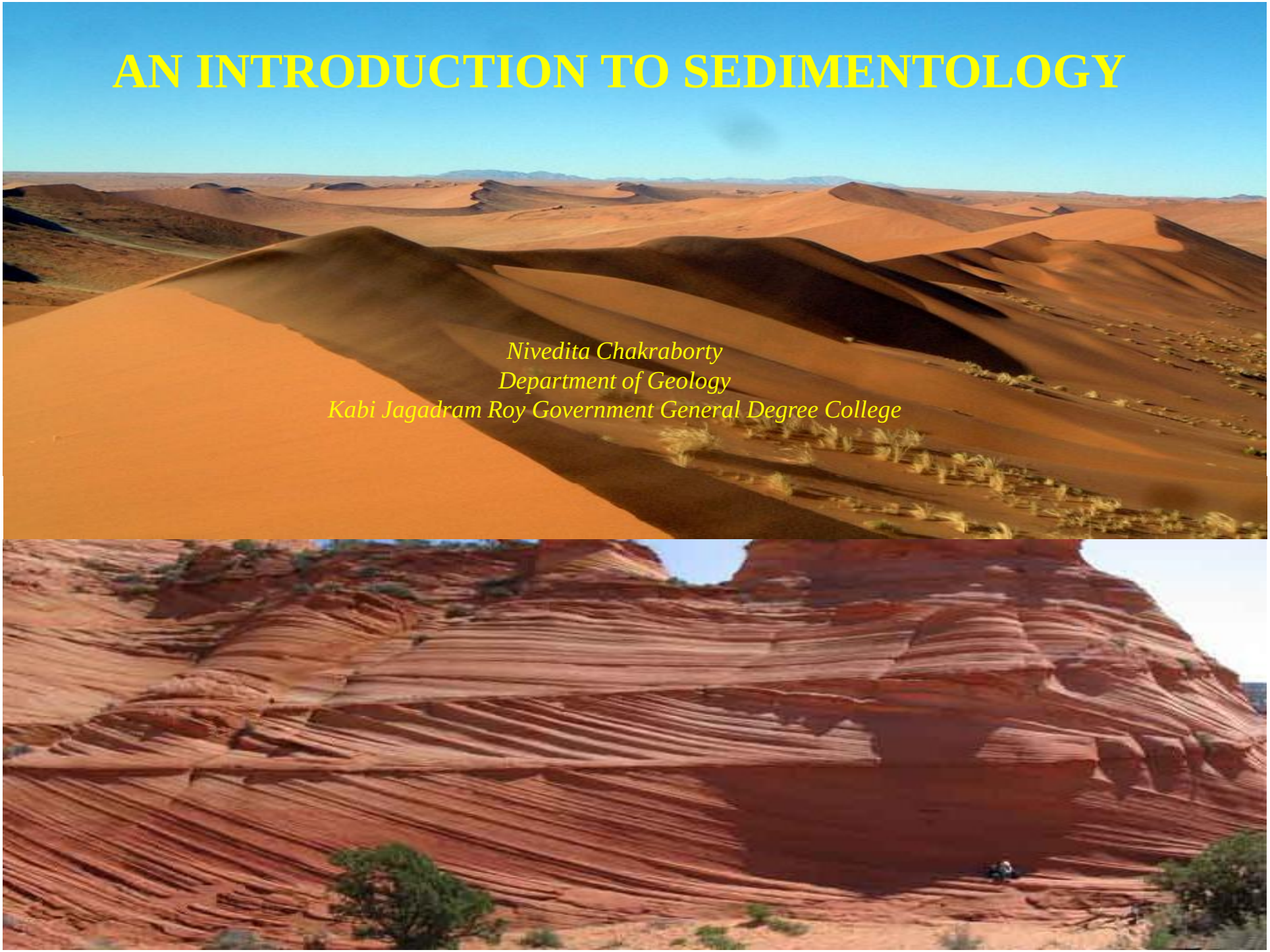
AN INTRODUCTION TO SEDIMENTOLOGY



Nivedita Chakraborty
Department of Geology
Kabi Jagadram Roy Government General Degree College

SEDIMENT

Mass of particles, generally derived from pre-existing rocks exposed on the earth's surface, precipitated under the earth surface condition through a fluid medium
(Exceptions include coal, pyroclastics and chemogenic deposits)

↓

SEDIMENTATION

Settling out of particles of the fluid medium through mechanical, chemical or biochemical processes

↓

SEDIMENTARY ROCK

Consolidated mass of particles

⇓

SEDIMENTOLOGY

Study of both modern and ancient sediments, their origin, transportation, deposition, near-surface penecontemporaneous changes and changes after burial
(changes are referred to as ***Diagenesis*** as long as that happens below 200^{O}C)

WHY IS SEDIMENTOLOGY IMPORTANT?

- Sediments and sedimentary rocks cover more than 70% of the earth's surface.

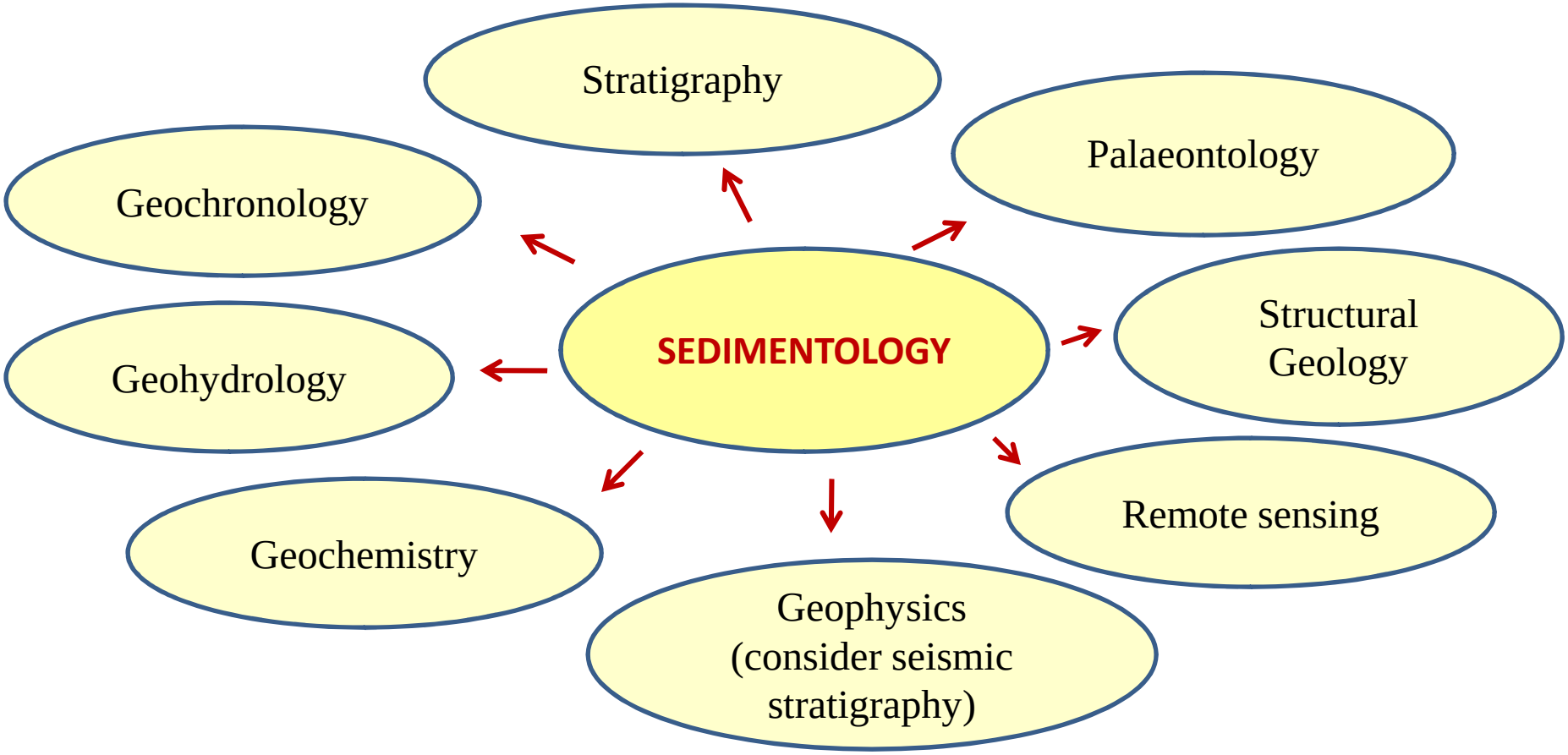
- Forming at the interface between atmosphere and biosphere, sedimentary rocks provide the only records of past life and atmosphere.

- Sedimentary environment is the prime control of life, growth or destruction of human civilization.

- Sedimentary records provide the only means to understand the earth's own natural balancing mechanism to encounter antagonistic perturbations in earth's surficial processes. Consider landslide, flood, sea level rise or global warming.

- Sedimentary rocks host a large number economic mineral deposits. Some of the essential ingredients of human civilization are exclusively sedimentary in origin. Consider coal, petroleum and iron.

LINKED WITH OTHER BRANCHES OF GEOLOGY…



- Igneous rocks are primary sources
- Sedimentary rocks are often metamorphosed and the metasediments can also serve as sediment sources.

FOUR BASIC FOOTSTEP IN SEDIMENTOLOGY

a) Sediment generation ------ weathering + erosion
b) Sediment transportation
c) Sediment deposition
d) Diagenesis

WEATHERING
(Decay and disintegration)
Climate & relief-dependent

Physical | Chemical | Biophysical/Biochemical

EROSION (Displacement)

↓

TRANSPORTATION
(Suspension, Traction, Saltation, Solution)

↓

DEPOSITION

↓

DIAGENESIS

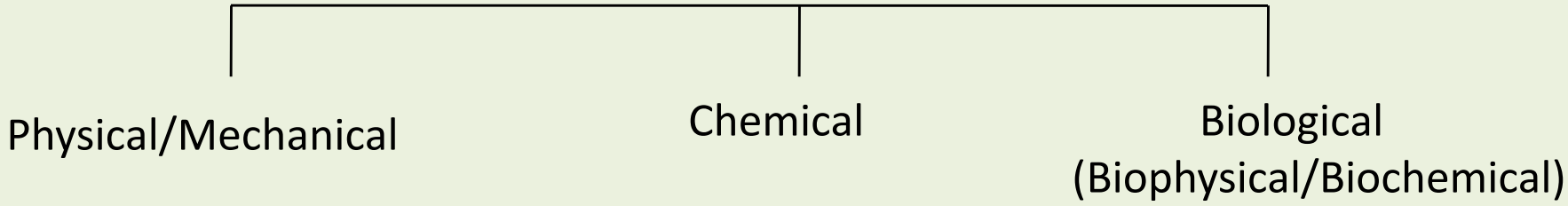
Exhumation and repetition of the same cycle – the process of **Recycling**

