INTRODUCTION TO PALEONTOLOGY

Shubhabrata Paul

Things to remember…

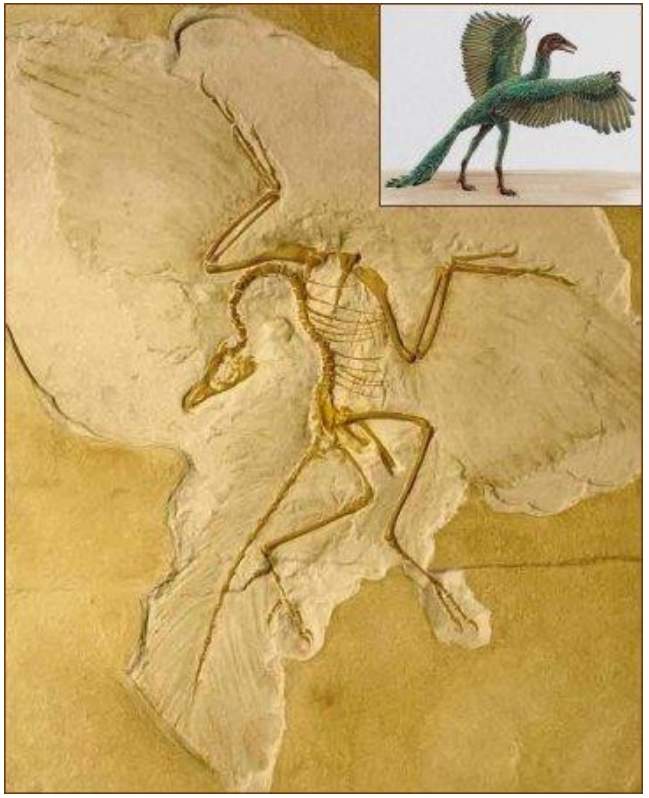
- What is a fossil?
- Types of fossils
- Fossilization
- Factors influencing preservation
- Preservation potential
- Modes of preservation

What is a fossil?

- Fossil is the remains of an ancient organism or the trace of its activities and must be preserved under natural condition.

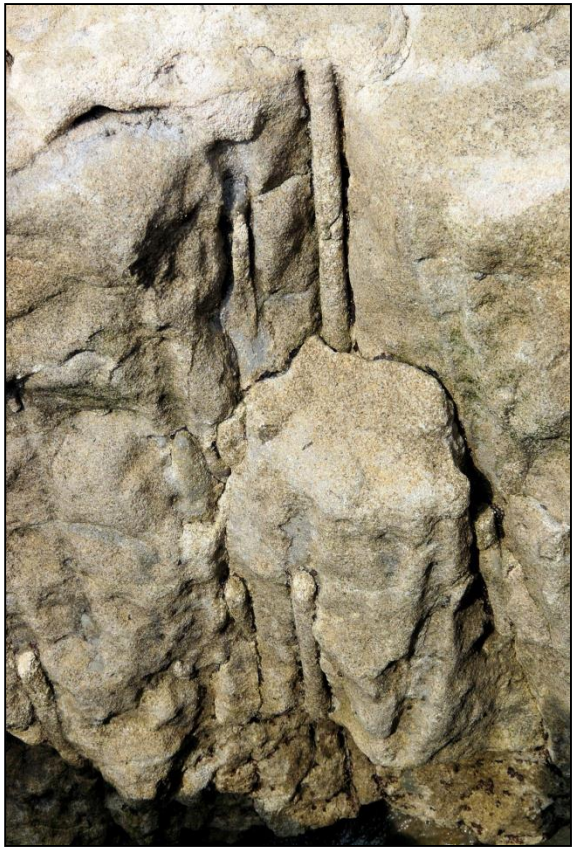
Types of fossil – Body fossil

- Complete / partial record of the body of an organism.



Types of fossil – Trace fossil

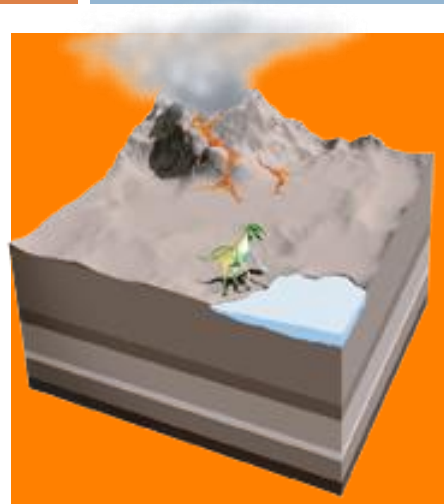
- Records activity of an organism.



Types of fossil – Chemical fossil

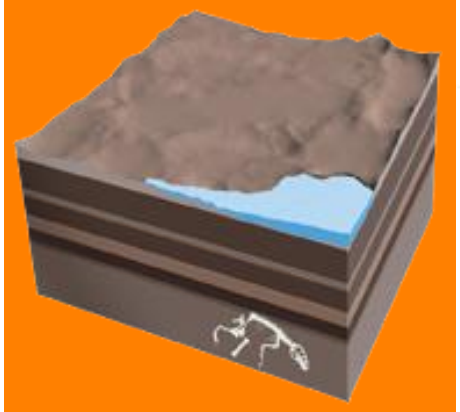
- Molecular fossil
- Isotope data

How are fossils formed?



1. Sediment

An animal is buried by sediment, such as volcanic ash or silt, shortly after it dies. Its bones are protected from rotting by the layer of sediment.

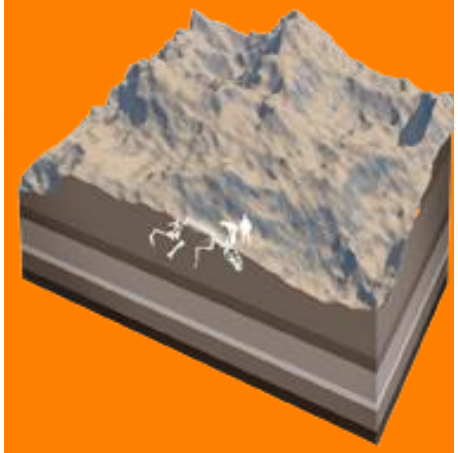


2. Layers

More sediment layers accumulate above the animal's remains, and minerals, such as silica (a compound of silicon and oxygen), slowly replace the calcium phosphate in the bones.

3. Movement

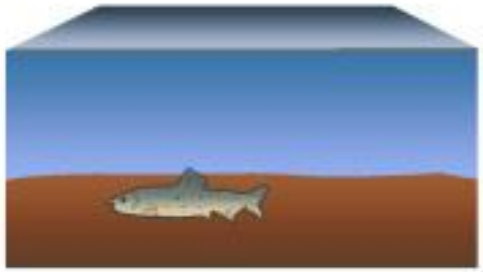
Movement of tectonic plates, or giant rock slabs that make up Earth's surface, lifts up the sediments and pushes the fossil closer to the surface.



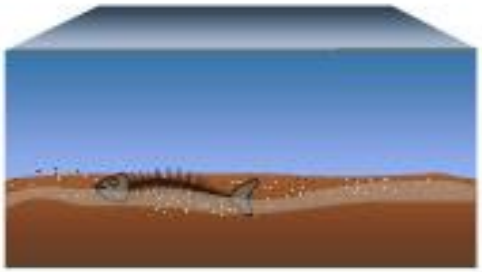
4. Erosion

Erosion from rain, rivers, and wind wears away the remaining rock layers. Eventually, erosion or people digging for fossils will expose the preserved remains.

