

Physical Landscapes and the Geosphere (ACNA 4007)

Sedimentology: Clastic sediments and clastic sedimentary rocks

Activity Outline:

Sedimentology is a branch of geology which is focused on the study of sedimentary rock and geological sediments. A practitioner of sedimentology is known as a sedimentologist. Sedimentologists study soil, sand, and sediment of dry and wet land to extract data useful to industry and academic study.

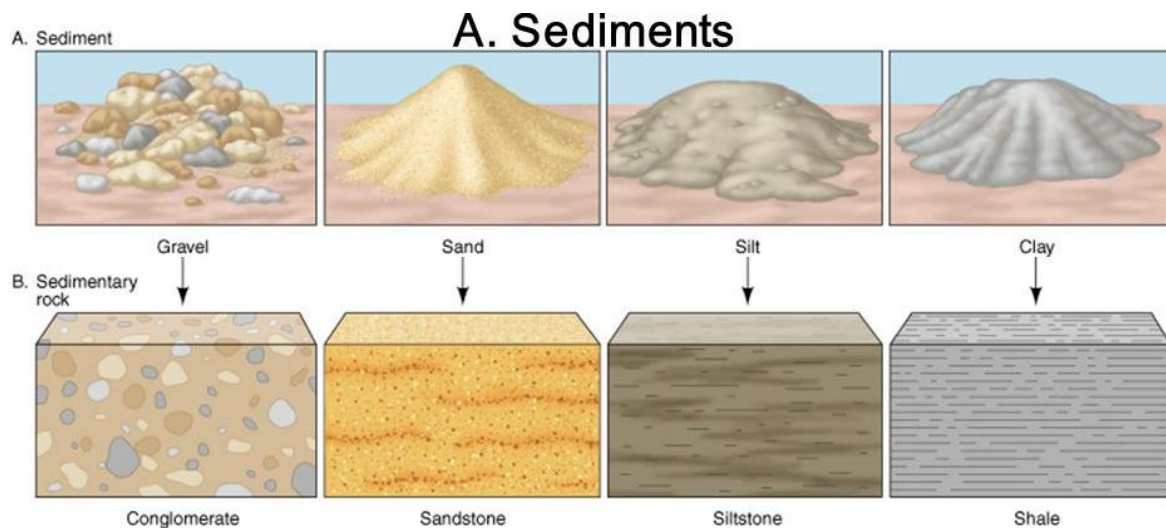


Figure 1. Example of clastic sediments and sedimentary rocks

Sedimentary rocks are not classified in the same systematic way that the igneous rocks are classified. Instead, we look primarily at the **composition of the sediment particles or grains**. Secondary classification is done based on **grain size**. If grains are dominated by silicate minerals like quartz, feldspar, muscovite, clays etc, we classify the sediment as siliciclastic and the rocks formed from these grains siliciclastic sedimentary rocks. If the grains are composed of calcium carbonate (calcite and aragonite) that was mostly derived from living organisms (e.g., shells, skeletons, tests), we classify the sediment as biochemical (or bioclastic) and called the rocks formed from this sediment biochemical sedimentary rock.

For our purposes, most biochemical rocks are limestones. Chemical sedimentary rocks are derived from mineral precipitation from water. Sea water evaporation leads to the evaporite minerals (halite, sylvite, dolomite, gypsum and anhydrite). Evaporation of saline lakes leads

to banded gypsum. Water percolating underground may result in precipitation of calcite in caves, forming travertine. Organic sedimentary rocks were produced from plant materials, such as coals (e.g. peat, lignite, bituminous coal, anthracite).

Aim

In this lab we will be analysing, measuring, and describing clastic sediments. To do this, you will be trained up in use of light microscopes and image analysis to answer sedimentological questions.

Background

Sediments are commonly described in terms of their **grain size, shape, sorting and sphericity**. Understanding sediments is important for environmental conservation, in addition to interpretation of the geological record. The figure below shows a graphic sedimentary log example. We can use the sediment characteristics to infer process and environmental interpretation (e.g., what setting occurred).

