What are Rocks?

- Most rocks are an aggregate of one or more minerals and a few rocks are composed of non-mineral matter.
- There are three major rock types:
  - 1. Igneous
  - 2. Metamorphic
  - 3. Sedimentary

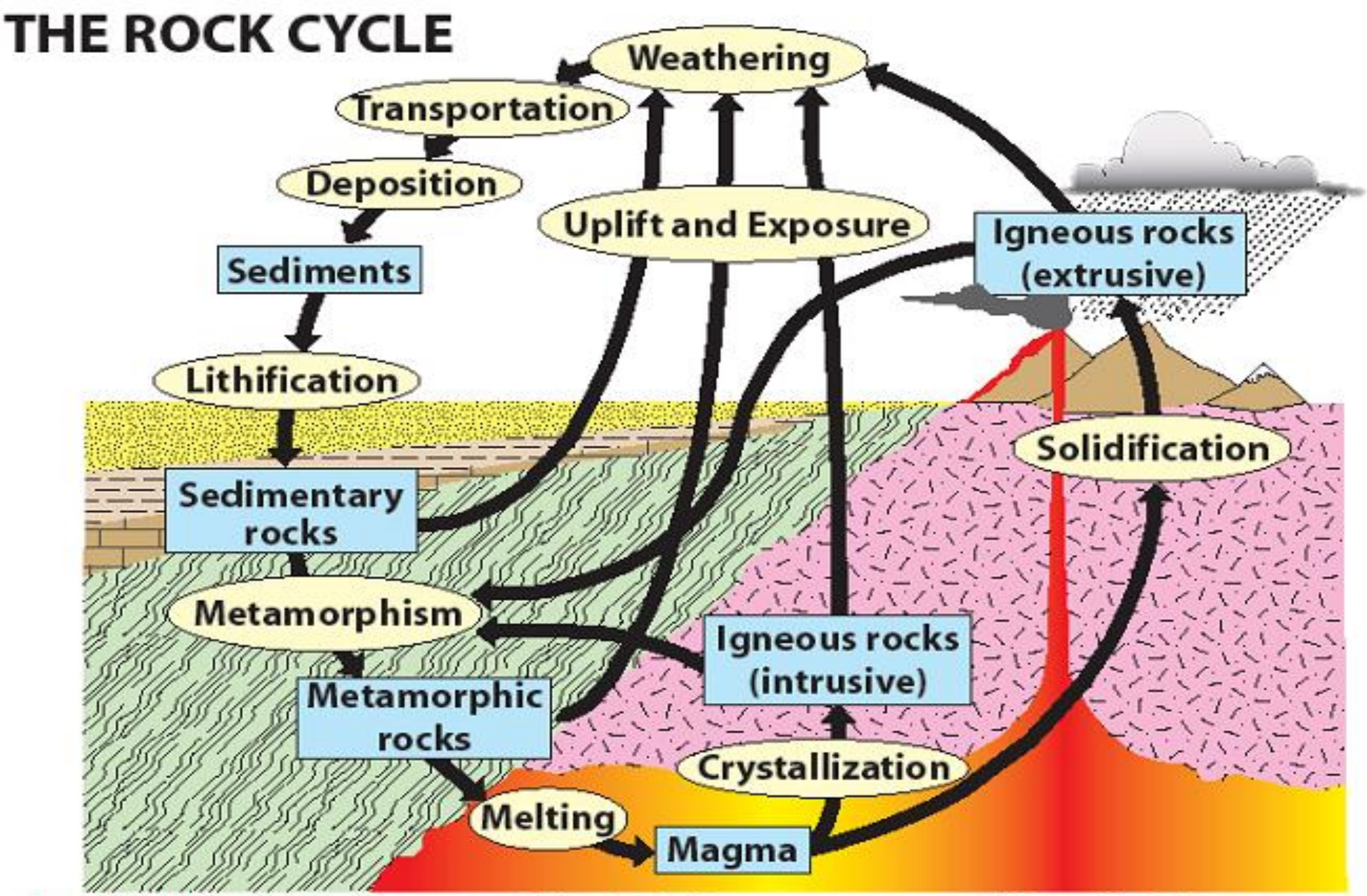
Major Rock Types

- Igneous rocks are formed by the cooling of molten magma or lava near, at, or below the Earth's surface.

- Sedimentary rocks are formed by the lithification of inorganic and organic sediments deposited at or near the Earth's surface.

- Metamorphic rocks are formed when preexisting rocks are transformed into new rocks by elevated heat and pressure below the Earth's surface.

The Rock Cycle



Igneous Rocks -
Rocks that form from the cooling of motlen rock (magma), Example: granite and basalt

Sedimentary Rocks -
Rocks that are fromed from pieces of other rocks, Example: sandstone, or that are deposited from the ocean by chemical processes, Example: limestone

Metamorphic Rocks -
Rocks that are changed by heat and pressure without melting, Example: gneiss

Sedimentary rocks

- **Sedimentary rocks cover some 80 percent of the earth's crust. All our knowledge of stratigraphy, and the bulk of our knowledge of structural geology are based on studies of sedimentary rocks.**
- **Sedimentary rocks of the geological record were deposited in the whole range of natural environments that exist today. The study of these modern environments and their sediments and processes contributes much to the understanding of their ancient equivalents**

The importance of sedimentary rocks

- There are many reasons for studying sedimentary rocks
- 1-Economic minerals and materials contained within them. The fossil fuels oil and gas are derived from the maturation of organic matter in sediments and these then migrate to a suitable reservoir, mostly a porous sedimentary rock. The other fossil fuel, coal, is also contained within sedimentary sequences.
- 2- Sedimentological and petrological techniques are increasingly used in the search for new reserves of these fuels and other natural resources.
- 3-Sedimentary rocks supply much of the world's iron, potash, salt, building materials and many raw materials.
- 4- Environments and processes of deposition and palaeogeography and palaeoclimatology can all be deduced from studies of sedimentary rocks. Such studies contribute much towards a knowledge and under-standing of the Earth's geological history

Naming and Classifying Sedimentary Rocks

- Geologists name and classify sedimentary rocks based on their mineral composition and texture
- **Mineral composition** refers to the specific minerals in the rock. For example sandstone will contain predominantly quartz, while limestone will contain mainly calcite (calcium carbonate).
- **Texture** includes the grain size and shape, sorting, and rounding of the sediments that form the rock.