How are fossils formed?



1. A fish dies and sinks to the bottom of a lake.



2. The fish rots and only the bones are left. The fish is covered with mud.

3. Millions of years pass and the mud turns to rock. Over time, the bone matter is completely changed into mineral matter. The fish is now a fossil.

Modes of preservation

Modes of preservation…

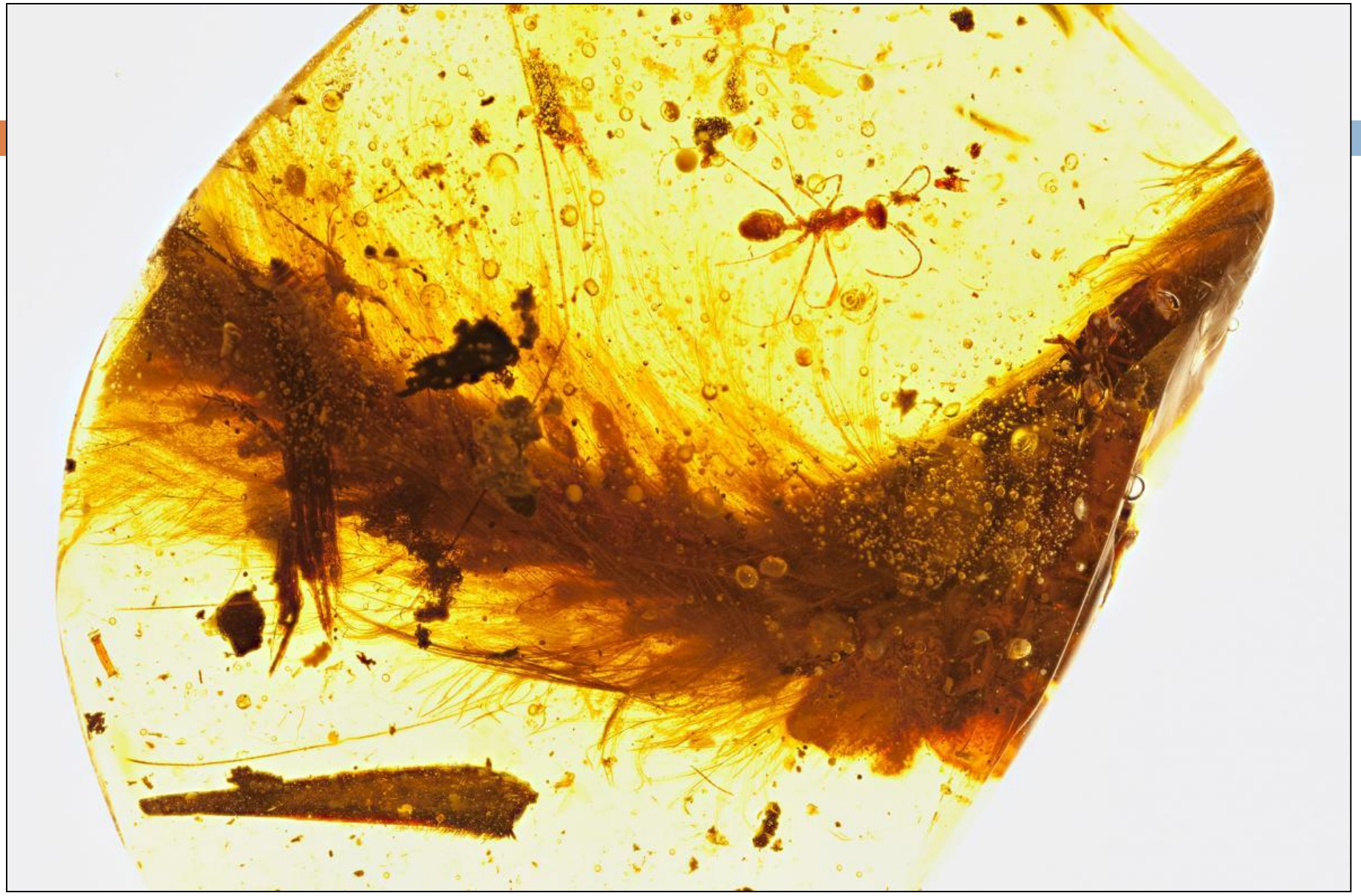
- Freezing
- Preservation in amber
- Carbonization
- Permineralization
- Replacement
- Recrystalization
- Molds & Casts

Freezing…

- Preserves an organism wholly without any alteration to the chemical composition of the organism.

Preservation in amber…

- Amber, the fossilized resin of a plant or tree, sometimes preserves not only the external, but also the internal structure of an organism.



Carbonization…

- **All living things contain an element called carbon.**
- **When an organism dies and is buried in sediment, the materials that make up the organism break down.**
- **Eventually, only carbon remains.**
- **The thin layer of carbon left behind can show an organism's delicate parts, like leaves on a plant.**

Permineralization…

- Voids in the hard parts of organisms are filled with minerals.

Replacement…

- Skeletal material is replaced by some new alien material.

Recrystalization…

- The original mineral crystals are altered in size and/or geometry over time, yet the chemical composition remains unchanged.

- Example:
  - Aragonite recrystallizing to calcite

Molds & Casts…

MOLD FOSSIL

This mold, or imprint, is of an extinct mollusk called an ammonite.

CAST FOSSIL

This ammonite cast was discovered in the United Kingdom.

- **A mold forms when hard parts of an organism are buried in sediment, such as sand, silt, or clay.**
- **The hard parts completely dissolve over time, leaving behind a hollow area with the organism's shape.**
- **A cast forms as the result of a mold.**
- **Water with dissolved minerals and sediment fills the mold's empty spaces.**
- **Minerals and sediment that are left in the mold make a cast.**
- **A cast is the opposite of its mold.**

Molds & Casts…

Everything is not preserved

Everything is not preserved…

TABLE 1–1 Estimates of the total number of living marine invertebrate species described and of the number of these that may be fossilizable because they have hard skeletons.

	Total living species described	Total described species "fossilizable"
Foraminiferida and Radiolaria	20,000	20,000
Porifera (sponges)	2,250	1,750
Cnidaria (largely corals)	9,500	6,200
"Worms"	20,000	1,000
Bryozoa	3,000	3,000
Brachiopoda	225	225
Mollusca	54,300	53,100
Arthropoda	23,000	10,500
Echinodermata	6,000	5,000
Others	2,000	
TOTALS	140,275	100,775

Source: Modified from Valentine.

