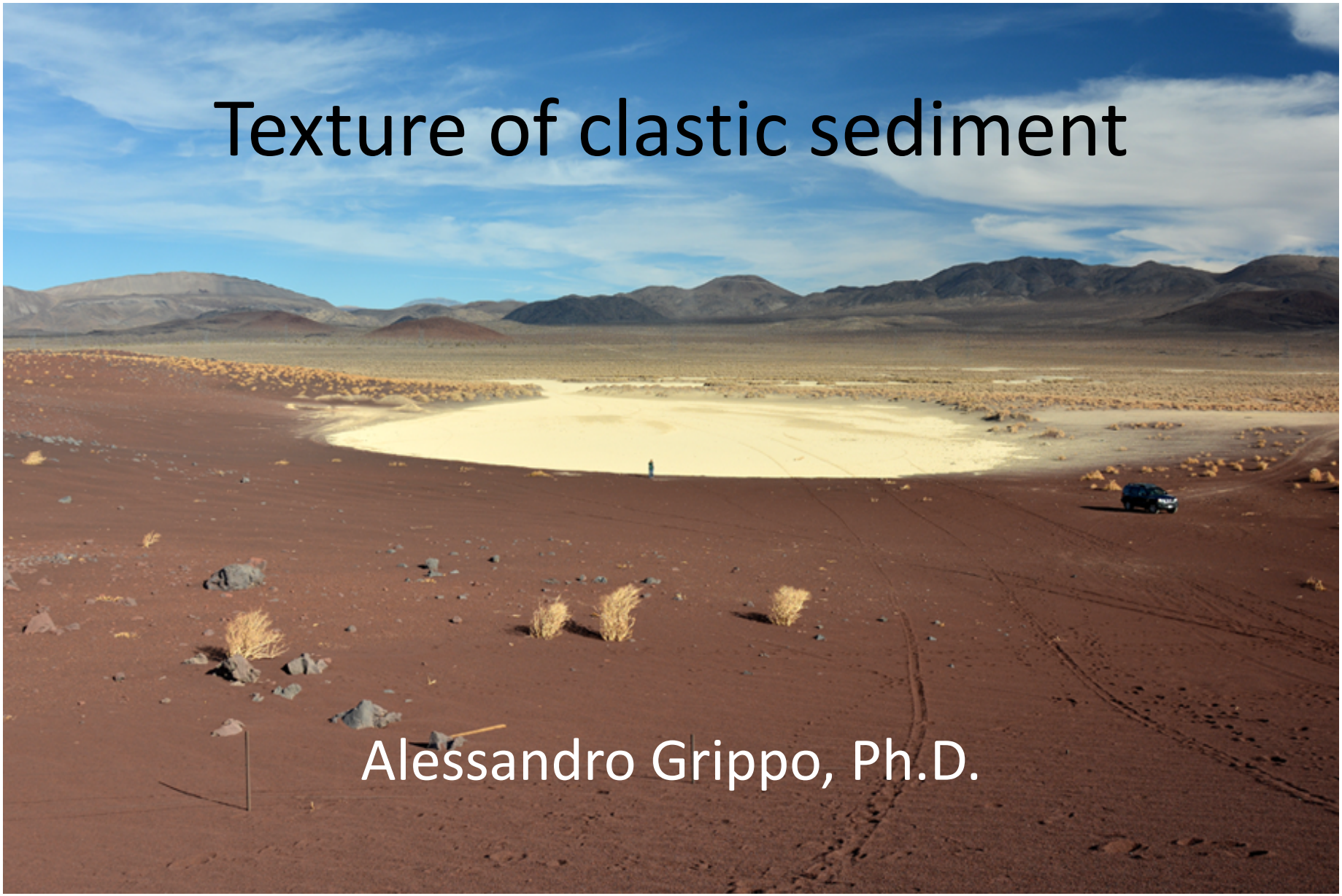
Texture of clastic sediment



Alessandro Grippo, Ph.D.

