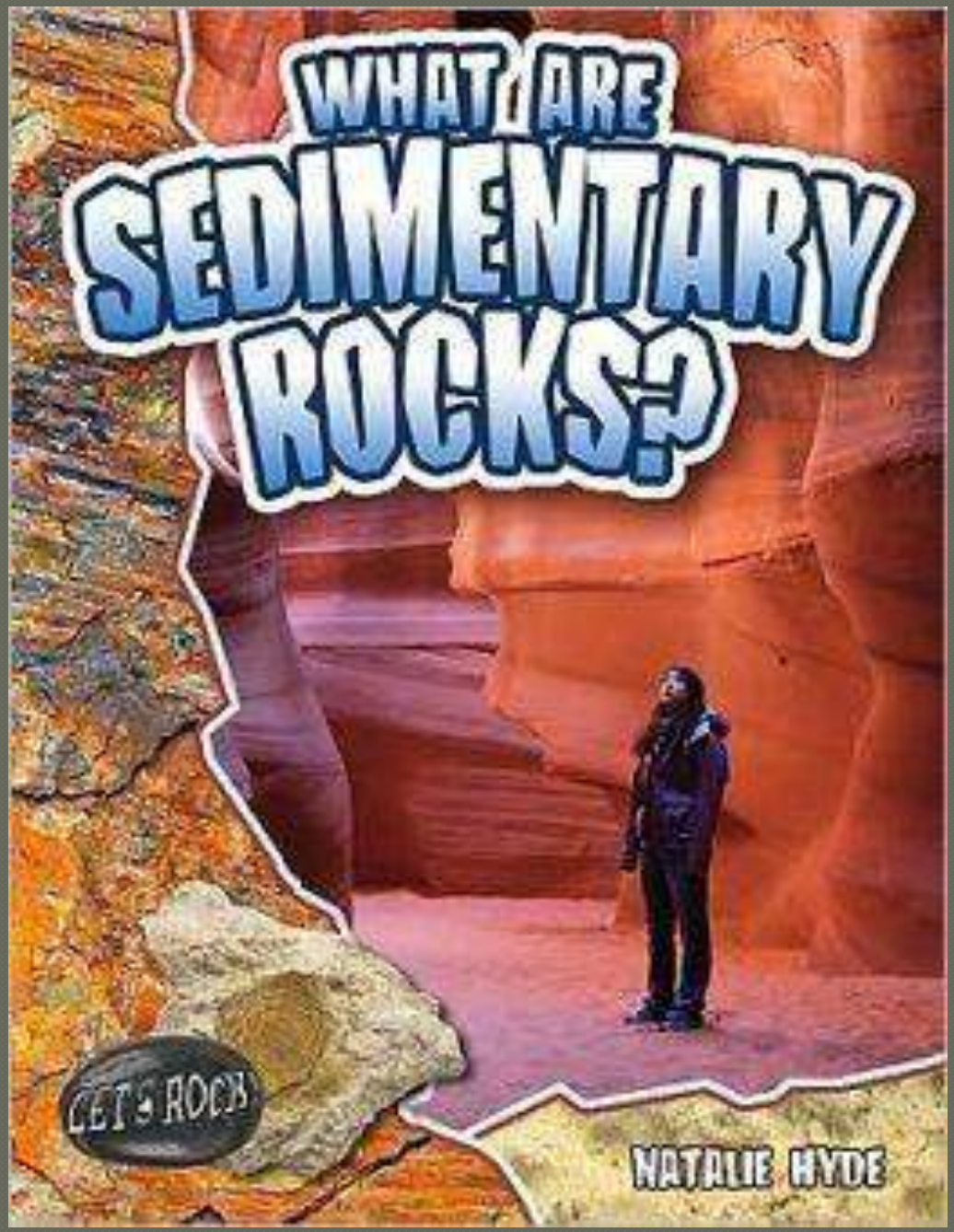
SEDIMENTARY ROCKS

TOPICS COVERED

- INTRODUCTION
- FORMATION
- CLASSIFICATION
- TEXTURES
- STRUCTURES
- IMPORTANT SEDIMENTARY ROCKS
- ENGINEERING IMPORTANCE


WHAT ARE
SEDIMENTARY
ROCKS?
LET'S ROCK
NATALIE HYDE

- Sedimentary rocks are the type of rocks that are formed by the deposition of material at earth's surface and within the bodies of rocks.

- Contributes about 8% of total volume of crust.

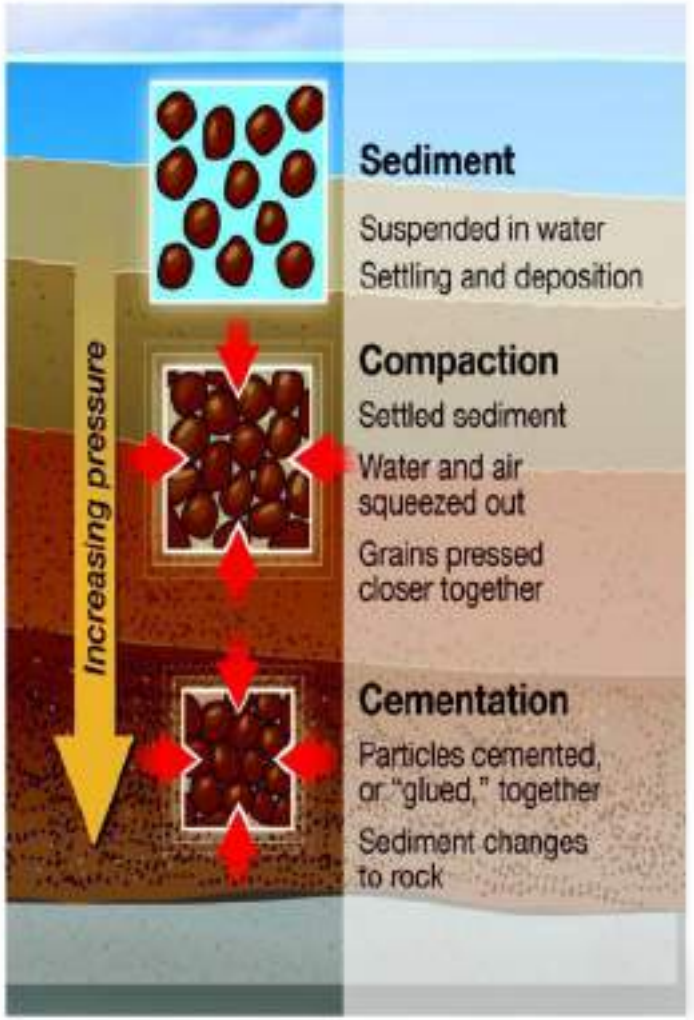
The study of sedimentary rocks and rock strata provides information about the subsurface that is useful for civil engineering

For eg.,
Construction of roads, houses, tunnels, canals, etc ……

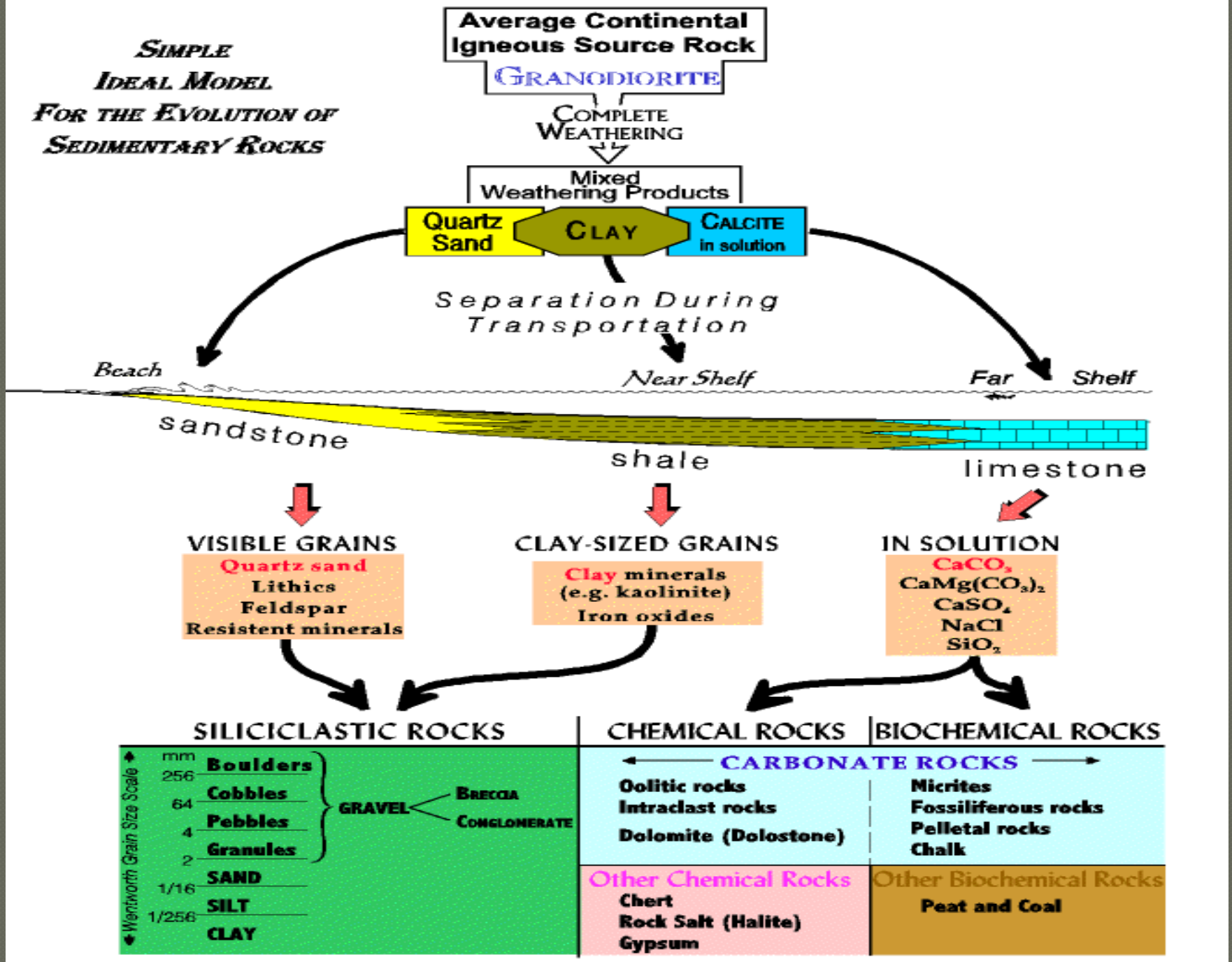
FORMATION OF *SEDIMENTARY ROCKS*

Sedimentary rocks are formed at or near the Earth's surface by accumulation and lithification of fragments of pre-existing rocks or by precipitation from solution at normal surface temperatures.