SEDIMENT GENERATION ------ WEATHERING + EROSION

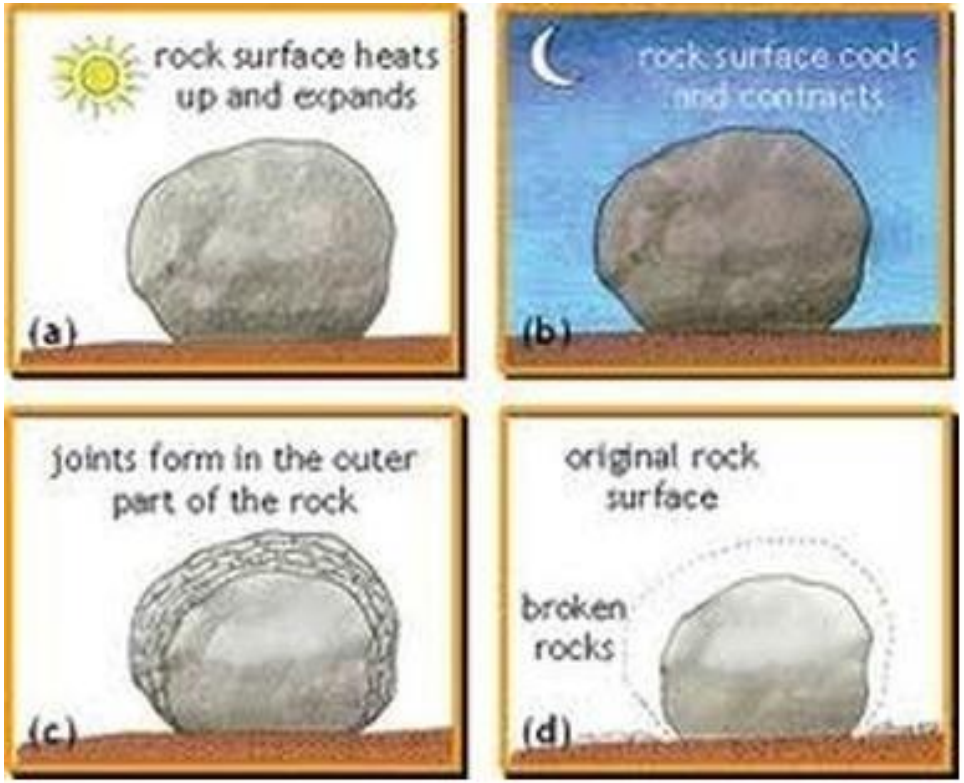
WEATHERING

(Decay and disintegration)

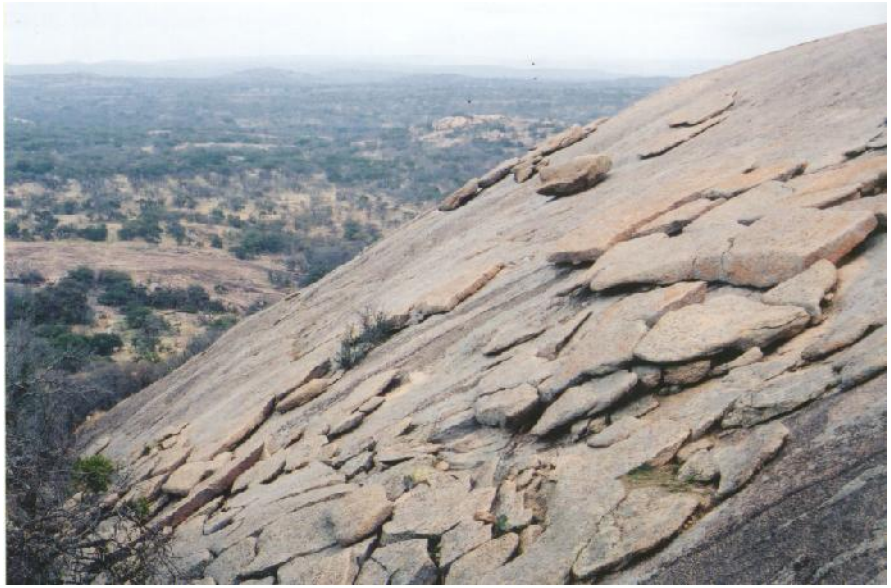
Climate & relief-dependent



Mechanical/Physical weathering: breakdown of rocks by external force/natural agents (change in temperature, effects of rain, wind, wave etc.).



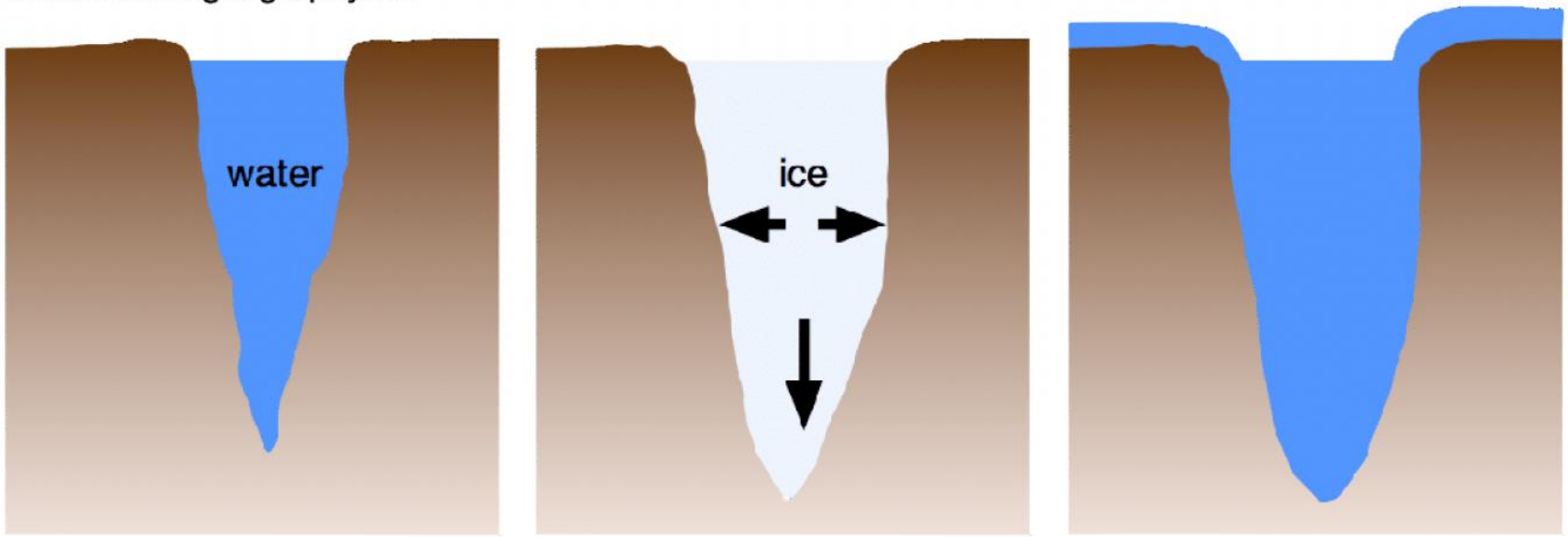
Exfoliation



Picture source: Google.com

How does freeze-thaw weathering take place?

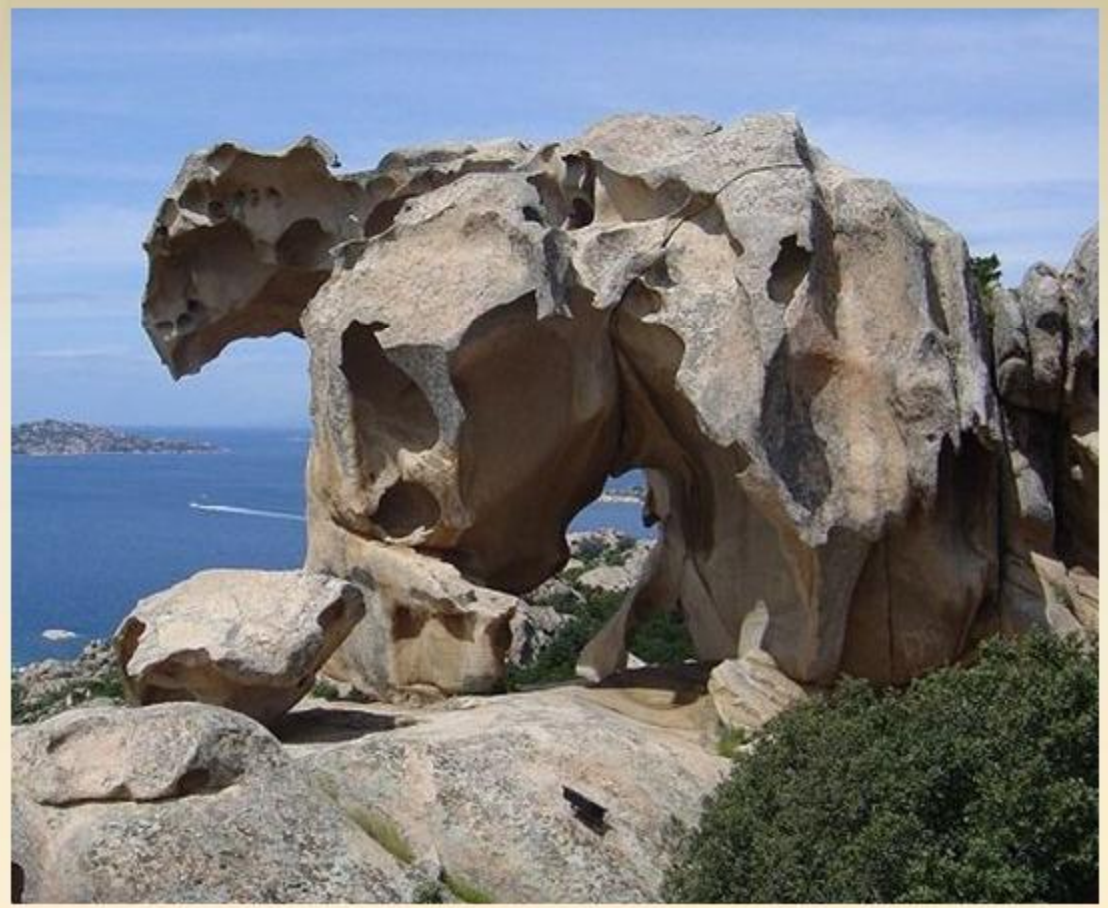
www.internetgeography.net



Water enters cracks in the rock. Temperatures fall at night, causing water to freeze. When water turns to ice it expands by ten percent. This puts pressure on the rock, prising the crack apart. The ice melts, water seeps deeper into the crack and freezes again. Over a period of time large blocks of rock can be shattered by repeated freeze-thaw weathering.

