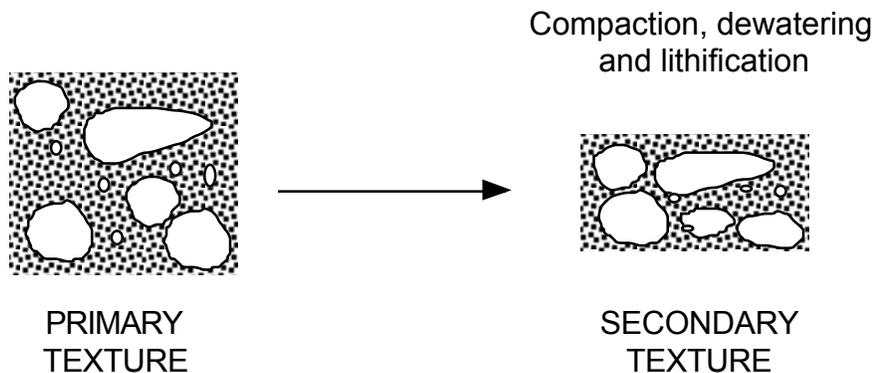


## SEDIMENTARY TEXTURES (GEOL 243.3)

Sediment texture refers to the shape, size and three-dimensional arrangement of the particles that make up sediment or a sedimentary rock.

Textures can be **clastic**, where they are composed of grains from pre-existing rocks (allochthonous grains) or **crystalline**, where the crystals (“grains” *sensu lato*) grew from a fluid producing an interlocking mosaic of crystals.

Textures are **primary**, where the grains possess their arrangement that existed after they came to rest (or after precipitation in the case of crystals). In sedimentary rocks, however, textures are commonly **secondary**, because they have been altered in some way from their original condition. The most common effect is compaction, where the weight of overlying sediments causes the component grains to rearrange themselves or even become fractured.



### Grain Size

Particles are generally measured by their maximum grain diameter. The most common classification in use is the Wentworth scale. In this classification, terms such as pebble, sand and gravel have well-defined limits. Many statistical methods can be applied to particle size distributions (e.g., median, mean, skewness, kurtosis, *etc.*) to try to characterize the depositional processes that produced them (e.g., wind, swash, *etc.*), and even to distinguish depositional environments. This was popular in the 1960s and 1970s, but is a rarer approach today.

The Wentworth scale is a geometric scale--adjacent orders differ by a factor of two (either doubling or halving). A common practice in studying grain size distribution is to use the **phi scale**. As well as mm, the boundaries between each class can be expressed by the negative logarithm of this dimension to the base 2:

$$(\text{phi}) \Phi = -\log_2 d$$

where  $d$  is particle size in mm. Phi values are dimensionless, but because they are based on mm, the scale is metric.

The advantages of using the phi scale are:

- particle size distributions can be plotted easily on arithmetic (as opposed to log) paper, and statistical parameters can be interpolated easily
- the boundaries between different size units become whole numbers

Note that increase phi values correspond to decreasing particle size.

mm	phi	Class terms	Sediment terms	Rocks (within the whole range)
<hr/>				
<b>BOULDERS</b>				
256	-8			
128	-7			
64	-6	<b>COBBLES</b>		
32	-5		gravel	conglomerates and sedimentary breccias
16	-4	<b>PEBBLES</b>		
8	-3			
4	-2			
2	-1	<b>GRANULES</b>		
1	0		coarse	
0.5	1		sand	sandstones arenites
0.25	2	<b>SAND</b>		
0.125	3		fine	
0.062	4		coarse	
0.031	5	<b>SILT</b>	silt	siltstones and mudstones
0.016	6			
0.008	7		fine	
0.004	8	<b>CLAY</b>	clay	claystone

**Particle size scale for sediments and sedimentary rocks (modified from Udden and Wentworth).**

Most sedimentologists estimate the particle size range in a sediment or sedimentary rock rather than physically measure it, but in some situations quantitative measurement of particle size and its range is desirable or needed.

Different methods are required for determining grain size in loose (unconsolidated) sediment and sedimentary rock. Methods also vary with particle size range.

*Unconsolidated sediments*

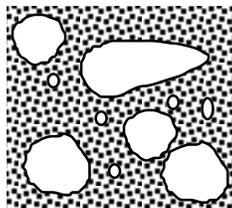
Gravels and pebbles can be measured using calipers. Sands can be measured using sieves of different mesh size that are mechanically shaken. The amount trapped in each sieve is weighed and taken as an estimate of the particle size range in the sample. Silts and clays are more difficult to measure -- the commonest method is elutriation, where a sample treated with a dispersant is placed in cylinder. The finest fractions stay in suspension longest, whereas the heavier (larger) fractions generally sink more rapidly, but at a predictable rate according to Stokes' Law. Samples are withdrawn at a given depth at specific intervals, then dried and weighed. From these data, it is possible to calculate the particle size ranges semi-quantitatively. Direct measurement of clay particles is only possible using an electron microscope. Digital image processing can also be applied to particle size measurement (but only in 2D).