Forming Sedimentary Rocks



Sedimentary Rock Models



L.S. Fichter, 1993, 2000

http://geollab.jmu.edu/Fichter/SedRx/sedclass.html

On the basis of their mode of formation, sedimentary rocks are classified as

1) Mechanically formed or Clastic rocks

2) Originally formed rocks

3) Chemically formed rocks

Clastic sedimentary rocks such as breccia, conglomerate, sandstone and shale are formed from mechanical weathering debris from pre-existing rocks.

The following steps are involved in the formation of clastic rocks.

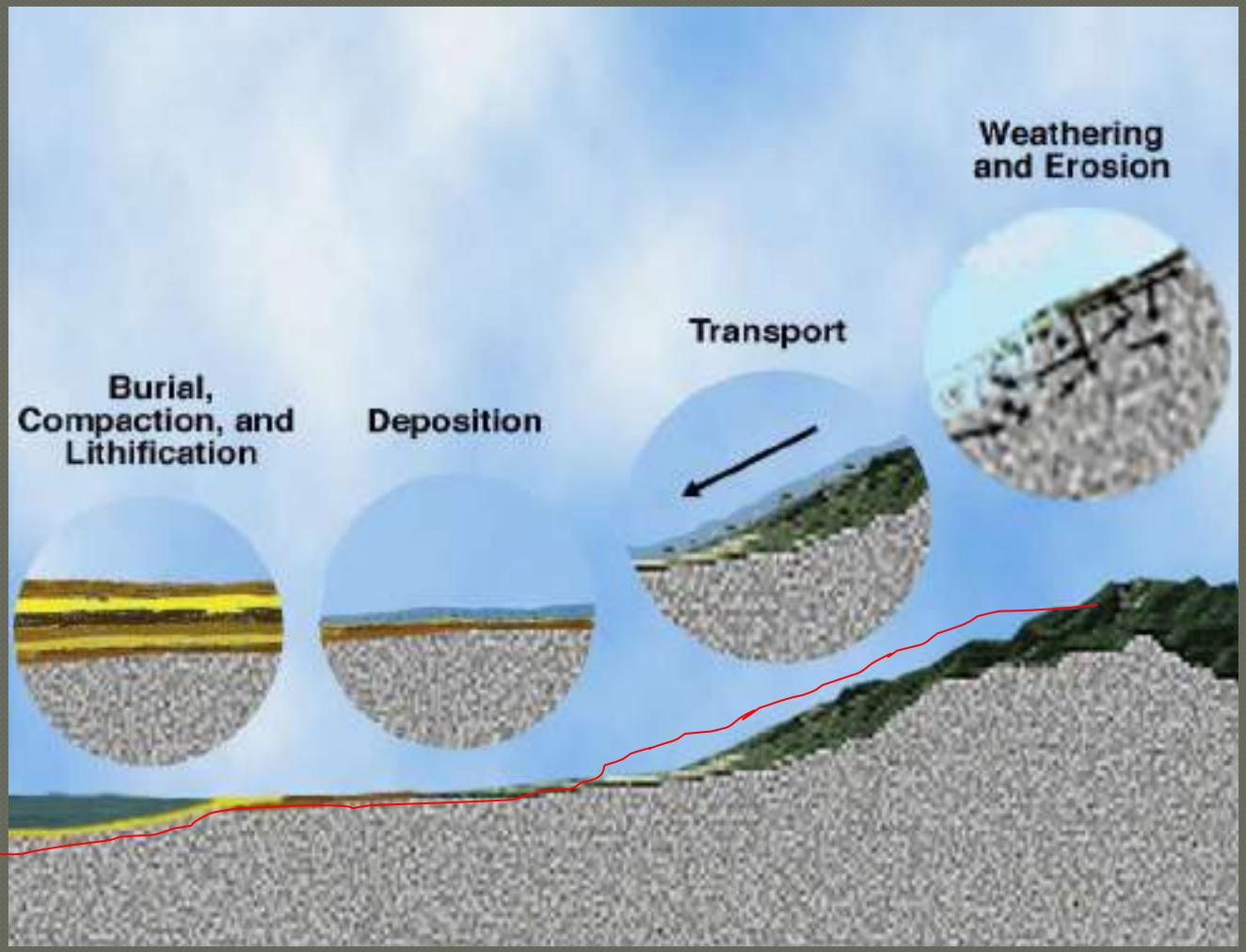
- **Decay and disintegration:** Hard coherent rock mass are gradually disintegrated and loosened. Such loosened materials accumulated near the source is called detritus.

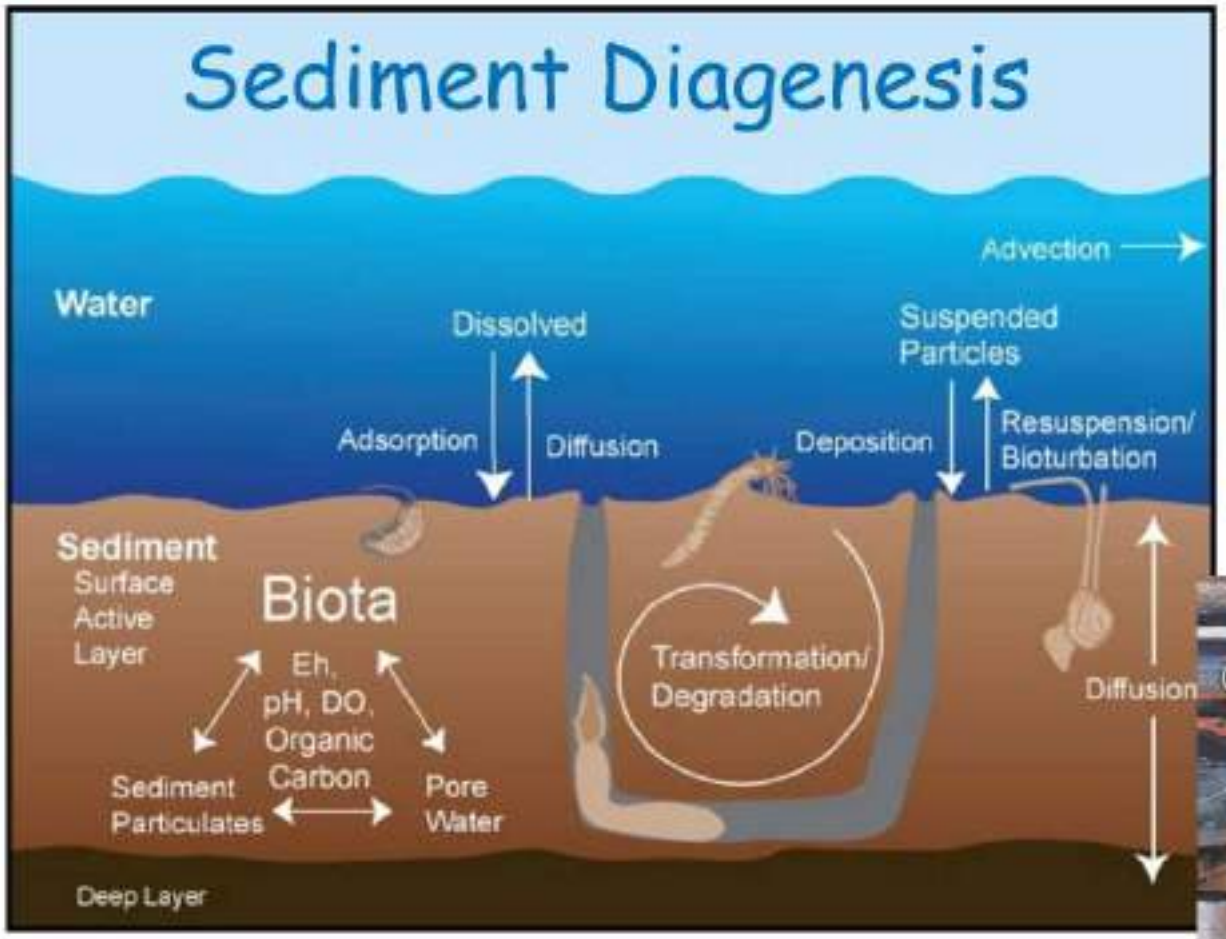
- Transport of sediments: Common agents of transport like wind, running water (rivers & streams)and glaciers carry millions of tones of detritus to various places.

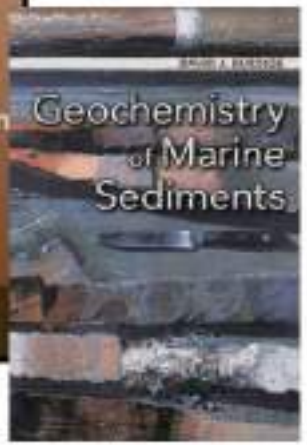
- **Gradual deposition:** The sediments which undergo grading according to their size, shape and density get deposited in layers under ordinary pressure and temperature conditions.

- **Diagenesis:** The proce**ss** of transformation of sediments into cohesive, hard and massive rock because of compaction, consolidation and cementation is called diagenesis.