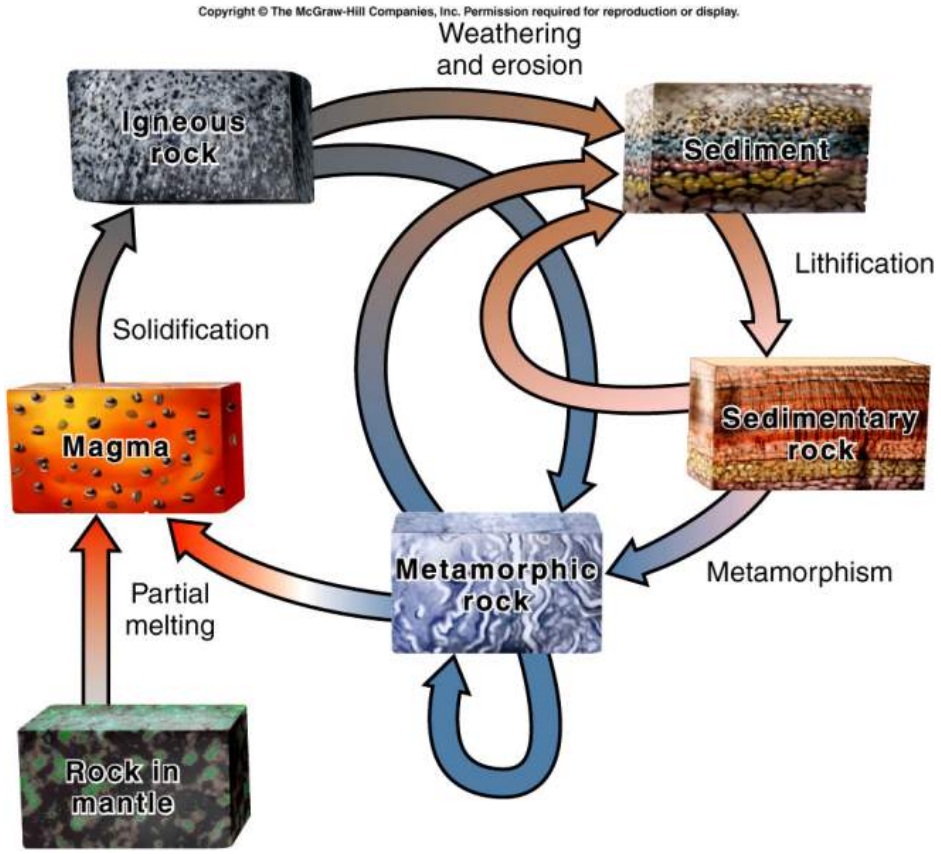
Clastic sediments: gravel, sand, and mud
Coso playa lake, Coso Junction, California

review

what are sediments?

- there are **three kind of rocks**
  - igneous (from cooling of magma or lava)
  - metamorphic (from exposure to high temperatures and/or pressures)
  - sedimentary (from cementation of rock fragments and/or precipitation from a solution)

- all rocks can be weathered, producing **sediments**
  - mechanical weathering
  - chemical weathering



mechanical weathering

– all physical processes that **break down** rocks in smaller fragments

– fragments are identified by their size as gravel, sand, silt, and clay (silt and clay together are defined as mud)

chemical weathering: action of oxygen

- all chemical processes that change the composition of rocks
- two agents: oxygen and acids
- the action of oxygen in the atmosphere and in water causes iron minerals present in rocks to “rust” (**iron oxides**)
- $4Fe + 3O_2 \rightarrow 2Fe_2O_3$ (hematite)

chemical weathering: action of acids

- the action of acids “corrodes” rocks and turns them into quartz, clay minerals, and ions in solution

- **Quartz**
  - a very common, resistant mineral
  - typical component of sand at the beach
- **Clay Minerals**
  - a very common byproduct of weathering
  - have special properties: they are flat, they absorb water and ions, they “swell”,
- **Ions in solution**
  - anything mineral that can be dissolved in water (Ca^{2+}, Mg^{2+}, Fe^{2+}, Na^{+}, K^{+}, CO_3^{2-}, etc.)

what is next?