General classifications of sedimentary rocks

- 1- The broad general classifications that embrace all sedimentary rocks. These are the most difficult classifications as most sediments are mixtures
- 2- The specialized classifications which may include the classifications of sandstones only, or carbonates only, etc.

Sedimentary Rocks

- Sedimentary rocks are formed by the lithification of inorganic and/or organic sediments, or as chemical precipitates.

- There are two types of sedimentary rocks: Clastic and Chemical

  - Clastic sedimentary rocks form when existing parent rock material is weathered, fragmented, transported, and deposited in layers that compact, cement, and lithify to form sedimentary rocks.

  - Chemical sedimentary rocks are formed by a variety of processes and are divided into sub-categories including inorganic, and biochemical or organic chemical sedimentary rocks.

    - Inorganic chemical rocks form from chemicals that are dissolved in a solution, transported, and chemically precipitated out of solution.
    - Biochemical or Organic sedimentary rocks form when plant or animal material is deposited and lithified. Those classified as biochemical chemical generally involve some form of fossilization or the accumulation of fossilized organism or organism remains, such as shell fragments. Organic rocks that are classified as clastic, involve the deposition of plant material and formation of peat and coal deposits.

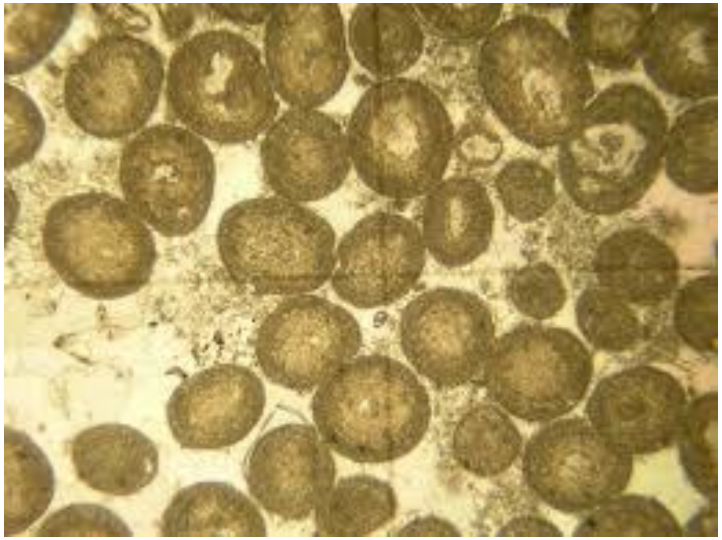
- The physical, chemical, or biological changes that occur during the lithification of sedimentary rocks are described by process collectively referred to as diagenesis.

Genetic Classification of Sedimentary Rocks (Folk classification)

- **Folk classification**, **he believed** Sediments consist fundamentally of three components, which may be mixed in nearly all proportions: (I) Terrigenous components, (2) Allochemical components, and (3) Orthochemical components.

Terrigenous, Allochemical components

- **Terrigenous components** are those substances derived from erosion of a land area outside the basin of deposition, and carried into the basin as some examples: quartz or feldspar, heavy minerals, clay minerals, chert or limestone pebbles derived from erosion of older rock outcrops.
- **Allochemical constituents** (Greek: "**Allo**" meaning different from normal) are those substances precipitated from solution within the basin of deposition but which are "abnormal" chemical precipitates because in general they have been later moved as solids within the basin; they have a higher degree of organization than simple precipitates. Examples: broken or whole shells, oolites, calcareous fecal pellets, or fragments of penecontemporaneous carbonate sediment torn up and reworked to form pebbles

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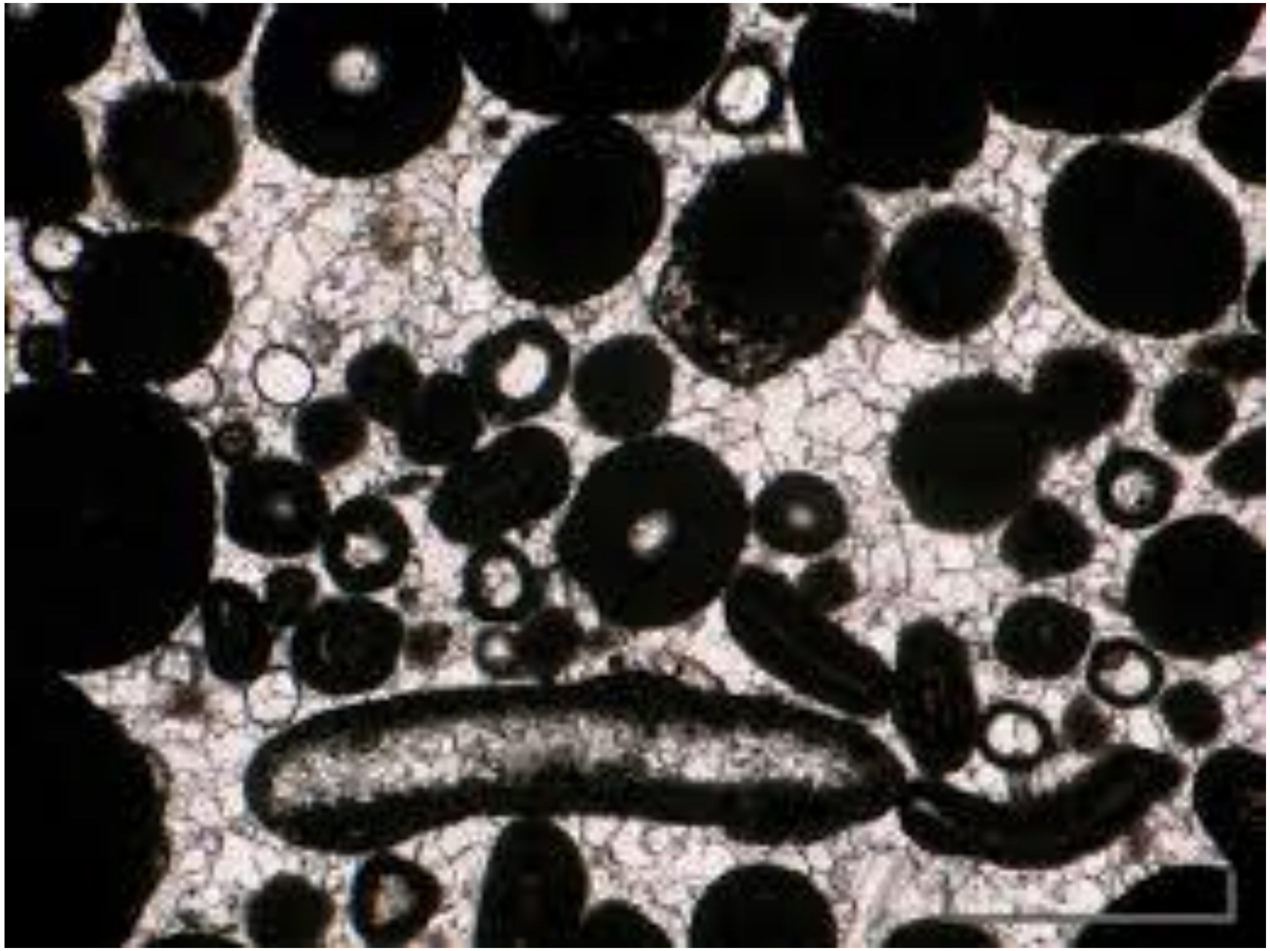
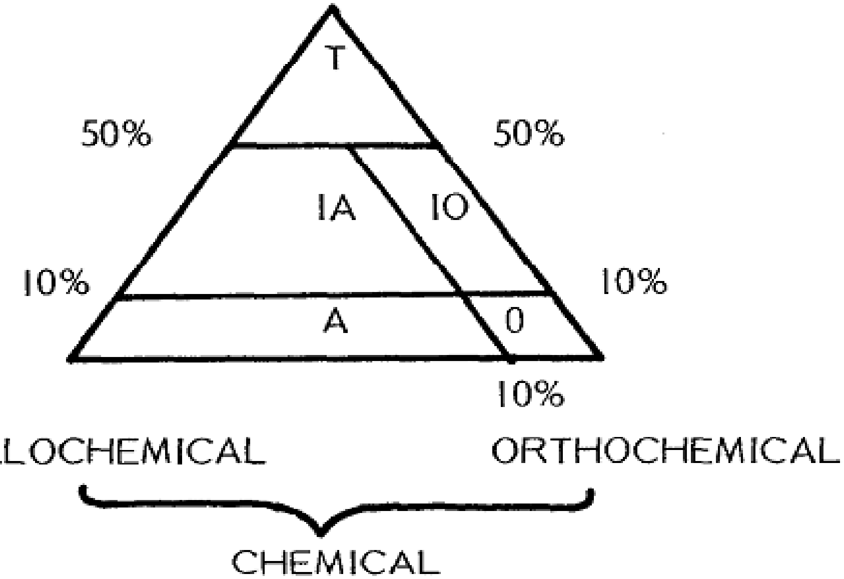
Orthochemical constituents