FORMATION OF CLASTIC ROCKS



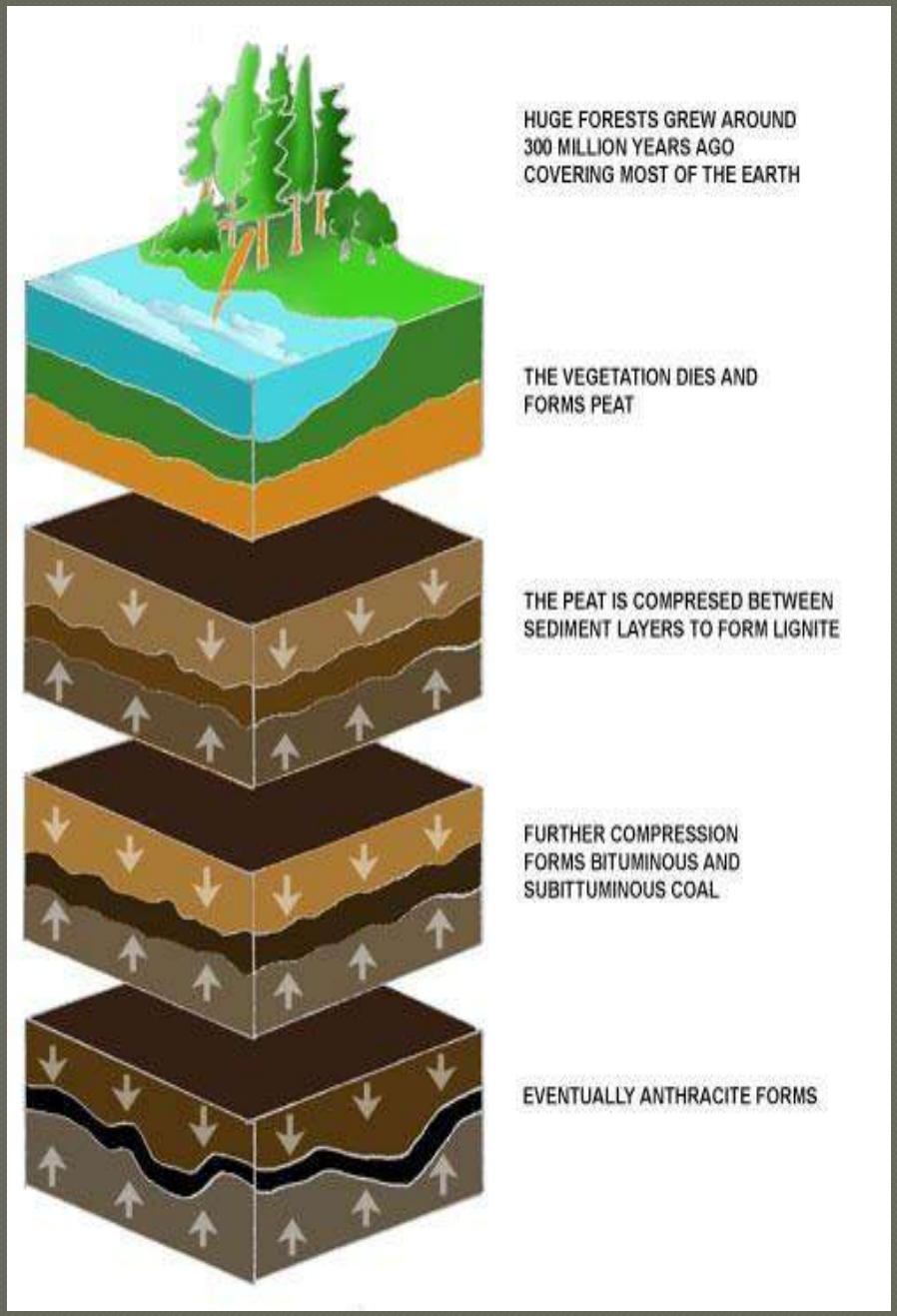




http://eps.mcgill.ca/~courses/c542/

Chemical sedimentary rocks such as rock salt,gypsum, anhydrite and some limestones are formed when dissolved materials precipitate from solutions.

Organic sedimentary rocks such as coal, and some limestones are formed from the accumulation of plant or animal debris.


HUGE FORESTS GREW AROUND
300 MILLION YEARS AGO
COVERING MOST OF THE EARTH
THE VEGETATION DIES AND
FORMS PEAT
THE PEAT IS COMPRESED BETWEEN
SEDIMENT LAYERS TO FORM LIGNITE
FURTHER COMPRESSION
FORMS BITUMINOUS AND
SUBITTUMINOUS COAL
EVENTUALLY ANTHRACITE FORMS

2. Sedimentary Rocks

CLASSIFICATION OF *SEDIMENTARY ROCKS*

Based on the average grain size of the sediments Clastic rocks are classified as:

- GARVEL: (grain size > 2 mm)

All sediments and fragments of rocks above size of 2 mm irrespective of composition and shape are called gravels.

Further classified as :

BOULDERS (grain size >256mm)
COBBLES (grain size btwn 256-16 mm)
PEBBLES (grain size <16-2 mm)

- SANDS: (grain size in range of 2 – 1/16 mm)

  Petrologically the term sand is used for siliceous sediments.

Further classified as :

  COARSE SAND (size range btwn 2 – ½mm)
  MEDIUM SANDS (size range btwn ½ – ¼ mm)
  FINE SANDS (size range btwn ¼ – 1/16 mm)

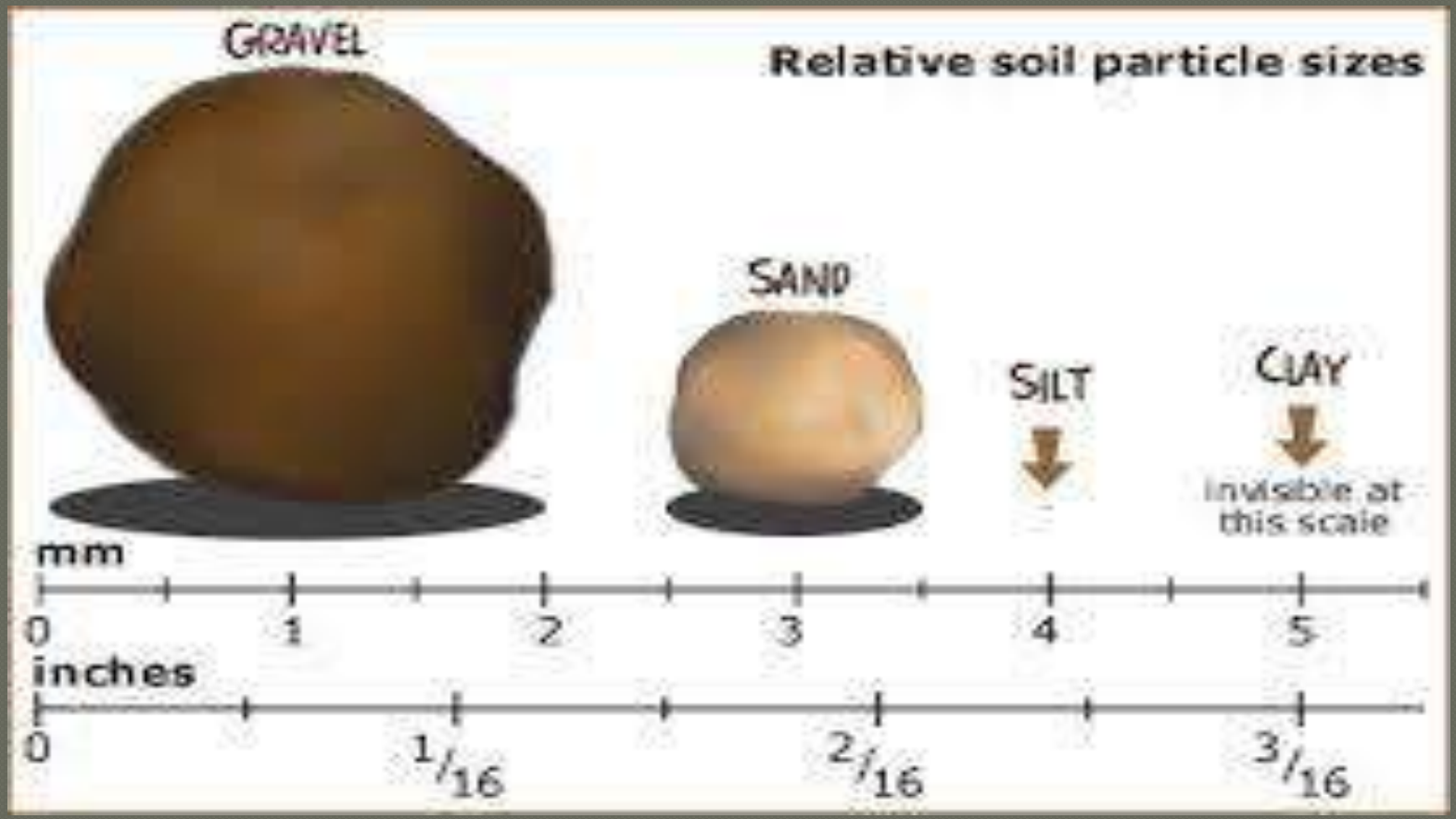
- SILTS: (grain size 1/16 – 1/256 mm)

  Silts are major constituents of rocks known as shales.

Further classified as :

  COARSE SILT
  MEDIUM SILT
  FINE SILT

- CLAYS : (grain size less than in 1/256 mm) They are formed in variety of ways and abound in nature as soils and rocks as claystone, mudstone, shales, etc.



Phi Units*	Size	Wentworth Size Class	Sediment/Rock Name
-8	256 mm	Boulders	Sediment: GRAVEL Rock: RUDITES: (conglomerates, breccias)
-6	64 mm	Cobbles	
-2	4 mm	Pebbles	
-1	2 mm	Granules	
0	1 mm	Very Coarse Sand	Sediment: SAND Rocks: SANDSTONES (arenites, wackes)
1	1/2 mm	Coarse Sand	
2	1/4 mm	Medium Sand	
3	1/8 mm	Fine Sand	
4	1/16 mm	Very Fine Sand	
8	1/256 mm	Silt	Sediment: MUD Rocks: LUTITES (mudrocks)
		Clay	

*** Udden-Wentworth Scale**

TYPES OF CLASTIC ROCKS (based on grain size)

Table 6-1 Detrital Sediments and Rocks

Particle Size (mm)	Particle Name		Name of Rock Formed	
<0.004	Clay*	Mud	Shale	Mudstone
0.004–0.063	Silt		Siltstone	
0.064–2	Sand		Sandstone	
2–4	Granule	Gravel	Breccia (if particles are angular)	
4–64	Pebble			
64–256	Cobble		Conglomerate (if particles are rounded)	
>256	Boulder			

1 mm = 0.039 inch

*Note that the term "clay," when used in the context of sediment size, denotes very fine particles of any rock or mineral (as opposed to the term "clay mineral," which refers to a compositionally specific group of minerals); all clay minerals have clay-sized particles, but not all clay-sized particles are composed of clay minerals.

- Based on the predominance of sediments, Clastic rocks are divided into :

- RUDITES (psephites) :
  - →rudaceous rocks
  - →average grain size greater than 2mm
  - →made of boulders, cobbles & pebbles

Eg : Breccias , conglomerates.

