## Lab 10: Sediments & Sedimentary Minerals 100 pts

### *Introduction*

All rocks exposed at the earth's surface are subjected to **mechanical disintegration** and **chemical weathering**. The material which is produced during this weathering process is then eroded, transported, deposited, and finally *lithified* to produce *sedimentary rock.* The more durable of the minerals we have previously studied (especially quartz and orthoclase) are often simply mechanically broken up by the process of weathering and transportation. Thus these minerals are often found as major constituents of some sedimentary rocks. However, many less durable minerals undergo chemical changes during weathering. The ferromagnesian minerals, and some feldspars (especially calcium-rich plagioclase) are particularly susceptible to this chemical weathering and produce new minerals that make up a major part of many other sedimentary rocks. The most abundant of these new minerals are the clay minerals (kaolinite, smectite etc.). Other types include calcite, gypsum, various salts (especially halite), and chalcedony (microcrystalline quartz), all of which are dissolved during weathering and later precipitate to form new minerals. Various iron oxides and hydroxides (rust) produced by weathering of ironbearing ferromagnesian minerals include hematite and limonite.

Once a rock has been mechanically broken down and/or chemically weathered, the material is collectively called **sediment**. It is eroded (picked-up) and **transported** (moved along) to a new location. The most common mode of transport is the running water in rivers, ocean currents, etc. Wind, glaciers, and mass movement (such as landslides) are other less common modes of transport. The sediment is then deposited and may eventually be buried to produce a solid sedimentary rock.

### Changes during transport

During the process of transport, particles of sediment undergo a number of changes depending on the mode of transport, the distance and rate of transport, etc. Some of these changes are listed below:

1. **Size:** The size of the particles of sediment generally decreases with the distance the sediment is transported. For instance, as sediment is transported by running water, abrasion grinds it down to smaller particles. Likewise, impact of one grain against another in a rushing mountain stream tends to break the grains into pieces and produces finer grained particles of sediment.

2. **Rounding:** Abrasion and mutual impact of particles during transportation also rounds off the sharper corners to produce progressively rounder grains, again in proportion to the distance they have been transported. Very angular grains are likely to have been moved only a short distance. Subangular to subrounded sand grains have probably been transported somewhat greater

distances, while well rounded grains usually represent sediment that has travelled a great distance from its original source.

3. **Sorting:** Sorting is *poor* if particles of *all sizes* are present in more or less *equal amounts*, and *good* if *all particles* are about the *same size*. Sorting depends upon the carrying power of the transport medium as well as the distance the sediment has been transported. In general, *sediment transported for short distances is more poorly sorted than sediment that has been transported longer distances.*

## Transport Medium

*Mudflows, landslides, and glaciers* typically deposit very poorly sorted sediment because the distance of transport is usually relatively short. In the case of glaciers the medium of transport is very viscous therefore large pebbles and even huge boulders can be transported almost as easily as smaller sand and silt particles.

*Water currents* tend to produce well sorted sediment. The coarser particles in a river usually are deposited near the headwaters where rushing streams have greater carrying power. Farther down the river near its mouth, the original larger particles have been broken down by abrasion by the time they have been transported such great distances. In areas where the water is flowing very slowly (most ocean and lake currents, etc.) only the finest particles can be transported, thus producing well sorted, very fine-grained sedimentary deposits.

Where the carrying power is strong, one finds coarser particles from which the fine particles have been totally washed out. Farther downstream, or especially in a lagoon or well offshore, slow currents can carry only the fine-grained particles, until eventually they settle out to produce well sorted deposits of fine-grained sediment.

*Wind* produces the most well sorted sediment of all. Wind (air) has the lowest viscosity of any of the modes of sediment transportation. Thus the *velocity* of wind is extremely critical in determining the size of particles it can carry. The wind simply cannot move particles larger than coarse sand. Dust or extremely fine particles can be moved quite effectively, even at slower wind velocities. Larger particles (sand) bounce along the ground when transported by strong winds. Thus, strong winds deposit dunes of sand composed of particles which are nearly all the same size, forming perhaps the best sorted of the sedimentary deposits. Where the wind is slower, only the very fine particles of dust tend to settle out, again producing extremely well sorted deposits.

## Summary

In summary, these sedimentary processes separate the various components of the sediment by size, degree of sorting and rounding, and mineral composition.

1. Particle size is largely a function of the distance that a sediment has been transported, but it is also a function of the agent of transport - i.e. wind, water or ice.