TABLE 1.4
Proportion of Living Taxa with a Fossil Record

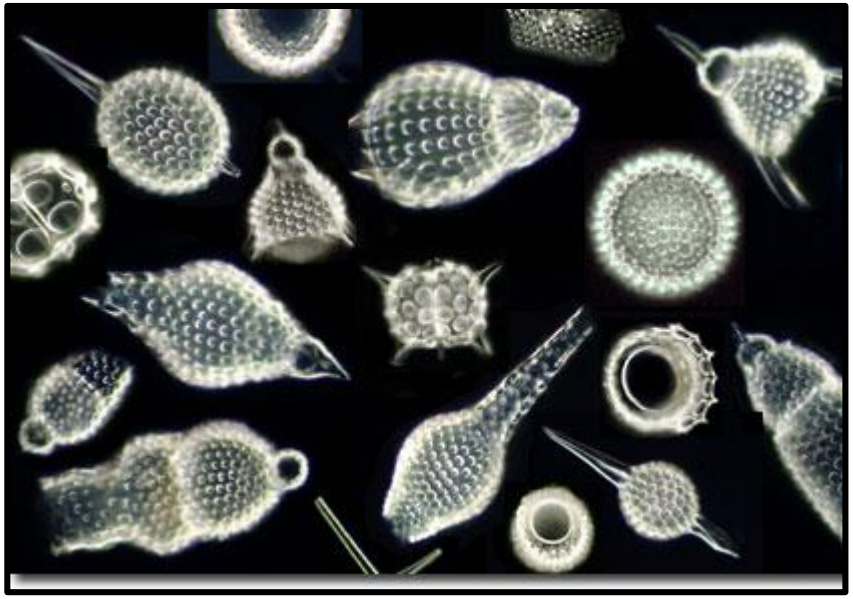
Group	Taxonomic Level	Percent
Sponges	Family	48
Corals	Family	32
Polychaetes	Family	35
Malacostracan crustaceans	Family	19
Ostracodes	Family	82
	Genus	42
Bryozoans	Family	74
Brachiopods	Family	100
	Genus	77
Crinoids	Family	50
Asterozoans	Family	57
	Genus	5
Echinoids	Family	89
	Genus	41
Bivalves	Family	95
	Genus	76
Gastropods	Family	59
Cephalopods	Family	20
Cartilaginous fishes	Family	95
Bony fishes	Family	62
Arachnids	Genus	2
	Species	< 1

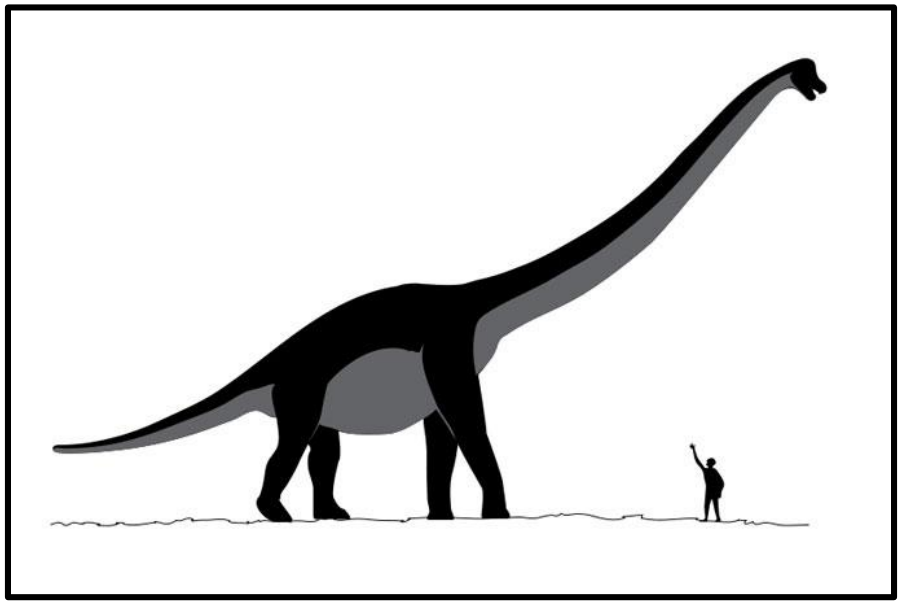
SOURCES: Raup (1979); Foote & Sepkoski (1999); Valentine et al. (2006). Data are global.

Intrinsic biases in preservation

- Features of an organism that affect its preservation
  - Size
  - Robustness
  - Number of elements
  - Chemistry of the hard parts

