

GGY 4031
LECTURE NOTES 6



PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

FACIES

The sum of the characteristics of a sedimentary unit resulting from some particular set of physical, chemical and biological parameters that work to produce a unit with specific textural, structural, and compositional properties (after Boggs, 2001)

- **Generally interpretive**
- Not specific to a rock, but to a predicted set of characteristics associated with some depositional environment
 - Sometimes used differently
 - E.g., To describe a rock unit in an outcrop
 - sandstone facies

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

SEDIMENTARY FACIES

- **Facies** is a distinctive kind of sedimentary deposit, which was deposited in a distinctive setting.
- **Facies** refers to stratigraphic units distinguished by lithologies, structural and organic characteristics detectable in the field.

SEDIMENTARY FACIES: is therefore a unit of rock that, owing to deposition in a particular environment, has a characteristic set of properties detectable in the field.

Facies may be given informal designations or descriptive designation which will eventually be given an environmental interpretation.

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

“The nature of the material deposited anywhere will be determined by the physical, chemical or biological processes which have occurred during the formation, transport and deposition of sediment. Those processes also define the environment of deposition”

TYPES OF FACIES

- × **Lithofacies**
 - + **Based on lithology**
- × **Biofacies**
 - + **Based on fossil assemblage**
- × **Ichnofacies**
 - + **Based on trace fossil assemblage**



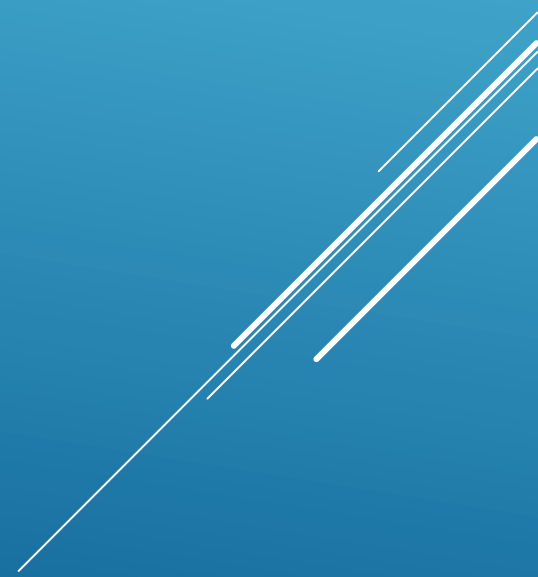
PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Lithofacies: characteristics of a rock which are the products of PHYSICAL and CHEMICAL processes. E.g. coarsening upward, fining upward

Biofacies: observations are based on fauna and flora present
Ichnofacies focuses on trace fossils

Examples

gray limestone rock = lithofacies
echinoid and crinoids = biofacies
burrows and tracks = ichnofacies

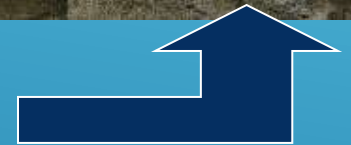


PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

- × Sedimentological analyses allow us to determine the environment in which a sequence of sediments or rocks accumulated by considering:
 - + Texture
 - + Composition/ Classification
 - + Petrographic analyses (e.g., evaluate diagenesis)
 - + Identify sedimentary structures
 - + Compare results to modern environments
 - × Also simulate conditions in laboratory experiments

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

- × Sedimentary (litho) facies
 - + Lithostratigraphic Units (time independent)
 - + Defined by sum total of (relevant) rock properties
 - + Reflects *processes* during *genesis* and may include
 - × Lithology
 - × Sedimentary Structures
 - × Fossils
 - × Bedding style and geometry (on various scales)
 - × Paleo-sediment transport indicators



PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

- × Paleocurrent indicators are oriented sedimentary structures interpreted to have been deposited by ancient flows
 - + Cross-beds slip faces,
 - + pebble imbrication,
 - + parting lineation,
 - + tool marks and groove casts, and
 - + ripple crest orientation



PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

COBBLE IMBRICATION



PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Examples of facies **descriptive** and **genetic** terms:

- Sandy facies
- Shaly facies
- Carbonate facies
- Turbidity facies
- Deltaic facies
- Deep water facies

Facies characteristics

- Lithofacies:** are facies distinguished by physical characteristics such as color, lithology, texture and sedimentary structures
- Biofacies:** facies defined on the basis of paleontologic characteristics

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

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PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

- Degree of randomness or non-randomness of the succession themselves e.g:

- **Facies** may be distributed vertically in a random manner or show a definite or preferred pattern of vertical change

- Two common types of vertical facies change are **Coarsening-Upwards** and **Fining-Upward Succession**.

