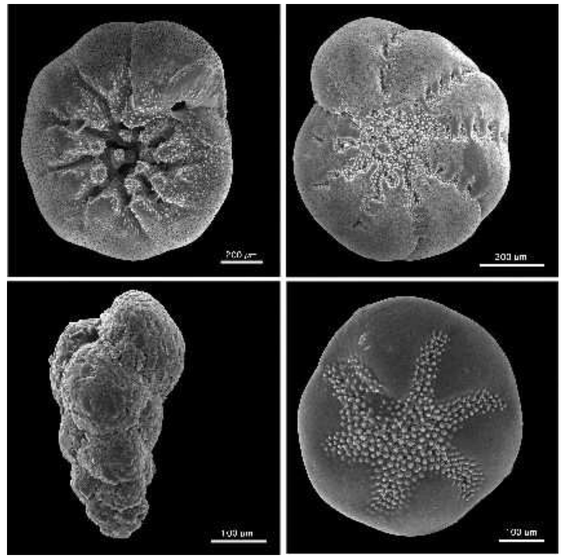
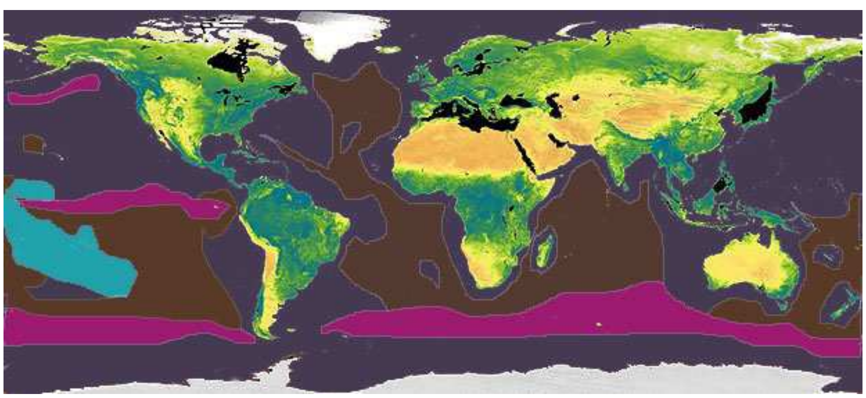
GEOL 595 - Mathematical Tools in Geology
Lab Assignment # 1 - August 28, 2008

Name:

Settling Foraminifera





You will now apply what you have learned to study the settling rate of foraminifera to the bottom of the ocean after they die. Foraminifera are a single-celled organism with shells abundant over the last 540 million years. The shells are commony divided into chambers that are added during growth, but many in their simplest forms are tubes or spheres. On the map provided you can see where different types of foram are found on the ocean floor. Your task is to determine how long it would take an average foram to settle to a deep part of the abyssal plain (ignoring effects of dissolution). For abyssal depth, use the deepest depth from your map of Hawaii in the North Pacific.

Part I: Laboratory test
You will do a preliminary measurement in the laboratory by dropping foram samples through a graduated cylinder of deionized water. Based on the settling velocities that you calculate, you can use this model to predict the settling rate of forams on the ocean floor which is much harder to access. Be sure to look at your final results and try to determine if these values are

reasonable and make sense to you. If not, you may need to look back and think about your steps, procedure, and assumptions.

1. List the physical properties which are relevant in your problem. Which of these properties do you already know ? Which of these are unknowns. ? What are you trying to find ? Do you see any resemblance in this problem to your questions about Hawaiin Islands ?

2. Draw a schematic of the problem you are about to test both in the lab and in the ocean.

3. Write a mathematical relationship relating your known variables to unknown variables. This will be your working model.

4. Measure the drop distance of each foram in your test tube.

Drop distance:

5. Measure the sinking time for each foram in your test tub. (You may do more than one and take the average. Show your work). Also measure and record the water temperature during descent.

Sinking Times Water Temperature:

Sinking Times: Water Temperature:

Sinking Times: Water Temperature:

6. Now let's use the mathematical expression you determined in #3 to obtain a settling velocity. First rewrite the expression and replace variables with your measured values (surrounded by paranthesis). Express you result in common units used for ocean settling velocities of cm/sec.

Settling Velocity (forams in lab):

7. Use the value for settling velocity obtained in your laboratory experiment to estimate settling time on the ocean floor. When extrapolating your calculations be sure to use

consistent units for distance, time, etc.. If you need to do any unit conversions, do this step with each value before inserting it into the final equation.