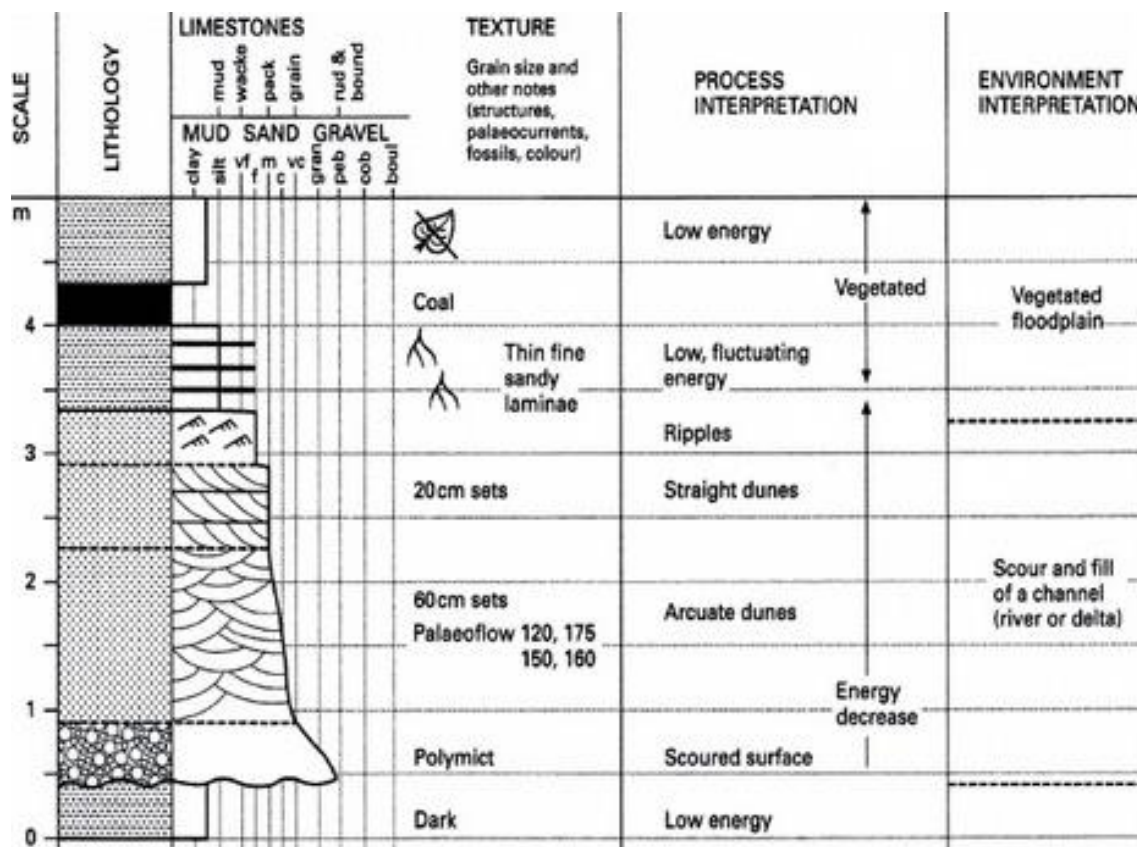


Figure 2. Example of a graphic sedimentary log.

The following details describe these stages. You won't be able to determine sorting, rounding, or sphericity from a hand sample if the clasts are too small to see without magnification.

1.0 Grain size

The siliciclastic and biochemical sedimentary rocks are largely distinguished on the basis of particle size. Grain size is the average diameter of clasts (particles) of clastic sediments and rocks. Grain size is the primary parameter in sedimentary geology to divide clastic rocks and sediments in different classes for classification purposes. This subdivision is based on the Udden-Wentworth scale, which differentiates four major classes of sediments (and corresponding sedimentary rocks) that are further divided in sub-classes (Figure 5).

- **gravel or ruditic grain size** (> 2 mm), which includes pebbles (2 – 64 mm), cobbles (64 – 258 mm) and boulders (> 258 mm). The corresponding rocks are conglomerate and breccia (further differentiated based on roundness);
- **sand or arenitic grain size** (0.0625 – 2 mm) and the corresponding sandstone
- **silt or siltitic grain size** (0.004 – 0.0625 mm) and the corresponding siltstone
- **clay or lutitic grain size** (< 0.004 mm), whose lithified counterpart is claystone

2.0 Grain Shape

Clasts in sedimentary rocks have different shapes, ranging from round (equant) to elongate and flat. Equant grains, whether they are cubes or spheres, can be approximated to spheres; they hence have high sphericity. Elongate and flat grains can be considered respectively as ellipsoids with a long axis (like a cigar) and flat ellipsoids with a short axis and two long axes. In other words, they have low sphericity. Sphericity describes how much a grain can be approximated to a sphere and differs from roundness, the textural parameters defining how well the outline of a grain is rounded (Figure 3).