2. Separation of minerals also results from the processes of chemical weathering. Some minerals are much more resistant to chemical weathering than others. Minerals like quartz are highly resistant to chemical attack while ferromagnesian minerals and some others weather easily, breaking down to form new minerals such as clays. Clay minerals are extremely fine-grained and can be transported long distances and deposited by very slow currents. Larger, more durable quartz grains are not usually washed so far downstream.

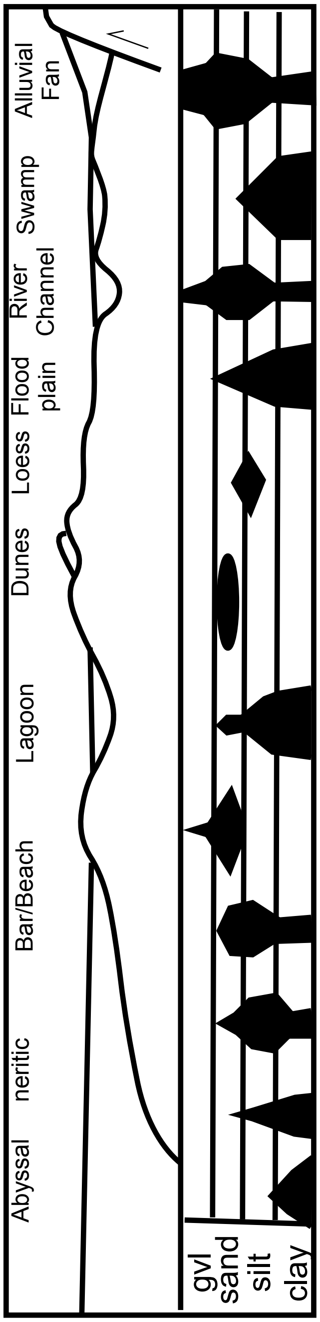
3. The chemicals required to form some sedimentary minerals are dissolved in water. When water flows into warm, shallow areas such as equatorial oceans or arid lakes, these chemicals may be concentrated by evaporation. If conditions are right, some of these dissolved substances may precipitate to form layers of minerals on the ocean or lake bottom. This precipitation usually produces a rock consisting almost entirely of a single mineral. Rocks such as limestone, rock gypsum, or rock salt are examples.

**Sediment composition**

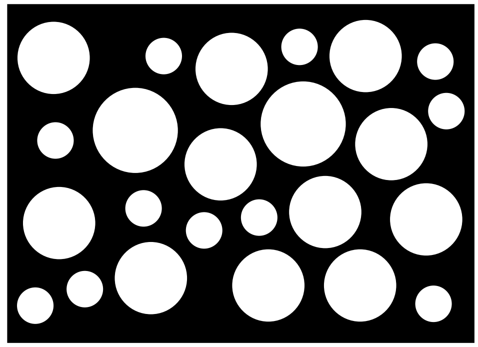
| ***Type of sediment*** | ***Abundant*** | ***Less abundant*** | ***Usu. <1 %*** |
|---|---|---|---|
| *Mechanically deposited* | Quartz<br>Clay minerals (e.g. kaolinite)<br>Micas<br>Calcite | Plagioclase<br>K-Feldspar<br>Biotite<br>Hematite<br>Limonite<br>Rock Fragments | Magnetite<br>Tourmaline<br>Garnet<br>Amphibole<br>Others |
| *Chemically deposited* | Calcite<br>Dolomite | Quartz<br>Gypsum<br>Halite<br>Hematite<br>Others | |

| ***Particle type*** | ***Diameter Range*** | |
|---|---|---|
| Boulders | >256 mm (10 in) | |
| Cobbles | 64-256 mm (2.5-10 in) | |
| Pebbles | 4-64 mm (0.15-2.5 in) | |
| Granules | 2-4 mm | |
| V. coarse sand | 1-2 mm | Individually recognizable to the naked eye |
| Course sand | ½ - 1 mm | |
| Medium sand | ¼ - ½ mm | |
| Fine sand | 1/8 – ¼ mm | |
| V. fine sand | 1/16 – 1/8 mm | |
| Coarse silt | 1/64 – 1/18 mm | Gritty appearance & feel; individual grains cannot be seen |
| Fine silt | 1/256 – 1/64 mm | |
| Clay | <1/256 mm | Smooth feel |

