled by the particle(s)
- The source of sediment, the location of sedimentation



Sedimentary Processes Flowchart:

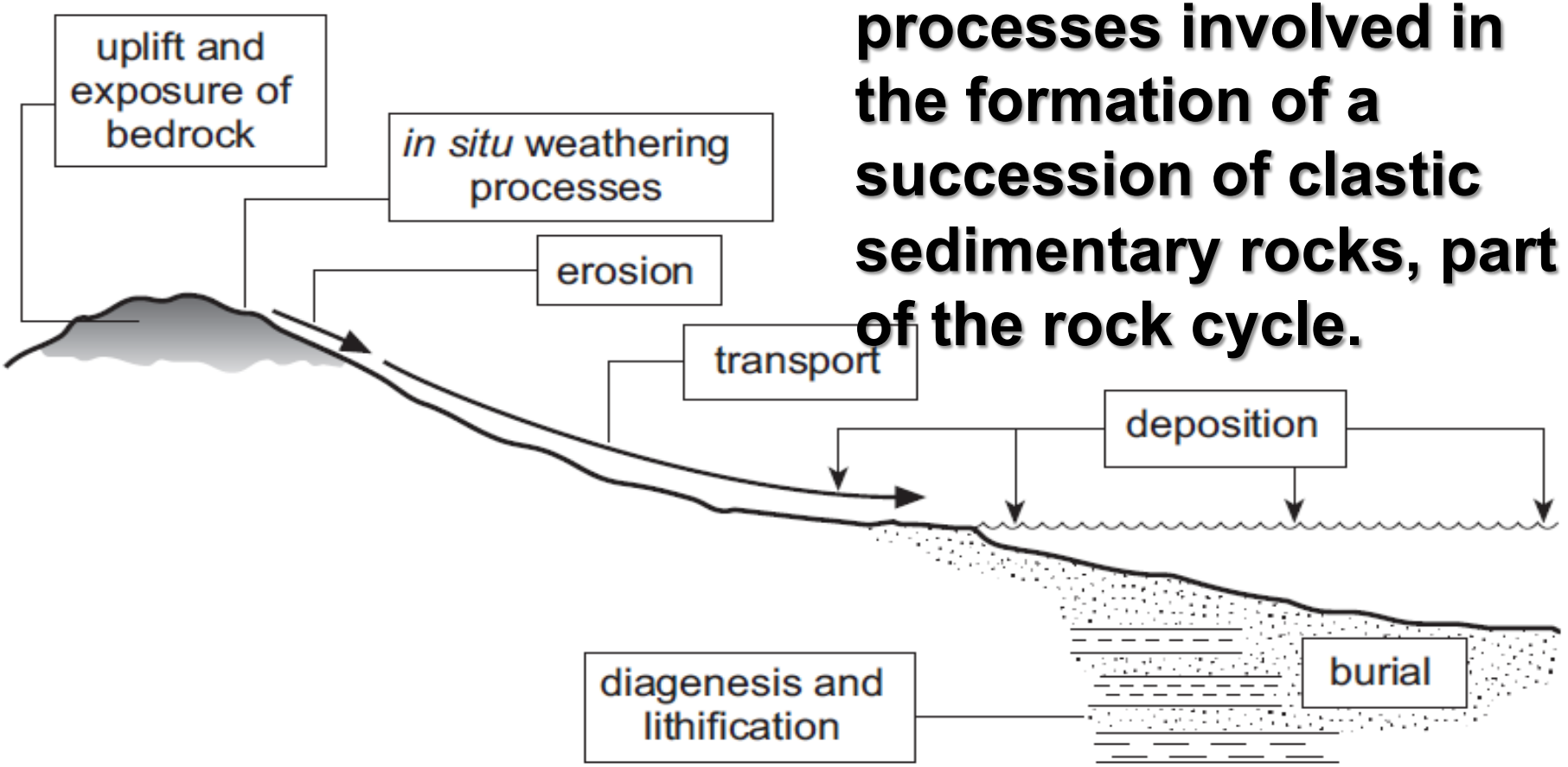
- Source Material
- Weathering
- Transport
- Deposition
- Diagenesis