Coarsening-upward succession:

- Display an increase in grain size upward from a sharp or erosive base

- Indicate an increase in transporting power of currents during deposition

- If change in thickness of individual beds increase upwards, then- **Thickening-upwards succession**

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Fining-Upward Succession

- Display a decrease in grain-size upward from a sharp or erosive base
- Indicates a decrease in transporting power of currents during deposition
- If change in thickness of individual beds decreases upwards then-**Thining-Upwards succession**

NOTE:

Coarsening-Upward and **Fining-Upward** successions should **NOT** be confused with Graded Bedding as they commonly involve many different beds that individually may **NOT** be graded.

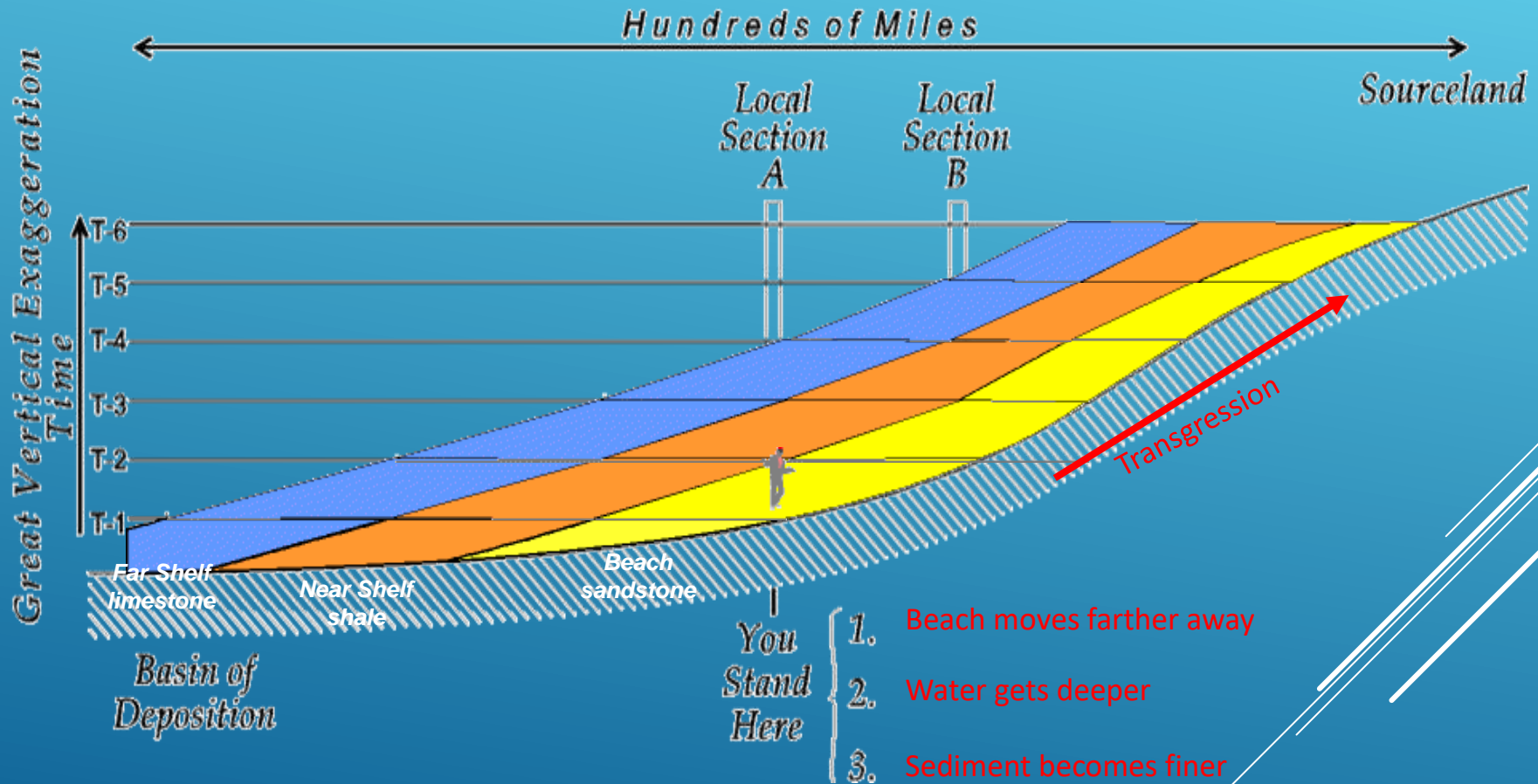
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Walther's Law = sedimentary environments that started out side-by-side will end up overlapping one another over time due to transgressions and regressions.