- **Orthochemical constituents** (Greek: “**Ortho”** meaning proper or true) are “normal” chemical precipitates. They are produced chemically within the basin and show little or no evidence of significant transportation or aggregation into more complex entities. Examples: microcrystalline calcite or dolomite ooze, probably some evaporites, calcite or quartz pore fillings in sandstones, replacement minerals.
- **Classes (b) and (c) are collectively referred to as “Chemical” constituents; classes (a) and (b) can be collectively termed “Fragmental.” Some people use “detrital” or “elastic” as equivalent to “terrigenous”; other people use “detrital” or “elastic” as a collective term including both “terrigenous” and “allochemical” above.**





T. Terrigenous Rocks. Example: most mudrocks, sandstones, and con glomerates. Comprise 65% to 75% of the stratigraphic section. Mos terrigenous rocks occur in the shaded area.

IA. Impure Allochemical Rocks. Example: very fossiliferous shales; sand; fossiliferous or oolitic limestones. Comprise 10-15% of the strati graphic section.

IO. Impure Orthochemical Rocks. Example: clayey microcrystalline lime stones. Comprise 2-5% of the stratigraphic section.

A. Allochemical Rocks. Example: fossiliferous, oolitic, pellet or intra clastic limestones or dolomites. Comprise 8-15% of the stratigraphi section.

O. Orthochemical Rocks. Example: microcrystalline limestone or dolo mite; anhydrite; chert. Comprise 2-8% of the stratigraphic section.

Collectively, "IA" and "IO" are classed as Impure Chemical Rocks, and "A ıd "O" as Pure Chemical Rocks.

Table 8.1
Classification of Sedimentary Rocks

Group	Class
I. Autochthonous sediments	(a) *Chemical precipitates*—the evaporites: gypsum, rock salt, etc. (b) *Organic deposits*—coal, limestones, etc. (c) *Residual deposits*—laterites, bauxites, etc.
II. Allochthonous sediments	(d) *Terrigenous deposits*—clays, siliciclastic sands, and conglomerates (e) *Pyroclastic deposits*—ashes, tuffs, volcaniclastic sands, and agglomerates.