A summary of the principal sedimentary environments

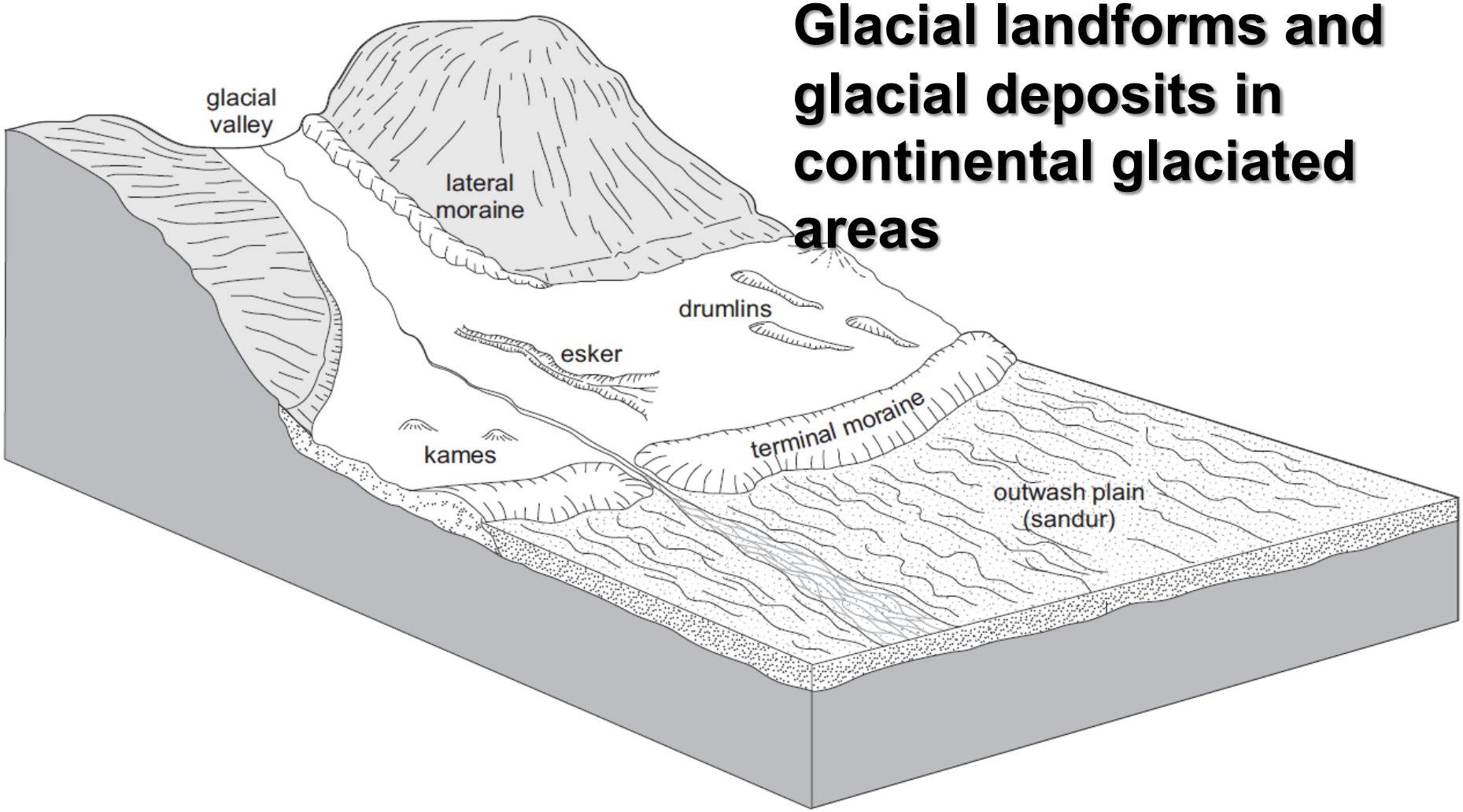


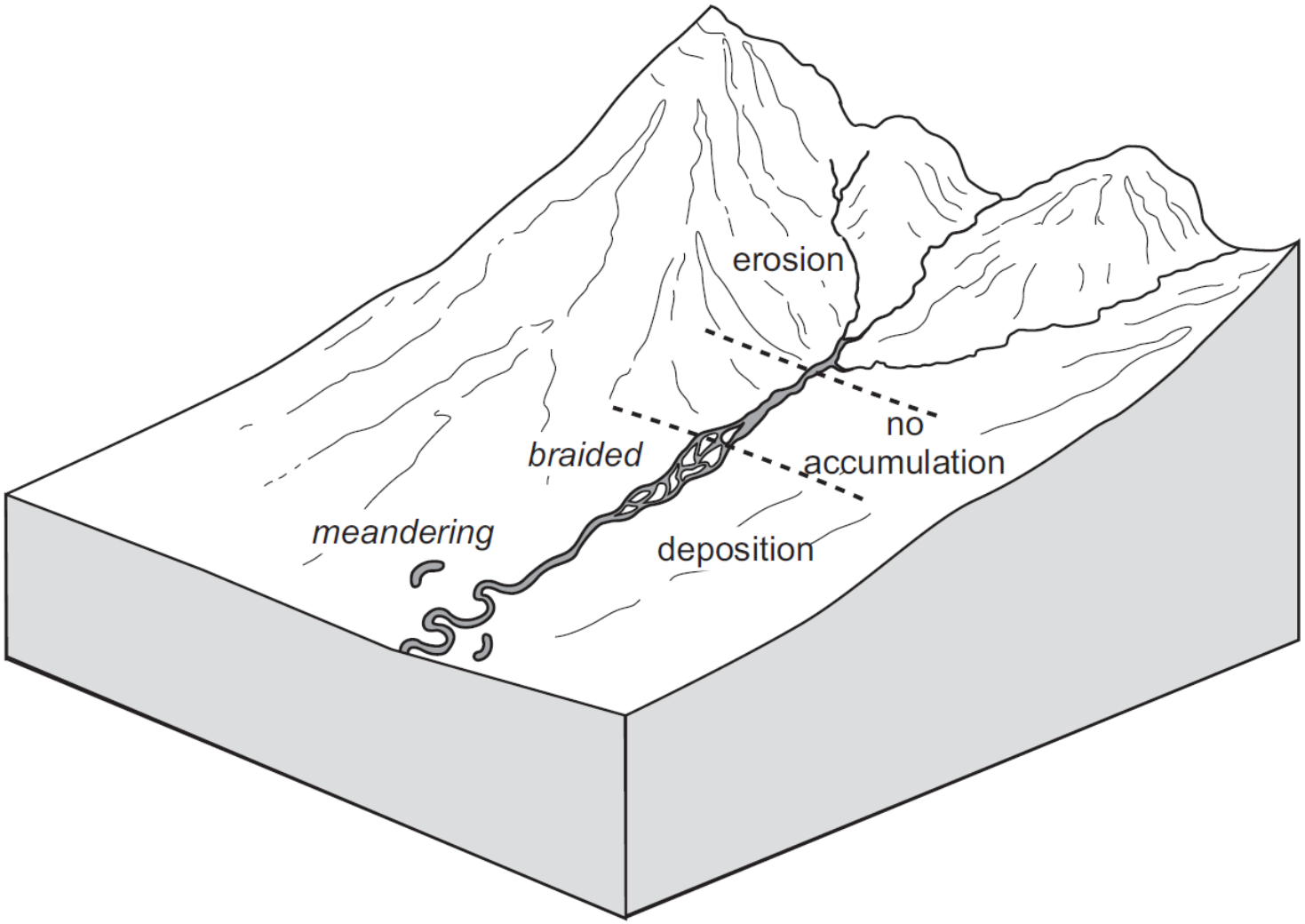
Nichols, 2009

The pathway of processes involved in the formation of a succession of clastic sedimentary rocks, part of the rock cycle.