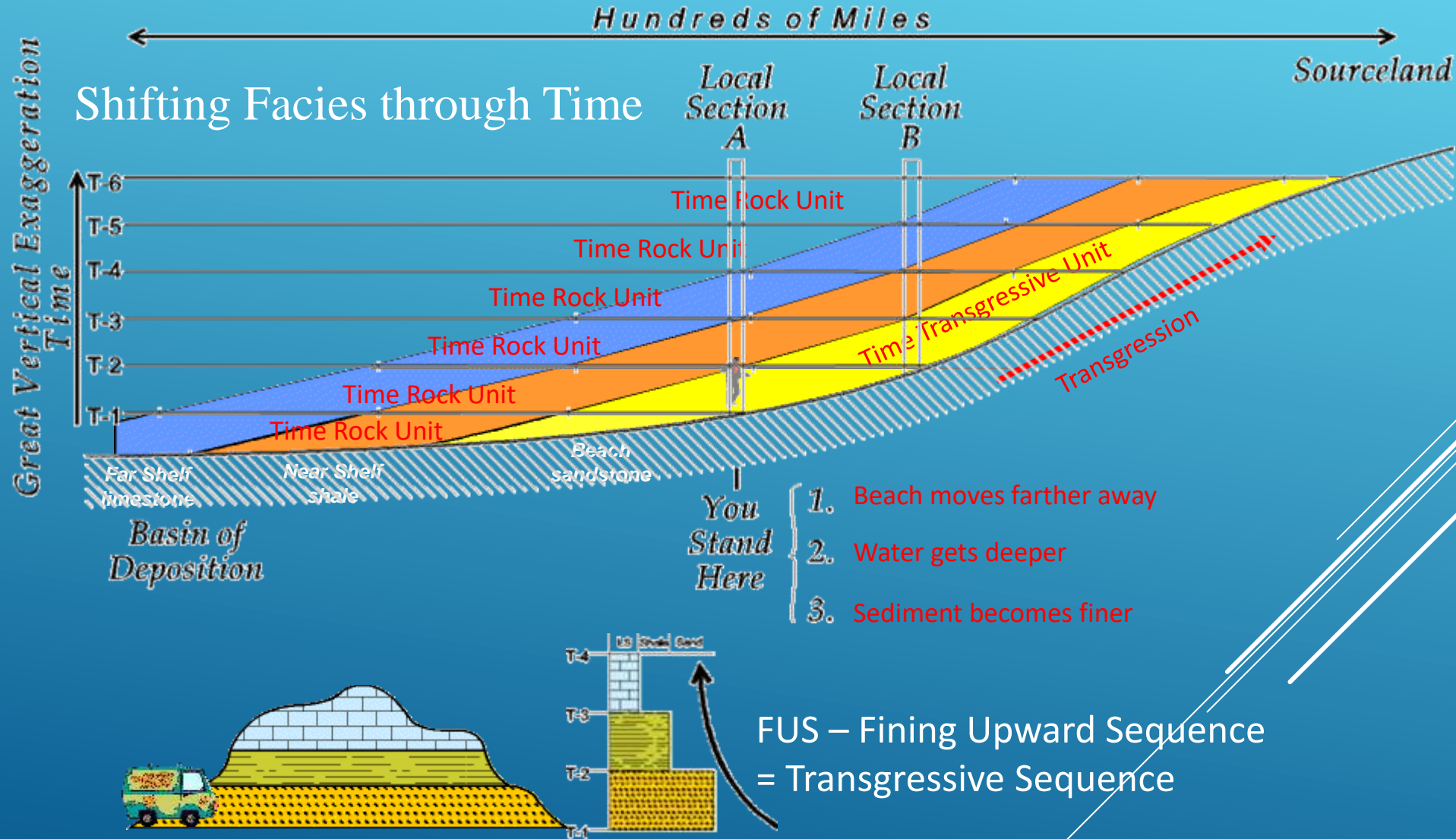
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Transgressive Sequence