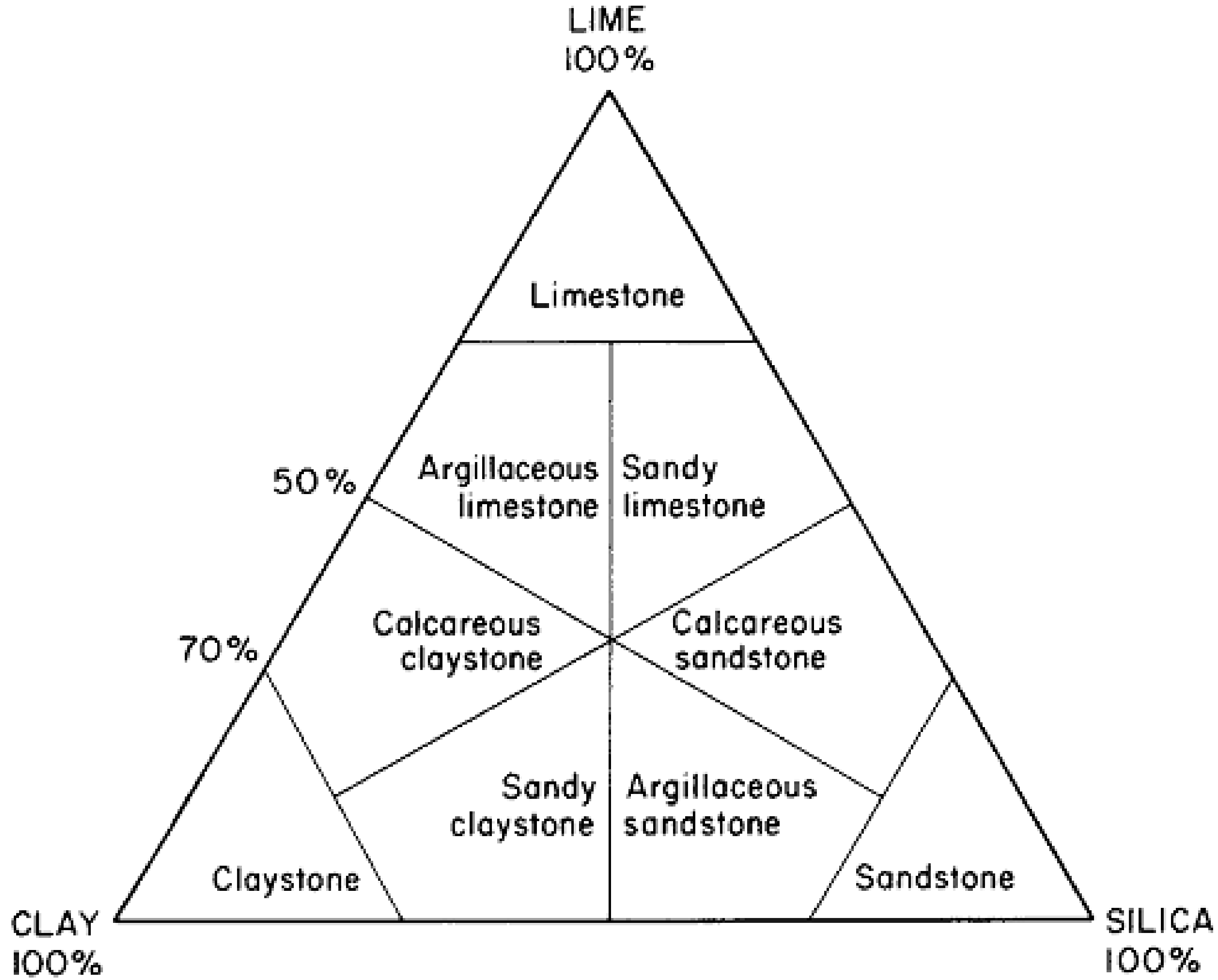


Fig. 8.1. An example of the end-member classification style. This triangle differentiates sands, claystones, and limestones.

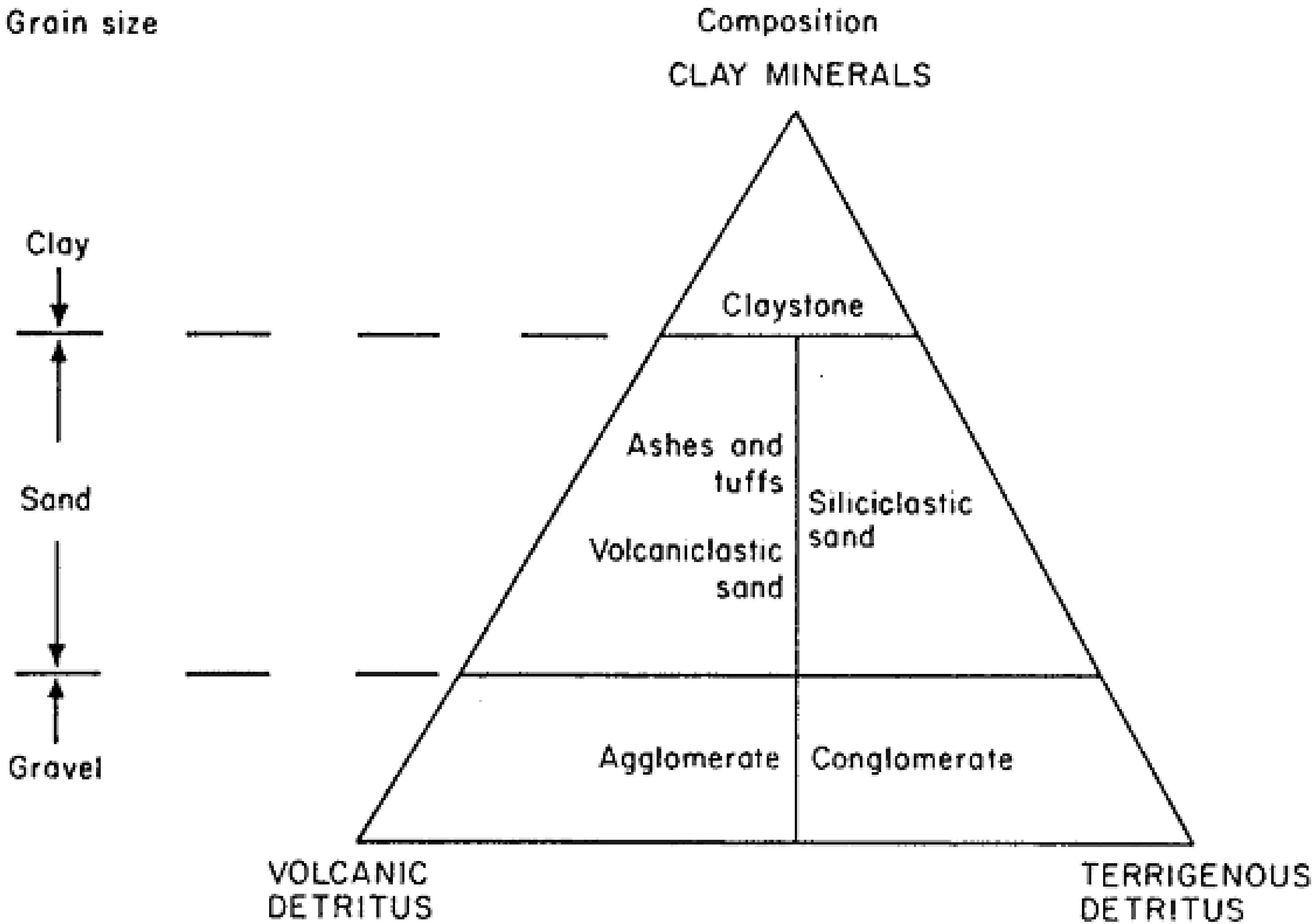


Fig. 8.3. A classification of the allochthonous sediments based on grain size and composition.