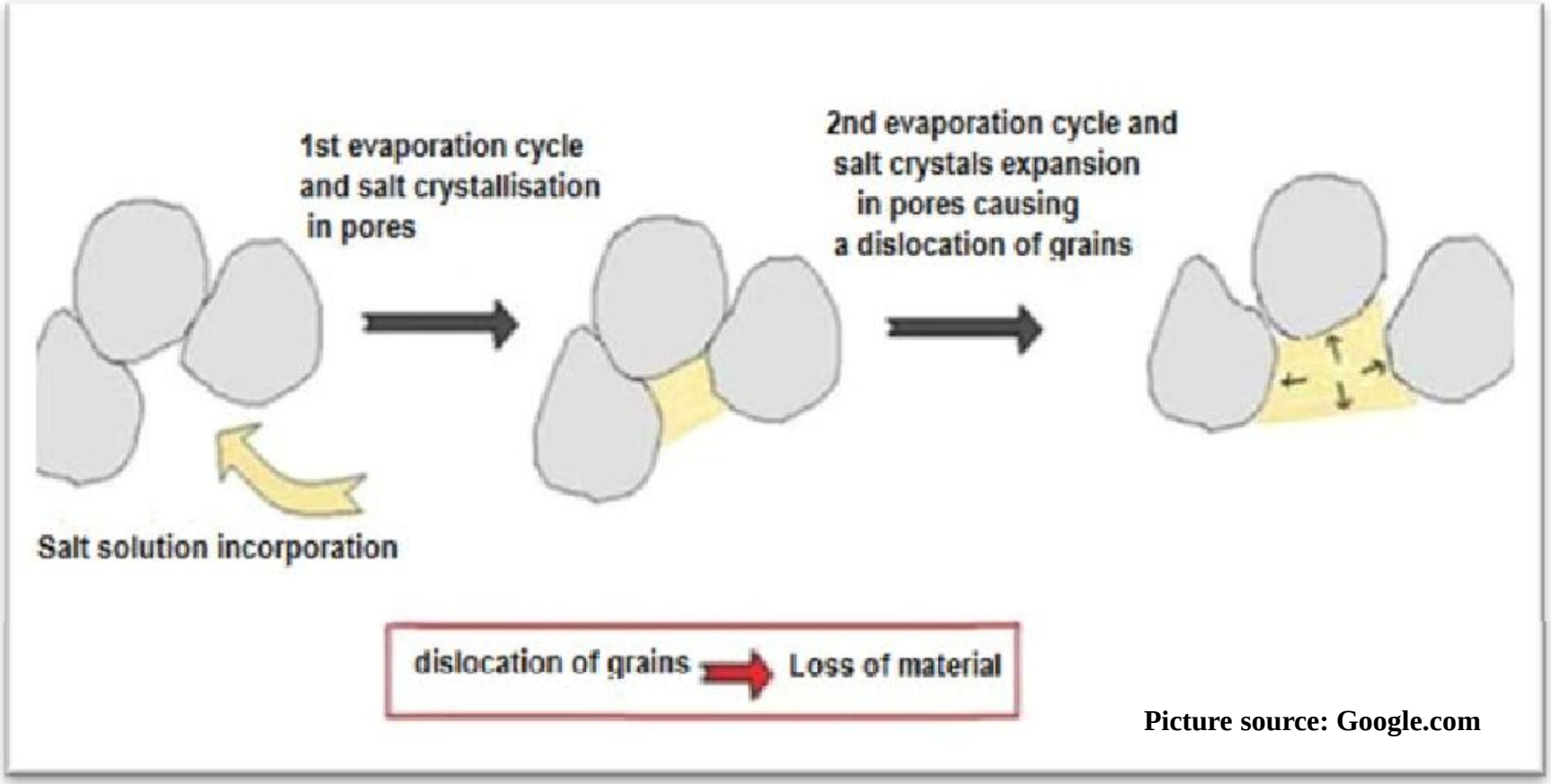
Picture source: Google.com

Crystal-growth



Weathering starts when water brings dissolved minerals to the rock surface. When the water dries, the minerals form crystals that force small particles to break off.

Picture source: Google.com



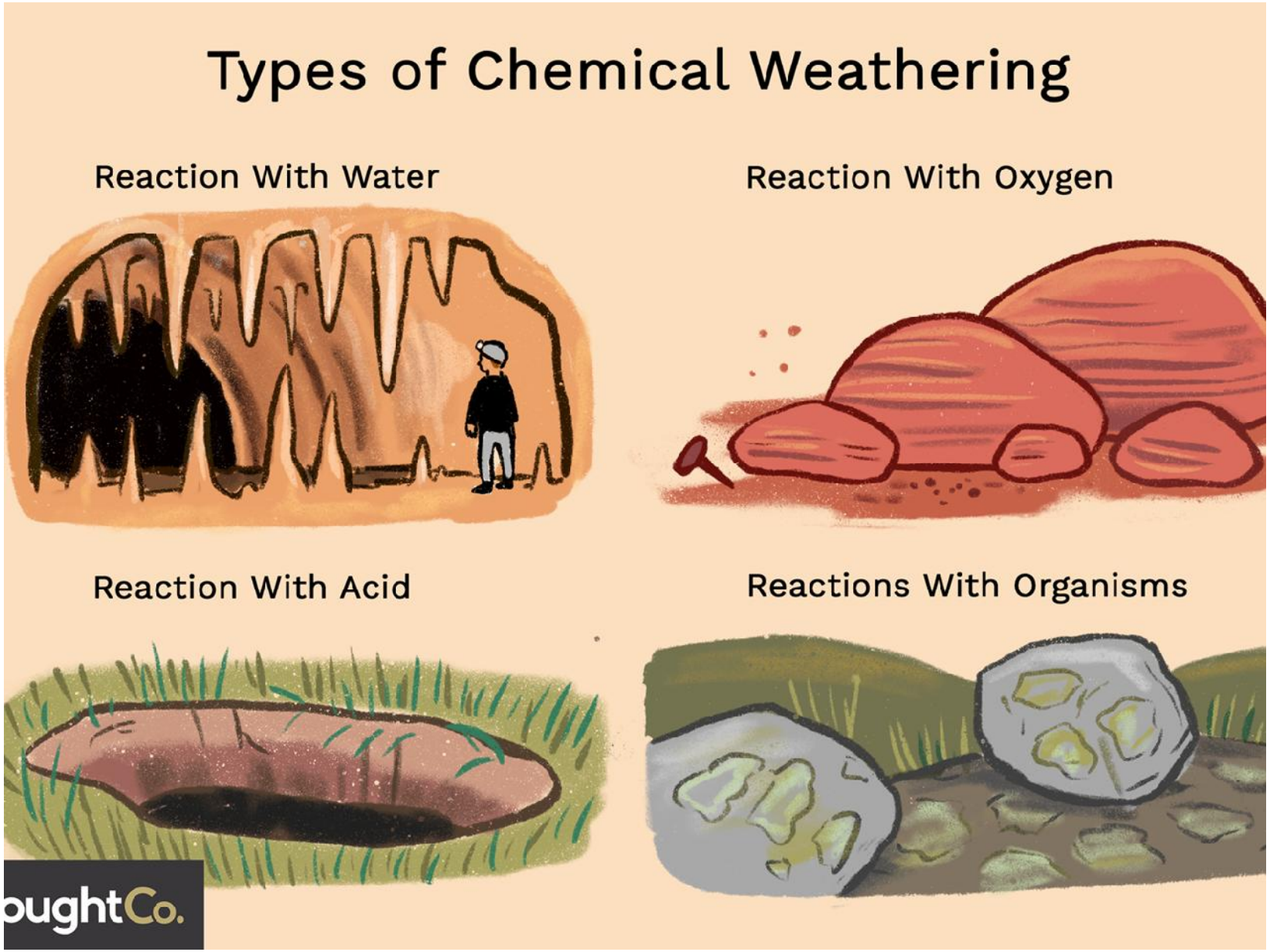
Picture source: Google.com

Salt weathering

Chemical weathering: decomposition, dissolution and alteration of rock through chemical processes

Types of Chemical Weathering

- **Oxidation**
  - when oxygen interacts chemically with minerals. (ex. when a nail rusts)
- **Hydration/Hydrolysis**
  - when water interacts chemically with minerals. (ex: when hornblende and feldspar join with water they eventually form into clay)
- **Carbonation**
  - when carbon dioxide interacts chemically with minerals. Forms carbonic acid--> ex:dissolves limestone creating caverns and caves. **Karst Topography**



Picture source: Google.com

Biological weathering:

Bio-physical weathering:

Bio-Chemical weathering:

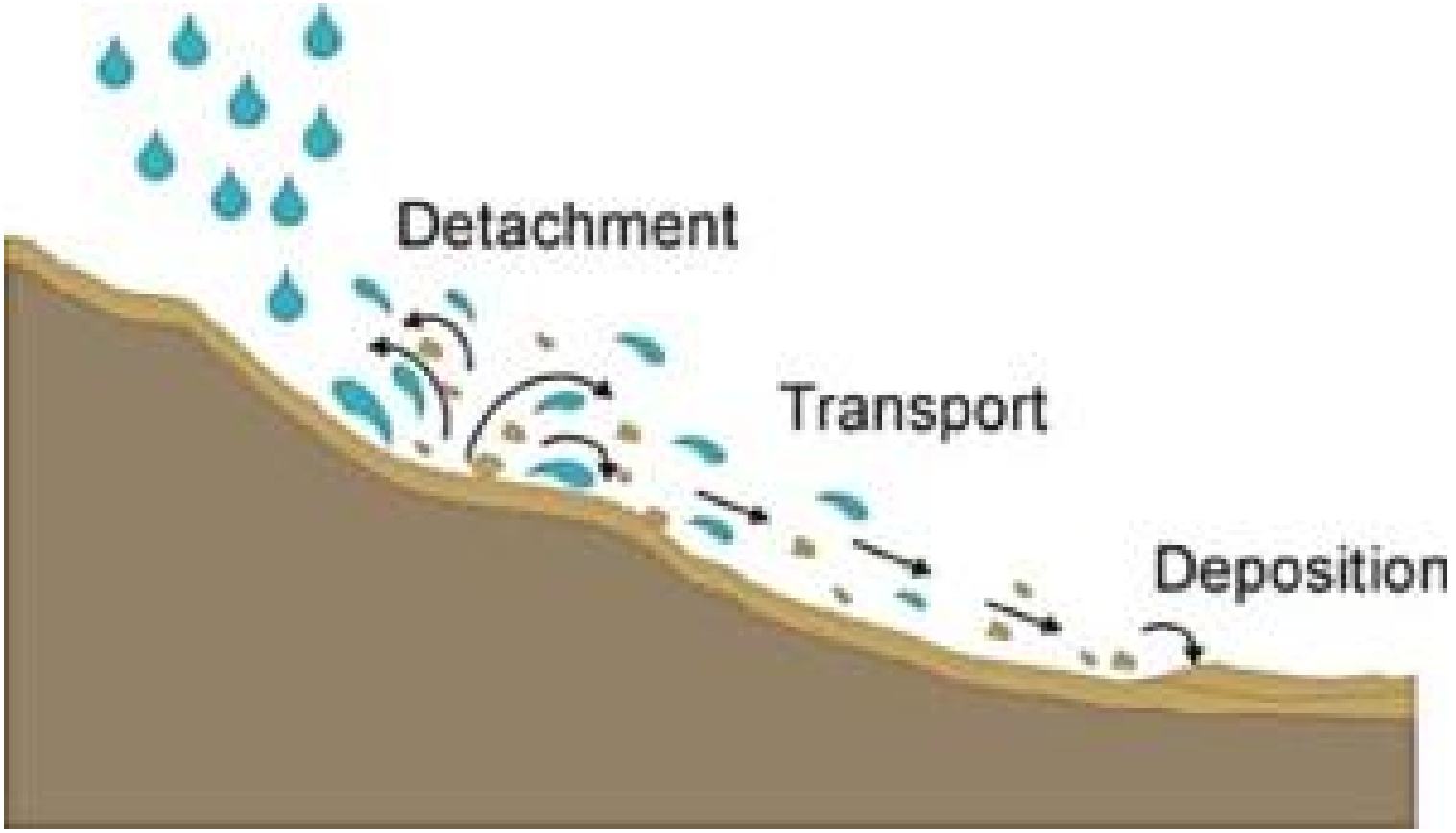
A lichen is a composite organism that arises from algae or cyanobacteria living among filaments of multiple fungi species in a mutualistic relationship.