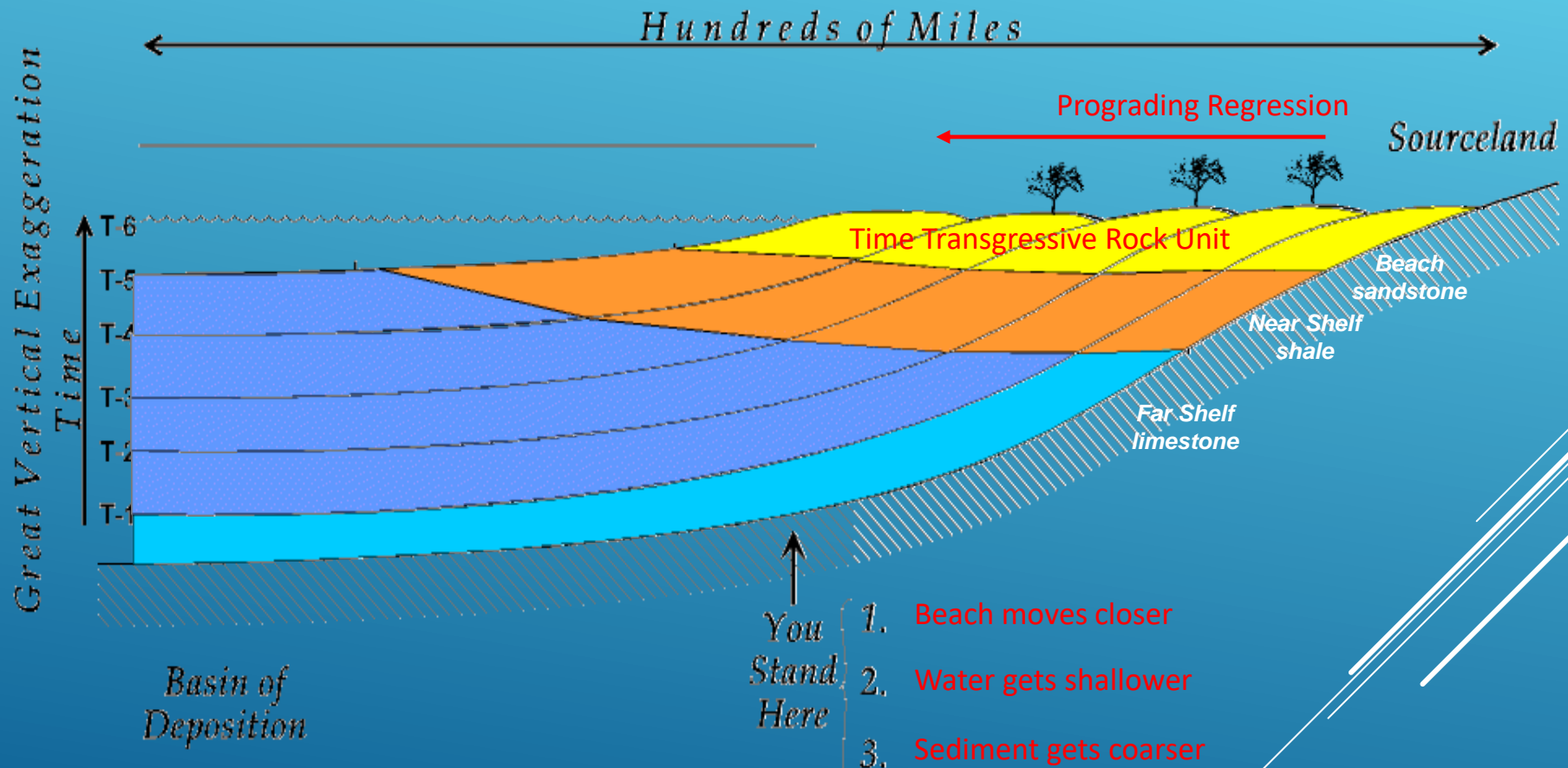
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Onlap (Transgressive) Sequences