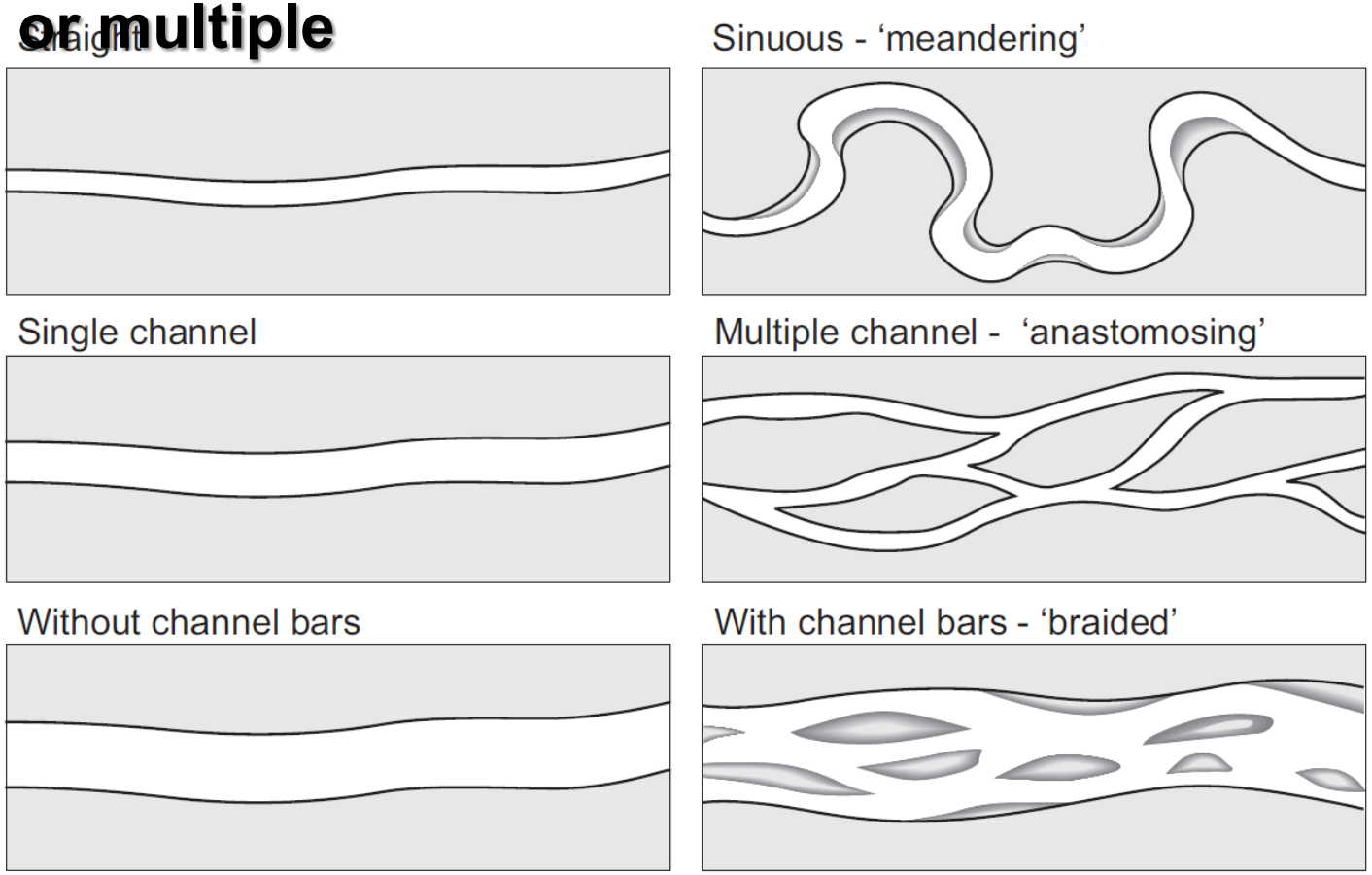
Glacial landforms and glacial deposits in continental glaciated areas