- ARNITES(psamites):
  - →arenaceous rocks
  - →sediments of sand grade 2-1/16 mm

  Eg: sandstones, grewackes & arkoses

- LUTITES (pelites) :
  - →argillaceous rocks
  - → made of slit and clay
  - → size less than 1/16 mm

  Eg: shales, clays, mudstones, siltstones

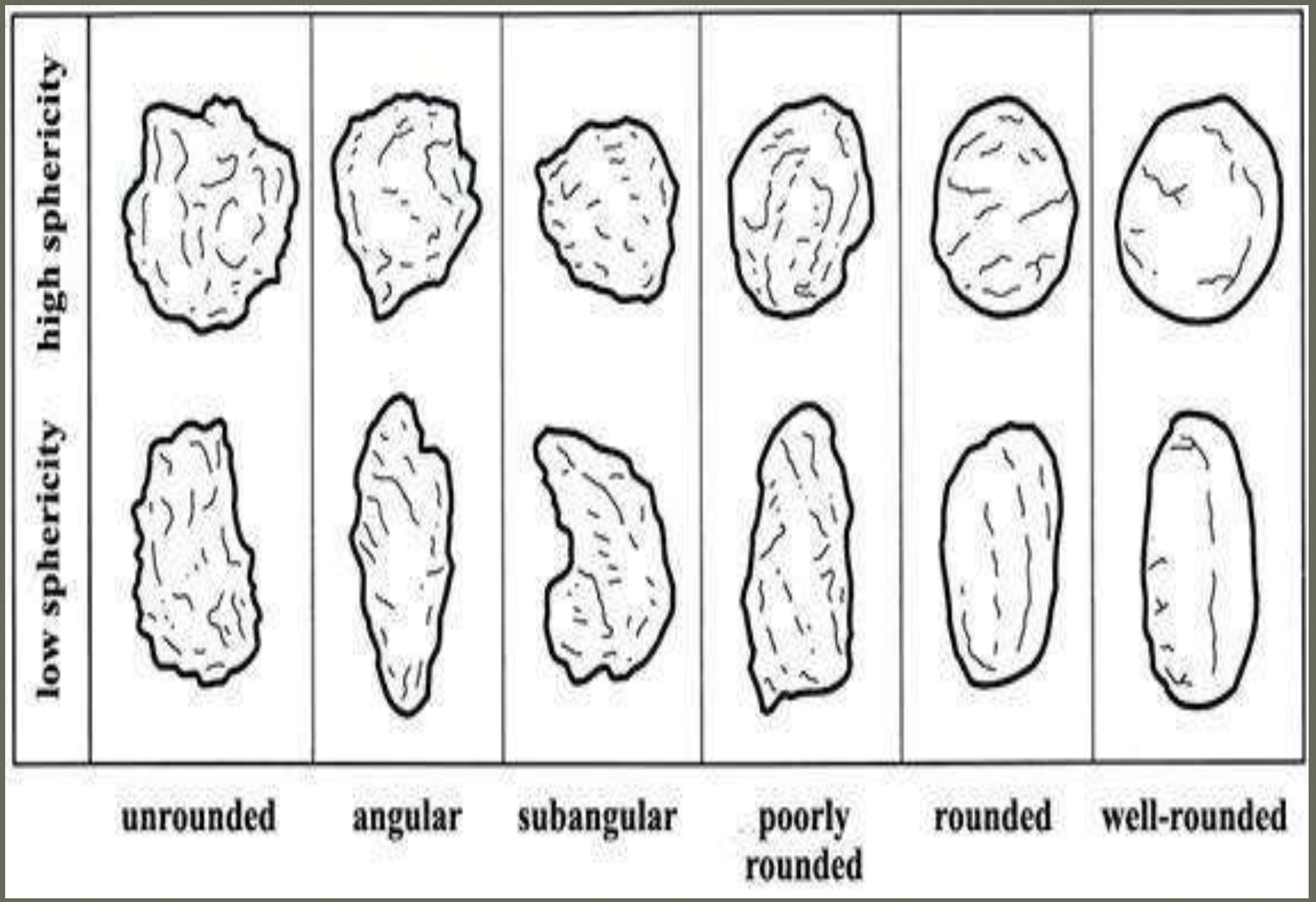
TEXTURE

- ORIGIN: Mostly clastic (allogenic) or non-clastic
- SIZE OF GRAIN: 0.002 < grain size < 250 mm

  Coarse-grained rocks: avrg grain size > 5 mm

  medium-grained rocks: avrg grain size 5-1mm

  fine-grained rocks: avrg size size < 1 mm
- SHAPES OF GRAINS: rounded, subrounded, angular, subangular, show sphericity
- PACKING OF GRAINS: open-packed
- FABRIC OF GRAINS: elongated
- CRYATALLISATION TREND: crystalline granular texture or non crystalline, collaidal particles.


high sphericity
low sphericity
unrounded
angular
subangular
poorly rounded
rounded
well-rounded

STRUCTURES

MECHANICAL STRUCTURE:

- most prevalent structure in sedimentary rocks
- developed due to physical processes at the time formation of the rocks

- Stratification:
  - layered arrangement in a sedimentary rock
  - strata may be similar or dissimilar in color, composition, grain size & texture.
  - bedding planes may separate the strata from each other

-thickness of each layer varies from few centimeters to many meters

- in lateral extension it may show continuity for several meters to hundreds of kilometers

- they may be horizontal, inclined , folded or bent & broken or overturned depending on the tectonic forces acting after their deposition

- Lamination:
  - layered structure
  - individual layers(laminae) are thinner(less than 1 cm)
  - characteristic structure of clays & shales

- Cross Bending:
  - layers lying one above other are not parallel
  - irregular or inclined relationship
  - deposition in shallow waters
  - stream suffers repeated change in direction of flow
  - false-bedding or current bedding

Types of false-bedding:

I) Tabular:

- top and bottom surfaces of the deposits are parallel
- intervening layers are inclined

ii) Lenticular:

- all layers show extreme irregularity in shape and deposition
- individual layers may be intersected by many others lying at different levels

iii) Wedge shaped:

- bears sets of parallel layers
- sets bear angular relationship
- appears like interwoven edges in vertical cross section

LAMINATION STRUCTURE

TABULAR CROSS- BENDING

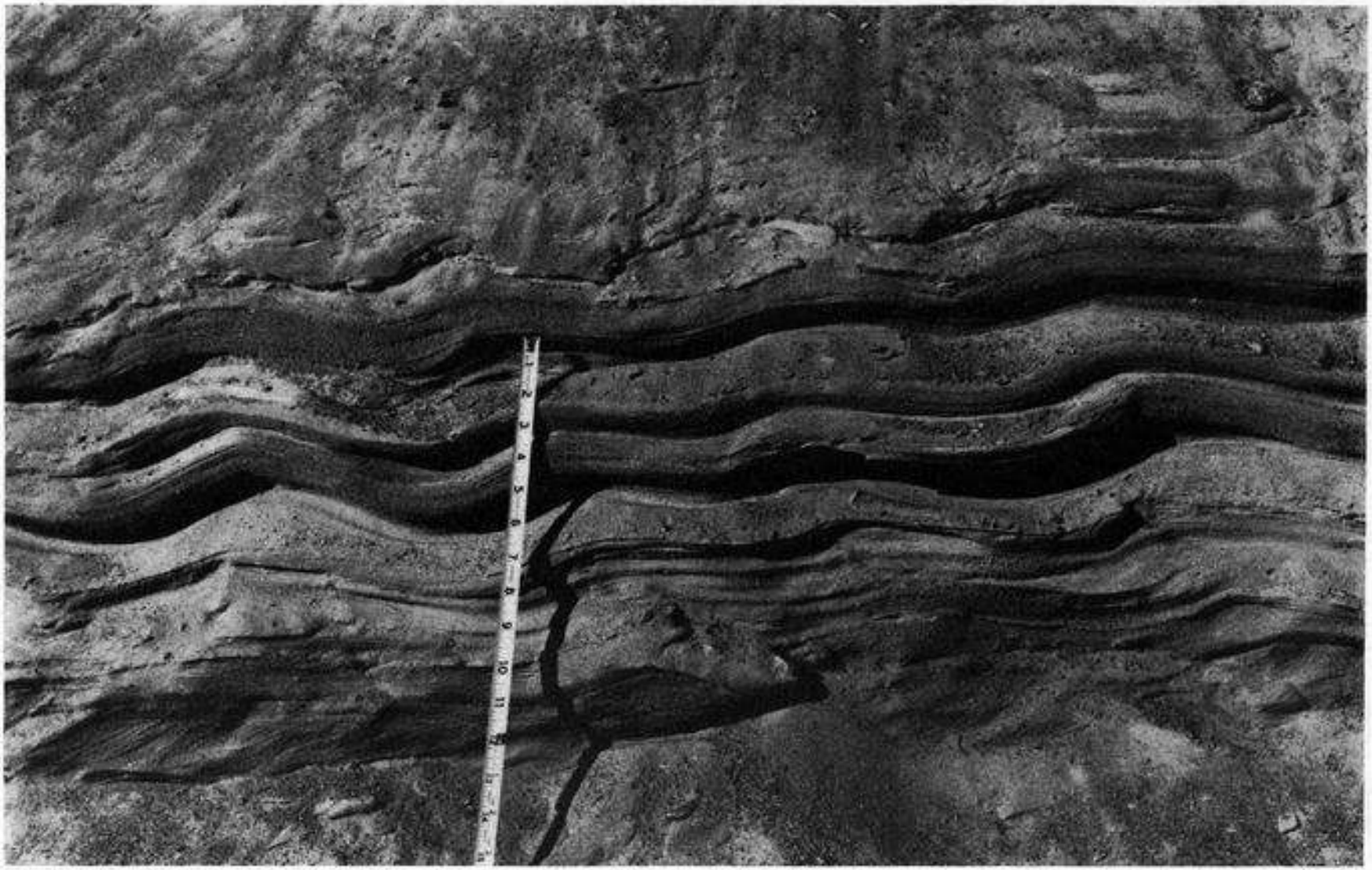


FIG. 11.—Sinusoidal ripple lamination, with some interbedded cross-lamination in the lower part of the photograph. Scale in inches.

LENTICULAR CROSS- BENDING

Early fabric of displacive enterolithic veins now preserved in late, secondary, (post anhydrite) porphyrotopic gypsum. Soft Cockle Mb, Purbeck Formation, Worbarrow Tout . Ian West (c) 2005

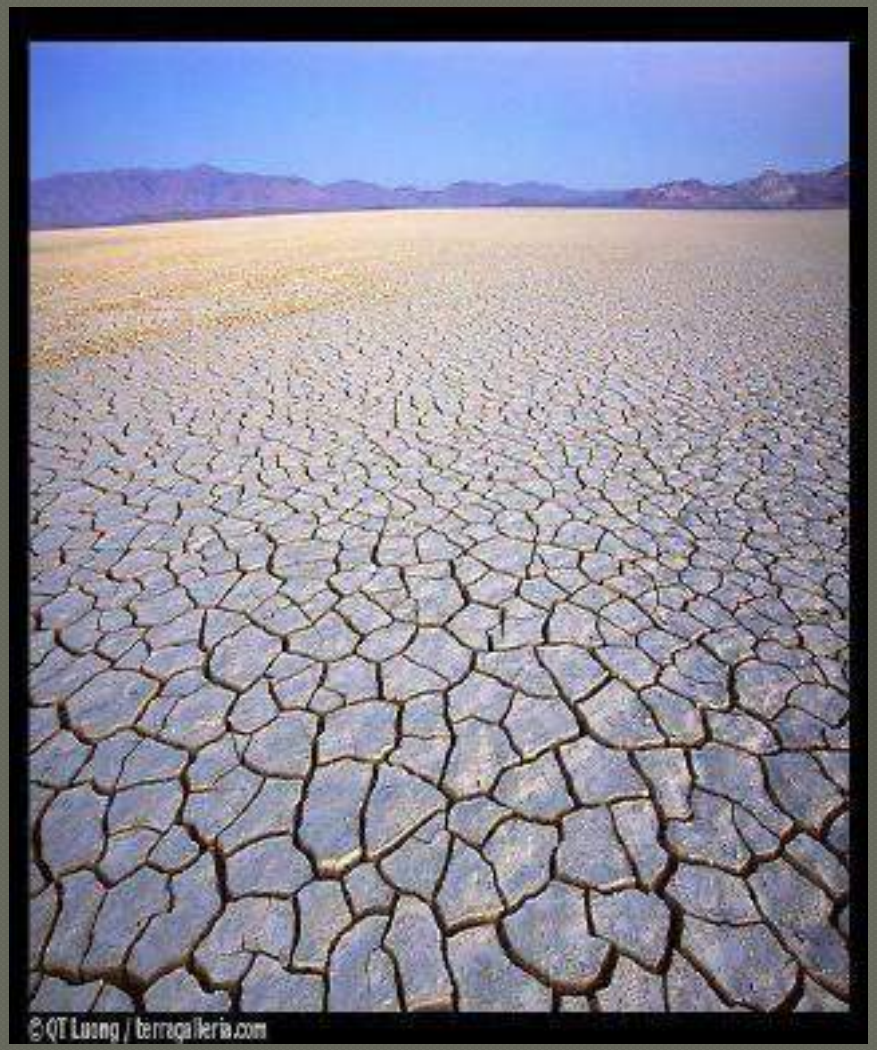
WEDGE SHAPED CROSS-BENDING

- Graded bedding:

  - component sediment in each layer appear to be characteristically sorted and arranged according to their grain size , coarsest at the bottom and finest at the top

  - result of sedimentation in standing water by gravitative settling or subaqeous landslides or submarine earthquakes

- Mud cracks:
  - polygonal or irregular cracks spread along the surface
  - cracks are developed on the surface of drying mud in shallow enviroments
  - they get preserved when layers of mud covers the deposits
- when overlying layers get eroded they become visible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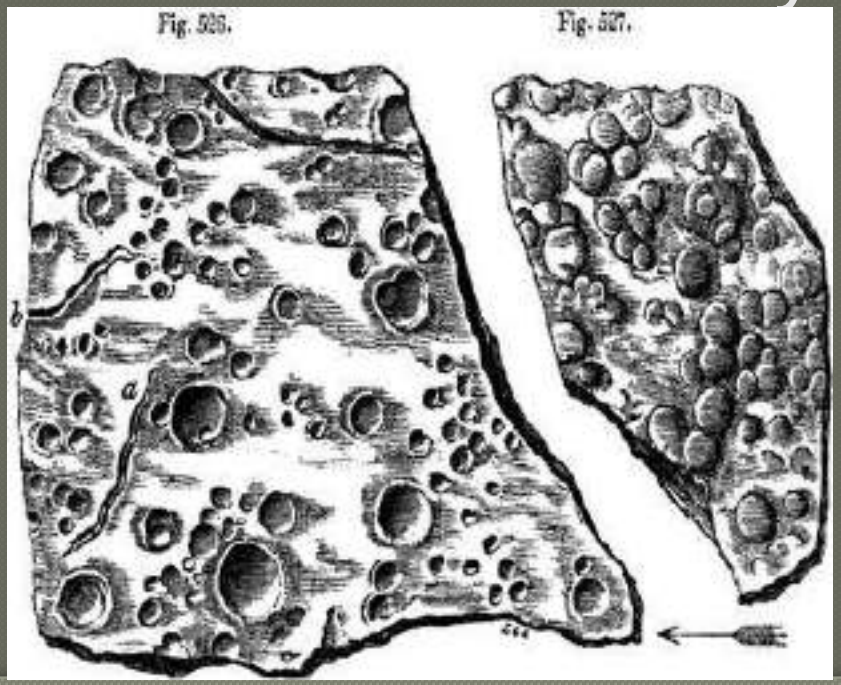
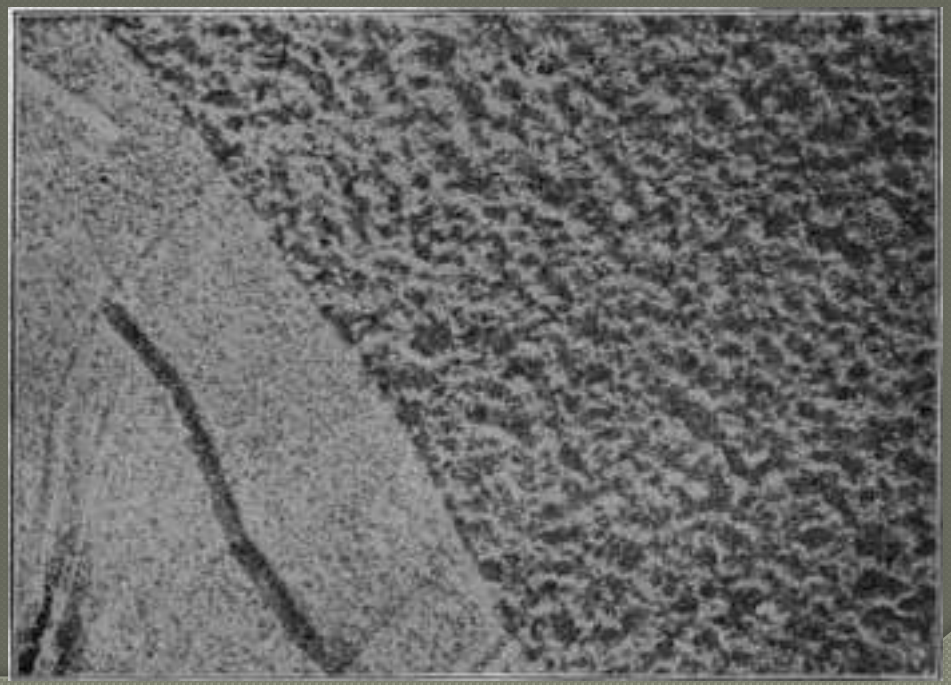
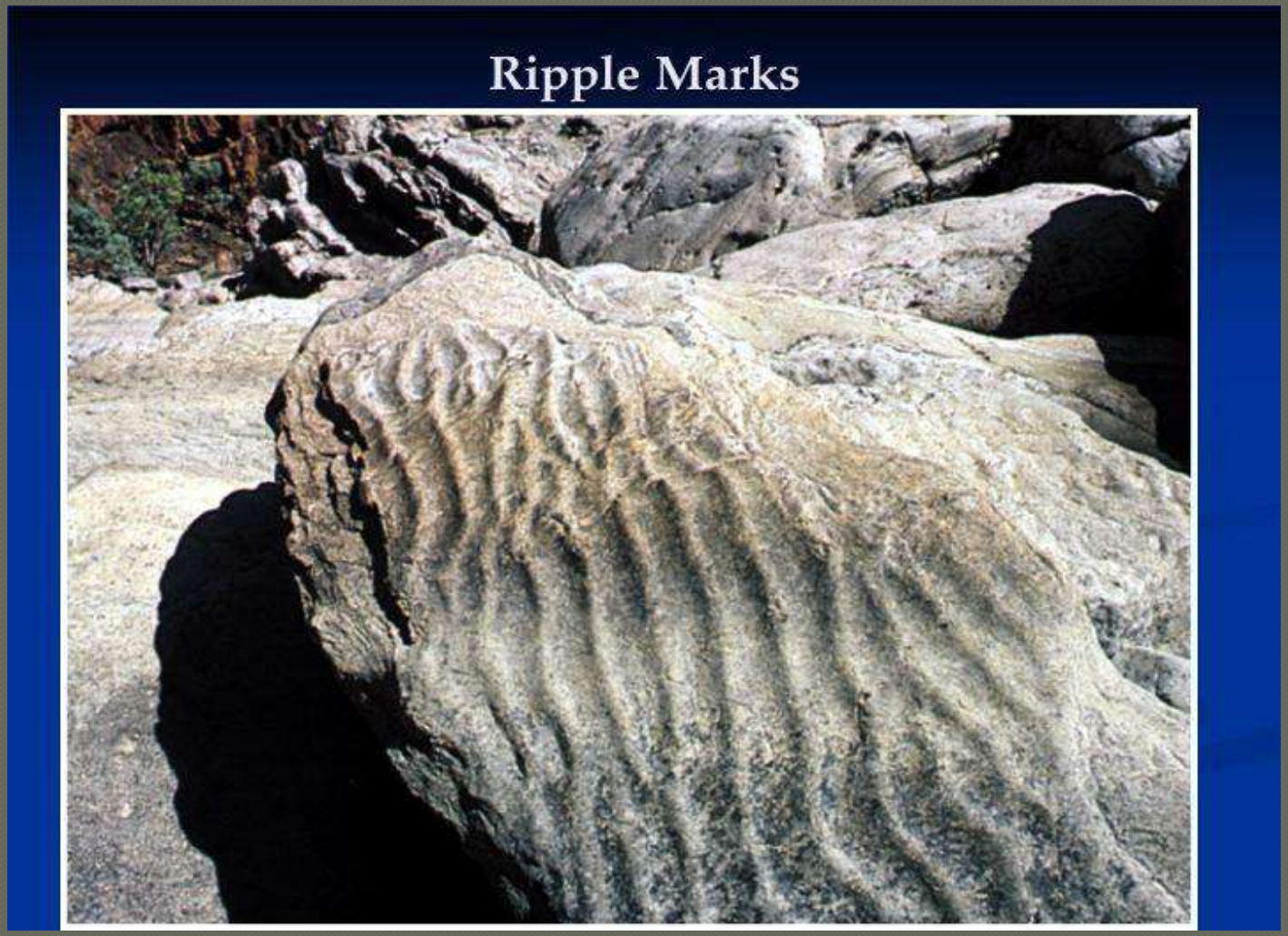
- Rain Prints:
  - irregular , small crater-shaped depressions seen on fine-grained dried sediments
  - rain falling on fine-grained compacted clays form crater like depressions
- these get dried up and preserved under another layer of mud





- Ripple Marks:
  - deposits made in shallow water
  - symmetrical asymmetrical, wave-like irregularity in a layer
  - due to wind action or wave action during deposition



- Mud cracks, rain prints, ripple marks are the confirmatory evidence for the formation of deposits in shallow water environment.

