Name______________________________

89.325 Geology for Engineers
Gravel Shape and Sedimentary Environment

I. Introduction

Shape, size and composition are the fundamental properties of particles. Since shape is derived mostly by the processes of transport and deposition, studies of gravel assemblages can yield information on the environmental history of the sediments. Shape however is not easily measured or defined. Typically four elements of shape - form, sphericity, roundness and surface texture - are used to characterize particles.

Form: Form is a measure of the relative lengths of the three orthogonal axes of the clast. The longest axis (L), intermediate (I) and short axes (S) are measured with a vernier caliper. The oblate-prolate index (OP), determined by Dobkins and Folk (1970), ranges from $-\infty$ to $+\infty$. The OP is a measure of the clast on a continuum from disc to blade to rod.

Sphericity: Sphericity measures the degree to which a particle approaches a spherical shape. It was defined by Wadell (1932) as the ratio between the diameter of a sphere with the same volume as the particle and the diameter of the circumscribed sphere.

Roundness: Roundness refers to the sharpness of the corners and edges of a grain. Roundness was defined by Wadell (1932) as the ratio of the average radius of curvature of the corners to the radius of the largest inscribed circle. Since it is quite time consuming to measure roundness, the common method of estimating roundness is to visually compare grains of unknown roundness with standard images of grains of known roundness.

Surface texture: Surface texture is described by features found on the surface of the clast.

II. Measurement of gravel clasts

Select a group of pebbles (Black, Red, Blue or Green numbers). **Record the color of the group at the top of your data sheet (spreadsheet).**

1. Determine the long (L), intermediate (I) and short (S) diameters of each of your pebbles using calipers. Enter the data on an Excel spreadsheet using the example below as a template. Do the necessary calculations.

No	D_L (mm)	D_I (mm)	D_S (mm)	D_S/D_L	$(D_L-D_I)/(D_L-D_S)$	**Form**	D_I/D_L	D_S/D_I	**Sphericity**	**Zingg Sphericity**	**Roundness**
						OP			$\boldsymbol{\Psi_p}$		
1	63.51	53.72	23.63	0.37	0.25	-6.84	0.85	0.44	0.55	Oblate	

2. Calculate **Form**: oblate-prolate index (OP) (Dobkins and Folk, 1970).

$$\mathbf{OP} = \{10\{[(D_L - D_I) / (D_L - D_S)] - 0.5\}\} / (D_S/D_L)$$

3. Calculate **Sphericity**: maximum projection sphericity for each pebble, using Sneed and Folk's equation (Sneed and Folk, 1958).

$$\boldsymbol{\Psi}_{\mathbf{p}} = (D_S^{\,2} / D_L D_I)^{1/3}$$

4. Classify the shape of each pebble using the Zingg diagram.

   Plot each clast on the Zingg diagram

$$D_I/D_L \text{ vs } D_S/D_L$$

5. Estimate roundness using Krumbein's visual comparison chart.

6. Calculate the mean and standard deviation of the form, sphericity and roundness for your clasts.

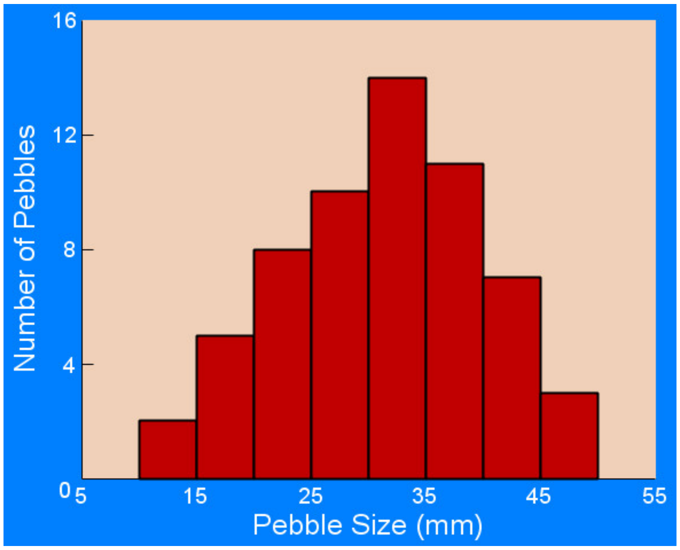
III. Data Analysis

Make the following plots

(1) A histogram showing the number of pebbles versus size (use the long axis measurement)
(2) Clast size versus sphericity
(3) Clast size versus roundness

The intervals for the histogram boxes will be determined after you have collected your data. For example, suppose your long axis dimensions vary from 10 to 50 mm, a size range of 40 mm. You want to have an adequate number of blocks so it might be convenient to divide the distribution into 8 blocks of 5mm each. In case you are not familiar with the construction of histograms an example is given here.

Size range	No. of Pebbles
10 – 15	2
15 – 20	5
20 – 25	8
25 – 30	10
30 – 35	14
35 – 40	11
40 – 45	7
45 – 50	3
Total	60



1. What is the size distribution of the clasts?

2. What is the most frequently appearing size?

3. Does size of clasts correlate with sphericity?

4. Does size of clasts correlate with roundness?

IV. Interpretation

When there is no correlation of grain size with sphericity or roundness (indicates process-controlled shape), then you can use clast shape to determine the paleoenvironment. Specifically using OP and $\Psi_{p,}$ Dobkins and Folk (1970) show that for isotropic clasts within the size range of 16 -126 mm the following:

(i) Water as a transporting agent has a great effect on sphericity. In general fluvial gravel has $\boldsymbol{\Psi}_{\mathbf{p}} \geq 0.67$ and beach gravels have $\boldsymbol{\Psi}_{\mathbf{p}}$ ≤ 0.65. Stratten (1974) and Gale (1990) found mean $\boldsymbol{\Psi}_{\mathbf{p}}$ for fluvial gravels are between 0.67 and 0.77 and beach gravels between 0.53 and 0.64.

(ii) Mean OP for fluvial gravel is near zero. Beach gravels have more negative OP (usually less and -2) and fluvial gravels are greater than -1.

(iii) Using the mean Modified Wentworth Roundness scale, fluvial gravels range between 0.26 – 0.65. Low energy beach gravels (0.34 – 0.61) are less than higher energy beach gravels (0.35-0.81).

(iv) Glacial environments have been studies by Boulton (1978) and Dowdeswell et al., (1985) such that plots of roundness versus sphericity can distinguish between the various transportation pathways.

For your clast set, determine the paleoenvironment it came from:

1. beach deposit
2. glacial environment
3. fluvial deposit
4. alluvial fan deposit