GG282 Geomorphology and Soils

**Laboratory Exercise One, Part Two  
Surficial Materials**

*This lab is to be completed and submitted* ***before*** *your lab next week.   
Submit to YOUR lab section’s DropBox!*

**Introduction**

In part one of this lab exercise we examined the textural characteristics of a variety of surficial materials and also estimated the sorting of some samples and the roundness and shape of some particles. In this portion of the exercise students will:

1. examine how particle size data can be tabulated, graphed and calculations done for mean and sorting,
2. produce a frequency histogram from a sample data set and determine the median and mean grain size and sorting of that sample,
3. use an electronic balance, mechanically sieve two samples, present the data in tabular and graphical form and undertake calculations on median and mean grain size and sorting.

A reference for the statistical measures used in this lab is:

Folk RL, Ward WC. 1957. Brazos River bar: a study in the significance of grain size parameters. *Journal of Sedimentary Petrology* 27: 3–26

**Particle Size Analyses**

From examination of materials last week we could see that a wide range of particle sizes can be present within a given sediment. To examine the distribution of grain sizes within a soil or sediment it is necessary to separate a sample into its constituent particle classes (e.g. % sand, silt, clay). From a particle size distribution curve it is possible to accurately determine the mean grain size and the degree of sorting in the sample.

There are several techniques and methods that may be used to divide a sample of soil or sediment into a series of grain size classes. When dealing with relatively coarse samples (i.e. little or no silt and clay) the particle classes can be separated using a mechanical sieving technique. There are a number of sieve designs but the most common is where a series of steel wires are held within a steel ring and form an orthogonal grid. A sample of material is introduced onto the grid and the sample is agitated, particles that are smaller than the openings in the grid pass through it while those that are larger in size are retained on the grid. When samples contain silt and clay, these finer particles can be separated using a wet settling technique and employing a device such as a hydrometer. In this lab, we will use mechanical sieving to examine the grain size distribution of three relatively coarse samples.

**Mechanical Sieving**

Mechanical sieving can be used to determine the particle size distribution over a range of particle sizes. Commonly these sieves are used to separate particles into size ranges that vary from -6 phi (64 mm) to 4 phi (0.0625 mm), although it is possible to set up an apparatus for materials that are coarser. Sieves with known size openings are assembled in a stack with the largest sieves at the top, and the smallest at the base. A sample of known weight is introduced into the top of the sieve stack, and the stack is then placed in a mechanical shaker for several minutes. This time allows the sediments within the sample to ‘settle’ down through the stack and stop at the smallest sieve opening that will not permit them to pass. The stack is then disassembled, and the sediment load contained on each sieve is weighed. By summing the weight recovered from all sieves, the percentage that each class represents can be determined and the distribution plotted.

To generate high quality data from sieving it is important to follow a consistent procedure. When selecting a sample for sieving and undertaking the sieving it is important to note the following:

1) The sample size must be sufficient to ensure that the weights that are retained on the sieves are high enough to yield weights well above the errors associated with the weighing procedure.

2) The sample size must not be so large that on one or more sieves the weight (volume) of the sample retained is so large that the sample interferes with the passage of materials through the sieve.

3) The sample drawn for the analyses should be representative of the larger sample in question. If the sample is being drawn from a larger container the sample should be mixed prior to selecting a sub-sample to ensure an even distribution of materials and the selection of the sub-sample should be done in a manner to ensure no bias is introduced in the procedure.

4) The sample should be completely disaggregated, aggregates of fine grained materials, such as silt and clay, may appear to be grains of sand or even gravel. These aggregates should be thoroughly broken apart before dry sieving. This should be done with a mortise and pestle if needed.

5) The samples should be dry and clear of fragments of organic materials. The sieves should be cleaned prior to use (with great care). Recovery of the samples from the sieves should be done carefully to ensure minimal sample loss.

6) When using a mechanical shaker on several different samples, a consistent time period should be selected for the shaking time to ensure consistent results, as a general rule that time period should be at least 5 minutes (preferably 10 minutes). In normal procedure a given sample would be sieved at least two times to check for the reproducibility of the results.