Another attempts to classifications

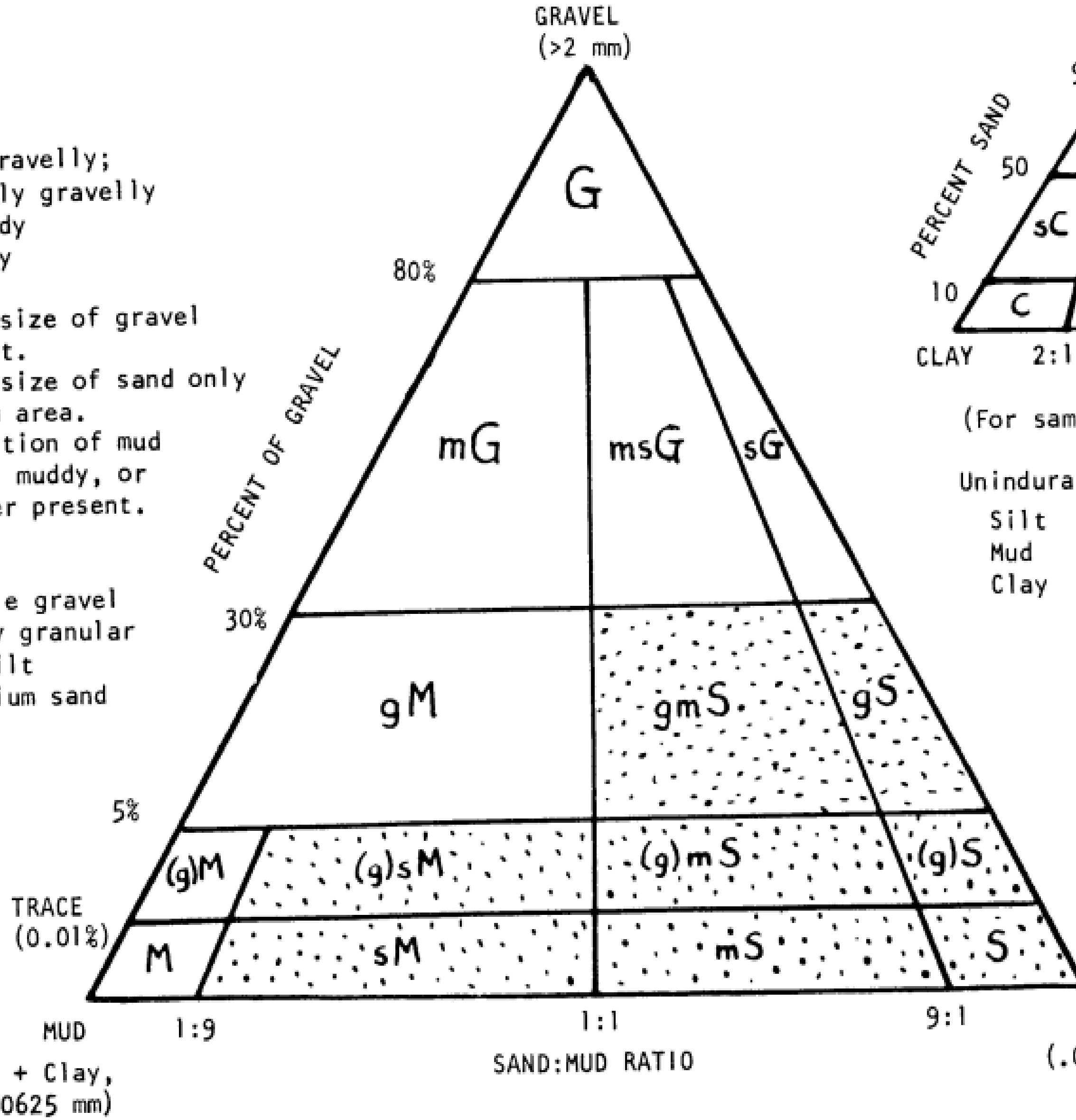
- 1- **Descriptive basis**: based on texture (grain size) or based on composition

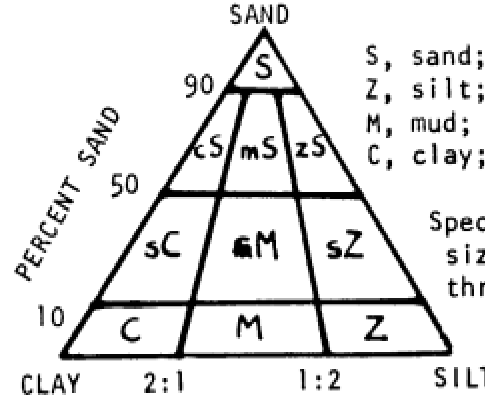
- 2- **Genetic basis**, based on the sedimentary origin

G, gravel; g, gravelly;
(g), slightly gravelly
S, sand; s, sandy
M, mud; m, muddy

Specify median size of gravel wherever present.
Specify median size of sand only in the stippled area.
Specify composition of mud (whether silty, muddy, or clayey) wherever present.

Examples:
sG, sandy cobble gravel
(g)sM, slightly granular fine sandy silt
mS, clayey medium sand