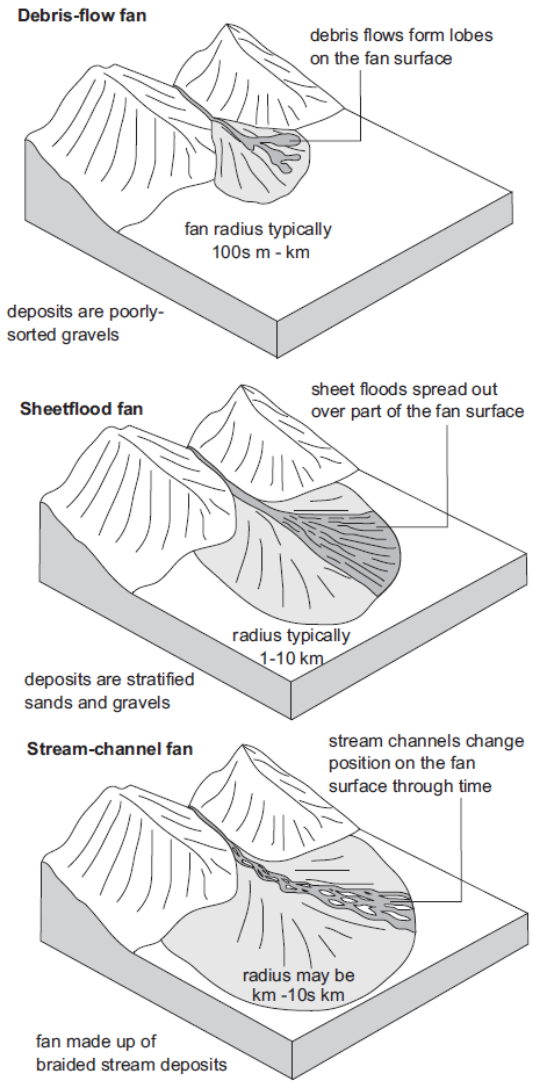




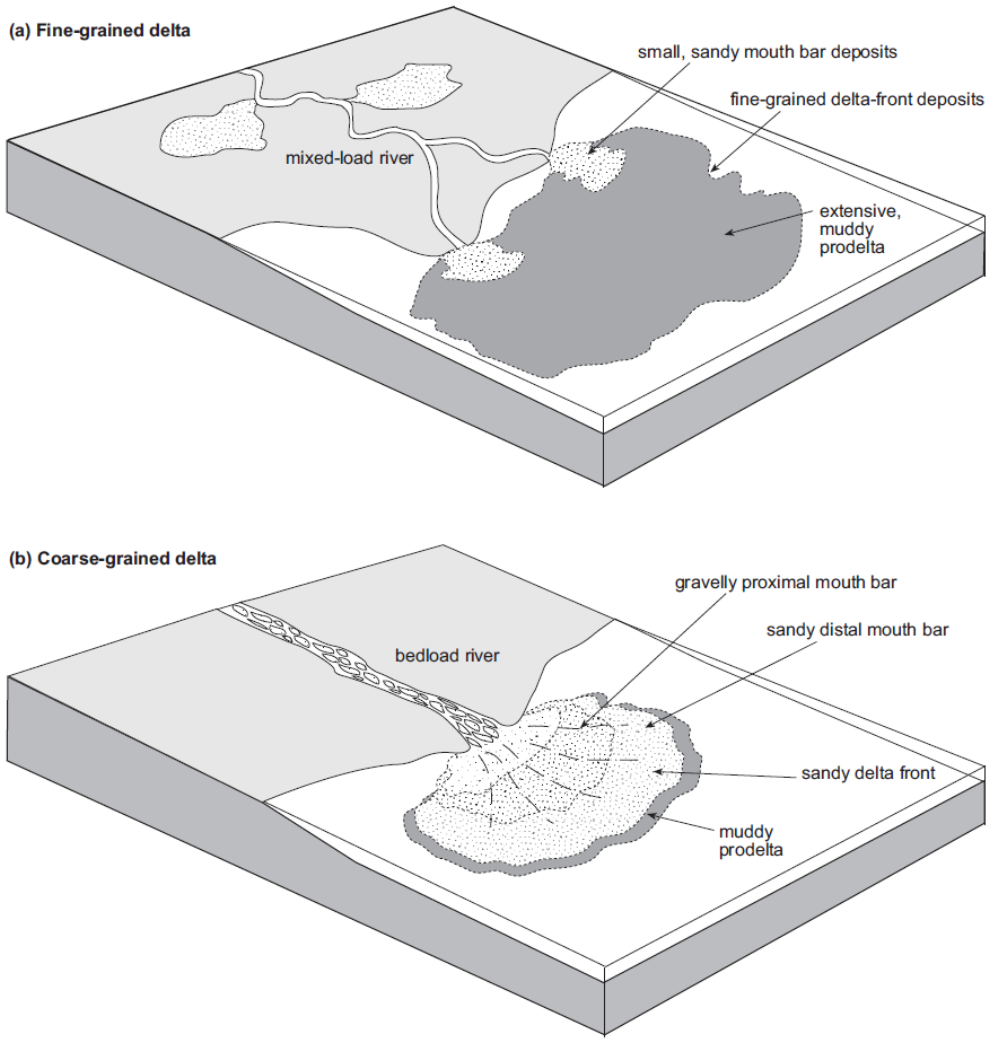
The geomorphological zones in alluvial and fluvial systems: in general braided rivers tend to occur in more proximal areas and meandering rivers occur further downstream.

Several types of river can be distinguished, based on whether the river channel is straight or sinuous (meandering), has one or multiple channels (anastomosing), and has in-channel bars (braided). Combinations of these forms can often occur.





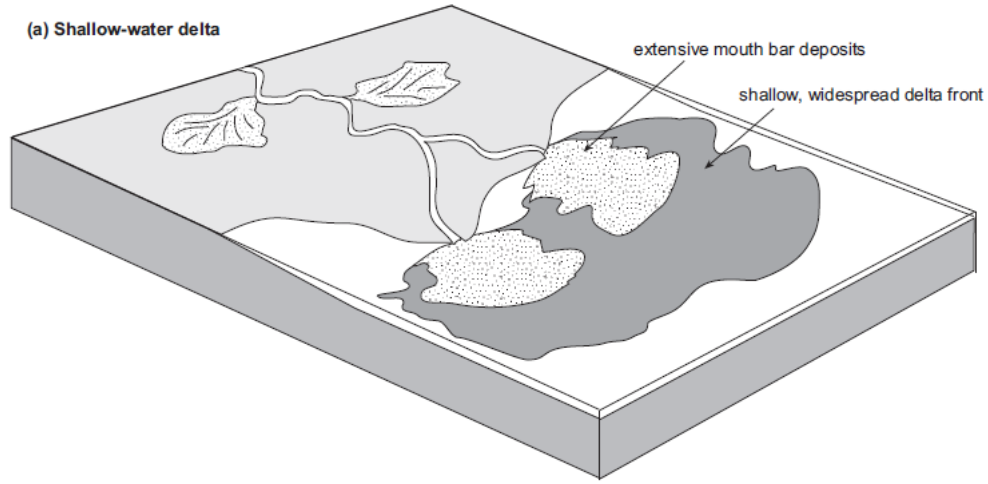
Types of alluvial fan: debris-flow dominated, sheet flood and stream-channel types – mixtures of these processes can occur on a single fan.