- now we have a bunch of
  - loose fragments at earth's surface, and
  - ions in solution

- these particles are picked up (**eroded**), moved around (**transported**) and resettled somewhere else (**deposited**) by:
  - water (rivers)
  - wind
  - glaciers
  - directly by rockfall/landslides

- Particles are eroded, transported, deposited
- Carried towards the ocean by:
  - Streams, Wind, Glaciers, Gravity

- Greatest quantity found around continental margins
  - mostly on shelves
  - also in continental rises or trenches


(a)


(b)


(c)


(d)

erosion

transportation

deposition

burial
compaction
cementation
} (lithification)

EXAMPLE

sand is picked up

then it is moved around
by rivers, wind, waves;
it gets more weathered

it is then deposited
(but it can also be picked up again)

it will get finally buried
by more recent sediment

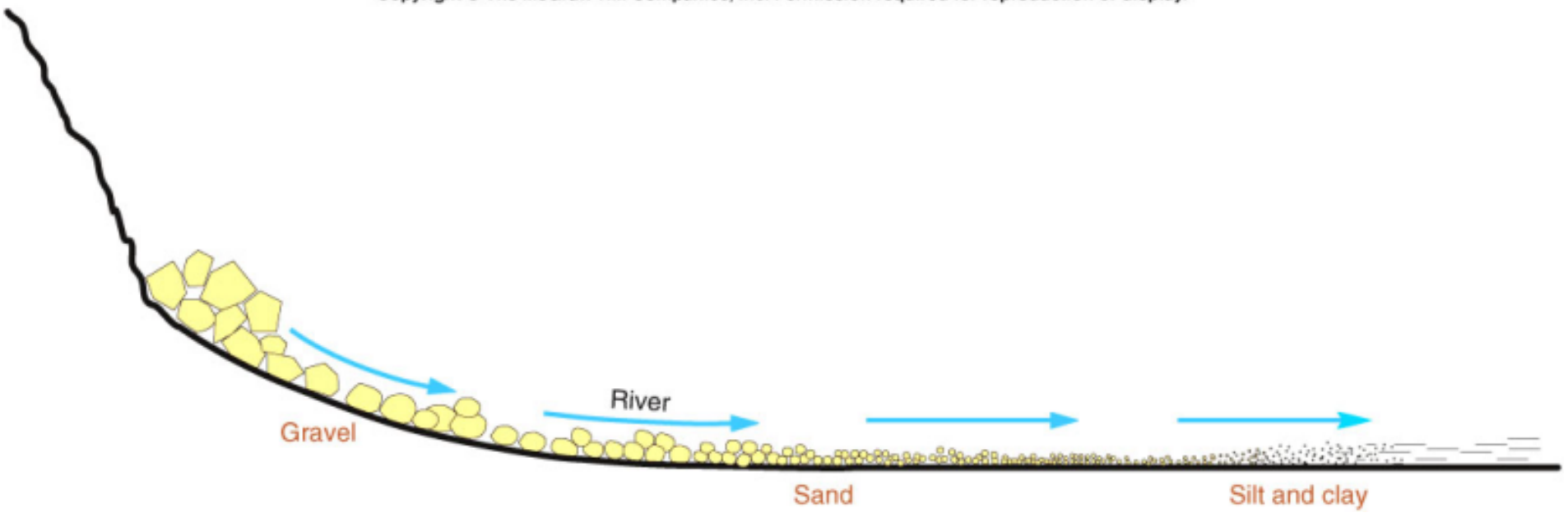
the weight compacts the sand

water enters the pores

ions in solution are released (cement),
turning the sand into a sandstone

distribution of sediments

because of erosion, transportation, deposition



Sorting and rounding

- Because of different levels of energy in the physical environment, grains are **sorted**, that is, separated one from the other according to their size

- Because of wear during erosion, transportation and deposition, grains lose their roughness and become abraded, causing their outer surface to become progressively more **rounded**

Maturity

- With time and distance, a sediment becomes more rounded, sorted, but also richer in quartz

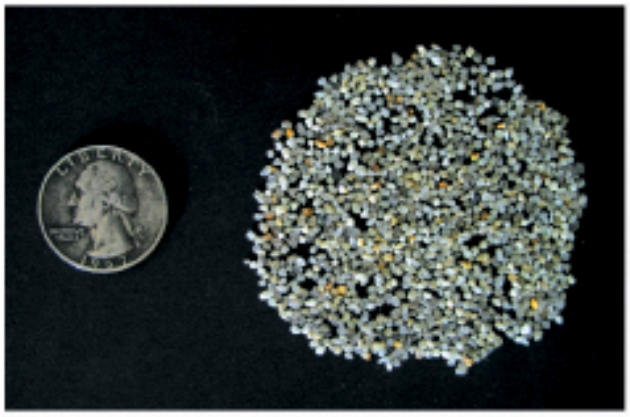
- **A sediment that is rounded, sorted, and rich in quartz is called mature**