Settling time (to the ocean floor):

8. How does this result compare with typical settling velocities for ocean water? Common values for settling of foraminifera are 0.44 cm/sec (Wolfgang and Piper, 1972). If your measurments are off, how will this change the settling time you estimated ? What are possible causes of the descrepency between your lab measurements and extrapolation to the ocean ? What are some possible affects on settling velocity in the ocean not accounted for in your test experiment ?

Part II: Another Way to Calculate Velocity Let's try revisiting the concept of settling velocity. Do you know of other ways to consider particle settling in a fluid ? Some have considered particle settling by using Stokes' Law. Could this apply here ?

9. Stokes law considers drag forces operating on a small spherical object as it passes through a viscous fluid. This approach considers a few more physical parameters than the simple velocity we layed out earlier (V = d/t). In this case we will calculate velocity using all the properties of the fluid and particle. Look at your particles, look at your fluids. What other physical properties may be useful in determining settling velocity ? How might the fluid you use in the lab differ from the water in the ocean ? (hint: there might be two fluid properties which you haven't considered yet. Also think about the particle). If you can find each fluid parameter, try to think of whether each has a direct or indirect relationship to velocity. List the new parameters here.

10. Now let's try to rewrite a new mathematical relationship for settling velocity. Place each new parameter on the appropriate side of the equation for velocity and in either the numerator or denominator according to its physical relationship to velocity. Let's also add in the effect of gravity (g). Where might this go in your equation ?

Finally, to check your equation, look at the units of each variable. Do the units on the left side match the units on the right side ? What adjustments need to be made ?

11. You can now determine the exact values of your material properties and plug them into your equation. You may want to consult the *Handbook of Chemistry and Physics* for properties of water, or Nesse's *Introduction to Optical Mineralogy* for properties of calcite (supplied in lab). Before making your calculations, list your variables and make sure each agree in units for *length*, *time*, *mass*, etc. (cm,sec,& grams, should be consistent with your previous calculations).

12. What do you obtain for a Stokes settling velocity ?

Velocity$_{Stokes}$:

What does this model predict for sinking time ?

Sinking Time:

Are the Stokes velocity and sinking time reasonable values for the ocean ? How do these values compare to your original measurements and calculations ? What have you accounted for in this calculation that you did not (or ignored) in the first case ? Are the results changing in the right direction ? Did we do something wrong ? Is it appropriate to use Stokes Law for this problem ?

13. How can we test whether Stokes law applies in the example we are using ? Can you use your lab tests in any way ? If so, try this.

14. How does you calculated velocity compare to the prediction in the Stokes case? From your knowledge of Stokes Law (check above), what could be causing this discrepancy ?

15. How does the material density of your Stokes spheres compare to the actual density of your forams ? Think about the details of forams, their shape, and how they form. Is there a way you could obtain a good estimate of the density of your forams ? Try using your experimental results and the Stokes equation.

16. With this improved estimate of foram density, try calculating the settling velocity and sinking time once again. Is this closer to a reasonable result for the ocean ?

Review your work. What were the assumptions you made at the start. How did your assumptions change as you explored your problem, made measurements, calculations, and tested your hypotheses ?

Figure 1: Varieties of Foraminifera

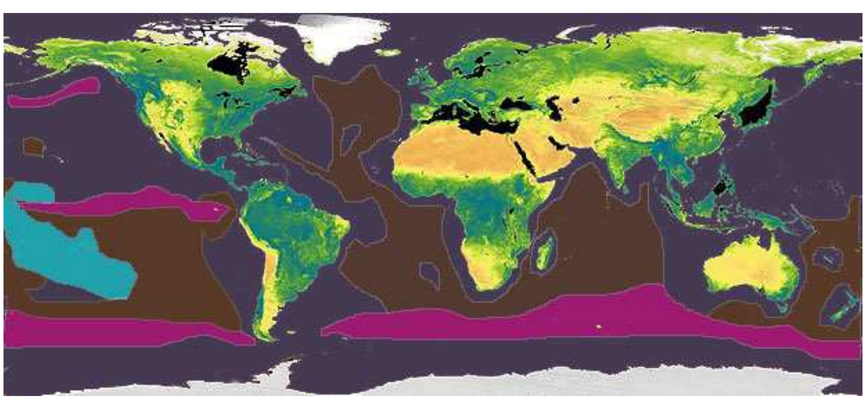


Figure 2: Ocean bottom sediment map. Lithogenous areas are mauve, biogenous areas are purple and brown (purple = siliceous ooze, brown = calcareous ooze), and hydrogenous areas are blue.