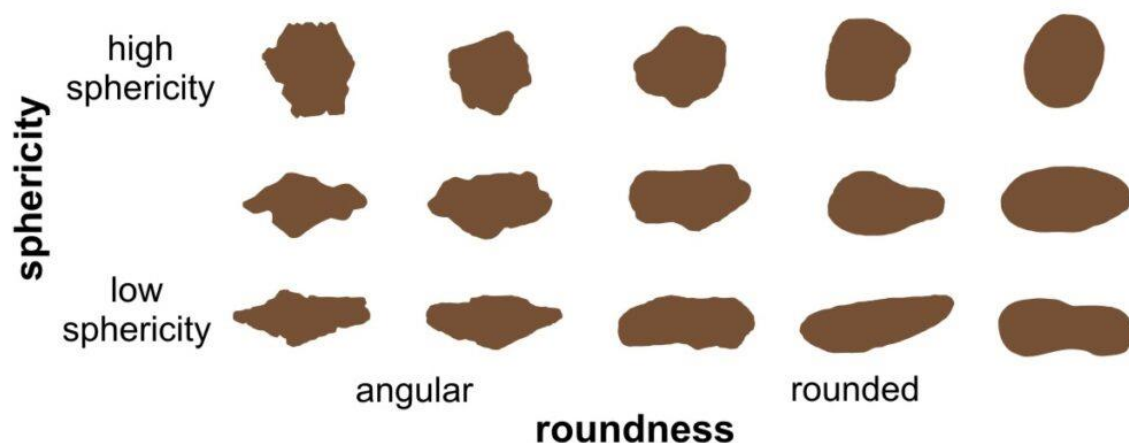


Figure 3. Particle sphericity

Some processes tend to produce grains with spherical shape, like rivers, where sediment is transported on the bed, rolling, and becoming equant in the process. Other processes, like waves on a gravel beach, tend to act always on the same side of a clast favouring flatter (low sphericity) shapes, which are yet well rounded. Composition of clasts is also important: lithic clasts of foliated rocks tend to break along the foliation during, facilitating the development of flatter, low-sphericity shapes. In a similar fashion, a rock with a strong lineation can produce elongate grains during erosion and subsequent transport.

3.0 Sieving

Sieve analysis is an accurate way of determining the grain sizes that are present in a sediment. Loose sediment passes through a series of sieves with decreasing mesh size (Figure 4). The trapped sediments can, then, be weighted to determine the class size distribution of a sediment. After sediments have been sieved, they can be weighed to determine the quantity of each sediment size. From here, since you know the weight of your sample, you can calculate the percentage of sediment in each sample size. *You will be shown how to sieve your sediment samples in the lab.*



Figure 4. Sediment sieve stack.

4.0 Sorting

Sorting is the variability in grain size in a clastic sedimentary rock. This parameter measures how well a sediment has been 'sorted' by the process that transported it. A sediment can be:

- *very well sorted: nearly all grains have the same size*
- *well sorted: most grains fall in a single grain size class with few outliers*
- *moderately sorted: more than one grain sizes are present, but one prevails*
- *poorly sorted: several grain sizes are present, none of them prevails*
- *very poorly sorted: a wide spectrum of grain sizes of very different sizes*

Sorting (Figure 5) is linked to the type of transport experienced by the sediment. Some processes (e.g. glaciers and gravity flows) transport sediments en masse, producing poorly sorted deposits. Other processes, on the other hand, can transport only some grain sizes, efficiently selecting the sediment. Wind, for instance, can carry away the finer particles and deposit heavier sand, forming well-sorted sand dunes. Other examples of selective transports include rivers, waves, and sea currents.