- If any of these three conditions is missing, the sediment is deemed immature

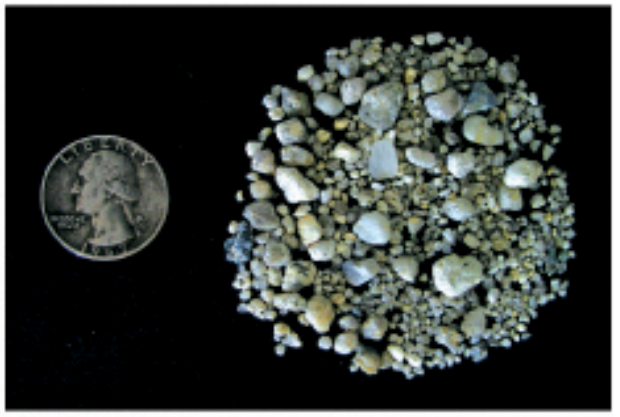
- Gravels always contain smaller grains, like sand, silt, and clay (immature)
- Silts are essentially always rounded, sorted, rich in quartz (mature)
- The concept of maturity cannot be applied to clay minerals (they are flat, and cannot be weathered)
- In the end, different levels of maturity can be applied **only to sands**

Sorting

- Measure of grain size distribution
  - Indicate effectiveness of depositional medium in separating grains of different sizes
- Poor sorting usually means limited transport
- Better sorting usually means greater distance of transport