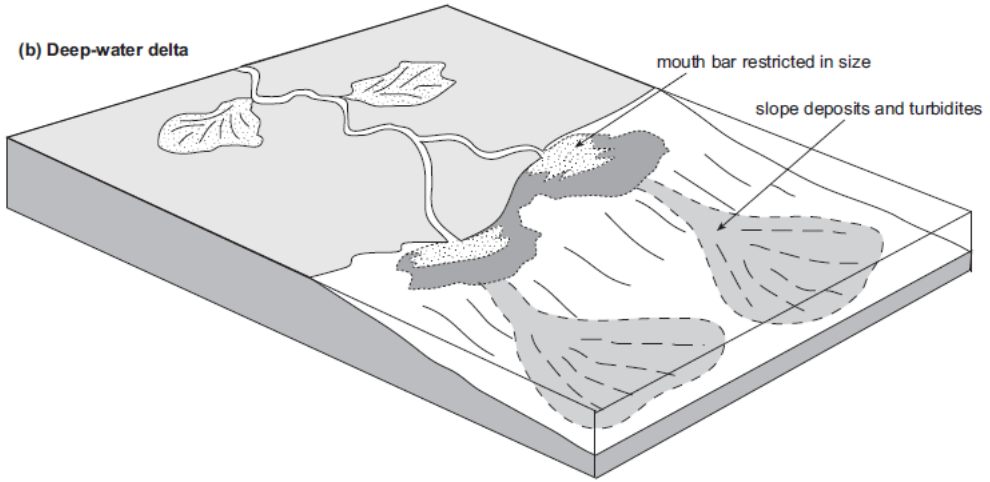


Differences in the grain size of the sediment supplied affect the form of a delta:

(a) a high proportion of suspended load results in a relatively small mouth bar deposited from bedload and extensive delta-front and prodelta deposits

(b) a higher proportion of bedload results in a delta with a higher proportion of mouth bar gravels and sands.