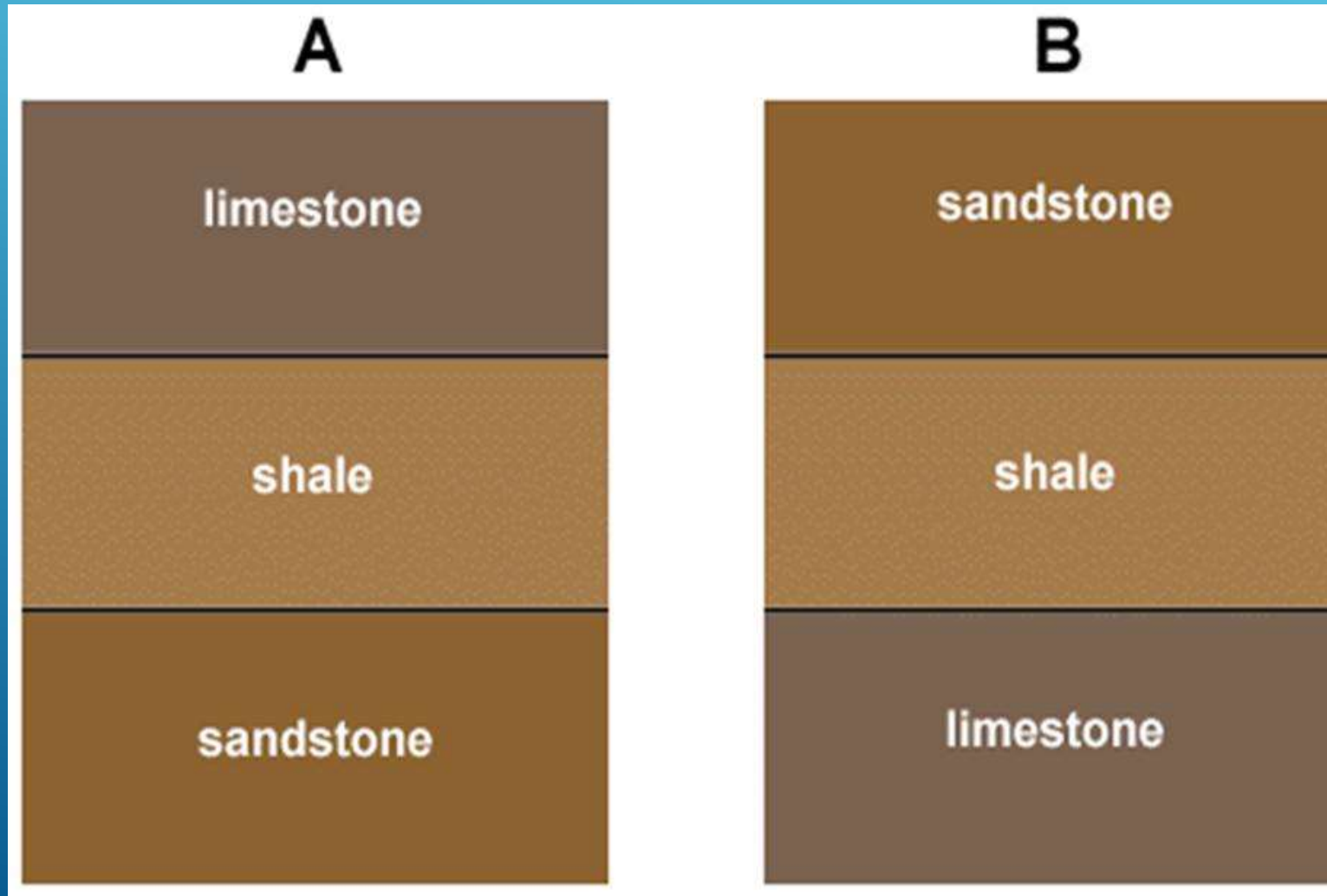
PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Regressive Sequence



PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

At an outcrop scale; transgressive sequences are distinguishable from regressive sequences.



PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Facies Model

- To interpret the depositional environment of an ancient sedimentary rock, many different properties of rock must be examined and compared to some mental picture of properties of rock deposited in known depositional environment
- This mental picture is an Environmental Model – **FACIES MODEL**

FACIES MODEL: is a general summary of a given depositional system, written in terms that make the summary usable, substantiated by many individual examples from recent sediments and ancient rocks (Walker, 1992)

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Facies Models are expressed in several different ways:

- As idealised sequences of facies (vertical profile logs)
- As block diagrams
- As palaeogeographic sketch map
- As combinations of all three
- As graphs and equations (Miall, 1984; Walker, 1984)

Facies Models should fulfill four functions:


- It must act as a norm, for the purpose of comparisons
- It must act as framework and guide for future observations
- It must act as predictor in new geological situations and
- It must act as a basis for environmental interpretations

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Facies Models thus provide a method for:

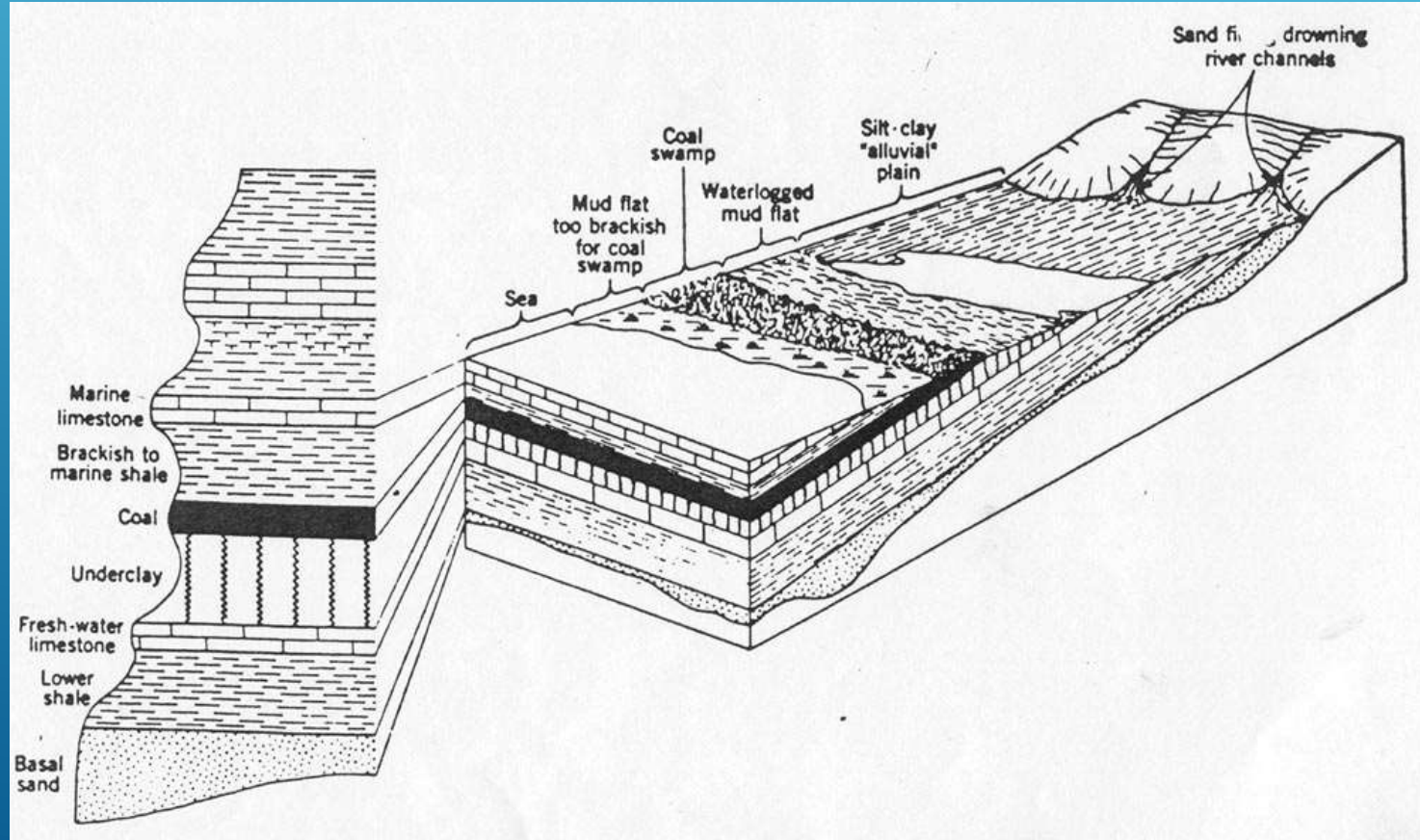
- Simplifying
- Ordering
- Categorising and
- Interpreting data that may otherwise seem random and confusing

TYPES OF FACIES MODELS

- Descriptive models are written summaries of the distinguishing characteristics of particular environments
 - Geometric models may consists of:
 - Topographic maps
 - Cross sections
 - Three-dimensional block diagrams
 - Four dimensional e.g. those that may portray changes in erosion and deposition with time
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PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

- ▶ It is a basic statement of far reaching significance that only those facies and facies areas can be super imposed primarily that can be observed beside each other at the present time



PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

- ▶ Gradational (vertical) transitions from one facies to another indicate original adjacency and genetic relationship during formation.
- ▶ Sharp/erosional (vertical) contacts between facies provides NO evidence of contemporaneous genetic relationship of depositional environments



PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

- ▶ How facies models are created
 - ▶ assign all beds in a succession to facies
 - ▶ look at patterns of distribution of facies
 - ▶ develop facies association and interpret in terms of depositional environment
 - ▶ e.g., fining upwards is associated with turbidite
 - ▶ there are OTHER environments that have fining up!
 - ▶ need multiple criteria!
 - ▶ In some of the criteria look at associations of facies within basin

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

- ▶ The interpretation of strata in terms of depositional environments
- ▶ How?
 - ▶ Recognize sedimentary environments
 - ▶ Interpret rocks based on facies
 - ▶ Because there are no unique solutions can't simply analyze one outcrop and understand it!
 - ▶ Rely heavily on facies associations
 - ▶ Vertical
 - ▶ Horizontal
 - ▶ Can use idealized model to assist in analysis

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Depositional Environment: is a particular geomorphic setting in which a particular set of physical, chemical and biological processes operates to generate a certain kind of sedimentary deposit characterised by specific texture, structural and compositional properties.

Physical elements includes factors such as:

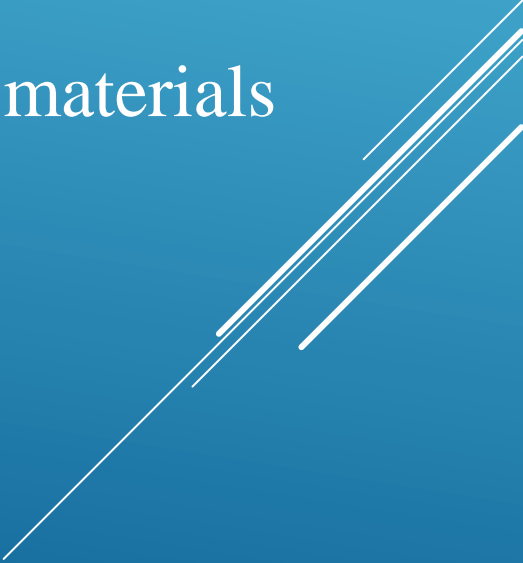
- Basin geometry
- Siliciclastic materials such as sediments
- Temperature
- Water depth
- Rainfal
- Energy and flow directions of wind, water and ice

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Chemical elements includes

- Salinity
- pH
- Eh

Biological aspects includes both:

- Activities of organisms (plant growth, burrowing, boring, sediment ingestion).
 - Presence of organic remains as depositional materials
- 

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

MAKING INTERPRETATIONS

- You take note objectively observable things in the rocks, and then you use your knowledge, your experience, and your intuition to make interpretations, specific or general.
- You can be right in your **observations** and wrong in your **interpretations**, and you're not doing any great damage. But if you are wrong in your **observations**, you are not going to be right in your **interpretations**


PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

- Don't make the mistake of mixing up **observation** and **interpretation**. Don't walk up to an **outcrop** and call the rock a beach sandstone or a point-bar sandstone. First of all, describe it, and then add an interpretation if you want to.



PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Here's a list of what you can look for in a sedimentary rock or a sedimentary bed that might tell you something about depositional environment:

- Grain size
 - Grain shape
 - Grain surface texture
 - Grain fabric
 - Sedimentary structures
 - Composition (siliciclastic; carbonate, evaporite, coal, chert)
 - Fossils (body fossils, trace fossils)
 - Stratification sequence
 - Sediment-body geometry/architecture
- 

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS


Deposition interpretations are based on three different kinds of things, basically:

- Study of modern environments
- Inferences about the results of known sedimentary processes
- Deductions about the causes of features seen in the ancient

It takes a lot of experience to get to be state-of-the-art in environmental interpretation, and nobody gets really good in all environments, just some. People who are best equipped to interpret ancient depositional environments are those who have experience in modern environments but also experience in dealing with ancient rocks and sequences. It's hard to do a good job without a combination of both.