**Sample Data Set**

The table below presents a particle size breakdown for a soil sample. Mechanical sieving was used between -2 phi and 4 phi, at 1 phi intervals. The upper sieve (-2) phi captured materials larger than granules (very fine pebbles), the materials that passed through the smallest sieve (4 phi or 0.0625 mm) are silt and clay and they are retained in a pan at the base of the sieve stack. Examine the data in the table, the weight retained on each sieve is given and from these data we can determine the total weight retained (200 g). We are also able to calculate the percentage of sample that is retained on each sieve and finally we accumulate those percentage values to fill in the data for the final column. The final column presents the data as cumulative %’s, determined by summing down the preceding column.

The data can be plotted in several ways. Data representing the % of sample retained on each sieve can be plotted on a histogram that will show the distribution of grain sizes for the sample (Figure 1). The cumulative % data can be plotted using a number of formats. A common approach is to plot cumulative % (or % coarser than) as a function of grain size (phi) using arithmetic graph paper (Figure 2). In Chapter 2 of Trenhaile there is an example of particle size data plotted as cumulative percentage curves.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Grain Type** | **Diameter (mm)** | **Phi (φ)** | **Sample Weight (g)** | **% of Total Weight** | **Cumulative %** |
| Pebble | > 4.0 | <-2 | 8 | 4 | 4 |
| Granule | 2.0 - 4.0 | -1 to -2 | 10 | 5 | 9 |
| Very Coarse Sand | 1.0 - 2.0 | 0 to -1 | 16 | 8 | 17 |
| Coarse Sand | 0.5 - 1.0 | 1 to 0 | 22 | 11 | 28 |
| Medium Sand | 0.25 - 0.5 | 2 to 1 | 40 | 20 | 48 |
| Fine Sand | 0.125 - 0.25 | 3 to 2 | 64 | 32 | 80 |
| Very Fine Sand | 0.063 - 0.125 | 4 to 3 | 32 | 16 | 96 |
| Pan | < 0.063 | >4 | 8 | 4 | 100 |
| Total Weight Retained |  |  | 200 |  |  |

Given the total weight of the sample retained (recovered) on the sieves was 200 grams. If the weight of the sample introduced into the top of the sieve stack was 203 grams prior to shaking, how much sample was lost during the shaking and weighing process expressed as a percentage of the original weight?

Should this sample loss be expressed as a positive or negative value?

Can sample be gained during a sieving operation?

What expression should we use to determine the % of the sample that is lost or gained?

**Descriptive Statistics**

From the cumulative % plot (Figure 2) the descriptive statistical properties of the distribution can be easily estimated.

**Median** Particle Size: read particle size from the 50th percentile value median = *ɸ*50



**Mean** Particle Size: calculate from,

**Sorting** (Inclusive graphic standard deviation), calculate from,



Chart, histogram

Description automatically generated

**Figure 1**

Chart, line chart

Description automatically generated

**Figure 2**

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Watch the brief [**video**](https://www.youtube.com/watch?app=desktop&v=UWQgmVh210Y&feature=youtu.be)of sieves and the Ro-Tap sieve shaker in the lab:

**Question 1**

a) Complete the table below by: (i) determining the total weight retained; (ii) for each grade (grain type) determine the % of the total weight retained, and (iii) determine the cumulative % values. (4 marks)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Grain Type** | **Diameter (mm)** | **Phi (φ)** | **Sample Weight (g)** | **% of Total Weight** | **Cumulative %** |
| Pebble (fine, med) | > 4.0 | <-2 | 2 |  |  |
| Granule (vf pebbles) | 2.0 - 4.0 | -1 to -2 | 7 |  |  |
| Very Coarse Sand | 1.0 - 2.0 | 0 to -1 | 12 |  |  |
| Coarse Sand | 0.5 - 1.0 | 1 to 0 | 22 |  |  |
| Medium Sand | 0.25 - 0.5 | 2 to 1 | 34 |  |  |
| Fine Sand | 0.125 - 0.25 | 3 to 2 | 48 |  |  |
| Very Fine Sand | 0.063 - 0.125 | 4 to 3 | 44 |  |  |
| Pan | < 0.063 | >4 | 26 |  | 100 |
| Total Weight Retained |  |  |  |  |  |

b) The original sample weight was 198 grams. Calculate the Percentage of Sample Lost or Gained. Show your work. (1 mark)

For the next step, you will be required to use Microsoft Excel.