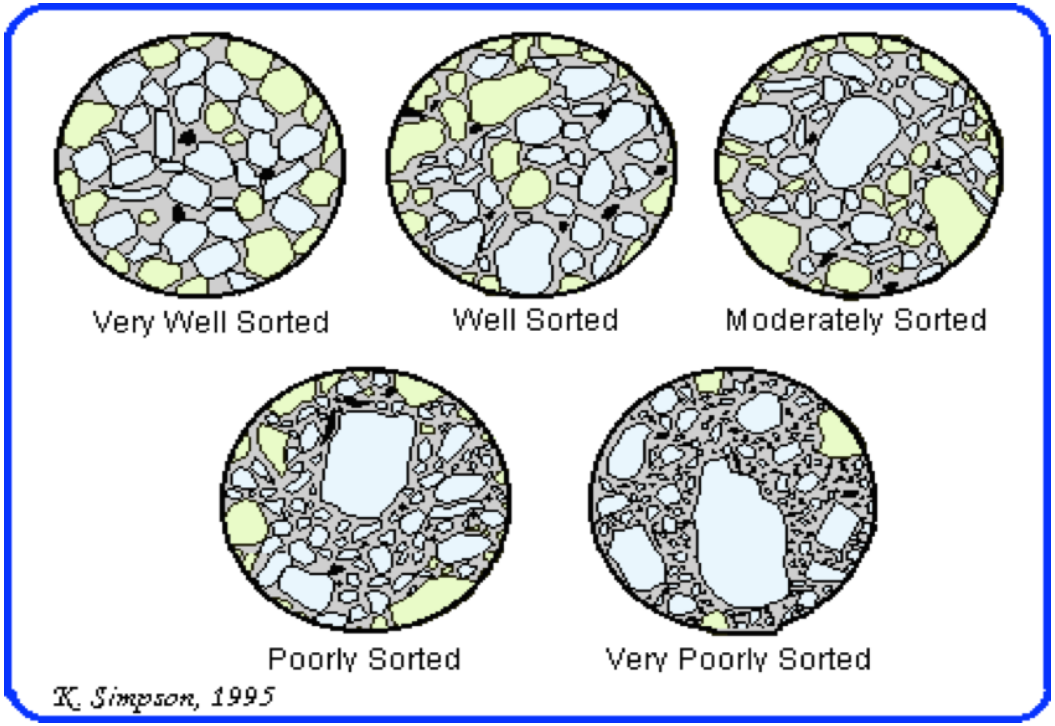
Well-sorted sand



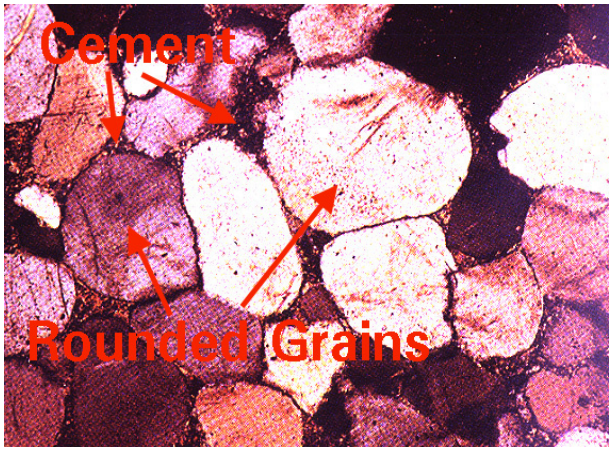
Poorly sorted sand

Sorted vs. unsorted sediment

- Components of a sediment/sedimentary rock:
  - Grains, Pores, Cement, Matrix



what makes up the sediment?



- **Grains**
  - Framework of your sediment or rock
  - Any size, any composition, any sorting, any rounding
- **Pores**
  - Empty spaces between grains
    - Porosity: percentage of pores volume / percentage of rock volume
  - They are reduced during burial and compaction
  - Filled with air or water in sediment
  - Filled with cement in clastic sedimentary rocks
- **Cement**
  - Any chemical precipitate that “cements” the grains one to the other
  - Most common cements are silica, calcite, hematite
  - Fills the pores: the more cement we have, the lower the porosity
- **Matrix**
  - Matrix is smaller size sediment that fills the pores in a coarser size sediment (for instance, mud within sand would make the sand matrix)
  - If matrix is absent, the sediment is sorted; if matrix is present, the sediment is unsorted