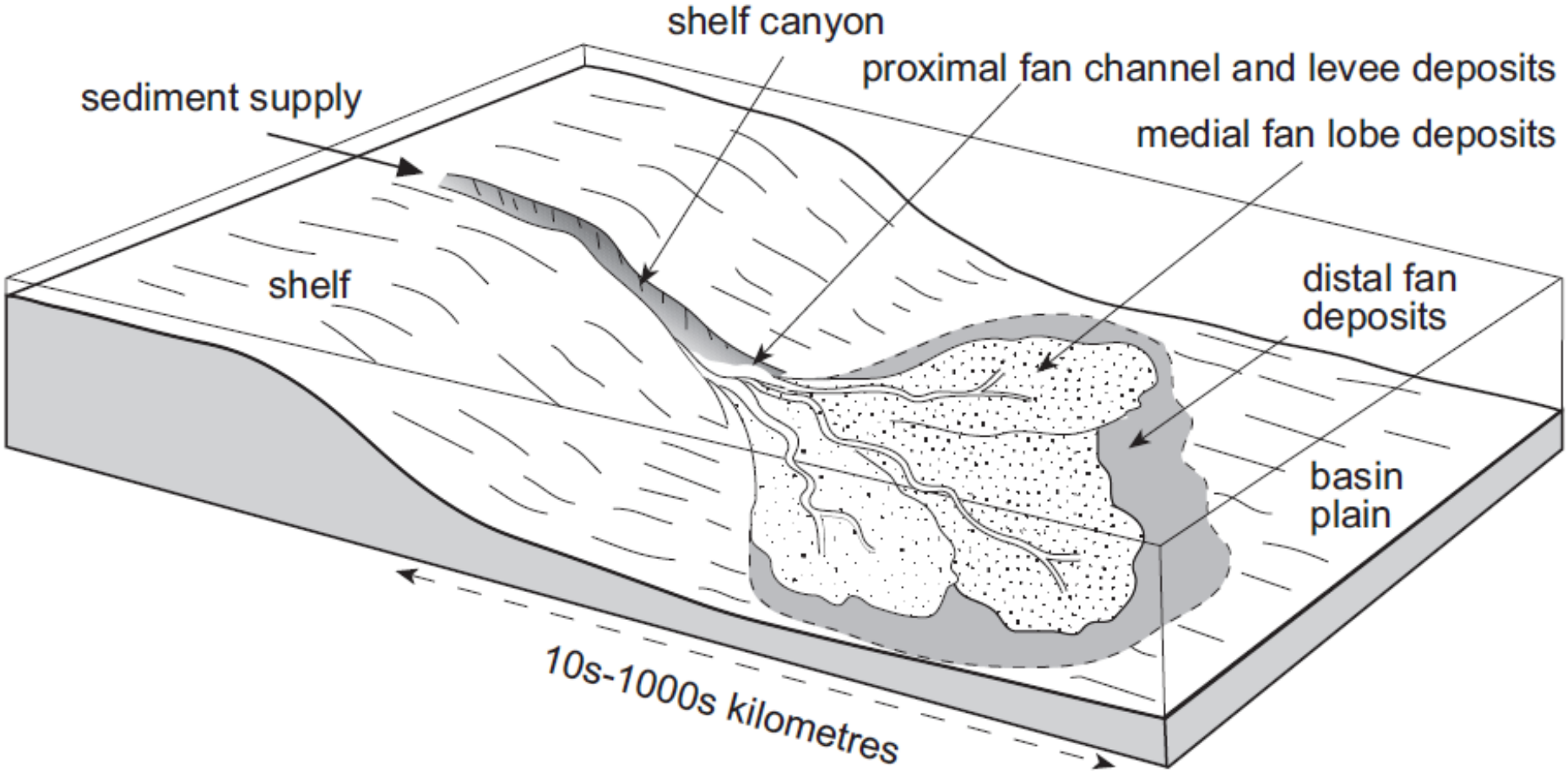




(a) A delta prograding into shallow water will spread out as the sediment is redistributed by shallow-water processes to form extensive mouth-bar and delta-front facies.

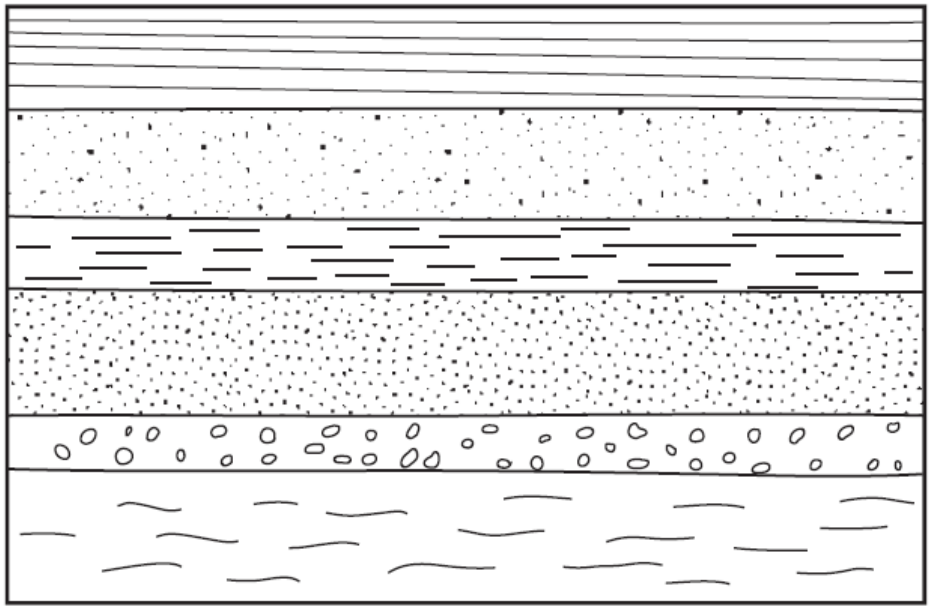
(b) In deeper water the mouth bar is restricted to an area close to the river mouth and much of the sediment is deposited by mass-flow processes in deeper water.

Depositional environments on a submarine fan.