CHEMICAL STRUCTURE:

- Concretionary Structure:

  - made up of concretions of various shapes and dimensions
  - individual concretions may be rounded, sub-rounded, rough or smooth and small
  - examples : oolitic & pisolitic

In OOLITIC structures, concretions are of the size of fish eggs(0.1 – 1 mm). Appears like assemblage of fish-eggs

In PISOLITIC structures, concretions are of peanut size . Eg: limestones, bauxite

- Nodular Structures:
  - irregularly shaped nodules of chert, iron oxides, iron carbonates, clayey ironstones
  - nodules show elongation or flattening parallel to bedding planes

- Geode Structures:
  - hollow shell of rock
  - interior is lined with inwardly projecting crystals
  - rock shell is made up of chalcedony & inner encrustations are made up of quartz crystals

OOLITIC CONCRETIONARY

PISOLITIC CONCRETIONARY

NODULAR STRUCTURE

GEODE STRUCTURE

ORGANIC STRUCTURES:

- Fossiliferous structure:
  - due to the presence of fossils of plants and animal life in the rock
- Stromalitic Structures:
  - due to the presence of remains of algae

FOSSILIFEROUS STRUCTURE

STROMALITIC STRUCTURE

IMPORTANT SEDIMENTARY ROCKS

LIMESTONES

- Definition:

  -most common non-clastic sedimentary rocks

- Composition:

  calcite ($CaCO_3$),dolomite ($CaMg(CO_3)$), quartz (SiO_2) , felspar minerals and iron oxides.

  Chemically CaO, CO_2 , MgO.

- Texture :
  - shows a variety of texture
  - fossiliferous nature
  - dense & compact texture
  - concretionary texture in limestones
  - fossils at all stages may be found

- Types :
  -autochthonous : formed by biogenic precipitations fron seawaters
  -allochthonous : formed from precipitated calcareous sediments

Common types are
chalk, shelly limestone, argillaceous limesone, lithographic limestone, kankar, calc-sinter

- Formation:
  purely organic or in-organic origin

Environments of formation:

- Biothermal limestones:

  -occur in the form of reefs or mounds transferred to corals

  -highly fossiliferous

- Biostromal limestones:

  sheet-like accumulations of biogenic deposits

- Pelagic limestones:

  formed from limy secretion of floating type of sea organisms

- Uses:

  I) important application in industries and engineering practices

  ii) it is the primary source material for portland cement

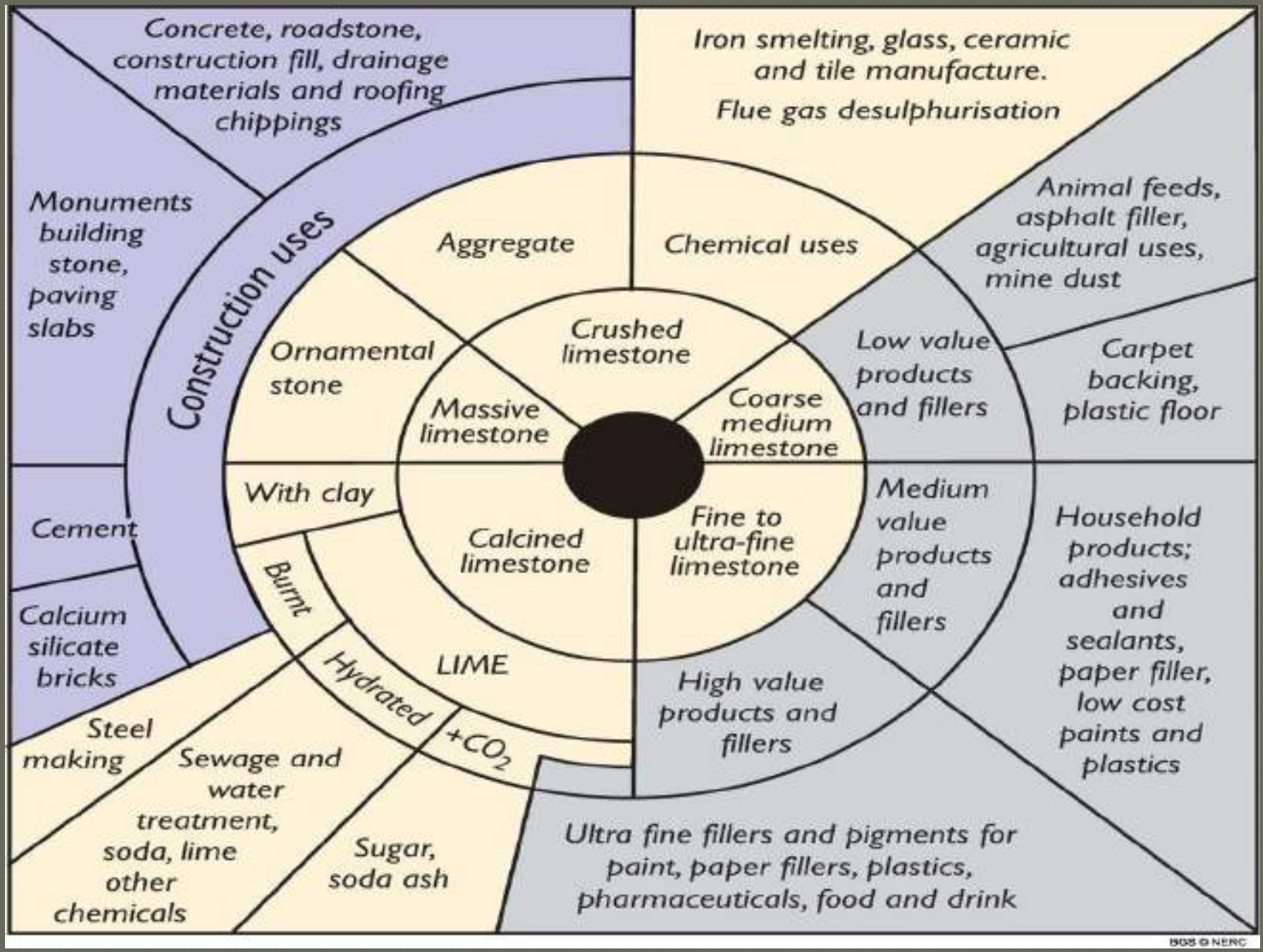
  iii) in metallurgical industries as flux

  iv)construction practice as building and road stones

  v) chemical industries

- Occurences:

  occurs as mountains and hills


Concrete, roadstone, construction fill, drainage materials and roofing chippings
Iron smelting, glass, ceramic and tile manufacture.
Flue gas desulphurisation
Monuments building stone, paving slabs
Construction uses
Aggregate
Chemical uses
Animal feeds, asphalt filler, agricultural uses, mine dust
Ornamental stone
Crushed limestone
Low value products and fillers
Carpet backing, plastic floor
Massive limestone
Coarse medium limestone
With clay
Cement
Calcined limestone
Fine to ultra-fine limestone
Medium value products and fillers
Household products; adhesives and sealants, paper filler, low cost paints and plastics
Burnt
Calcium silicate bricks
Hydrated
LIME
High value products and fillers
Steel making
Sewage and water treatment, soda, lime other chemicals
+CO_2
Sugar, soda ash
Ultra fine fillers and pigments for paint, paper fillers, plastics, pharmaceuticals, food and drink

OCCURENCE

SANDSTONES

- Definition:

  -mechanically formed sedimentary rocks of Arenaceous group.

  -Silica in the form of Quartz is the dominant mineral constituent of most sandstones

- Composition:

  -quartz (SiO_2), felspar, micas, garnet, magnetite

- Texture:

  I) varies in size range as follows:

  coarse-grain : 2 – ½ mm

  medium-grain: ½ – ¼ mm

  fine-grain : ¼ – 1/16 mm

  ii) round or angular in outline

iii) loosely packed or densely packed Their texture plays the main role in deciding whether these rocks are useful or useless

- Color:

  -variety of colors: red,brown,grey & white

  -depends on the composition

- Types:

  -Based on the composition and nature of cementing material the following types are identified