*Sedimentary rock*

Measuring particle size in lithified rocks is difficult, tedious, and calls for different methods from those applied to loose sediments. Particle size can be measured in thin sections using a systematic sampling method (e.g., intersections on a grid or all particles intercepted along a line). These measurements are for that part of a grain that is cut by the plane of the section: this may not be the longest axis of the particle. Digital image processing can also be applied to thin sections.

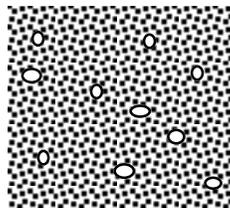
In most normal sedimentological work, estimation and experience are the main tools.

Probably the most useful aspect in grain size distribution is sorting (similar to standard deviation). Well-sorted sediment shows little variation in grain size distribution, whereas poorly sorted sediment has a large deviation from the mean (average) grain size. Sorting reflects the sedimentary process (e.g., wind, waves, *etc.*) plus the impact of post-depositional infiltration by other (usually finer) grains.



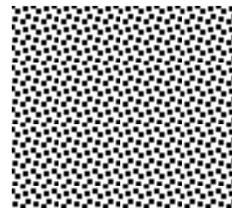
POORLY SORTED

Melting ice (till)  
Debris flows  
Mudflows



MOD. SORTED

Rivers  
Tidal currents  
Surf



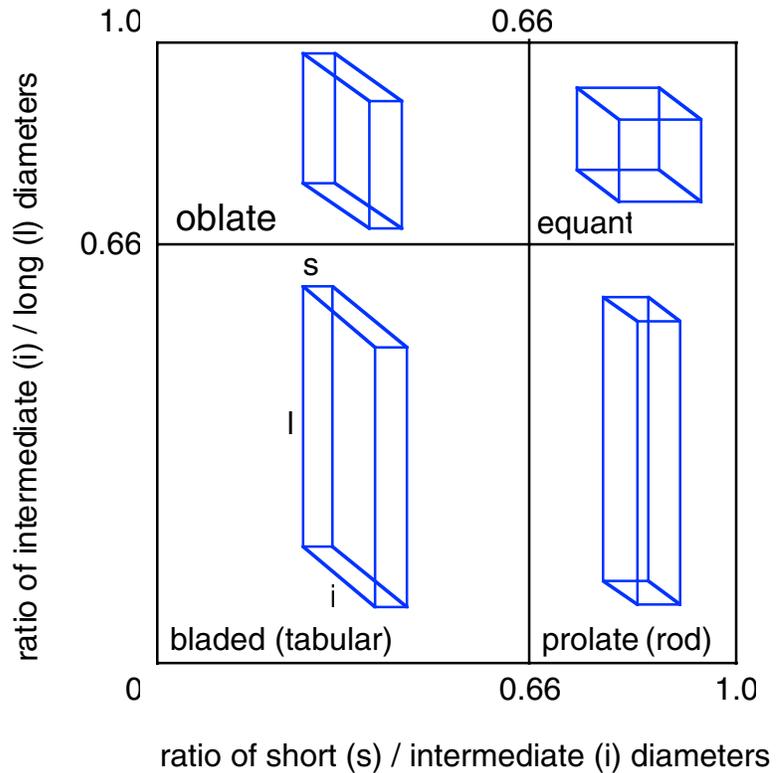
WELL SORTED

Wind  
Some beaches

## Shape

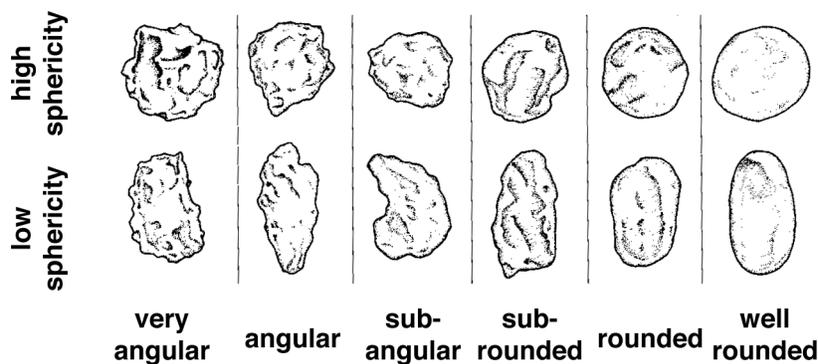
Particle shape is difficult to quantify or describe. Shape is commonly described with reference to three axes at 90° to each other that can theoretically be placed inside any particle. The longest axis is  $a$ , shortest  $c$  and the intermediate is  $b$ . In a sphere or cube, those axes intersect at the centre and have equal length. By comparing the ratios of the axes, it is possible to describe four basic "shapes" of particles:

The four main classes of grain shape, which are based upon the ratios of the long, intermediate and short diameters of any particle (after Zingg 1935).