Size bias

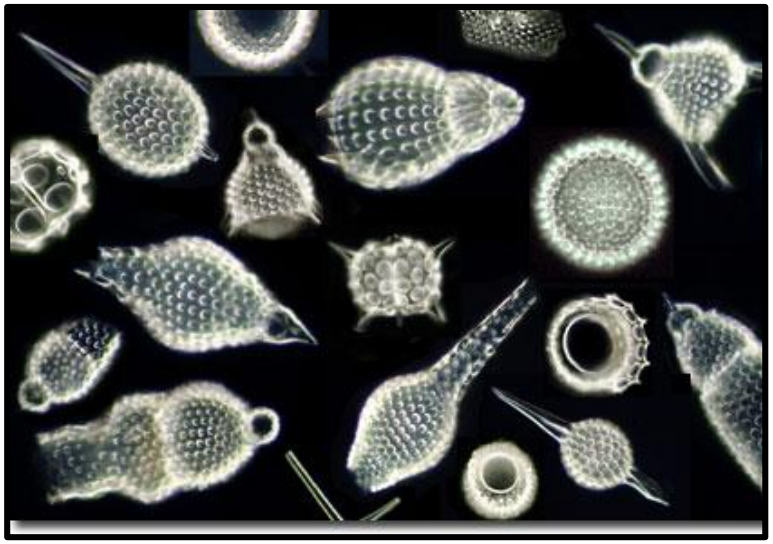


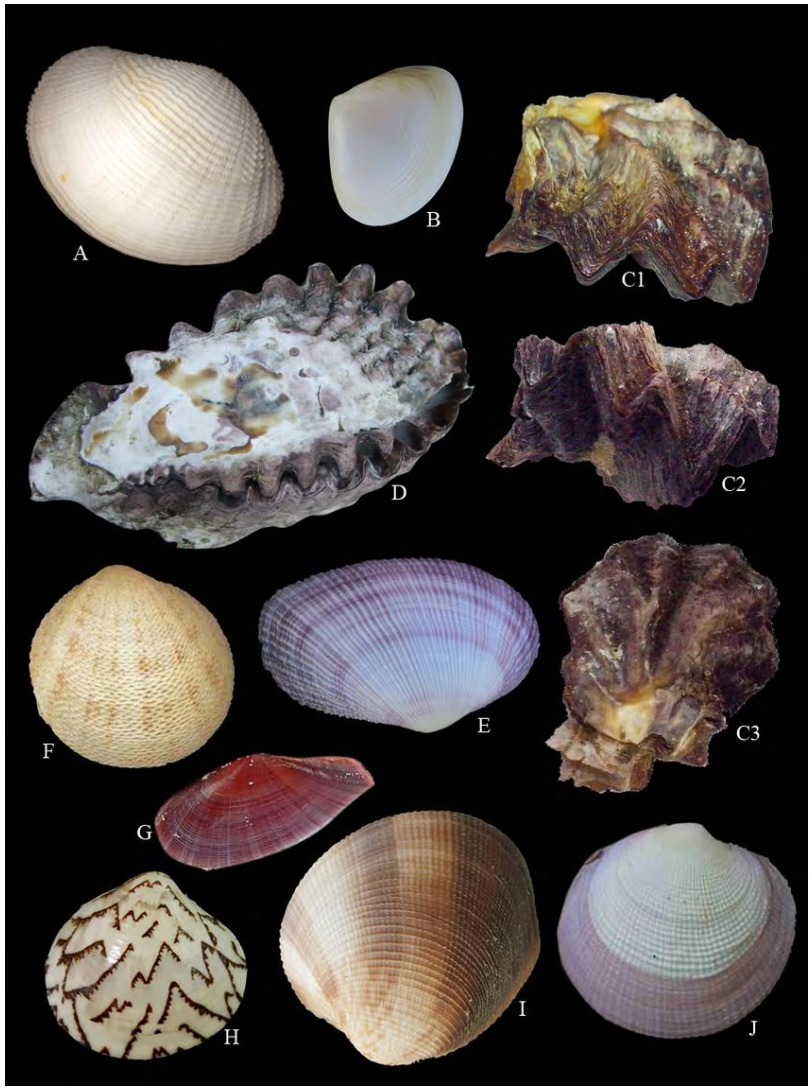


Robustness

Number of elements

Chemistry of hard body parts





Extrinsic biases in preservation

- Features of an organism's surrounding environment that affect its preservation
  - Biotic
    - Predation / Scavenging
    - Boring
  - Extrinsic
    - Decay
    - Transport
    - Burial
    - Depositional environment

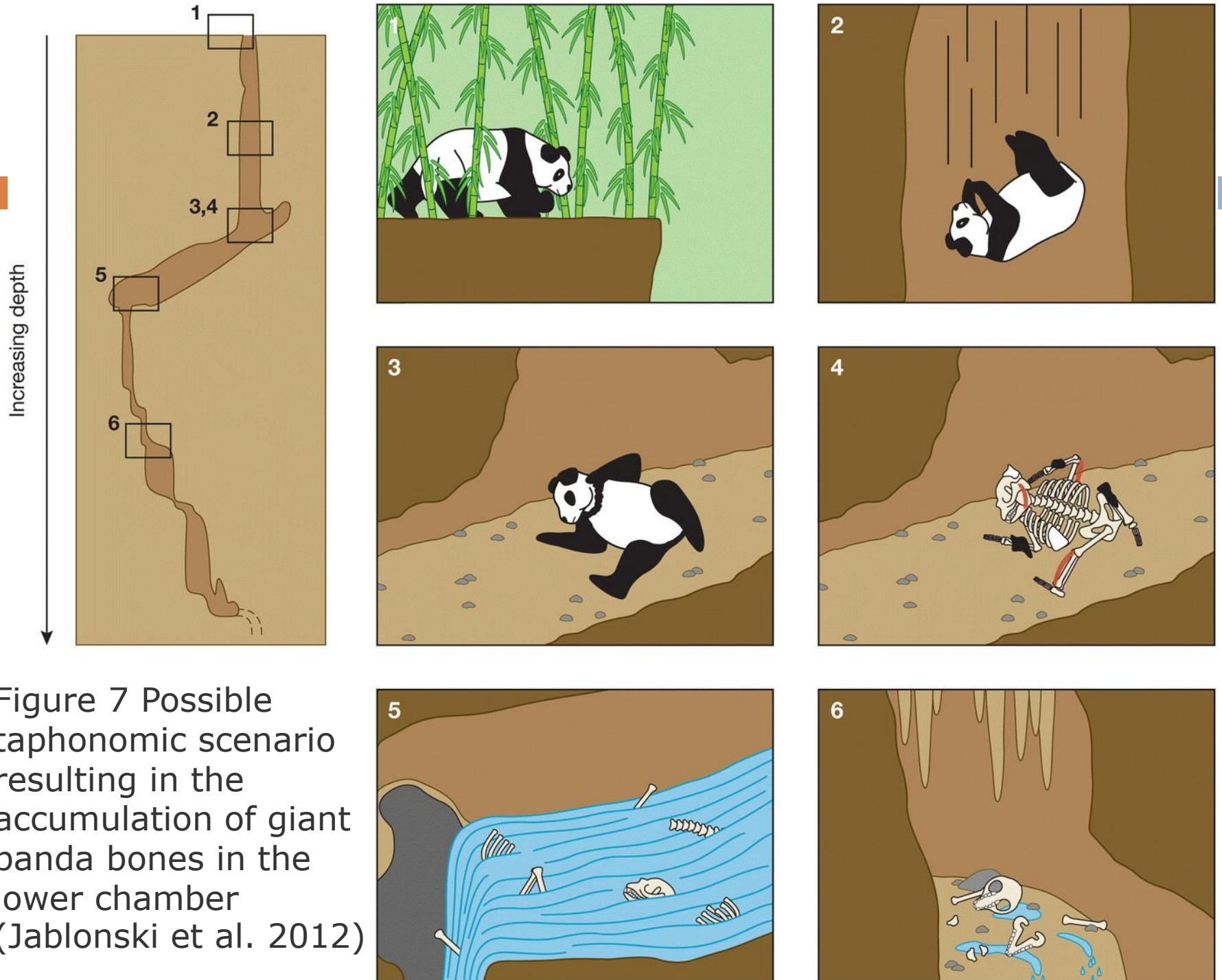


Figure 7 Possible taphonomic scenario resulting in the accumulation of giant panda bones in the lower chamber (Jablonski et al. 2012)

Boring


Sponge borings in old oyster shell (1)
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Predation/Scavengeing

Biological Destruction – predation/scavengeing

Decay

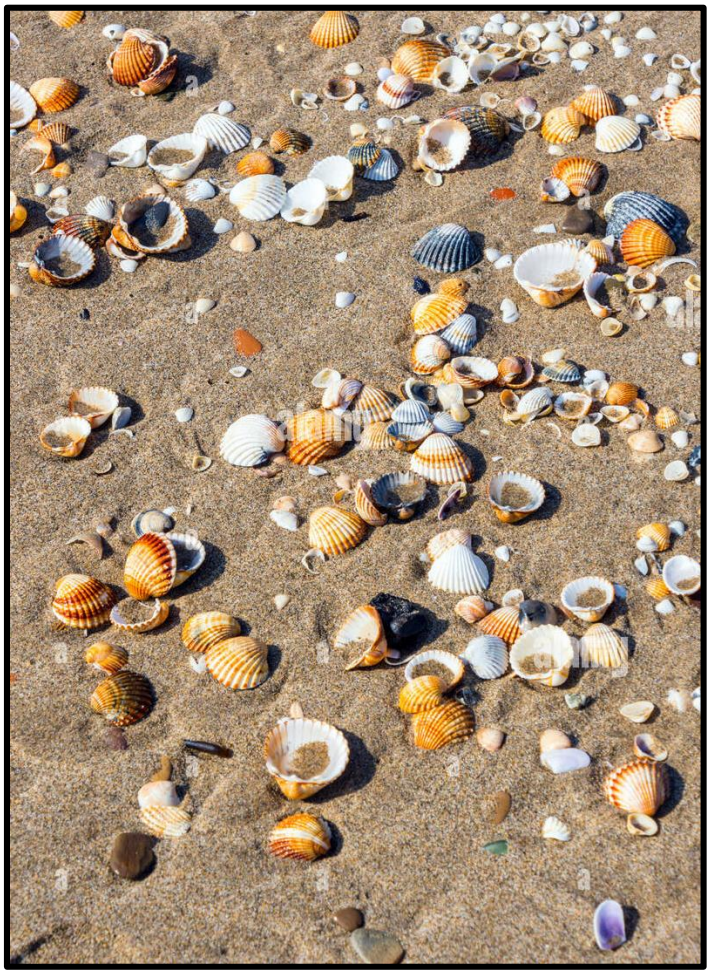
- Decay occurs from the action of microbes metabolizing the organic carbon from dead tissue