Picture source: Google.com

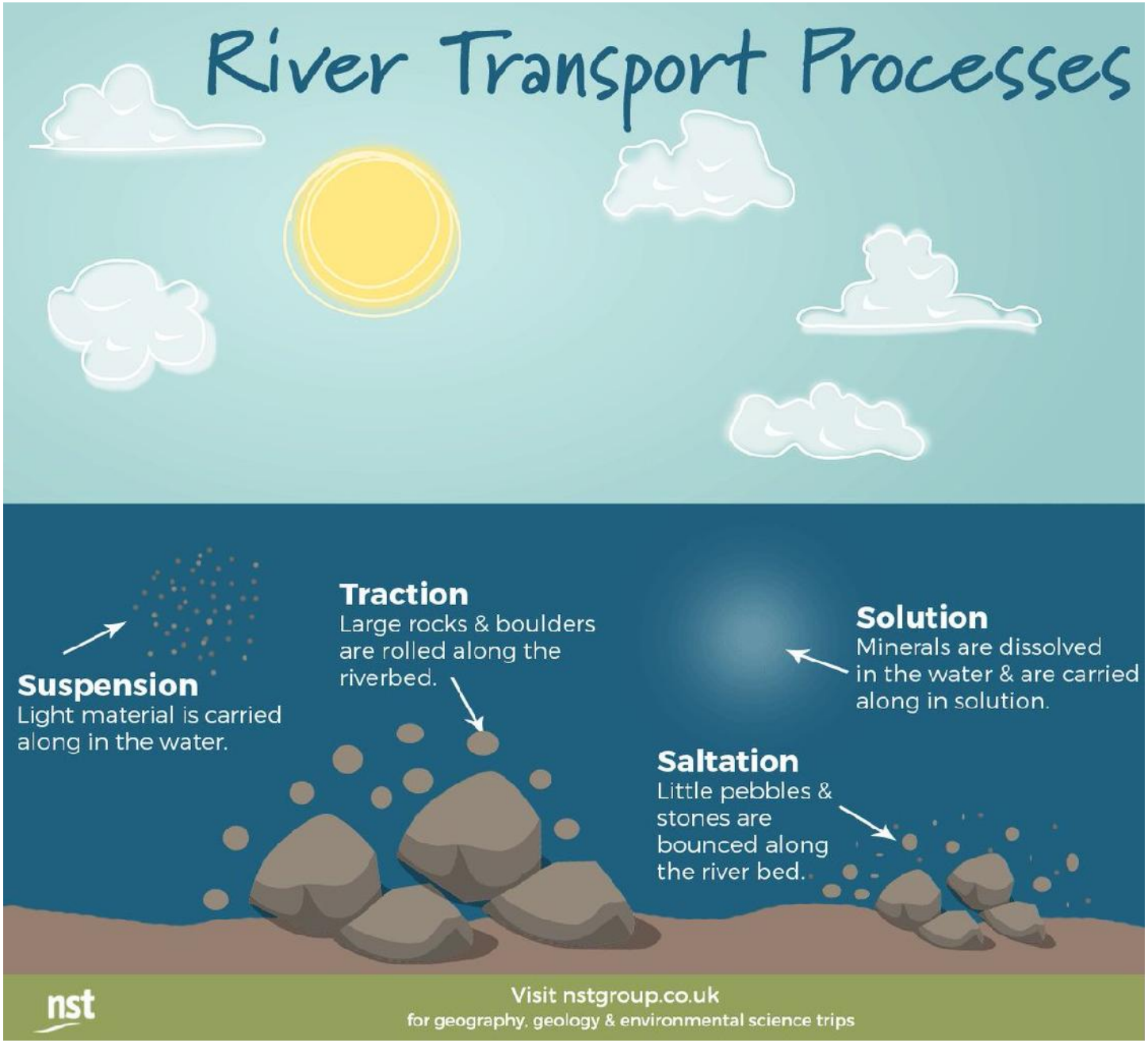
EROSION: Removal and transportation of weathered particles