  I) Siliceous sandstones

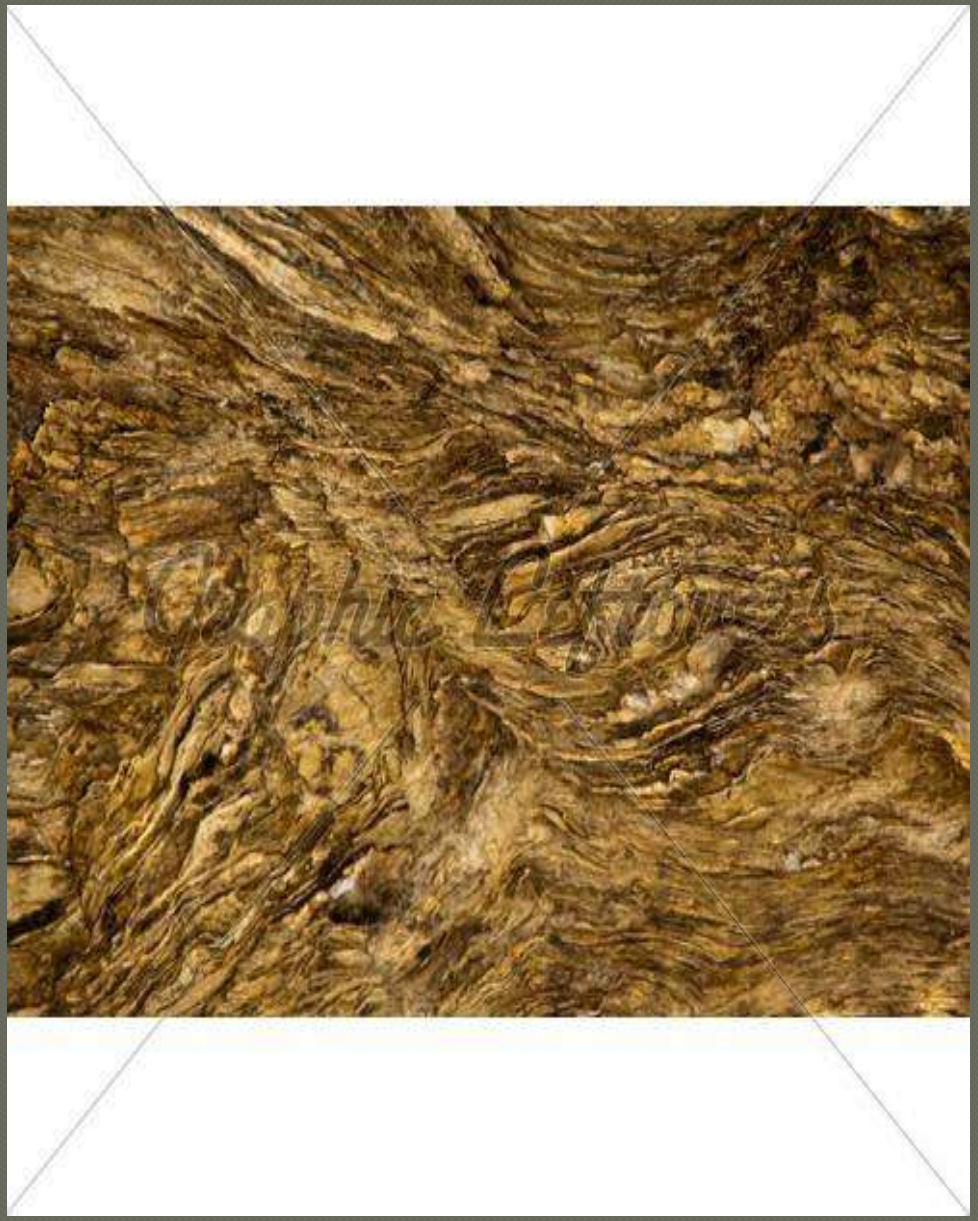
  ii) Calcareous sandstones

  iii) Argillaceous sandstones

  iv) Ferruginous sandstones

  -Based on the minerological composition sandstones are grouped as

  Arkose, reyeacke, Flagstone, Freestone, Ganister

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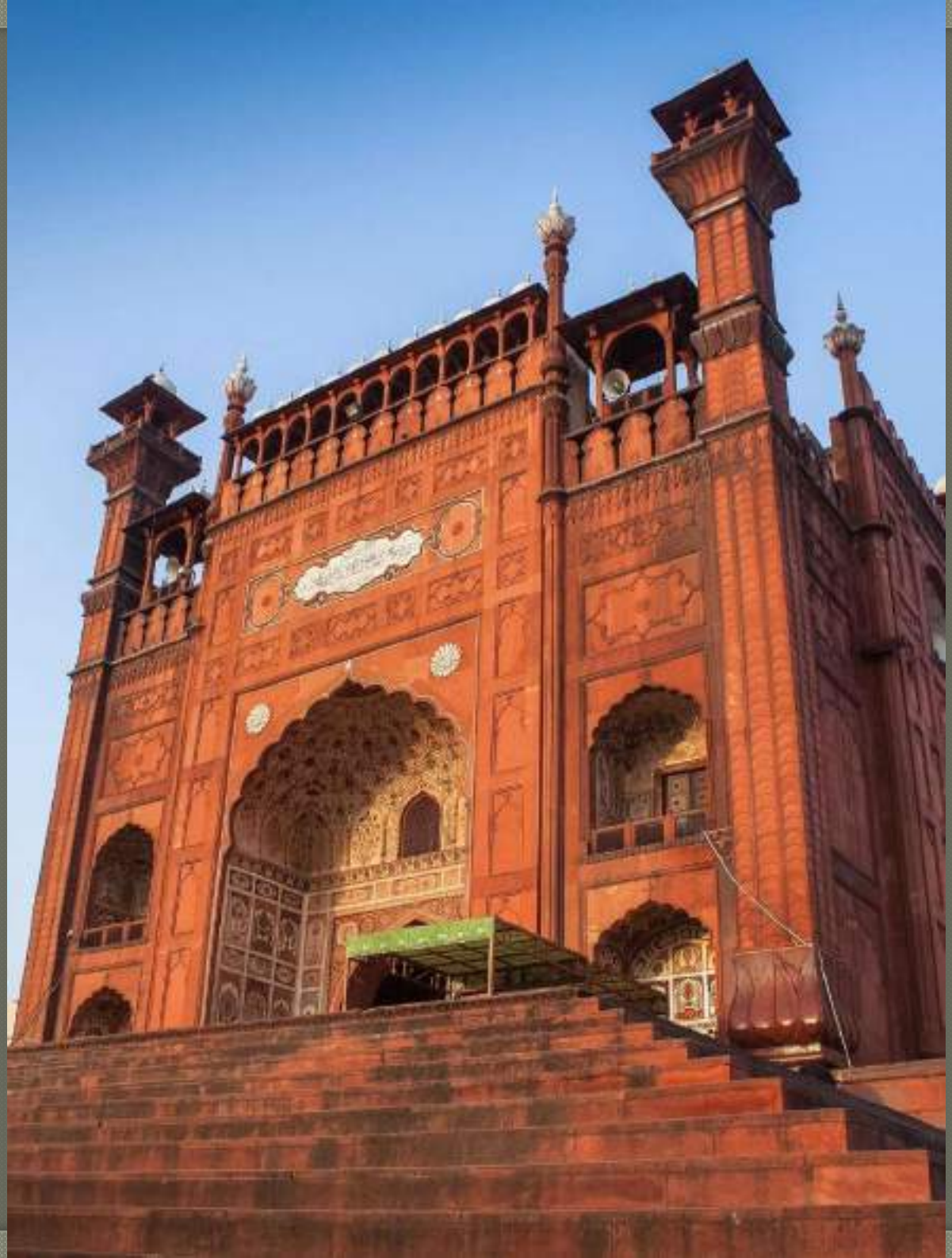
黄木纹砂岩 S001
CREAM SLAB STONE
黄山水纹砂岩 S002
CREAM SHANSHUI SANDSTONE
胡桃木砂岩 S003
HUTAO SANDSTONE
紫龙红砂岩 S004
ZILONG RED SANDSTONE
德红砂岩 S005
DE RED SANDSTONE
龙红砂岩 S006
LONG RED SANDSTONE
黑青砂岩 S007
BLACK GREEN SANDSTONE
阳青砂岩 S008
YANG QING SANDSTONE
白砂岩 S009
WHITE SANDSTONE
米黄砂岩 S010
YELLOW SANDSTONE
隆青砂岩 S011
LONG GREEN SANDSTONE
亚洲绿砂岩 S012
ASIA GREEN SANDSTONE
纯黄砂岩 S013
PURE YELLOW SANDSTONE
金红砂岩 S014
JIN RED SANDSTONE
青板岩 P001
QING SLATE
黑板岩 P002
BLACK SLATE

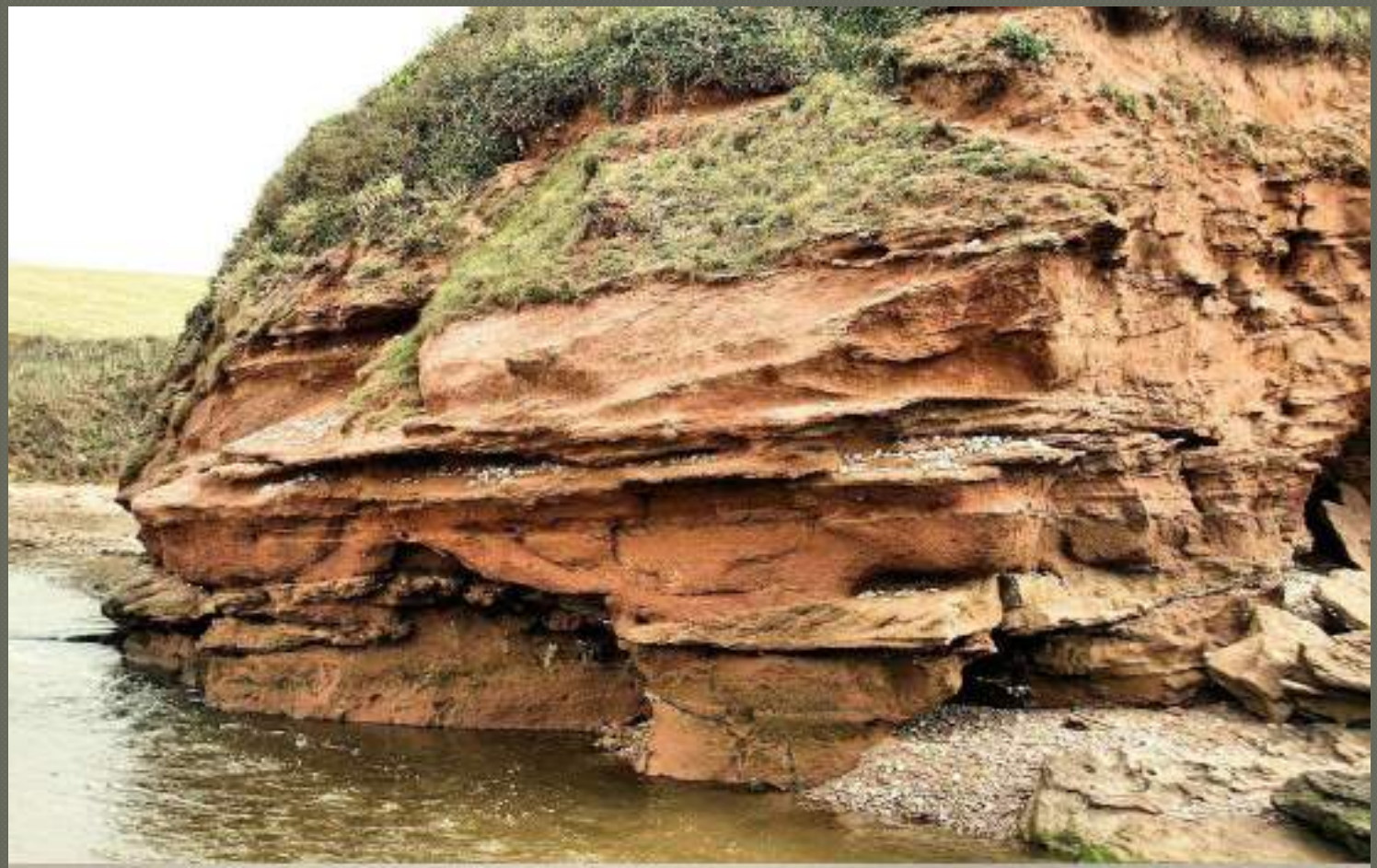
- Uses:

  I) building stones, pavement stones & road stones

  ii) redfort of india is made up of sandstones



- Distribution:
  -most abundant sedimentary rocks found in upper 15 km of the crust
  -15% of total sedimentary rocks



THE OTTER SANDSTONE IN FLUVIAL FACIES SEEN ACROSS THE RIVER OTTER, AT BUDLEIGH SALTERTON.
Breccia beds, buff in colour, alternate with reddish sandstones. The thin, wedge-shaped, breccia beds, show obvious cross-bedding with current direction from right to left. They are well-cemented and hard blocks fall out of the cliff onto the shore. The breccias are the results of brief flash floods in the Triassic desert. These lenticular beds occur at quite closed-spaced intervals in the fluvial facies of the Otter Sandstone. Rhizoconcretions occur at intervals but are not conspicuous in this photograph. Photo: 10th October 2011. Ian West (c) 2011.