S, sand; s, sandy
Z, silt; z, silty
M, mud; m, muddy
C, clay; c, clayey

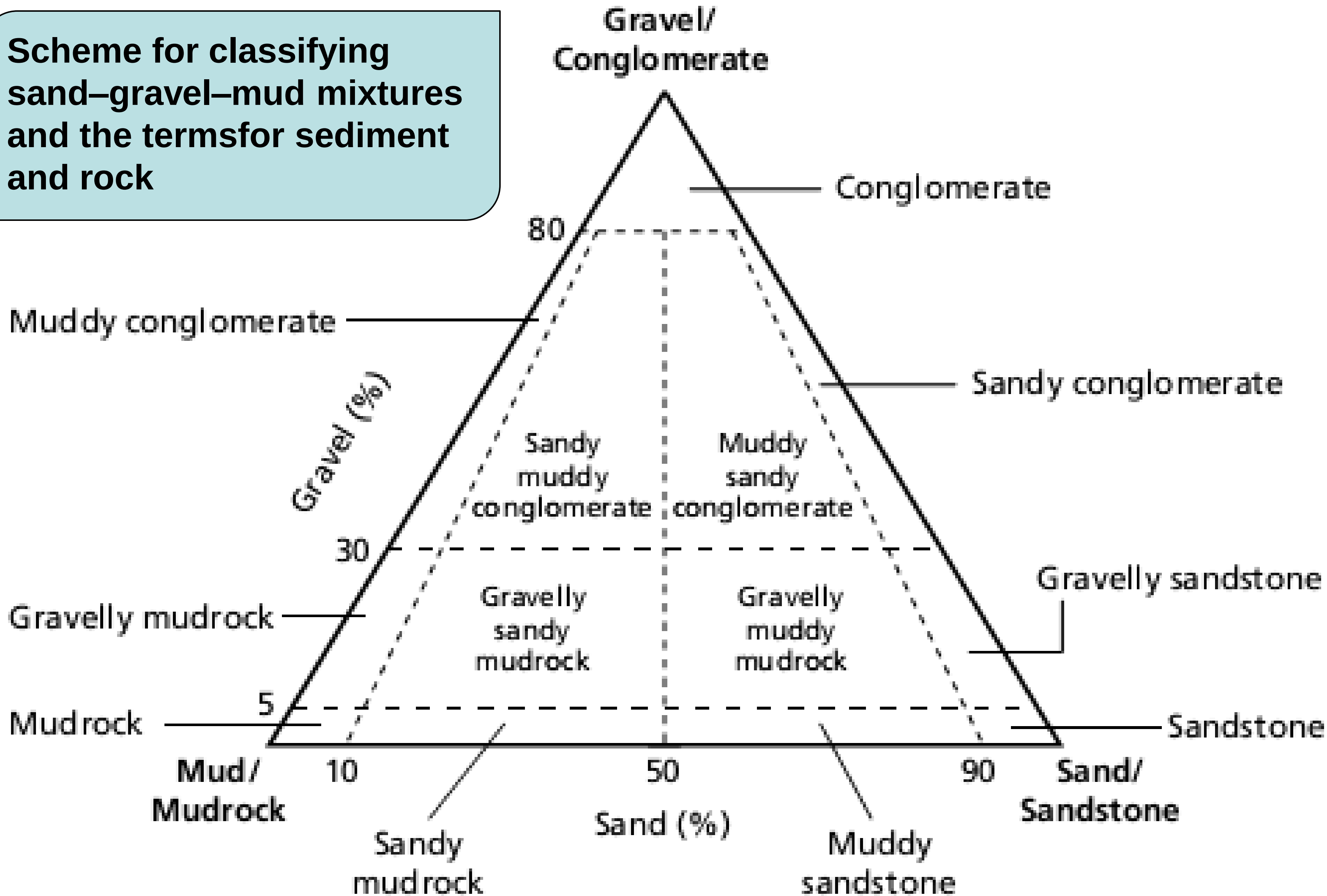
Specify median size of sand throughout.

(For samples lacking Gravel)

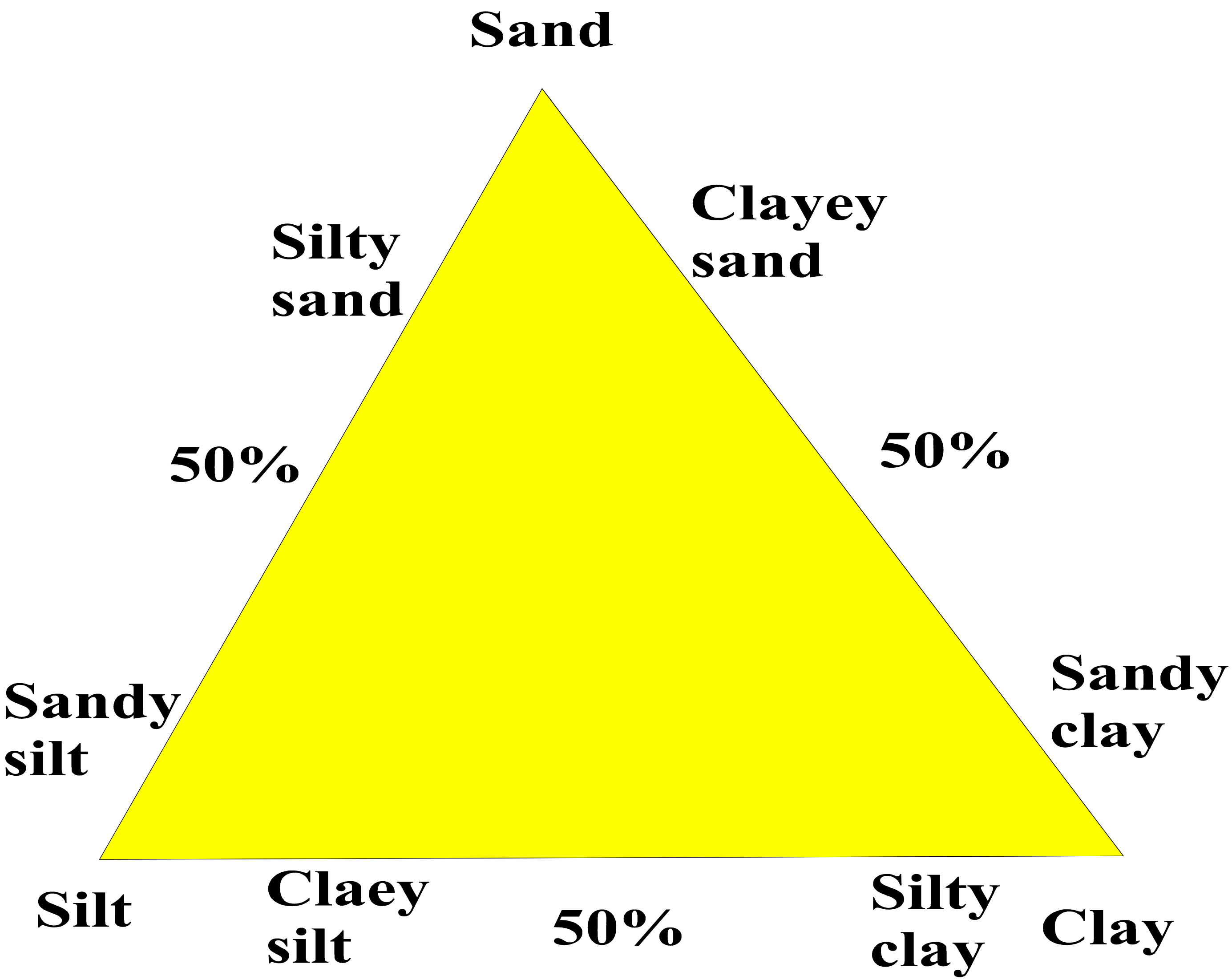
Unindurated	Indurated	Fissile
Silt	Siltstone	Silt-shale
Mud	Mudstone	Mud-shale
Clay	Claystone	Clay-shale

For details, see Folk, Jour. Geol. vol. 62, p. 345-351, July 1954.