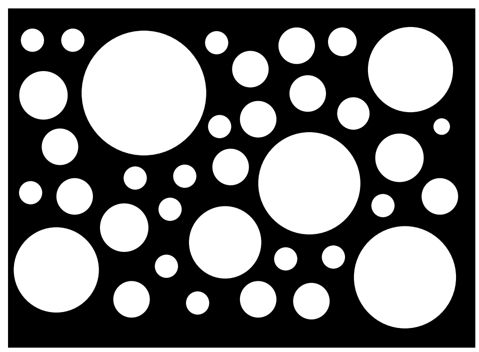
# Describing sediments & sedimentary rocks



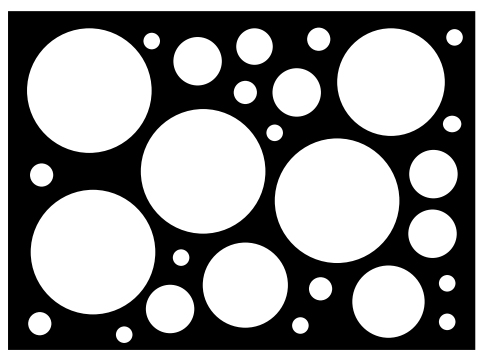

Grainsize distributions in major depositional environments



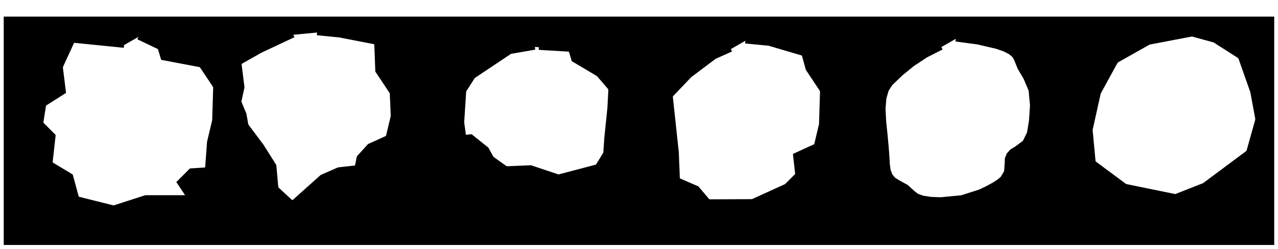
Very Well Sorted



Moderately Sorted



Poorly sorted



Very Angular | Angular | Sub-Angular | Sub-rounded | Rounded | Well-rounded

## *Procedure*

Before examining the sands in this exercise, you should know the common sedimentary minerals (11-22) found in your mineral set. You should also understand four basic sediment parameters: composition, size, rounding and sorting. You will need access to the PCC Sand collection, special sand slides and a microscope, either in the classroom or the study room, as well as your handlens. It is also handy to have your mineral set close by for easy reference. The second part of this lab may be done using the “virtual” sand collection available over the internet at: http://pasadena.edu/sand

**Part 1 (20 pts)** Follow the same procedure for the identification of minerals that you used in previous lab exercises. Name the mineral unknowns numbered 11-22 in your unknown set after first listing their properties on the Mineral Identification form that is included in this lab. Let your instructor check to be sure that you have properly identified these minerals before continuing on to Part 2.

**Part 2 (30 pts)** Examine at least 10 different sand samples from the sand collection provided in lab. To guide you in your observations, fill out the *Sand Identification Form* as you go along. Examine any sands you wish, but be sure and look at a wide variety of sand types. For example, don't do all white sands (however, as you will see, not all white sands are the same).

**Part 3 (50 pts)** Examine at least one sand from each of the six categories below and answer the questions that pertain to each. Complete a row on the Sand Identification sheet for each of the 6 categories. This may be done in class or in the study room using the sand in jars or the prepared sand slides provided. You may also complete this part using the Virtual Sand Collection on the Internet at the URL listed above.

Categories:

1. ***Heavy Mineral Sand*** (e.g. Dockweiler Beach, Redondo Beach black sand, Clifton Beach, CA, Murawai Beach, N.Z.)

2. ***Green Sand*** (e.g. Hanahma Bay, Toilet Bowl)

3. ***Sand*** (e.g. Great Salt Lake, UT)

4. ***Carbonate Sand*** (e.g. Banzai Pipeline, Barbados, Samoa, North Kawai, Marshall Is., etc.)

5. ***Volcanic "Black" Sands*** (e.g. Hawaii, 1957; South Panaluu; Jokulska River, Iceland, etc.)

6. ***olian (wind) Deposited Sands*** (e.g. Al Wasrah, Kuwait; Coral Pink Sand Dunes; Riyhad...)