Shape in some cases reflects erosional processes (how the rock broke up with weathering and transportation), but may also reflect structures and fabrics present in the parent rock. Shale, for example, will commonly produce flat particles, whereas quartzite (metamorphosed sandstone) may be more equant.

**Roundness** (or angularity) refers to how smooth or sharp are the edges of particles. It is usually measured with reference to a comparative chart (The commonest is: Powers, M.C., 1953, A new roundness scale for sedimentary particles. *Journal of Sedimentary Petrology*, 23: 117-119).



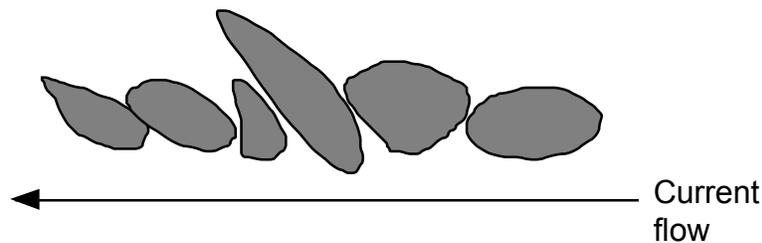
Roundness and sphericity are not the same thing. A grain with highly irregular shape can be well rounded; a cube has high sphericity but very low roundness.

**Grain surface texture** is an aspect usually reserved for sands and coarser particles. Many quartz sand grains develop v-shaped notches, pits, and uplifted flakes that can often be referred to specific transport processes. Some develop thin surface coatings. Wind blown sands, for example, develop a characteristic suite of surface textural features. To recognize surface texture, a scanning electron microscope is normally used.

## **SEDIMENT FABRICS**

Sediment fabric stresses the three-dimensional make up of the components in the rock -- especially whether the particles show any preferred orientation, and how individual grains are in contact with each other. Primary fabrics are those that formed during sedimentation; secondary fabrics reflect the imprint of post-depositional processes such as compaction by overlying younger sediments.

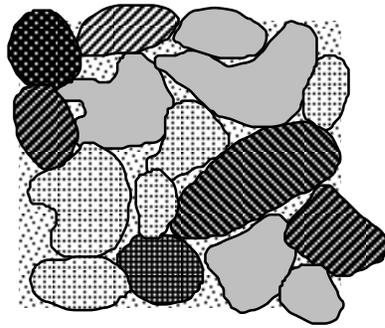
Fabric can be useful in determining the depositional processes. If particles are elongate, they may be aligned by currents parallel to the direction of flow. A common fabric in gravel and conglomerate is **imbrication**.



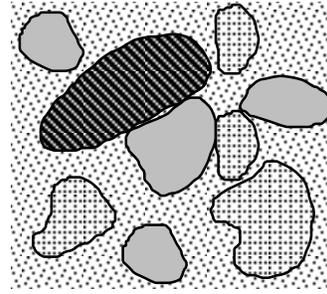
In imbricated gravels, the long axes of the clasts commonly dip upstream, subparallel to one another. This can be used to infer current flow directions in ancient rocks. Reconstructing former flow directions is termed **paleocurrent analysis**. Although common, some gravels do not develop imbricate fabrics.

In conglomerates, two different types of fabric are common: clast (or grain) support, and matrix support. In clast support, most individual clasts are in contact with each other. The matrix (finer material between the gravel clasts, such as sand, silt and mud) fills the spaces between the clasts. If the matrix were flushed from the rock, the particles would still be in contact, supporting each other.

In matrix support, the individual clasts are held together by the matrix (i.e. they are not necessarily in contact with each other). The rock may appear disorganized without any clear internal structure. In this case, removing the matrix will cause the coarse clasts to collapse and become in contact with each other.



Clast Support



Matrix Support

These differences in fabric are very important in interpreting the rocks. Clast-supported gravels are typically waterlain (e.g., stream bed or beach). In contrast, matrix-supported gravels are commonly deposited from “mass flows”, where the coarse and fine material is transported *en masse*, as for example in a mudflow.

Some fabrics are the result of compaction to varying degrees. These will be discussed later.