Scheme for classifying sand–gravel–mud mixtures and the termsfor sediment and rock



Classification Based on texture



Texture: Grain Size

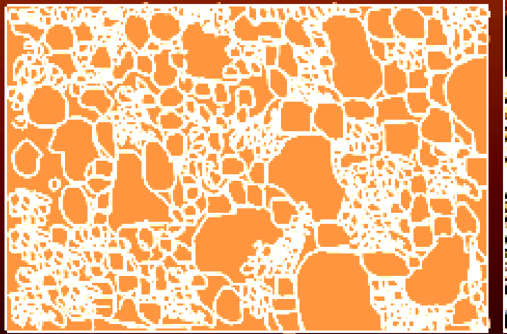
Grain size is used to describe the size of the individual mineral grains, rock fragments, or organic material that are cemented together to form a clastic or chemical sedimentary rock

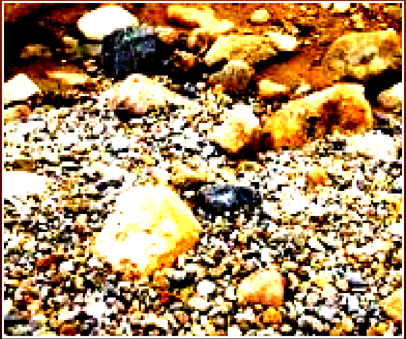
Grain Size Categories	Grain Size Divisions	
very coarse-grained	$\geq$	16 mm
coarse grained	$\geq$	2 mm < 16 mm
medium grained	$\geq$	0.25 mm < 2 mm
fine grained	$\geq$	0.032 mm < 0.25 mm
very fine-grained	$\geq$	0.0004 mm < 0.032 mm
cryptocrystalline	<	0.0004 mm (4 µm)

Texture: Sorting

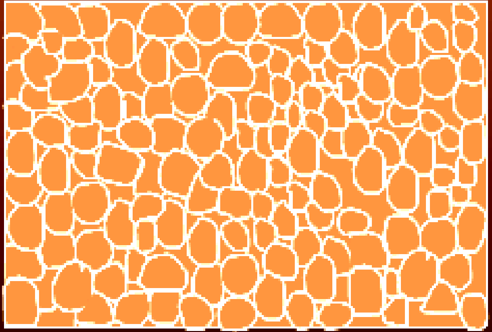
- Sorting is used to describe the grain size distribution or range of grain sizes in a rock.
    - Poorly sorted rocks contain a variety of different sized grains. Poorly sorted rocks contain a wide range of grain sizes including fine, medium, and coarse.
    - Well sorted rocks contain almost all grains of the same size.
    - Moderately sorted rocks contain particles of relatively similar grain sizes. Moderately sorted rocks may contain fine and medium grains, or medium and coarse grains.

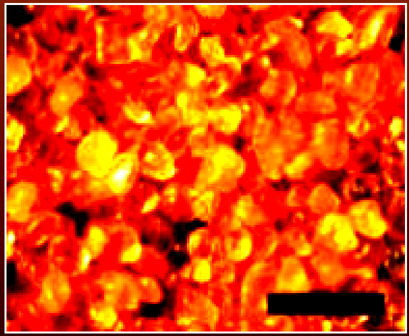
Poorly Sorted





Well Sorted





Texture: Rounding

Rounding is used to describe the relative shape of the grains. Classifications are describe as deviations from rounded or spheroidal grain shapes.

- **Well rounded** grains are smooth with rounded edges..
- **Moderately rounded** grains are in-between the sharp, angular edges of a poorly rounded grain and the smooth, roundness of a well-rounded grain.
- **Poorly rounded** grains may be sharp or angular.

Well-rounded, spheroidal grains

Poorly–rounded, angular grains

Texture and Weathering

The texture of a sedimentary rock can provide a lot of information about the types of environments that the sediments were weathered in, transported by, and deposited in prior to their lithification into sedimentary rocks.

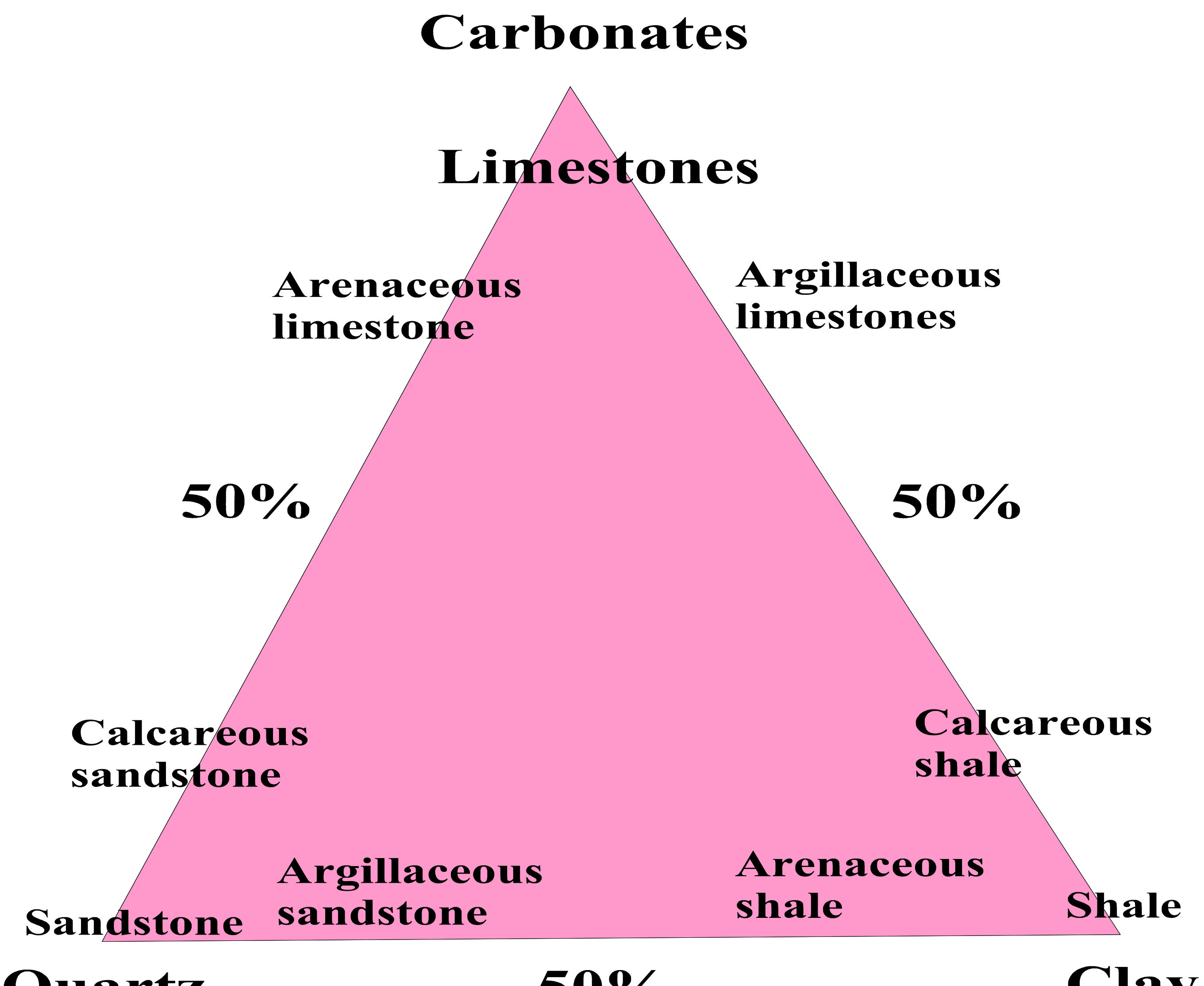
Most sedimentary rocks consist of grains that weathered from a parent rock and were transported by water, wind, or ice before being deposited.