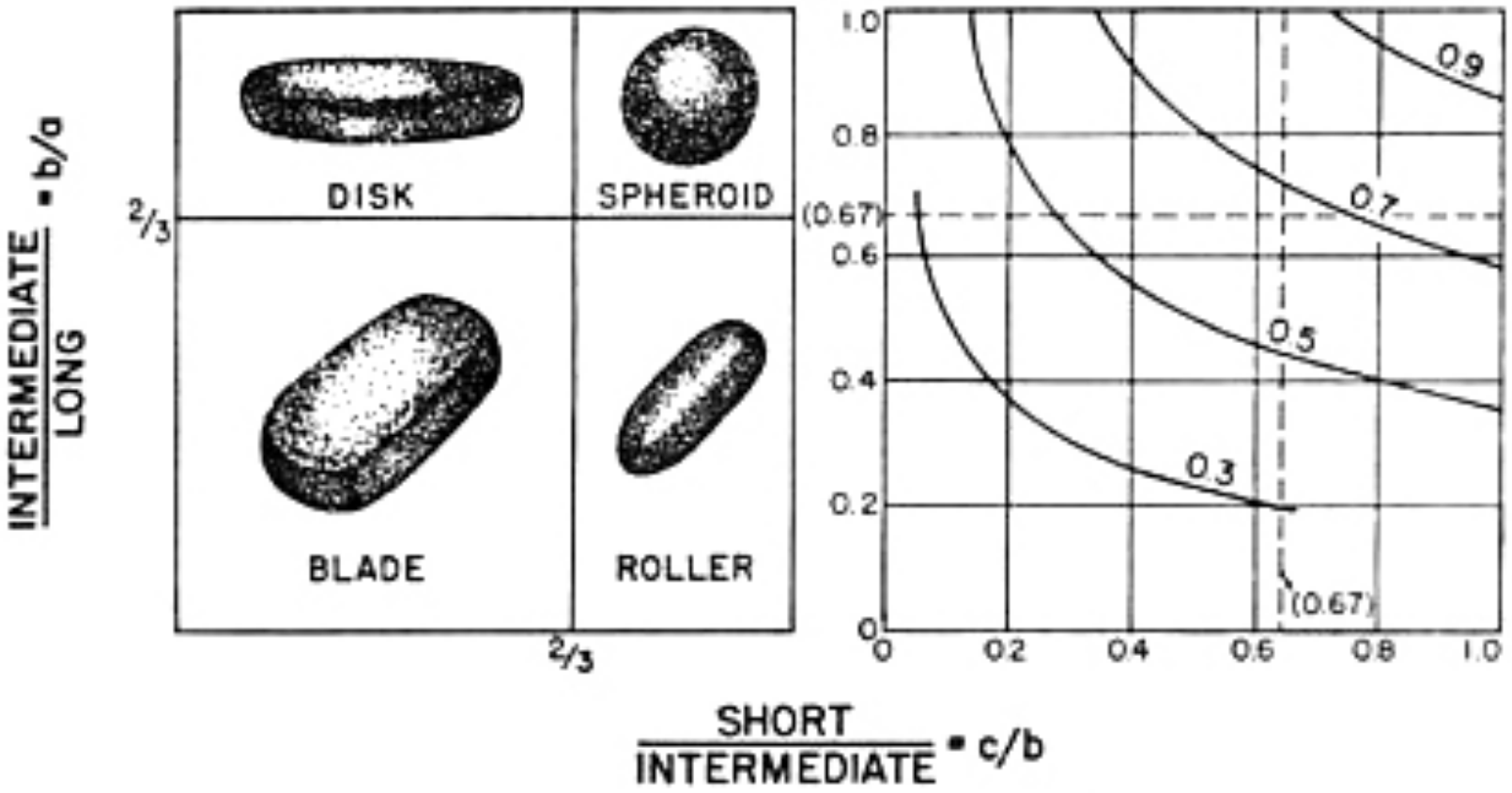
matrix

- grains floating in matrix = matrix supported
- grains in contact = framework/grain-supported

Roundness

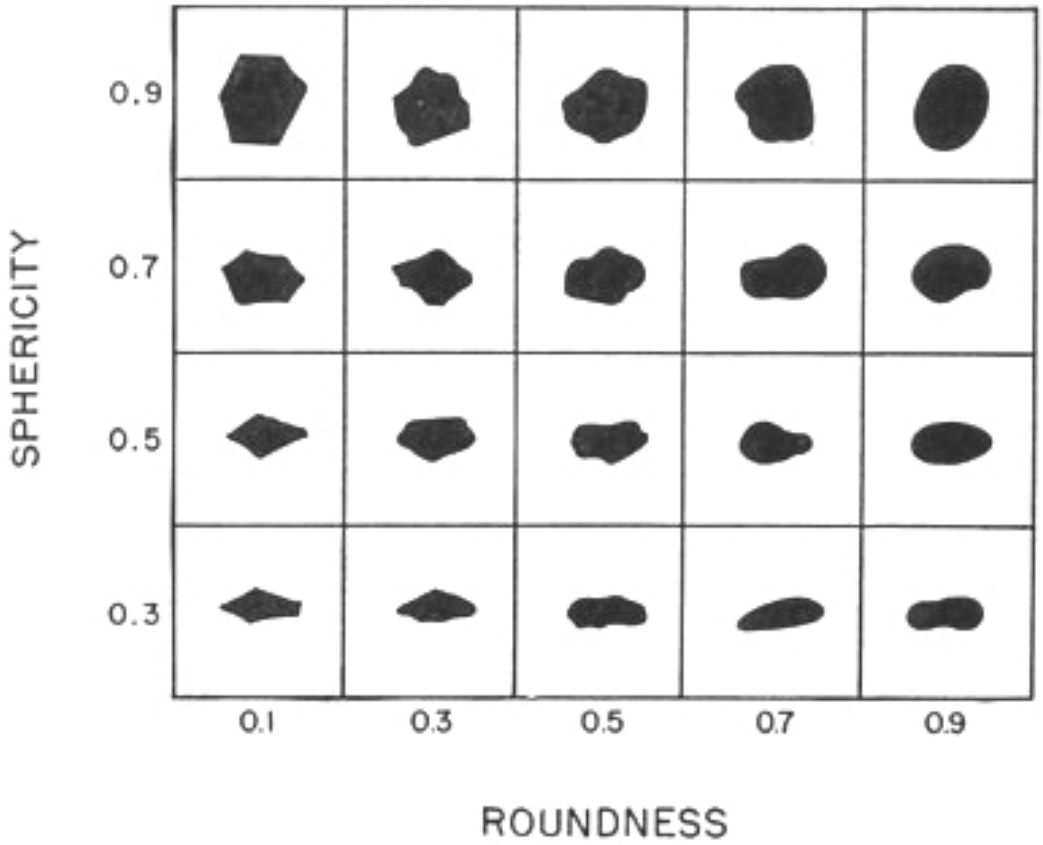
- Roundness refers to the smoothness of the outer surface of a grain (the curvature of the corners of the grains