Picture source: Google.com

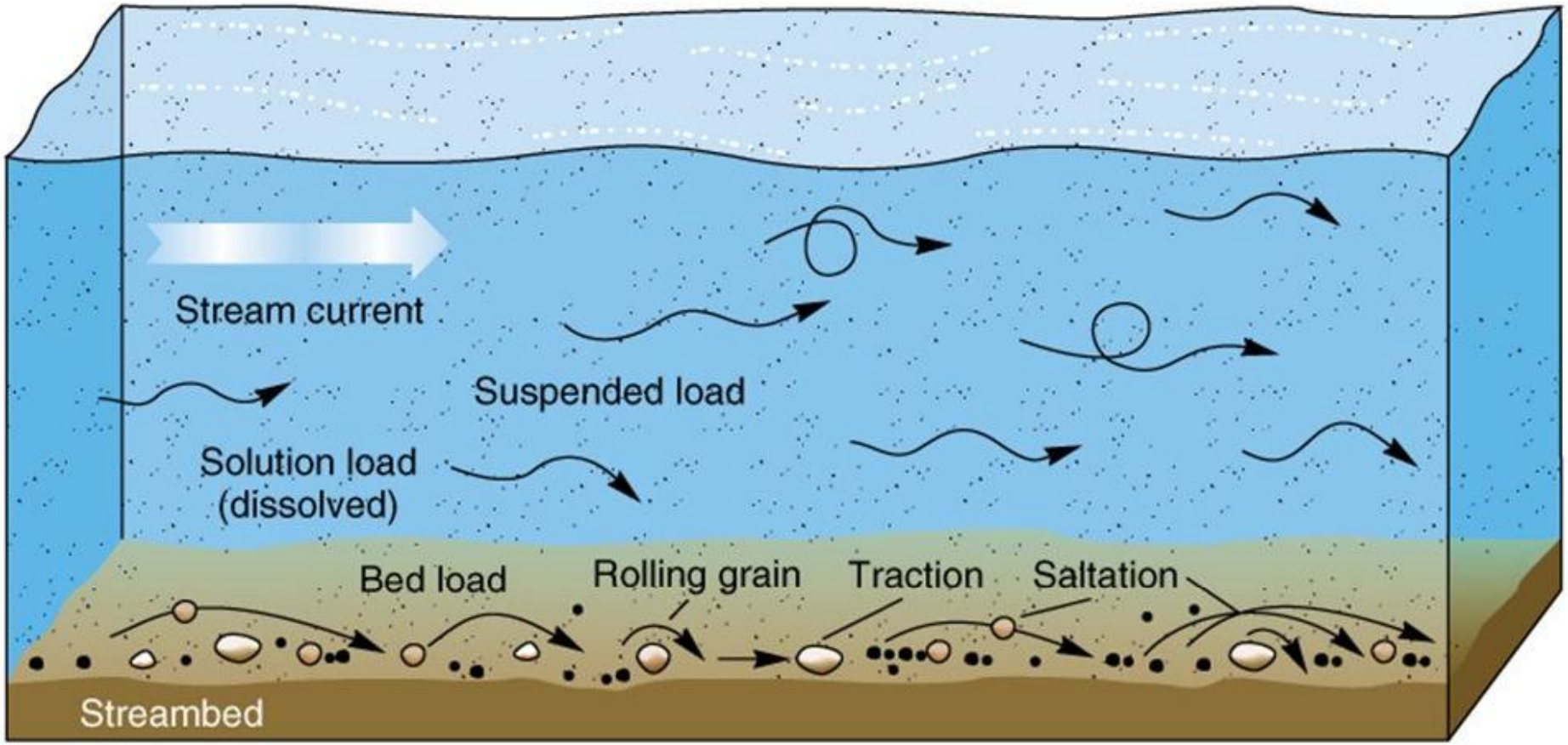
SEDIMENT TRANSPORTATION

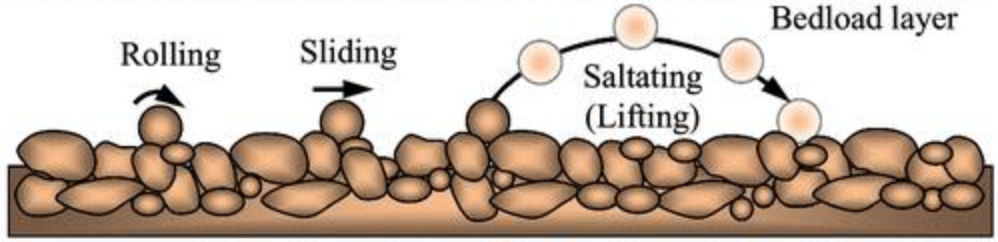


Picture source: Google.com



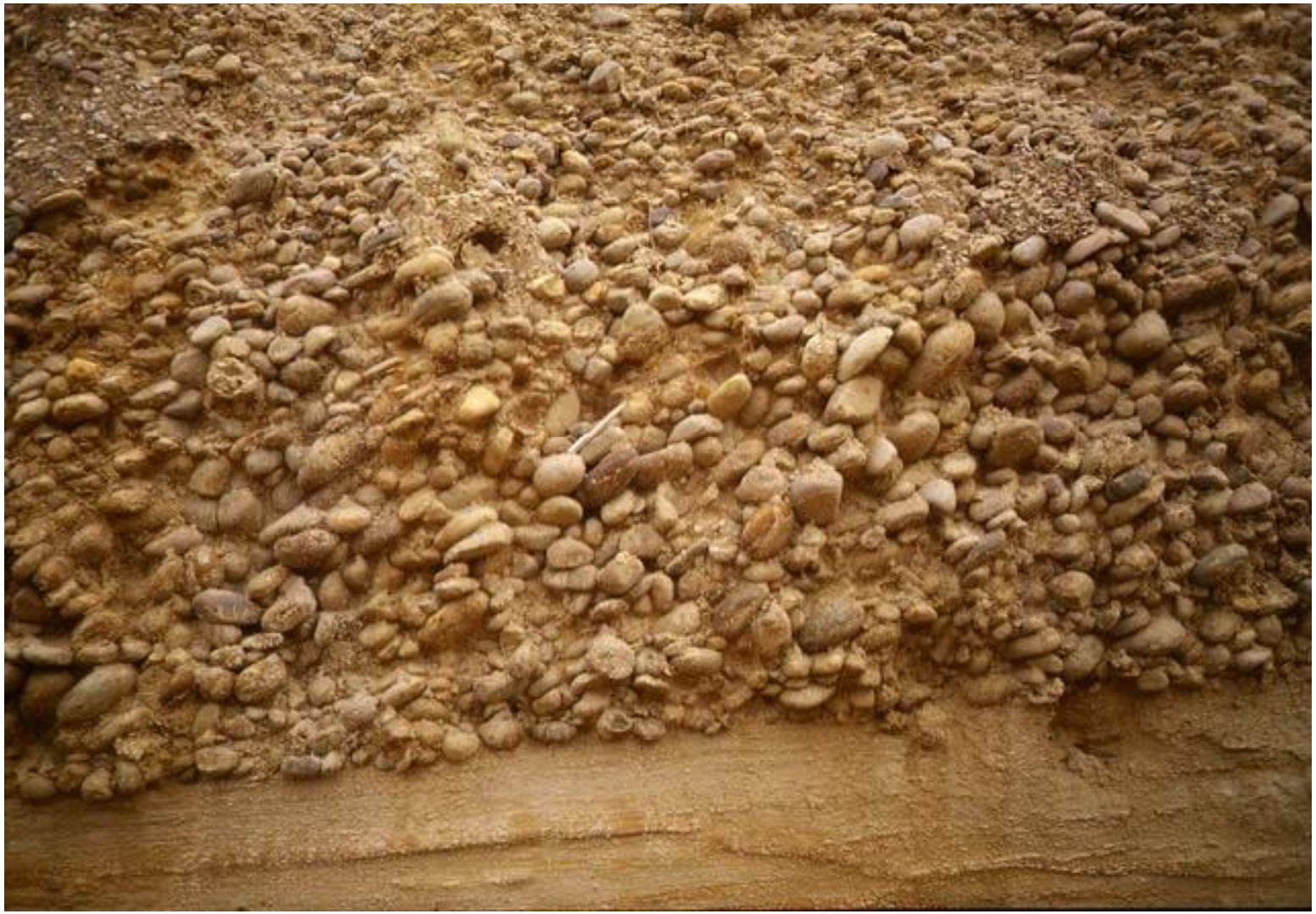
Picture source: Google.com





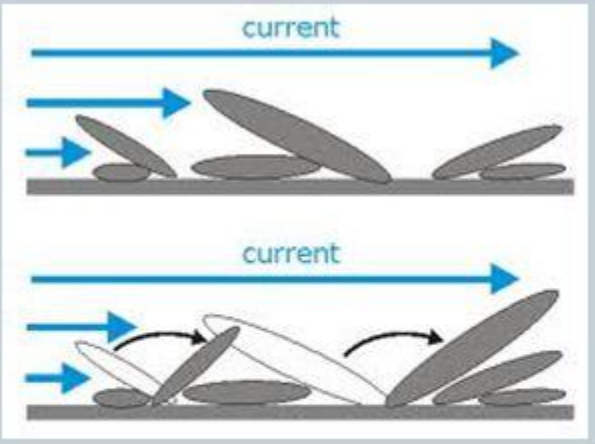
Picture source: Google.com

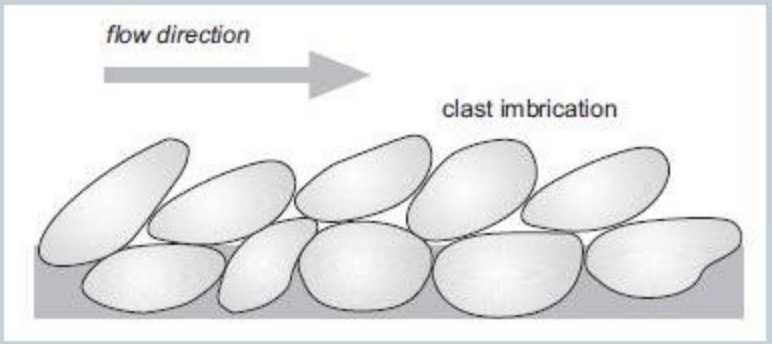
Pebble Imbrication



Picture source: Google.com

- When discoid clasts are moved in a flow of water they are preferentially oriented and stack up in a form known as **imbrication**.
- The direction of imbrication of discoid pebbles in a conglomerate can be used to indicate the direction of flow that deposited the gravel.



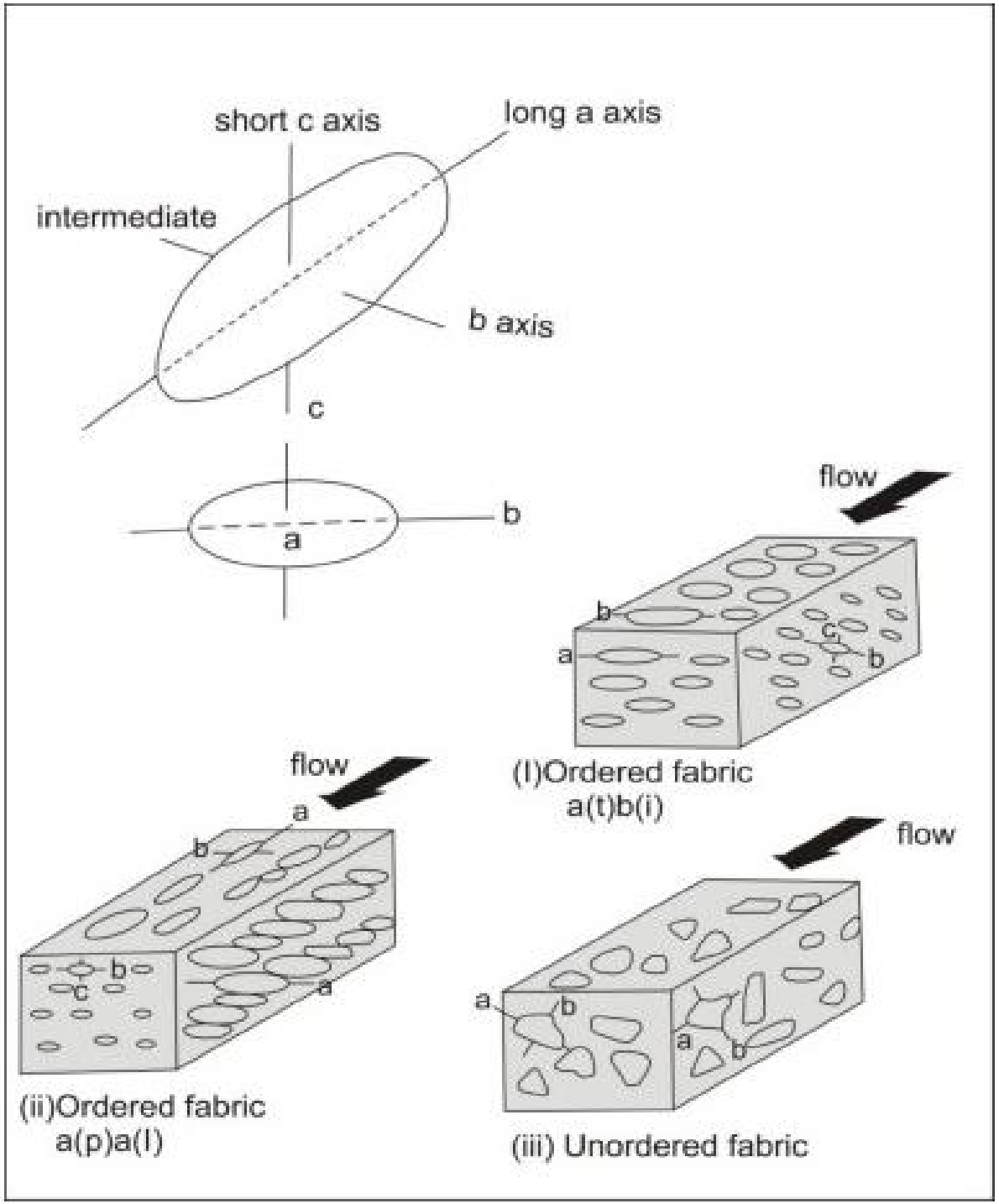


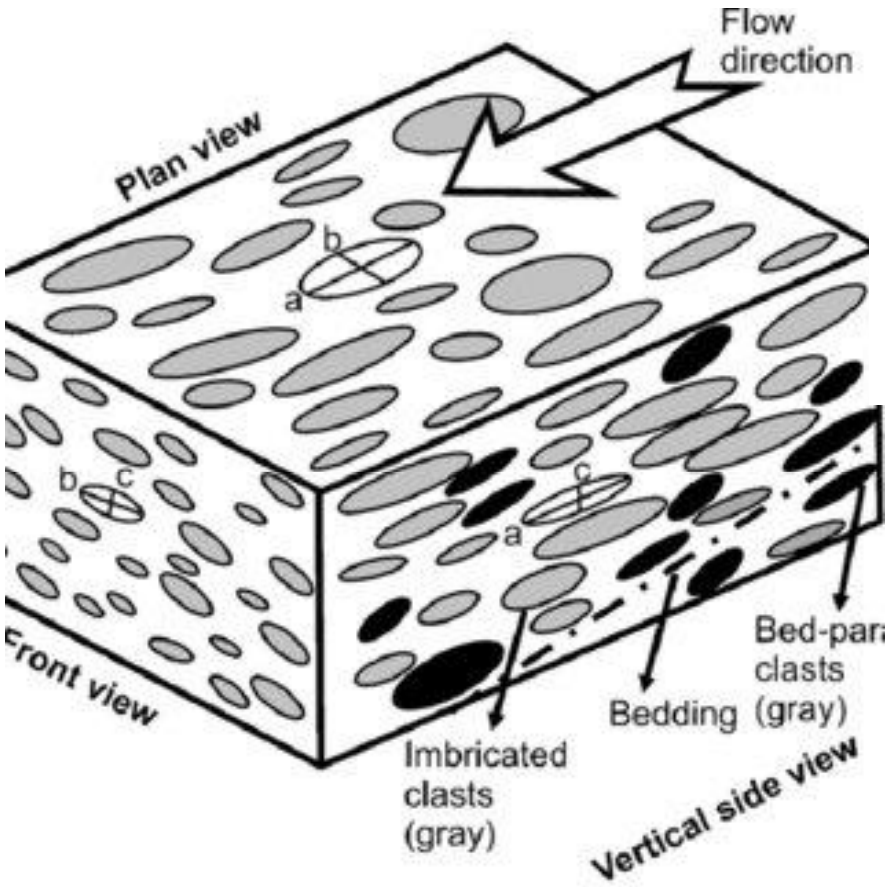
Picture source: Google.com

Grain orientation:

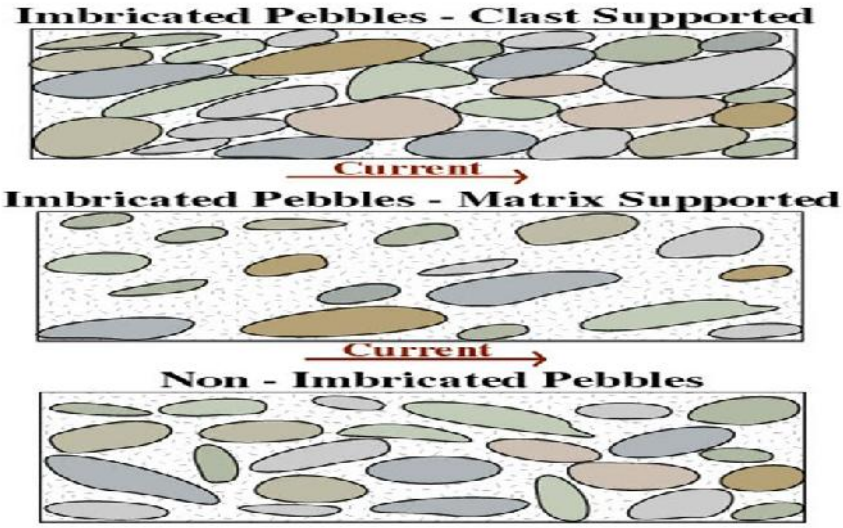
Orientation of a grain is commonly referred with respect to the direction of flow in which it got deposited and the horizontal plane. Sand grain orientation is difficult to document because of difficulty in measurement. However, for pebble/gravel size clasts a very common orientation pattern is referred to as 'imbrication', which often is used as a good paleocurrent indicator. Two different imbrication patterns are noted i.e 1) a(t)b(i) and 2) a(p)a(i); where 'a' refers to the longest axis of the pebble and 'b' refers to its intermediate axis. The a(t)b(i) imbrication (long axis transverse with the flow direction and intermediate axis dipping upcurrent) is noted in clasts transported as bed load, whereas clasts present within matrix- supported conglomerates, which are product of debris flows, can show presence of a(p)a(i) imbrication (long axis parallel with flow direction and dipping upcurrent).