- Grain size is a good indicator of the energy or force required to move a grain of a given size. Large sediments such as gravel, cobbles, and boulders require more energy to move than smaller sand, silt, and clay sized sediments. Grain size is also an indicator of the distance or length of time the sediments may have traveled. Smaller grain sizes generally indicate greater transport distances and duration than larger grains.

- Sorting will generally improve with the constant or persistent moving of particles, and thus can indicate if particles were transported over a long distance or for a long time period. Sorting can also indicate selective transport of a particular grain size.

- Rounding is a good indicator for the amount of abrasion experienced by sediments. In general, sediments that have been transported longer distances will be more rounded than those which have traveled shorter distances.

Classifications based on composition



Classifying Sedimentary Rocks

CLASTIC SEDIMENTARY ROCKS

TEXTURE	SEDIMENT PARTICLE SIZE	OTHER CHARACTERISTICS	SEDIMENTARY ROCK
CLASTIC	Gravel (> 2 mm)	Rounded rock fragments, Poorly-sorted	Conglomerate
		Angular rock fragments, Poorly-sorted	Breccia
	Sand (0.0625 mm – 2 mm)	Quartz (>50%), Moderate – well sorted	Quartz sandstone
		Quartz with Feldspar, Moderate –Well sorted	Arkose
		Quartz, Feldspar, Clays, Rocky Fragments, Well-sorted	Graywacke
	Mud (< 0.0625 mm)	Fine, thin layers, or cohesive clumps, Well-sorted	Shale, Siltstone, and Mudstone

CHEMICAL SEDIMENTARY ROCKS (INORGANIC AND BIOCHEMICAL)

GROUP	TEXTURE	CHEMICAL COMPOSITION	SEDIMENTARY ROCK
INORGANIC	clastic or non-clastic	Calcite, $CaCO_3$	Limestone
	non-clastic	Dolomite, $CaMg(CO_3)_2$	Dolostone
	non-clastic	Microcrystalline quartz, SiO_2	Chert
	non-clastic	Halite, NaCl	Rock salt
	non-clastic	Gypsum, $CaSO_4$ $2H_20$	Rock Gypsum
BIOCHEMICAL	clastic or non-clastic	Calcite $CaCO_3$	Limestone
	non-clastic	Microcrystalline quartz, SiO_2	Chert
	non-clastic	Altered plant remains	Coal

Incised alluvial fans, River San Juan, NW Argentina

Table 1.2 Scheme for the identification and description of sedimentary rocks in hand specimen

Examine the rock for colour, texture, composition, sedimentary structures and fossils and then identify the sedimentary rock type. If there is enough evidence, give an interpretation of the depositional environment and diagenesis of the sediment

Colour

It should be easy to describe the colour. The colour is usually a reflection of the organic content (grey to black with increasing organic matter) and oxidation state of iron: ferrous iron, occurring in clay minerals (e.g. chlorite) and iron minerals (such as berthierine–chamosite) gives a green colour; ferric iron, occurring in iron minerals, gives red (in hematite) and yellow–brown colours (in goethite–limonite). Some sedimentary minerals may have a particular colour, such as the white of pure anhydrite and gypsum

Texture

Determine the grain size of the rock with a hand-lens; look at the grain shape: rounded or angular? Look at the grain sorting, is it well or poorly sorted? Look for the nature of the contacts between the grains (if visible), and for any preferred orientation of the grains (fabric)

Composition

Identify the composition of the sediment using a hand-lens

Is it sandstone?—made of quartz, feldspar, rock fragments. If so, is it a quartz arenite, litharenite, arkose or greywacke (the four common types)?

Is it a limestone (fizzes with acid)?—made of bioclasts (fossils), ooids, peloids. If so, is it a grainstone, packstone, wackestone, mudstone or boundstone?

Is it a dolomite (dolomitized limestone, fizzes little)?—crystalline, poorly preserved fossils and structures, pale brown–buff colour

Is it a mudrock? If so, is it fissile (a shale) or not (mudstone)? Any nodules present? Composition?

Is it a conglomerate? Determine whether monomictic or polymictic (from clast composition), orthoconglomerate or paraconglomerate (from texture)

Less common sedimentary rock types are evaporites (may be salty or soft), cherts (hard and splintery) and ironstones (red or green, heavy, oolitic)

Sedimentary structures

Look for structures such as bedding, lamination, cross-bedding, cross-lamination, parting lineation, sole structures, burrows, nodules, stylolites, etc.

Fossils

If present (a hand-lens may be needed to see them) try and identify them to phylum level (further if you can). Also look for the preservation of the fossils (shells articulated, broken, bored, dissolved, etc.)

Interpretation

From all the evidence gathered, suggest a rock type and possibly depositional environment. There may be several alternatives. Comment on the rock's diagenesis: cementation, compaction, replacement, etc., and near-surface versus burial diagenetic effects