**1. Heavy Mineral Sand (e.g. Dockweiler Beach, Redondo Beach black sand, Clifton Beach, CA, Murawai Beach, N.Z.)** This is what we call a "heavy mineral sand" because it is largely made up of minerals which have a higher than average density. The minerals which are so beautiful under the microscope are mostly garnets.

a) What color garnets can you recognize in this sample? ***(1 pt)***

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b) There are several common rock forming minerals that compose the dark fraction of this sample. What are they? ***(2 pts)***

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c) What is common characteristic of the minerals you have listed above that make them "heavy minerals? ***(2 pts)***

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**2. Green Sand (e.g. Hanahma Bay, Toilet Bowl)** This is an unusual green sand.

a) In the space to the right, sketch the shape of several of the good crystals ***(2 pts)***

b) What do these well-formed crystals tell you about transport? ***(3 pts)***

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c) What do you think the green mineral is? ***(2 pts)***

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d) Where do you think the green mineral has come from? ***(1 pt)***

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e) Why is this sand so unusual (think about weathering...)? ***(2 pts)***

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**3. Oolitic Sand (e.g. Great Salt Lake, UT)** Beach sand like this is very commonly found in tropical and subtropical ocean regions.

a) Look at this sand carefully under the microscope. Sketch a few of these grains in the space to the right. ***(2 pts)***

b) These grains are composed entirely of calcium carbonate. How do you think these grains formed? ***(3 pts)***

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c) Is this a high energy or low energy environment? Why? (be creative) ***(3 pts)***

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**4. Carbonate Sand (e.g. Banzai Pipeline, Barbados, Samoa, North Kawai, Marshall Is., etc.)** These sands are unlike anything you will find on California beaches. The material is largely organically derived **calcite**, consisting of bits of shell, coral, algae, foraminifera tests, etc.

a) Sketch two or three interesting grains as they appear under the microscope. ***(2 pts)***

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b) Cite AT LEAST 2 good reasons why we do not find this kind of sand on our beaches. ***(4 pts)***

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**5. Volcanic "Black" Sands (e.g. Hawaii, 1957; South Panaluu; Jokulska River, Iceland, etc.)** These sands are almost entirely made up of black volcanic glass called obsidian. Look at the grains closely under the microscope.

a) What evidence can you see to suggest that this glass comes from volcanic rocks? ***(2 pts)***

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b) How do these black sands differ from the Heavy Mineral Sand? ***(3 pts)***

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**6. Eolian (wind) Deposited Sands (e.g. Al Wasrah, Kuwait; Coral Pink Sand Dunes; Riyhad)**

a) Describe (and sketch) the surface of these sand grains (using the microscope) as compared to a typical grain of California beach sand. This surface characteristic is diagnostic of this particular sedimentary environment. ***(4 pts)***

b) How far do you think these sands were transported and why? ***(3 pts)***

## Additional Questions

1. Is every beach sand unique? Why or why not? ***(4 pts)***

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2. Sand is a major mining commodity. What products rely on sand as a raw material? ***(2 pts)***

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3. What is the most important control on sand composition? ***(4 pts)***

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*Lab 10: Sand Identification Form*

| **Sample name, Location & #** | **Mineral Composition** Rock Fragments, Quartz, Feldspar, Other (%) | **Dark Minerals** (Opaques) % and ID | **Average Grain size (Wentworth)** | **Degree of rounding** | **Degree of sorting** | **Comments** |
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|---|---|---|---|---|---|---|
| ***Heavy Mineral*** | | | | | | |
| ***Green*** | | | | | | |
| ***Oolitic*** | | | | | | |
| ***Carbonate*** | | | | | | |
| ***Volcanic "Black" Sand*** | | | | | | |
| ***Eolian*** | | | | | | |

***Lab 10: Sedimentary Mineral Identification Worksheet***

| | Hard-ness | Luster | Color | Streak | Specimen structure or crystal form | Cleavage/fracture | Heft | Misc. Properties | Name |
|---|---|---|---|---|---|---|---|---|---|
| 11 | | | | | | | | | |
| 12 | | | | | | | | | |
| 13 | | | | | | | | | |
| 14 | | | | | | | | | |
| 15 | | | | | | | | | |
| 16 | | | | | | | | | |
| 17 | | | | | | | | | |
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| 19 | | | | | | | | | |
| 20 | | | | | | | | | |
| 21 | | | | | | | | | |
| 22 | | | | | | | | | |