Source: e-pathshala

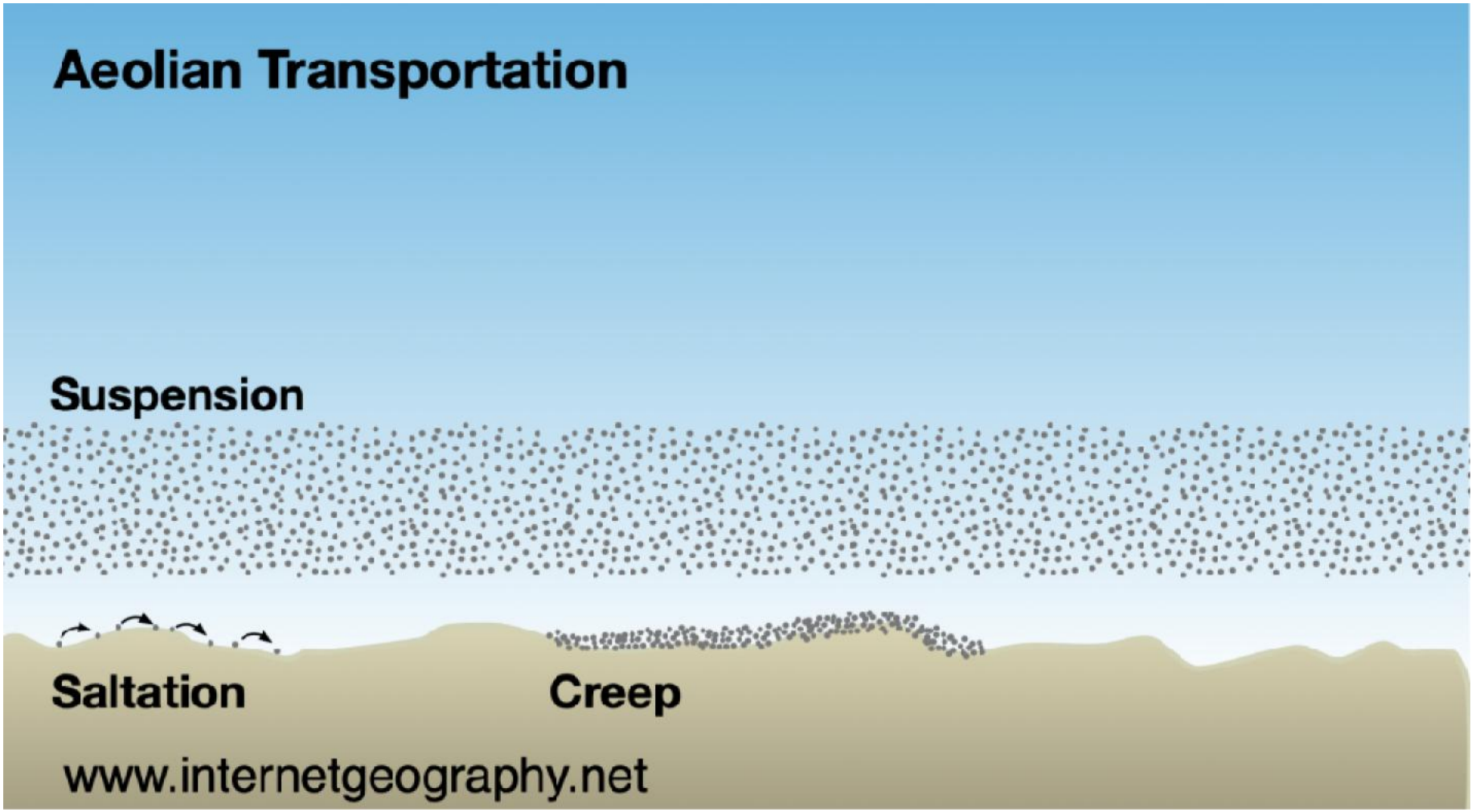

short c axis
long a axis
intermediate
b axis
c
a
b
flow
b
a
c
b
(I)Ordered fabric
a(t)b(i)
flow
a
b
b
c
a
(ii)Ordered fabric
a(p)a(l)
flow
a
b
a
b
(iii) Unordered fabric