$$C_6H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O$$

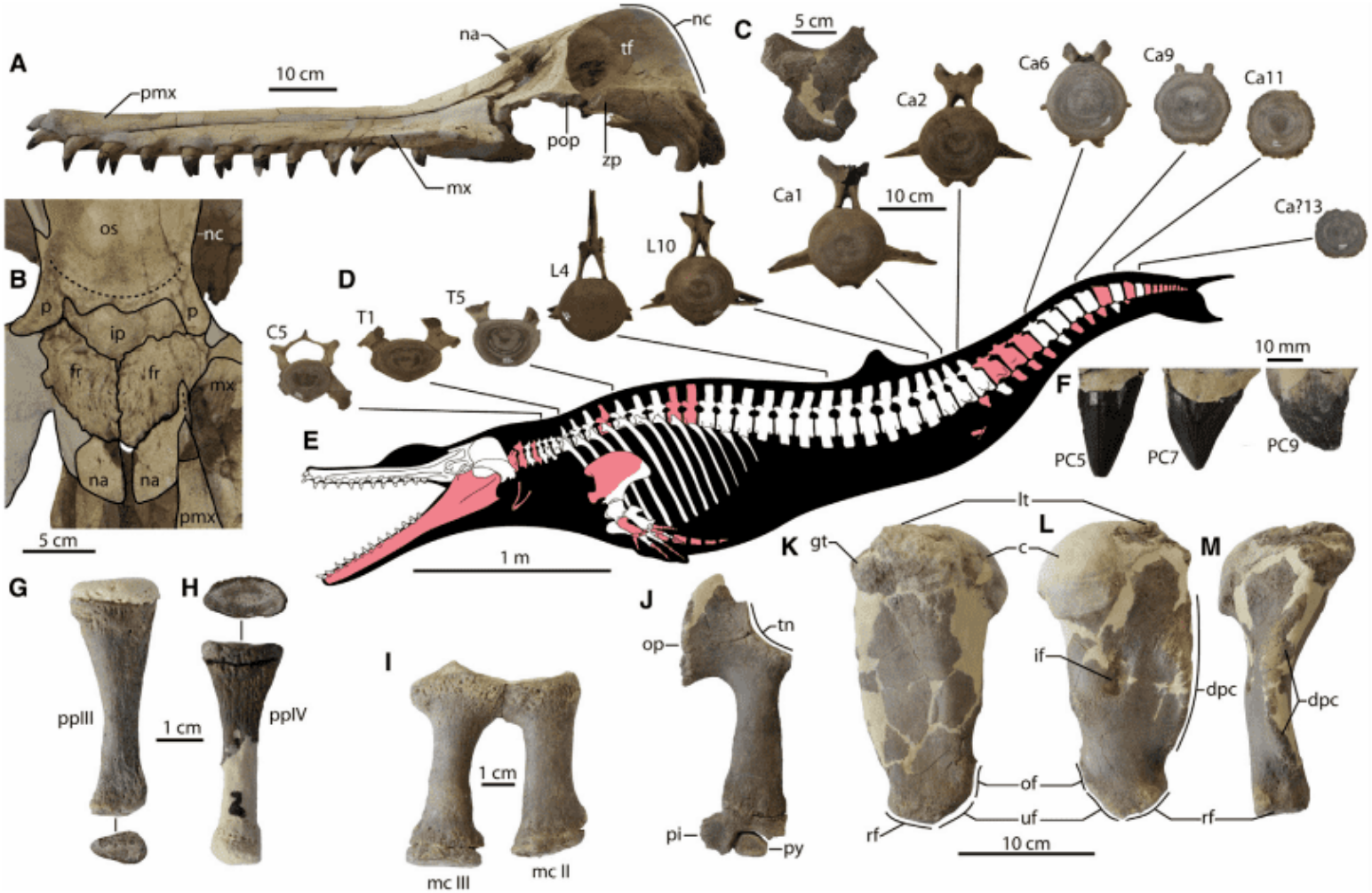
- Factors influence decay
  - Oxygen: More O_2 promotes faster decay
  - Temperature: Higher T promotes faster decay
  - pH: Lower pH promotes faster decay
  - Humidity: Higher humidity promotes faster decay