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Basic Tools of Environmental Interpretations


- Physical, chemical and biological characteristics of sedimentary facies (rocks) that can be related to environmental parameters.
 - All available properties of sedimentary rocks should be used. **NO** single criteria can be relied upon
 - Be careful to separate primary depositional features from postdepositional features caused by **Diagenesis**
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PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Important Physical criteria for Environmental Interpretations includes:

- Gross lithology (e.g. sandstone, shale, limestone)
- Facies associations and
- Sedimentary structures

Important Biological properties such as fossils are the most useful Environmental criteria because they provide information about:

- Water depth
 - Energy
 - Salinity
 - Temperature
 - Turbidity
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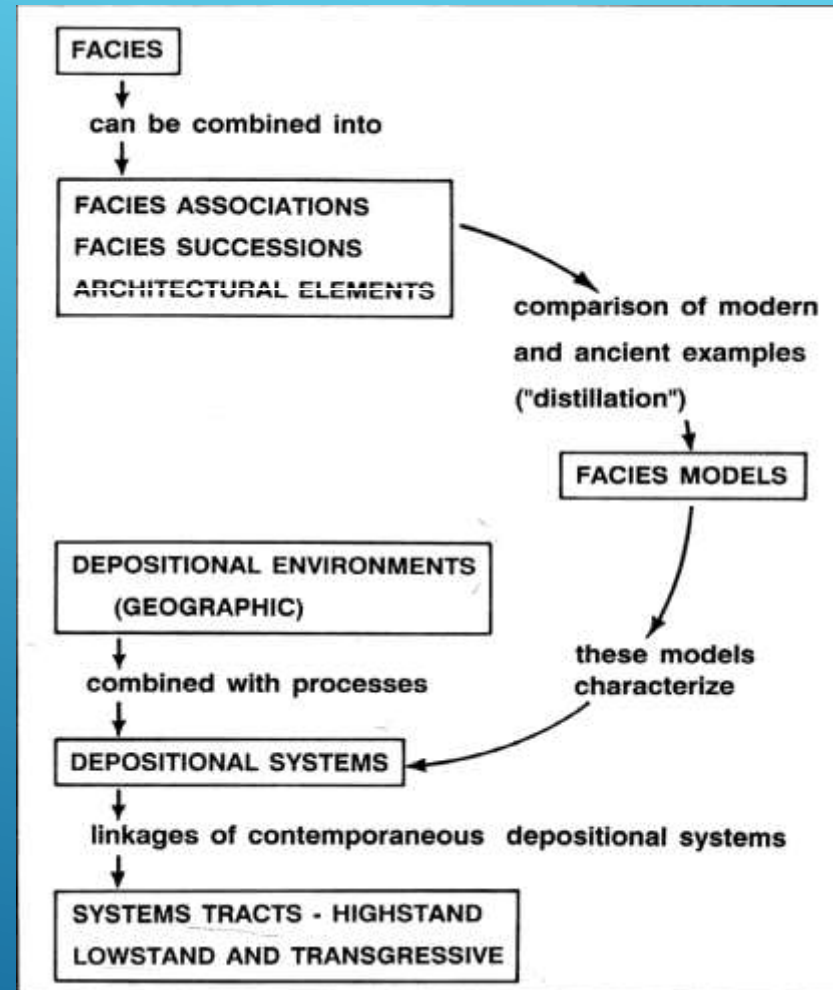
PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

Keypoints

- Depositional environment generates **sedimentary facies**.
- When we describe a sedimentary rock, we observe the results of the **processes** which have acted in the environment in which the rock was deposited.
- Facies are a **product** of depositional environment
- The characteristics properties of sedimentary facies are in turn a reflection of the conditions of the depositional environment
- Environmental interpretations must **ALWAYS** begin with study of sedimentary facies

PRINCIPLES OF ENVIRONMENTAL INTERPRETATIONS

- ▶ **Depositional Systems:**
(lithostratigraphic units)
 - ▶ Three dimensional assemblages of lithofacies, which are interpreted to be genetically linked by process and environment



How to make a stratigraphic column

▶ Look at the rocks

This may seem obvious, but it is important before you begin to get a general sense of the rocks in front of you. It will make it easier to make a description of the rocks later if you get a good overview first.

▶ Look for changes in rock type

If the rocks in one part of the outcrop appear very different, then it is possible that they should be their own "unit". Dividing the rock outcrop into units is based on changes either in fossils, color, rock type, and other factors, or all of these factors combined.

▶ Measure the section

Once you have determined different units, you may then measure the thicknesses of these units. (Geologists are generally not particularly interested in the *length* of the rocks, only the widths.)

▶ Start describing!

Now it's time to make specific observations about the rock you are looking at. What fossils do you see? What is the color? What kind of rock is it (sandstone, shale, limestone, or something else)?