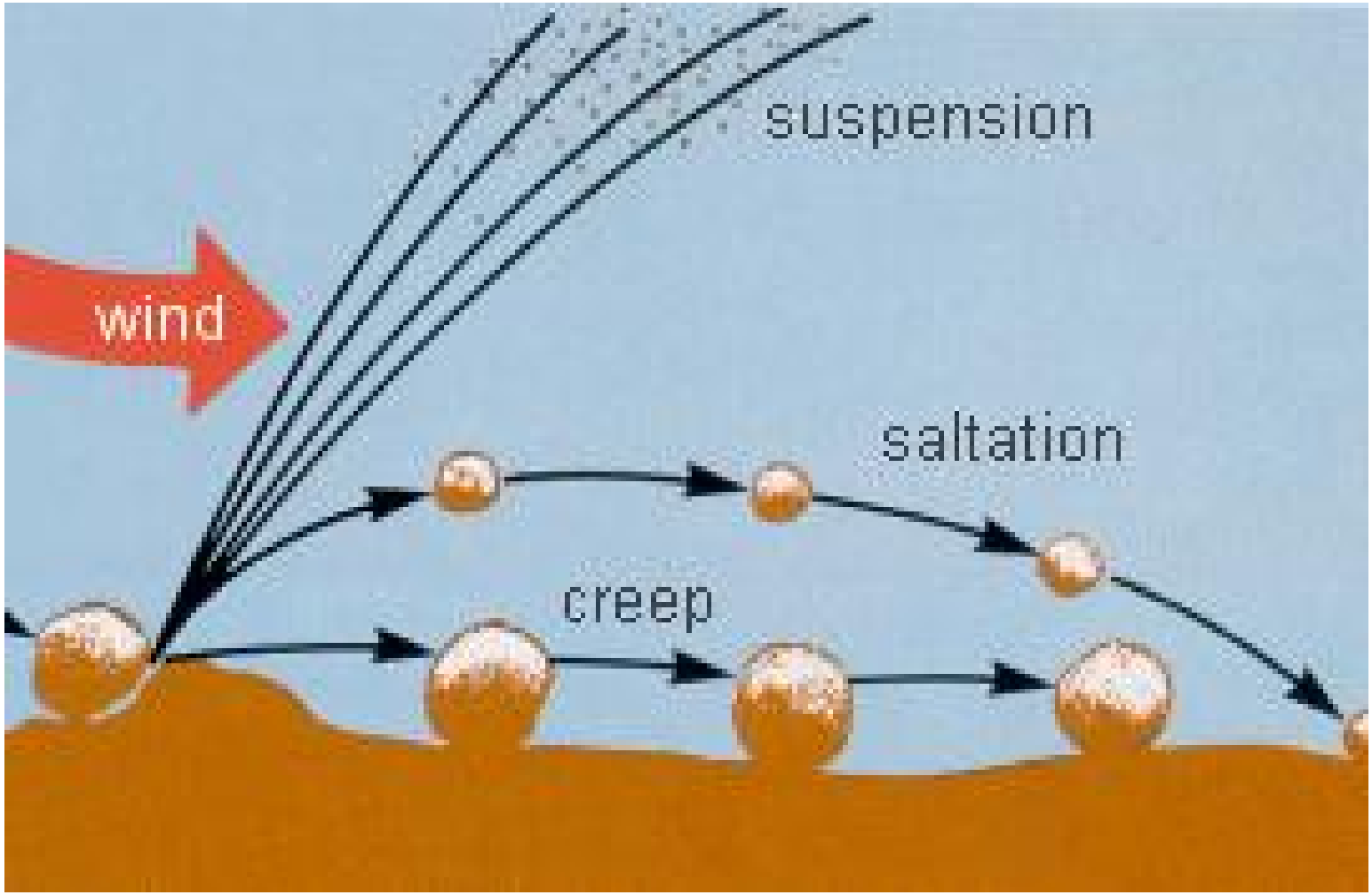
PEBBLE IMBRICATION



Picture source: Google.com

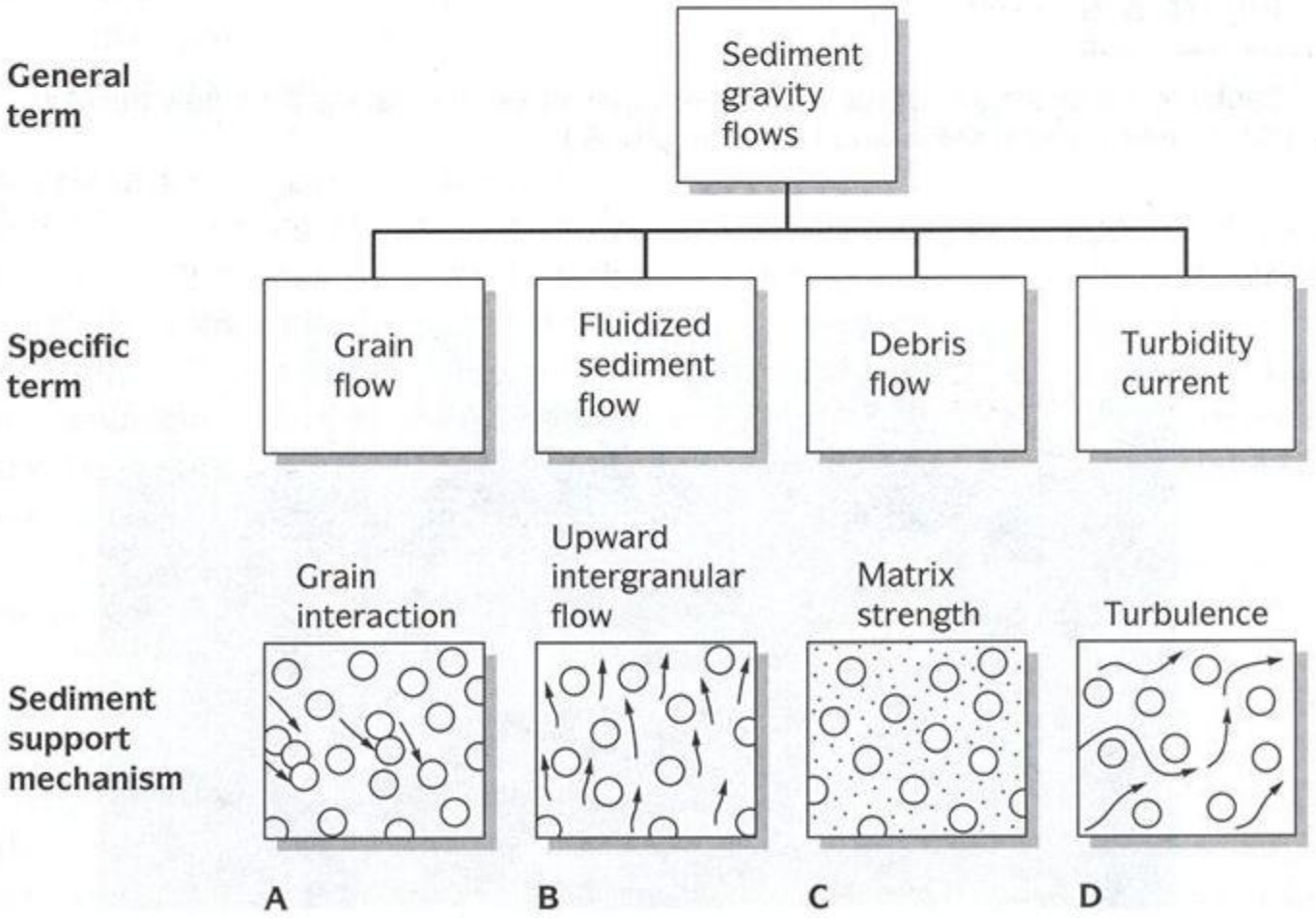


Picture source: Google.com



Picture source: Google.com

Four types of Sedimentary gravity flows

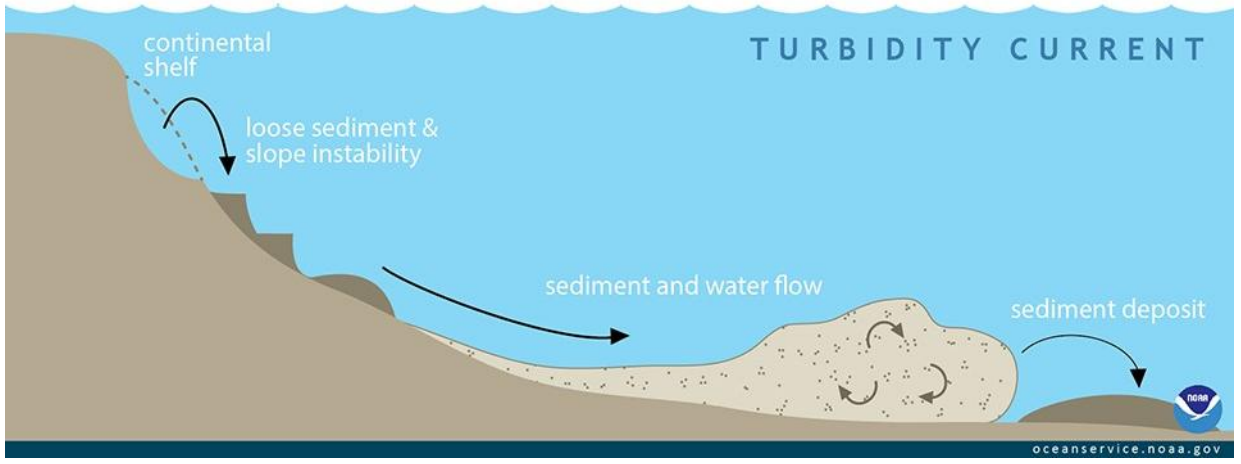


Classification of the four major types of sedimentary gravity flows, showing the interactions between fluids and grains that keep sediment moving during transport.

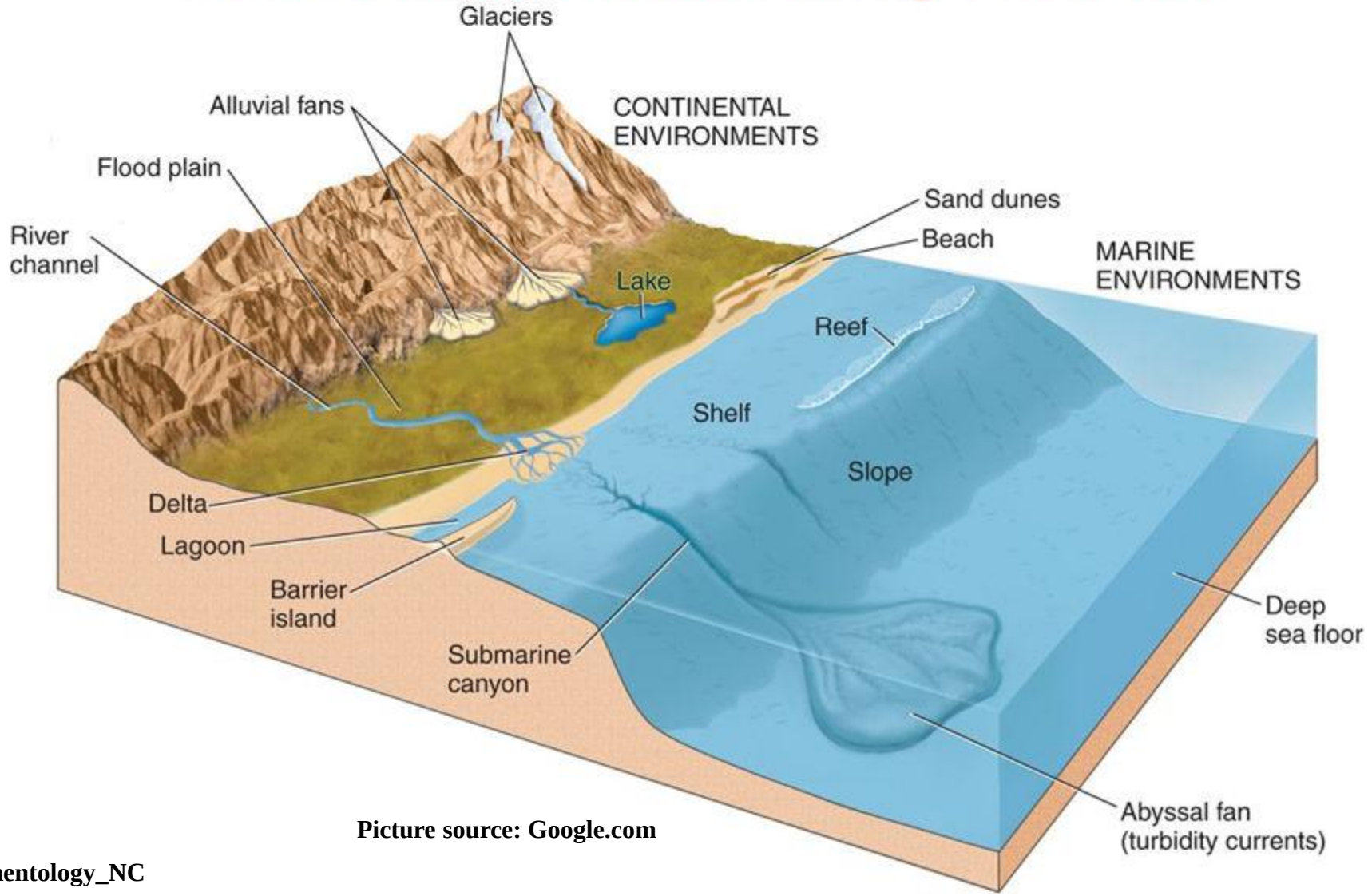
Debbris flow

Fluidised flow (dish structure)

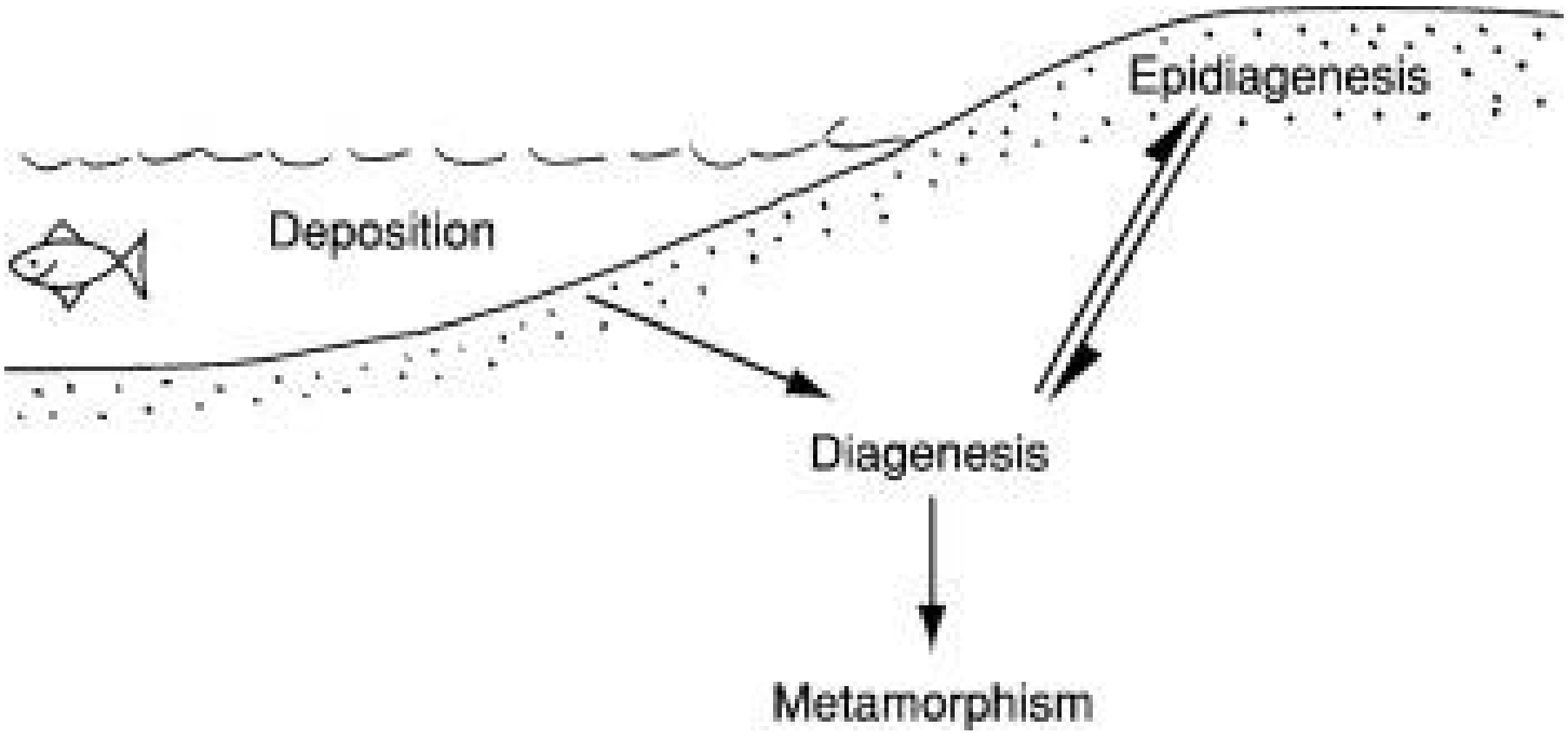
Picture source: Google.com



Environments of Deposition of Clastic Sedimentary Rocks



Picture source: Google.com



Picture source: Google.com

DIAGENESIS

- Diagenesis is the physical and chemical processes that convert sediment into sedimentary rock.
- This conversion is due to an increase in temperature, an increase in pressure, and changes in pore-water composition.