Transport - Disarticulation

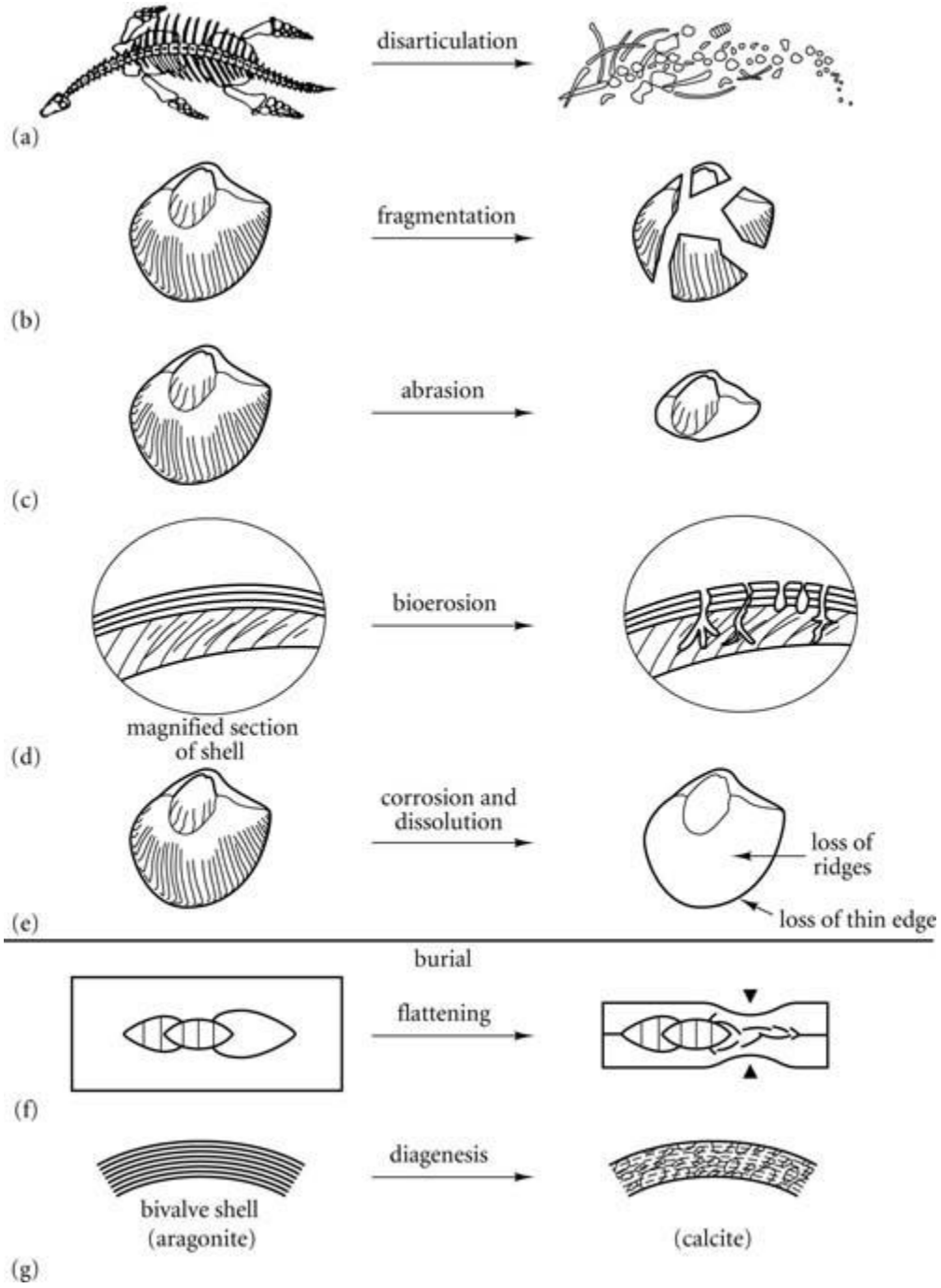
- Results in disarticulation



Transport - Fragmentation



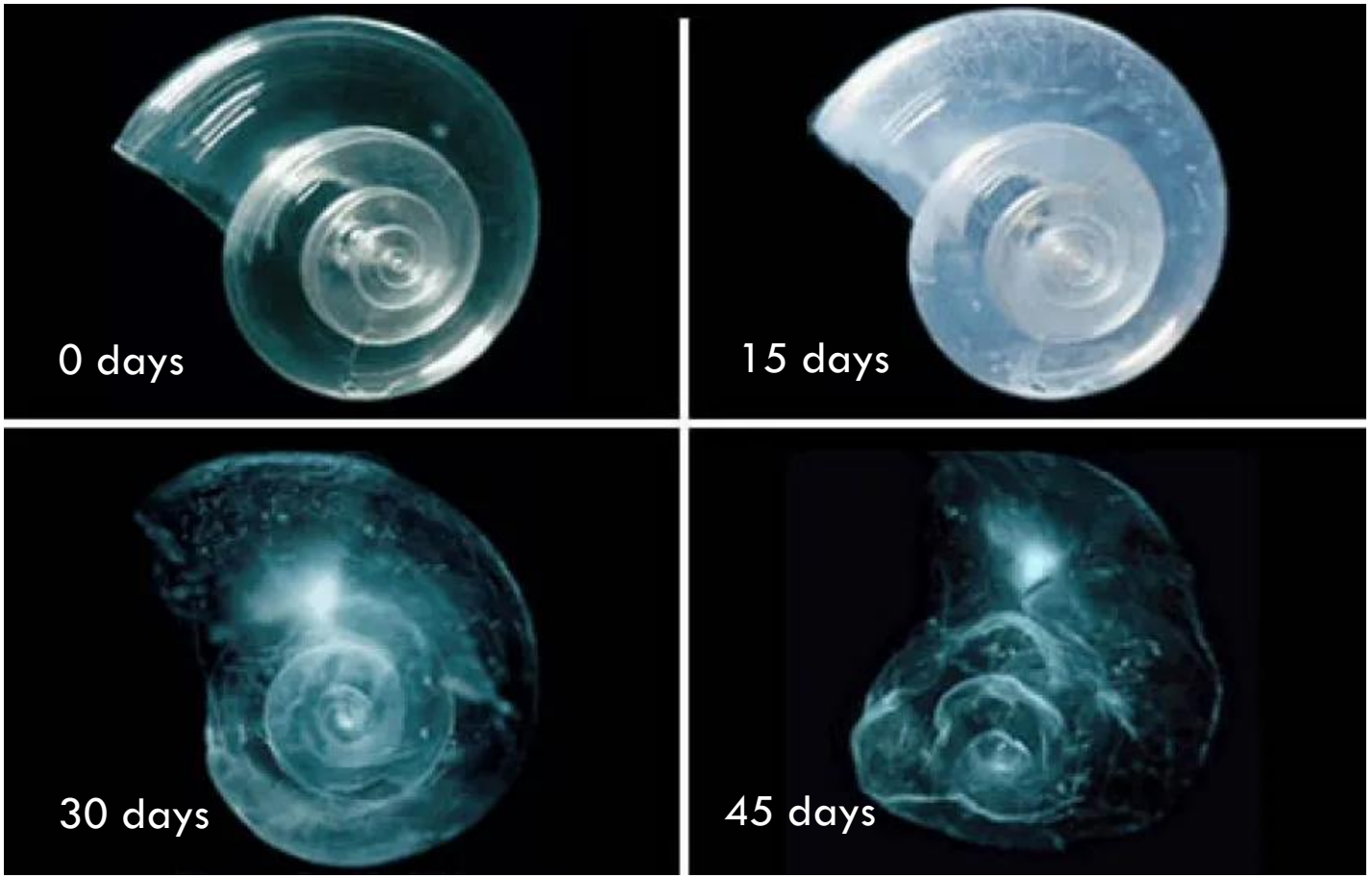
Burial



Benton & Harper, 2016

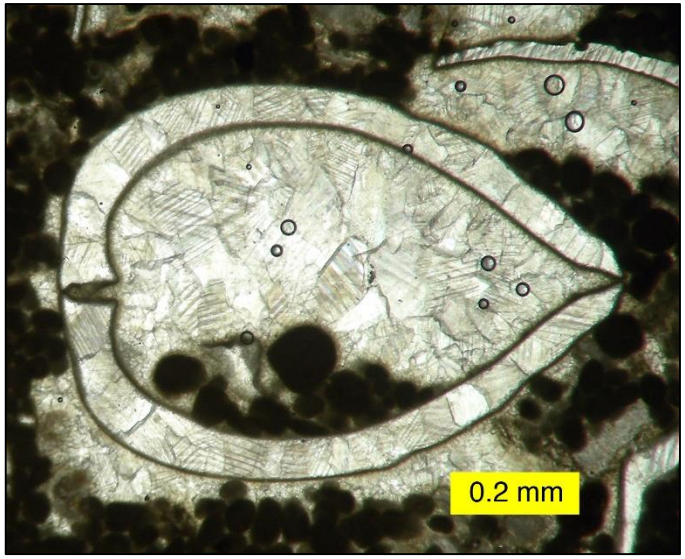
Dissolution

- Acidic water will dissolve carbonate shells



Chemical diagenesis

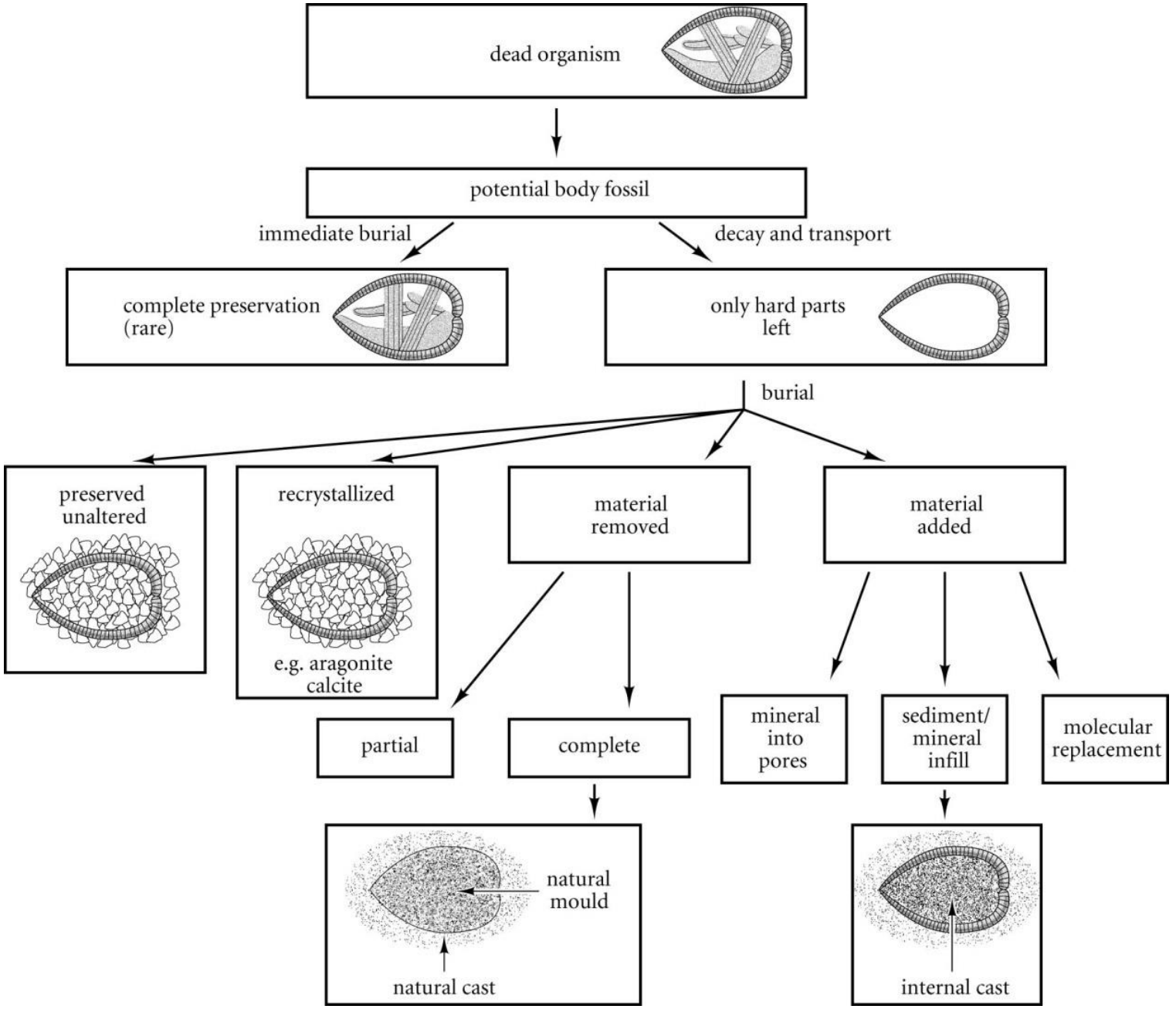
Recrystallization



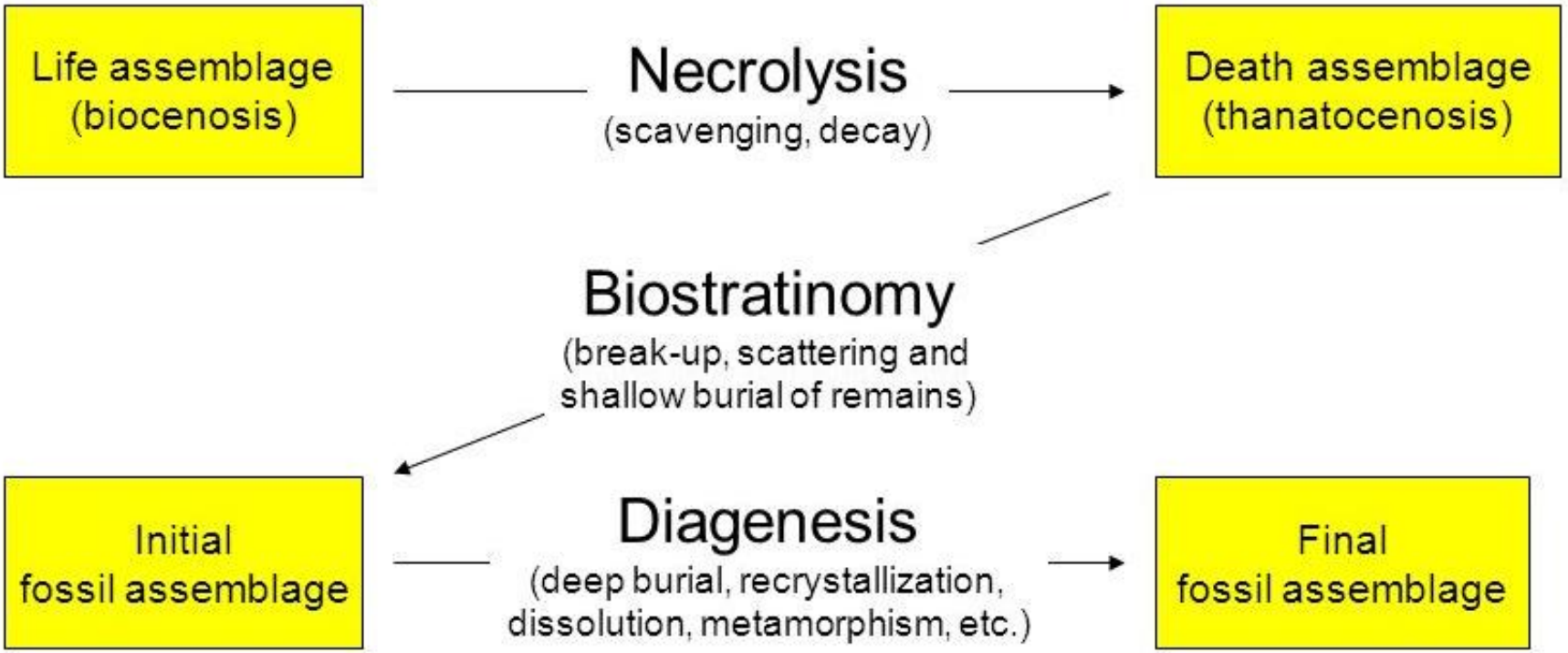
Replacement

Replacement - Pyritization

Permineralization



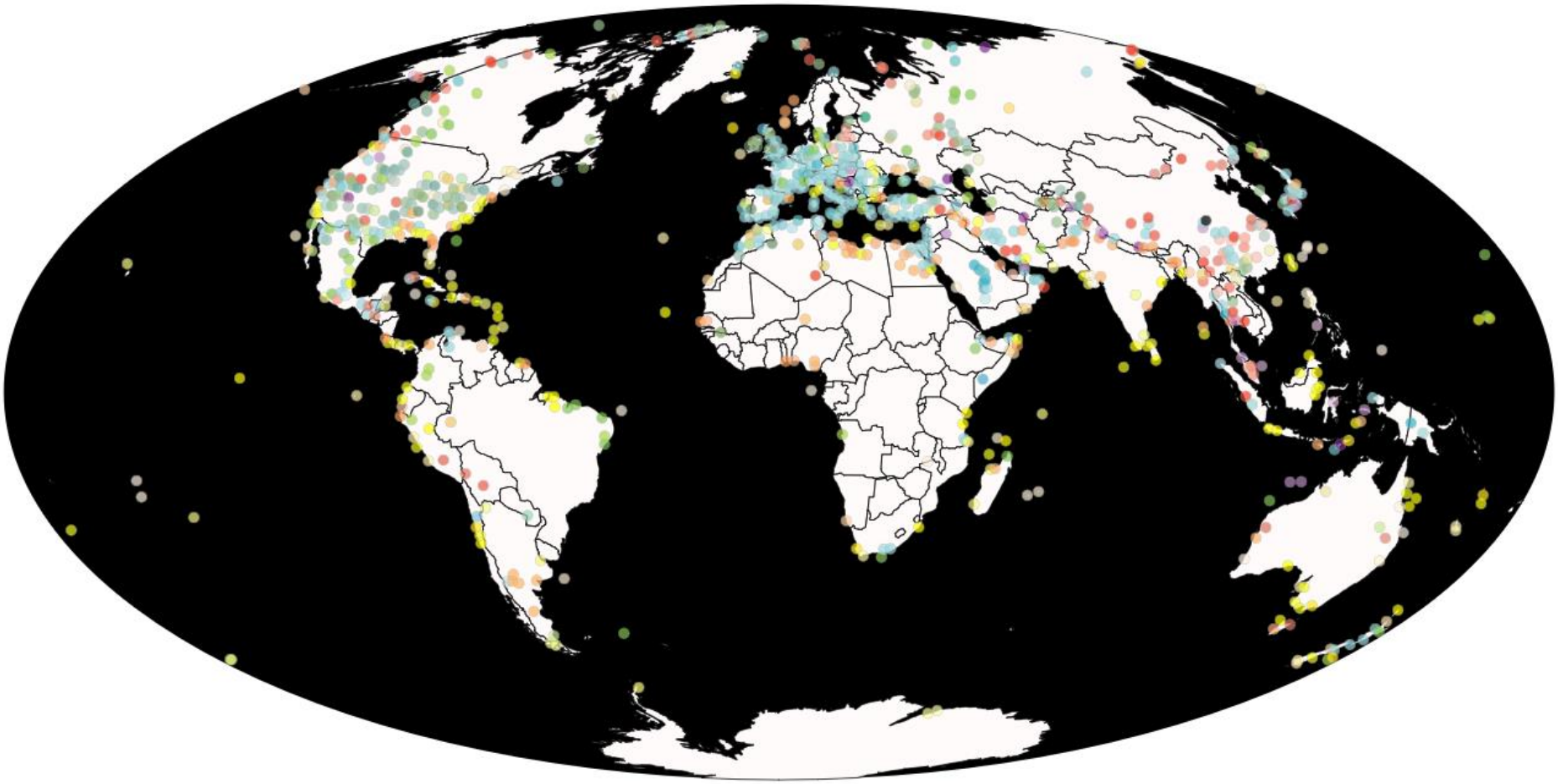
Benton & Harper, 2016


Life assemblage
(biocenosis)
Necrolysis
(scavenging, decay)
Death assemblage