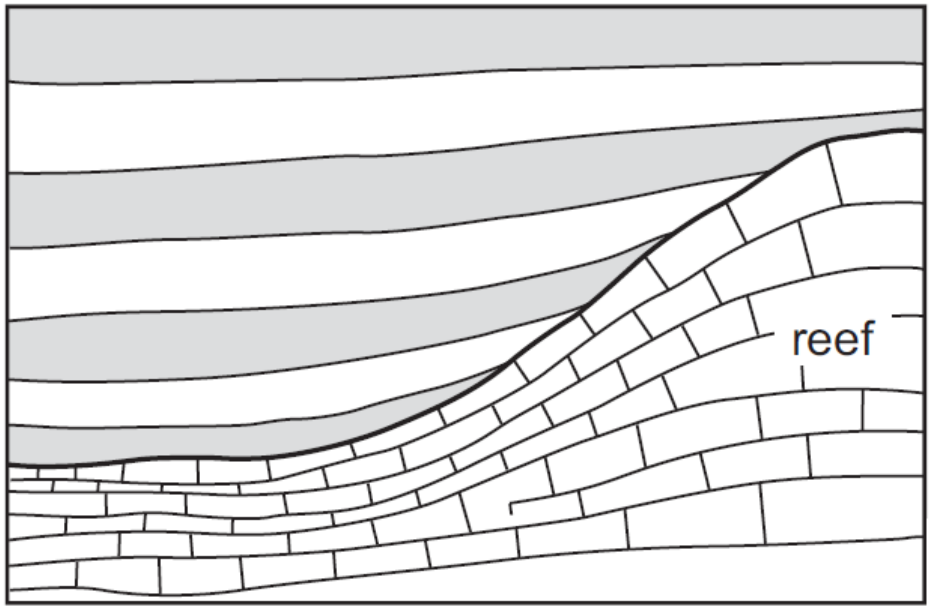


Principles of superposition: (a) a 'layer-cake' stratigraphy; (b) stratigraphic relations around a reef or similar feature with a depositional topography.

'Layer-cake' stratigraphy

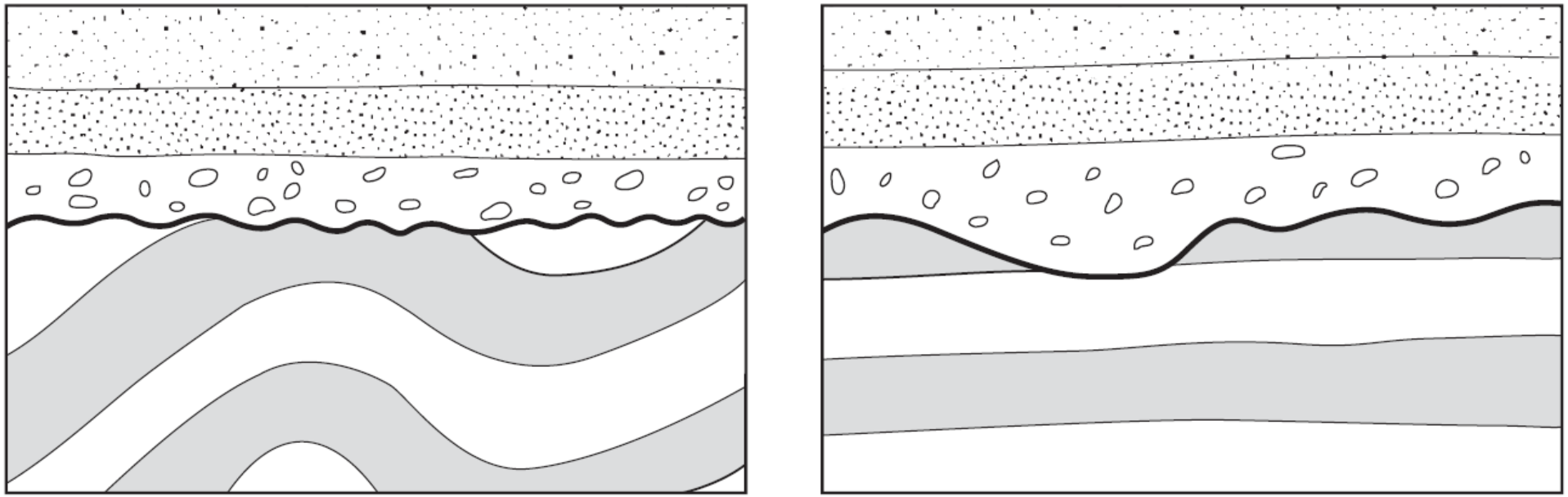


Stratigraphic relations around a reef or similar structure



Gaps in the record are represented by unconformities: (a) angular unconformities occur when older rocks have been deformed and eroded prior to later deposition above the unconformity surface; (b) disconformities represent breaks in sedimentation that may be associated with erosion but without deformation.

Unconformities



General Benefits of ESS Approach

- Identify groundwater flow paths and preferential contaminant migration pathways
- Map and predict contaminant mass transport (high permeability) zones and matrix diffusion-related storage (low permeability) zones
- Identify data gaps and determine a focused HRSC program, if needed
- Optimize groundwater monitoring program
- Improve efficiency and timeliness of remediating contaminated groundwater
- Reduce cost of remediation