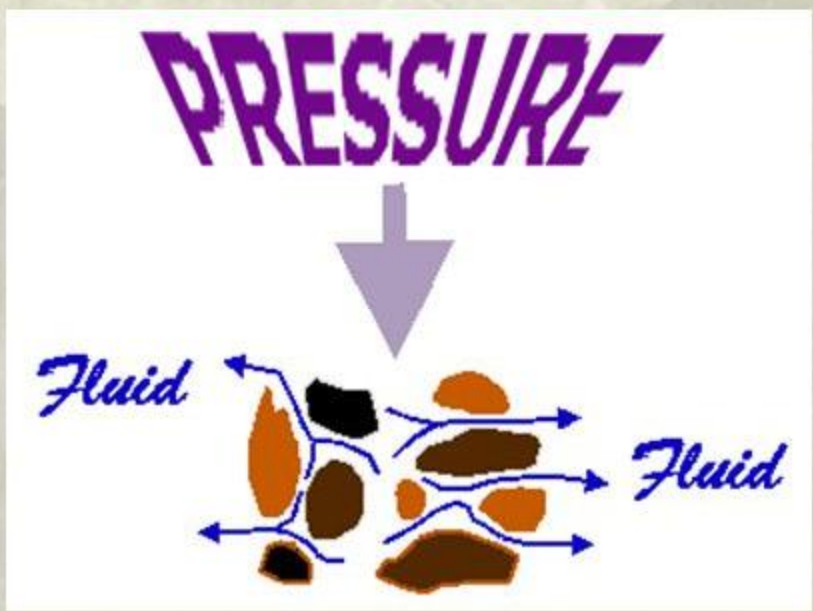
Three stages of diagenesis

- Eodiagenesis – earliest stage which takes place at very shallow depths
- Mesodiagenesis – occurs during deep burial
- Telodiagenesis – uplift of buried sediment into the system of meteoric waters.

Different processes of diagenesis

- Lithification
- Compaction
- Cementation
- Dissolution
- Authigenesis
- Replacement
- Recrystallization

Compaction Due to Pressure

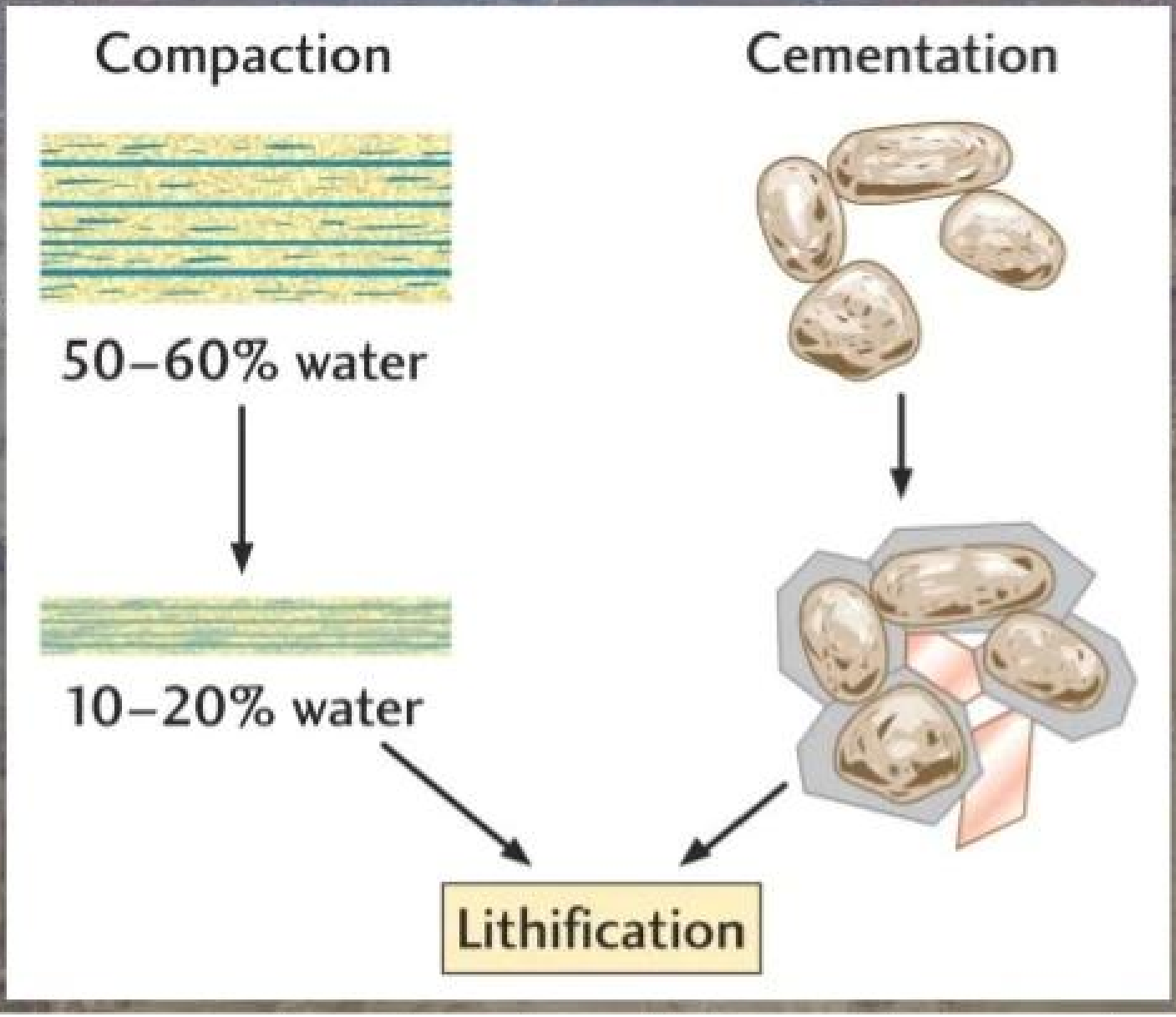


Factors that control compaction are: grain shape, sorting, original porosity, and pore fluid

Diagenesis: Lithification

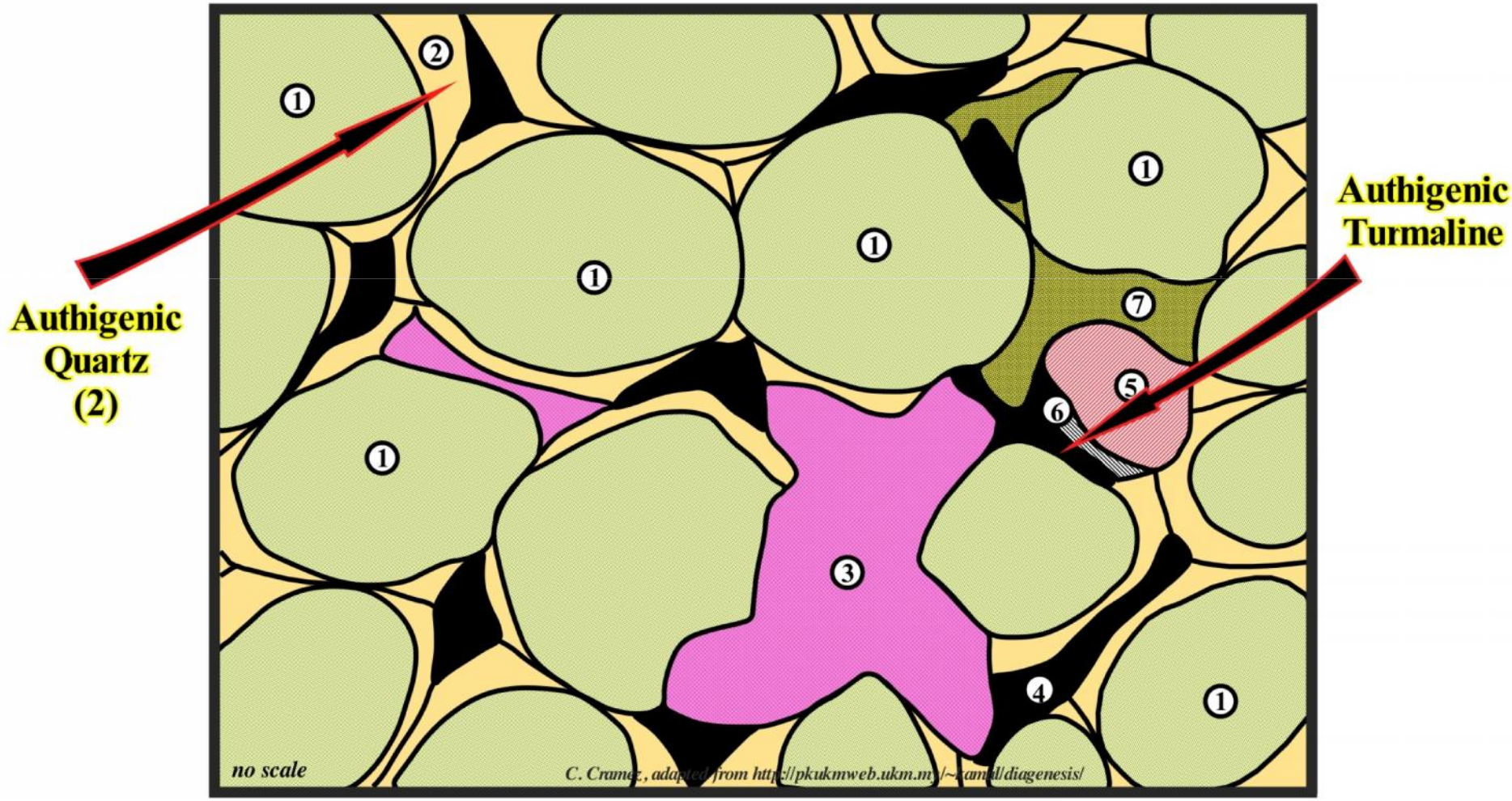
Sediment

Rock



Authigenesis

Diagenetic process in which there is formation of new minerals



Diagenesis in carbonate rock