(thanatocenosis)
Biostratinomy
(break-up, scattering and
shallow burial of remains)
Initial
fossil assemblage
Diagenesis
(deep burial, recrystallization,
dissolution, metamorphism, etc.)
Final
fossil assemblage

Imperfections of the fossil record

- Temporal Gap
  - Unconformities leading to major gap in the rock record
  - Subduction leading to destruction of older rocks
- Ecological / Environmental
  - Ecological / environmental bias in preservation
  - Selective preservation of some groups
- Anatomical coverage
  - Loss / Deformation of body parts

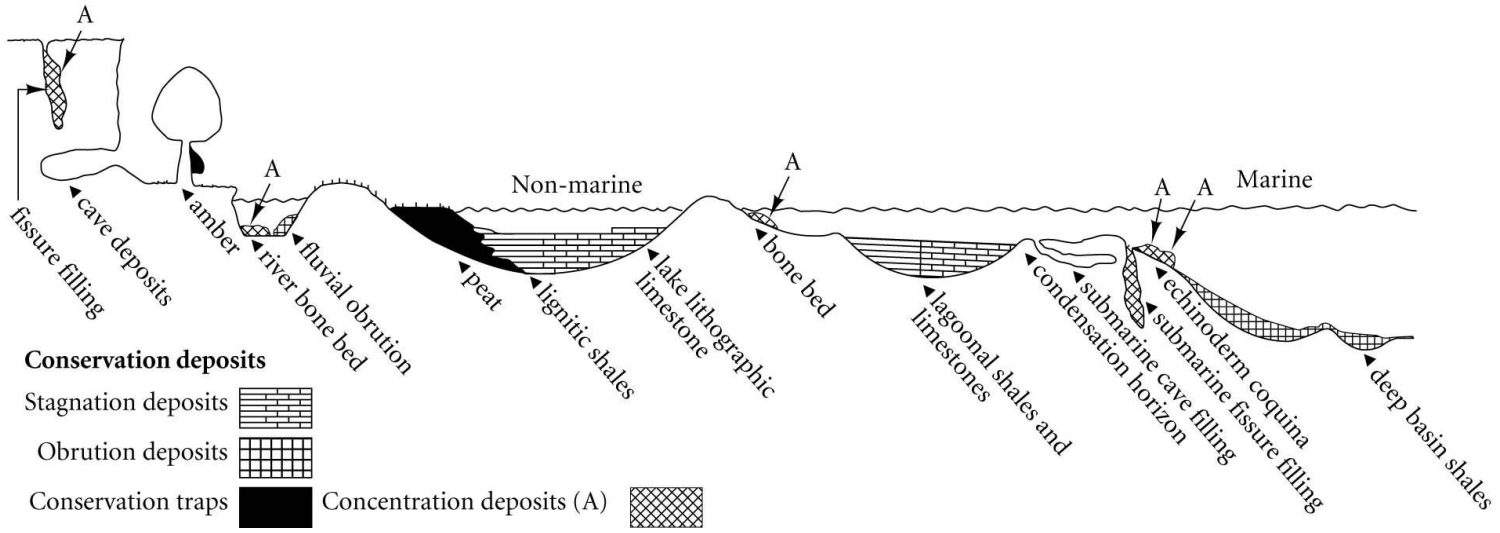
Collector bias



Global data from the Paleobiology Database; Foraminifera; Phanerozoic

Quiz: Who gets preserved?

Jellyfish	1
Clam	5
Crocodile	4 - 5
Soft-body coral	1 - 2
Butterfly	1 - 2
Leaves of trees that grow in a swamp	3 - 4
Leaves of trees that grow in a floodplain	1 - 2


A
A
A
A
A
Non-marine
Marine
fissure filling
cave deposits
amber
river bone bed
fluvial obrution
peat
lignitic shales
lake lithographic limestone
bone bed
lagoonal shales and limestones
condensation horizon
submarine cave filling
submarine fissure filling
echinoderm coquina
deep basin shales
Conservation deposits
Stagnation deposits
Obrution deposits
Conservation traps
Concentration deposits (A)