all these grains are rounded

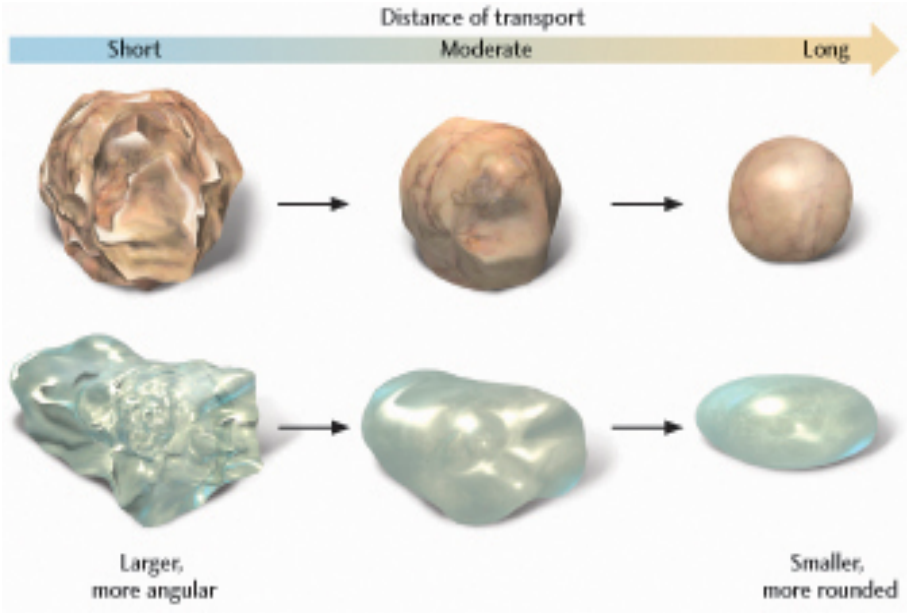


Roundness vs. Sphericity

- Sphericity refers to how similar to a sphere a grain is
- Sphericity does not have a geological meaning, it simply depends on how a grain originally broke off
- An angular grain can be spherical (see example in the upper left corner of the figure below)



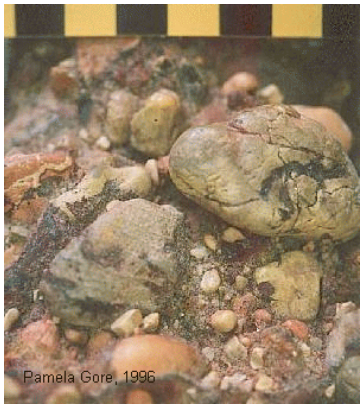
- The rounder the grain, the greater the distance of transport
- Rounded quartz grains imply many cycles of erosion, transportation, and deposition
- Beach and desert sediments are in general more rounded than river and glacier sediments
- Large, coarse grains round faster the fine grains



Maturity

- Again, a **mature sediment** is one where there is high sorting, high roundness, and most grains are quartz

Left: immature
Right: mature



- Examples:
  - Quartz sandstone is mature (beaches, sand dunes)
  - Arkose sandstone is immature: contains subangular to subrounded sand with grains of K-feldspar (alluvial fans)
  - Graywacke sandstone is immature: contains sand and mud)submarine fans / continental rises)

Fabric

- Fabric refers to the grain alignment in a sediment
- Results form grain transportation in wind and running water
- Its absence or presence are important diagnostic features

Depositional Environments and Grain Size

- Fine sediments (silt and clay) settle in low-energy environments
  - Deltas, floodplains, lakes
  - Swamps, marshes, lagoons
  - Deep ocean

- Coarse sediments (gravel and sand) settle in high energy environments
  - Beaches
  - Sand dunes
  - Rivers
  - Alluvial fans

So… clastic sediment form clastic sedimentary rocks
…and what about ions in solution?

- they need to “stay hydrated” (ions surrounded by water molecules)

- if there is not enough water, ions crystallize and form chemical sedimentary rocks (or are deposited as cement, as seen before)

next step…

- Gravel, sand, silt, clay are cemented in clastic sedimentary rocks

- Clastic sedimentary rocks are the ONLY group of rocks not formed by crystals but rather fragments of other rocks cemented together