Sorting

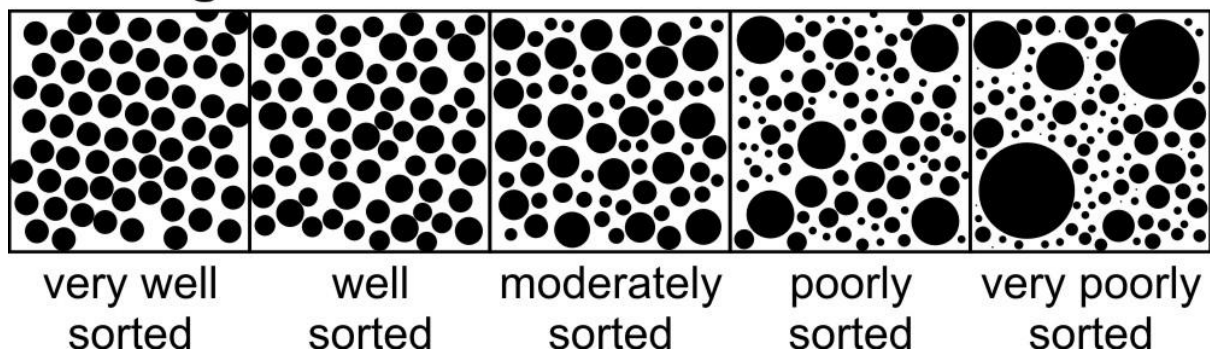


Figure 5. Particle Sorting

Exercise 1: Microscope Fundamentals

For this lab you have been provided with a series of sediment samples. By interpreting the sediment samples, you should be able to decipher information about where it may have come from. We have two-high resolution microscopes for this lab exercise as well as smaller desk microscopes.

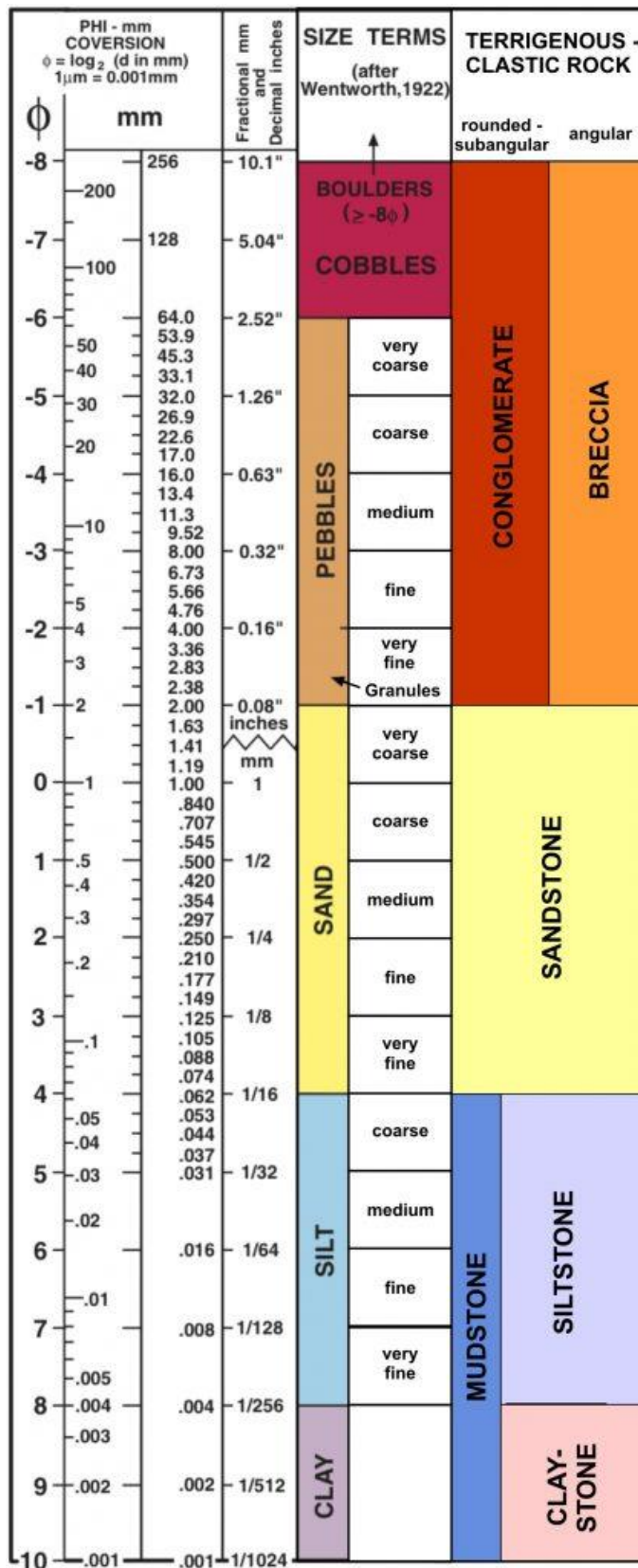
- a. First, familiarise yourself with the microscope, you will have been shown to set these up in the introduction. Try to get your sample in focus. Describe what you see in your sediment sample and your sedimentary rock (use Table 1). Take some time to look at your sample. Write some notes here and be as detailed as you can be at this stage. Feel free to draw a sketch of what you see.