CONGLOMERATES

- Defiinition:
  - clastic nature
  - rudaceous group
  - has rounded fragments
- roundness indicates the constituent garvels were transported to some distance

- Composition:
  - heterogeneous mixture
  - no definite composition
- has clasts of any rock material or weathering products washed downstream


Conglomerate

- Types:

  -On the basis of dominant grade of the constituent gravels

  I) boulder-conglomerate(gravels>256mm)

  ii) cobble- conglomerate (64 – 256 mm)

  iii) pebble- conglomerate (2 – 64 mm)

  - On the basis of source

  I)Basal-conglomerate (sea water over subsiding land)

  iv) Glacial-conglomerate (glacial origin)

  v) Volcanic-conglomerate (volcanic origin)

- On the lithological basis

I) Oligomictic (simple in composition)

ii) Polymictic (derived from rocks of all sorts)

- Texture:

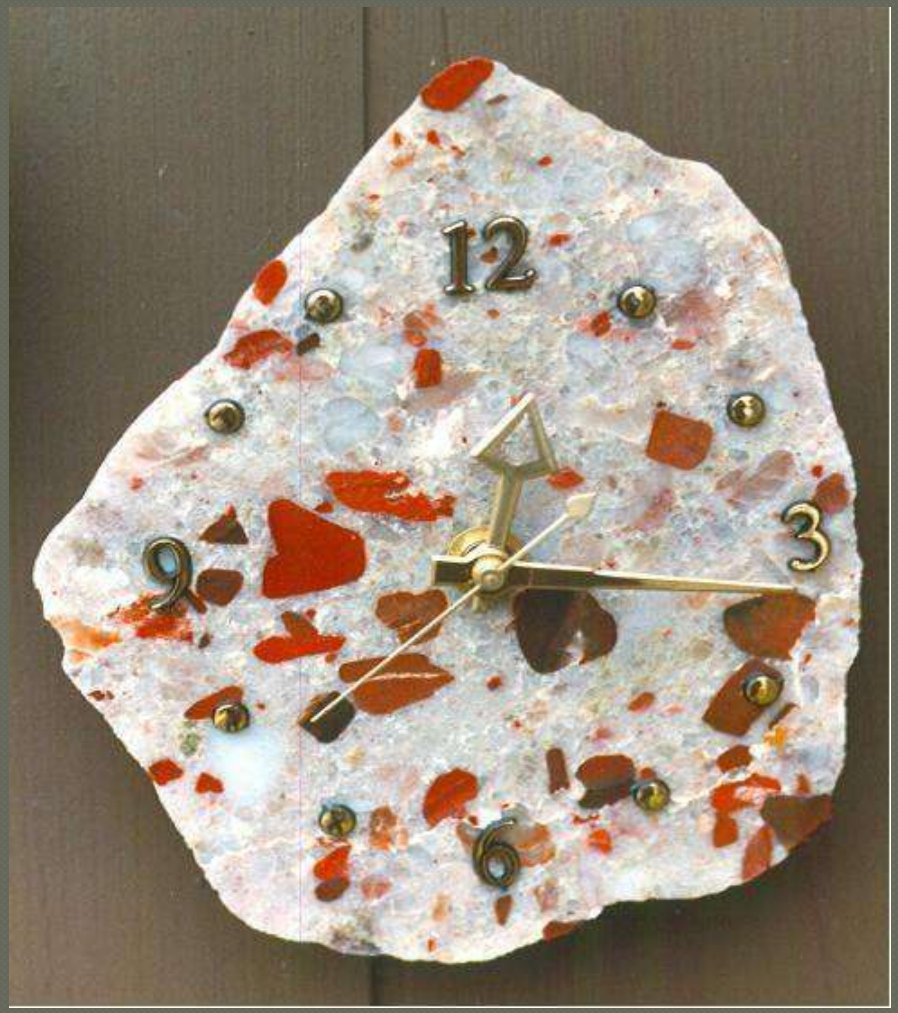
- matrix supported rocks

- contains 15% sand sized or smaller grains and the rest larger grains of various size

- Color:
  - many different colors
  - base color of brown, black or grey
  - rock fragments embedded on them may vary in size, shape & color

- Significance:
  - special geological significance when they occur in the form of well-defined layers of good thickness
  - indicative of shallow water phase in the depositional environment

- Uses:
  - decoration
  - in construction industry


12
3
6
9

ROCK SALT

- Composition:
  mineral halite (NaCl)
- Texture:
  varies from coarse-grained massive
- Color:
  white in purest form
  greyish or reddish in impure state
- Formation:
  evaporation of concentrated saline seawater
  subsidence of the basin of deposition during the process of evaporation

- Texture:
  thickness of about 100 m or more
- Distribution:
  many parts of the world interbedded with other sedimentary formations

DOLOMITE

- Definition:
  - carbonate rock of sedimentary origin
  - made up of the mineral dolomite $CaMg(CO_3)_2$
  - ferrous iron may also be present

- Texture:
  - coarsely crystalline, finely crystalline or interlocking crystals
  - rhombohedral habit

- Formation:

  - mostly formed from limestones by simple process dolomitization (replacement of Ca++ ions by Mg++ ions in rich waters)

- Color:

  - rusty

- Occurrence:

  - commonly associated with limestones
  - occur as intervening layers between limesone formations
  - extended boundaries of limestones

GYPSUM

- Definition:

- composed of the mineral gypsum $CaSO_4 . 2H_2O$

- Color:
  - white
  - other shades like yellow, red or dark gray due to impurities

- Formation:
  - result of evaporation of sea waters rich in sulphate salts

- Occurrence:
  - associated with rock-salt
  - independent deposits are also common

ANHYDRITE

- granular aggregate of mineral anhydrite $CaSO_4$
- hydration on anhydrite would give gypsum

ANHYDRITE

- Uses:

  - as a raw material in the manufacture of fertilizers
    - as an essential ingredient in the manufacture of cement
    - in the manufacture of plaster of paris
  - as fire proofing component of gypsum boards

FLINT AND CHERT

- FLINT:
  - dark colored sedimentary rock of siliceous composition
  - consists mainly of chalcedony and fine-grained quartz
  - occurs commonly as concretions or nodules in chalk (limestone) deposits

- CHERT:
  - composed of cryptocrystalline silica
  - variety of colors
  - occurs as beds or layers within limestones and other ddeposits

FLINT

CHERT

TILLITE

- sedimentary rock of glacial origin
- structureless matrix that has fragments of various sizes, shapes and composition
- bears striations indicating their transportation from glaciers
- compacted and consolidated form of glacial debris called till
- matrix or ground mass is of gray or greenish
- embedded fragments are extremely heterogeneous

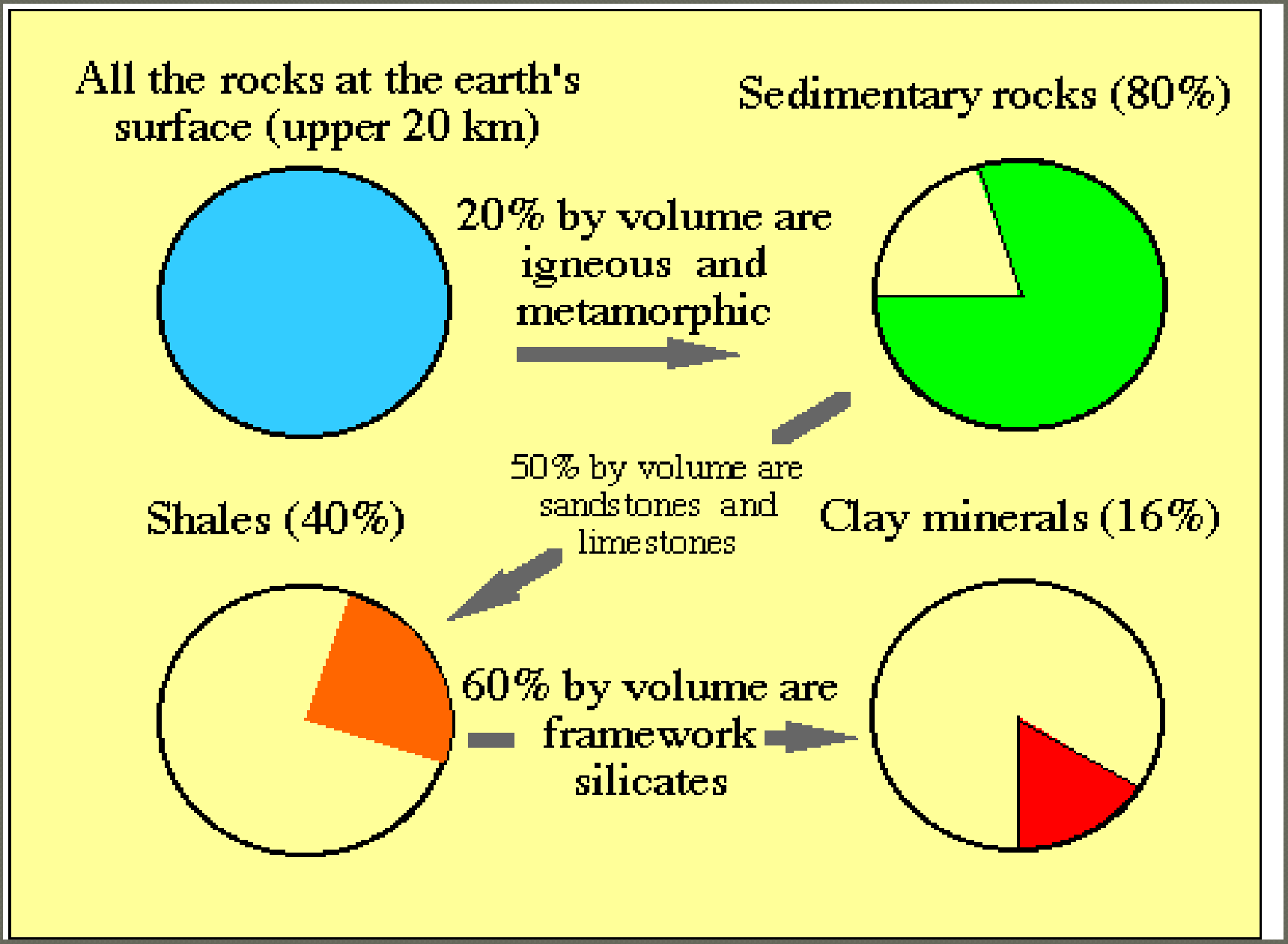
IRON ORES OF SEDIMENTARY ORIGIN

- most iron ores are of sedimentary origin
- occur interstratified with other sedimentary rocks
  - chemical precipitates in the form of oxides, carbonates and silicates from marine waters rich in corresponding salts
- metasomatic replacement for the formation of iron ore deposits
- Eg: Iron-Oxide ore series of Singhbhum, Orissa (interbedded with rocks like phyllites and made of oxides like hematite Fe_2O_3)

Iron-Oxide ore series of Singhbhum, Orissa

ENGINEERING IMPORTANCE

- Covers a great part of the earth's crust (75% of surface land mass)
- Withstand loads under heavy construction
- Natural reservoirs of oil and ground water supplies
- They may be used in cuts and tunnels in highway construction and also as reservoirs


All the rocks at the earth's surface (upper 20 km)
Sedimentary rocks (80%)
20% by volume are igneous and metamorphic
50% by volume are sandstones and limestones
Shales (40%)
Clay minerals (16%)
60% by volume are framework silicates

THE END