Download from MyLS and open the excel workbook file *Lab1data.xlsx* There are two worksheets in that file, labelled Question 2 and Question 3. Examine the data presented on the worksheet Question 2. These are similar data that are presented above as our sample data set. Work your way slowly through that table and examine how the total weight recovered was determined, how the percentage values for each sieve (grade class or grain type) were determined and how the cumulative % curves values were generated. Your TA will assist you in entering simple formulas in Excel.

Examine the two graphs: a histogram and cumulative percentage curve. Can you produce those graphs from this data set, see if you can! Your TA will demonstrate how to use graphs of these types in Excel.

From the cumulative % curve, determine the phi values that corresponds with the percentiles used in the median, mean and sorting calculations.

**Q2.** Determine the phi values at the 5th, 16th, 50th, 84, and 95th percentiles, present those in a table. Calculate the median, mean and sorting for the sample data set shown in the worksheet Question 2. Type your results below. (8 marks)

|  |  |
| --- | --- |
| 5th |  |
| 16th |  |
| 50th |  |
| 84th |  |
| 95th |  |

|  |  |
| --- | --- |
| Mean |  |
| Median |  |
| Sorting |  |

Open the worksheet tab labelled Question 3. On this worksheet there are similar data to the first question, but now we also have information on the original sample weight. Using the weight data recovered from each sieve, determine the total weight of the sample recovered and calculate for each grain type (class) the % of the total weight (recovered) and the cumulative %’s. Enter those values into your table (use formulas). Produce a cumulative % curve, and determine the phi values that correspond with the percentiles used in the median, mean and sorting calculations.

**Q3.** Determine the phi values at the 5th, 16th, 50th, 84, and 95th percentiles, present those in a table. Calculate the median, mean and sorting for the data set shown in the worksheet Question 3. Type your results below. (8 marks)

|  |  |
| --- | --- |
| 5th |  |
| 16th |  |
| 50th |  |
| 84th |  |
| 95th |  |

|  |  |
| --- | --- |
| Mean |  |
| Median |  |
| Sorting |  |

In the table on the next page you will find data for two samples already inputted into the table

**4.** a) For the two sample data sets, determine the % of sample retained on each sieve and the cumulative % values. Add those values to your table. Calculate the percentage lost or gained on each sample. (4 marks)

b) Produce a cumulative % curve for each of the two samples. Use the graph paper on the following page and add a title, legend (key) and your name. Print, or draw the graph. Add two lines, one line for each sample. Identify, 5, 16, 50, 84, and 95th percentile.   
Take a photo of your graph and add it to this Word file. (4 marks)

c) Calculate the median, mean and sorting of these materials using the formula in this handout. Show your work below. (6 marks)

d) BONUS (1 mark): What type of environment do you think Sample A and Sample B came from?

SAMPLE A

|  |  |
| --- | --- |
| Mean |  |
| Median |  |
| Sorting |  |

SAMPLE B

|  |  |
| --- | --- |
| Mean |  |
| Median |  |
| Sorting |  |

Question 4 Tables

Original Weight of Samples (Sw): A = **148g**; B = **154g**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Sample A** | | | **Sample B** | | |
| Phi | Sample Weight on Sieve  (a) | % of Sample  Retained  (a/Tw)\*100 | Cumulative % | Sample Weight on Sieve  (a) | % of Sample  Retained  (a/Tw)\*100 | Cumulative % |
| -2.0 | **7** |  |  | **0** |  |  |
| -1.0 | **18** |  |  | **1** |  |  |
| 0.0 | **24** |  |  | **28** |  |  |
| 1.0 | **38** |  |  | **68** |  |  |
| 2.0 | **28** |  |  | **54** |  |  |
| 3.0 | **18** |  |  | **2** |  |  |
| 4.0 | **11** |  |  | **0** |  |  |
| Pan | **4** |  |  | **0** |  |  |
| Total Weight (Tw) |  |  |  |  |  |  |
| Sieve Loss/Gain Percent |  |  |  |  |  |  |