Table 1. Clast description table.

	Clast size	Shape	Sorting	Sphericity
Sediment Sample 1				
Sediment Sample 2				
Sediment Sample 3				
Sediment Sample 4				
Sediment Sample 5				

- b. When the imaging microscope is available, prepare your sediment sample and locate an 'interesting' section of your sample (This will be subjective).
- c. Click to the software to activate the software tab. You will need to set your scale (your demonstrator can help you do this).
- d. Next, add a scale bar to the view you can see on your microscope.
- e. Measure the A and B axis of 5-10 features on your view of your sediment (this can be individual clasts or sand grains). Make a note of these measurements. You can do this by writing it down or taking a photo.
- f. Can you determine a depositional environment for your sediments. Justify your answer.

Figure 5. Classification of clastic rocks and sediments based on the Udden-Wentworth grain size chart. Modified after USGS Open-File Report 2006-1195



Exercise 2: Measuring sediment samples and plotting their Grain Size Distribution (GSD)

In this part of the practical you will measure the particle size distribution of your sediments and then use the underlying data to create a plot of grain size distribution. Use Table 2 on the following page to record your weights.

Seive Analysis:

- (1) Write down the weight of each sieve as well as the bottom pan to be used in the analysis.*
- (2) Record the weight of the given dry sediment sample (your sediment samples have been dried for you).*
- (3) Make sure that all the sieves are clean and assemble them in the ascending order of sieve numbers. Place the pan below the smallest sieve. Carefully pour the sediment sample into the top sieve and place the cap over it. Be careful not to overfill it.*
- (4) Place the sieve stack in the mechanical shaker and shake for 5 minutes.*
- (5) Remove the stack from the shaker and carefully weigh and record the weight of each sieve with its retained sediment. In addition, remember to weigh and record the weight of the bottom pan with its retained fine soil.*

Table 2. Calculation of Percent Finer

Sieve No.	Particle Size (mm)	Mass Retained (g)	% Retained	% Finer
4	4.75	0	0	100
10	2	25.6	6.277587052	93.72241295
20	0.85	50.5	12.38352133	81.33889161
40	0.425	99.6	24.42373713	56.91515449
60	0.25	85.1	20.86807258	36.0470819
100	0.15	96	23.54095145	12.50613046
200	0.075	51	12.50613046	0
	Total	407.8		

Once you have completed the sieving and weighting of your sediment samples, you can now create a Grain Size Distribution Curve in Excel. There is a spreadsheet and instructions provided on Moodle. If you are unable to access this in the lab, you will draw of your grain size distribution as a histogram (with grain size on the X axis and Percent (%) on the Y) as shown below:

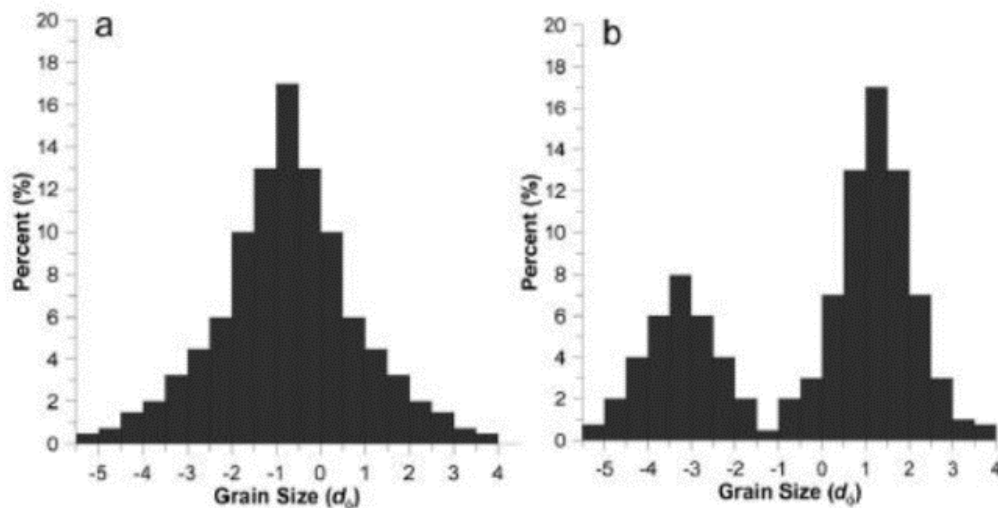


Figure 6. Example of grain size distribution histogram.

Questions

- What does your sediment distribution look like?
- What is the d_{50} (app. average dimension) of your sediment sample?
- Does this differ from your observations under the microscope? *Think back to your microscope fundamentals table, or the measured the A and B axis of your sediment.*
- What does your GSD tell you about the kind of environment your sediment was in?
- What can you determine from the microscope that you cannot determine from GSD?
- What can you determine from GSD that you cannot determine from the microscope?

Sedimentary Depositional Environments						
Depositional Environment	Environmental Characteristics	Organisms	Sediment	Sedimentary Structures	Sedimentary Rocks	
non-marine	river channel	variable stream current (high- to low-E), water may dry-up, oxidation	land-freshwater plants & critters	gravel, sand, mud; variable sorting & rounding	crossbeds, ripple marks, graded beds, mudcracks, plant & animal fossil fragments	conglomerate sandstone mudstone
	flood plain	floods (low-E), drying, oxidation, soil formation	land-freshwater plants & critters	mud, sand; well-sorted	bedding, ripple marks, graded beds, mudcracks, abundant fossils	mudstone (red beds) sandstone
	river delta	stream current, tides low-E	land-freshwater plants & critters	sand, mud; well-sorted	bedding, cross beds, ripple marks, graded beds, abundant fossils	sandstone mudstone
	alluvial fan	periodic flash floods, mudflows high-E	land plants & critters	gravel > sand; poorly-sorted & angular	plant & animal fossil fragments	sedimentary breccia arkose
	desert dune	variable wind current (high- to low-E), dry, oxidizing	small insects & reptiles; sparse plants	sand; well-sorted & well-rounded	cross beds, ripple marks, trace fossils	sandstone
	playa	low-E, high evaporation, floods periodically, dry	small insects, reptiles; few plants	evaporites, mud	mud cracks, ripple marks, trace fossils	evaporite mudstone
	lake	low-E, shallow-deep standing water	land-freshwater plants & critters	mud, sand, carbonate sediment	bedding, ripple marks, graded beds, abundant fossils	mudstone sandstone limestone
	glacier	ice, bare rock, cold	sparse plants & critters	gravel; angular & poorly sorted	few	till
transitional	beach	waves (high- to low-E), tides, currents, wind	marine & non-marine critters	gravel, sand, mud, carbonate sediment; well-sorted & well-rounded	ripple marks, crossbeds, abundant fossils & fossil fragments	conglomerate sandstone mudstone limestone & coquina
	lagoon	low-E, tides, not very oxidized	marine & non-marine plants & critters	mud	bedding, ripple marks, abundant fossils	mudstone (green-black, not red)
marine	shallow marine	waves (high- to low-E), tides, strong ocean currents, wind	marine plants & critters	sand, mud, carbonate sediment; well-sorted & well-rounded	bedding, crossbeds, ripple marks, abundant marine fossils	sandstone mudstone limestone
	reef	waves (high- to low-E), tides, strong ocean currents, wind	marine plants & critters	gravel, sand, mud; carbonate sediment; variable sorting	abundant marine fossils	limestone breccia sandstone mudstone
	deep marine	low-E, variable currents	weird marine plants & critters	mud, carbonate & siliceous ooze	abundant marine fossils	mudstone limestone chert

Table 3. Common depositional environments and sedimentary characteristics.