Geology 202, Fall 2005
Lab 12: Density-modified flow

A very important process in sediment transport is the flow of fluids above, within, or below fluids with a different density. Gravity plus the contrast in density determine the behavior of these "density modified flows". These flows can also be properly called "turbidity currents" because the flow is truly turbulent. The sediment deposit/rock is a "turbidite". Density differences can be caused by temperature, salinity, and/or sediment suspended in the water. This experiment is designed to allow you to observe the details of how density differences affect the behavior of fluids.

The model:
Our "basin" is a clear tank with a sloping bottom, filled with clean water at room temperature. The tank bottom is marked at 10cm intervals. The slope of the bottom is adjustable. Our "dense fluids" are mixtures of water and $MgSO_4$, dyed to make them visible in the tank.

Safety Caution: Epsom salt ($MgSO_4$) is relatively harmless. If swallowed it produces a laxative effect. Fluorescein dye is possibly dangerous if swallowed in large quantities (read the label). The more immediate risk is the intense green, permanent stain that results if you get it on your hands or clothes. Please be careful.

Preparing the dense fluids: Each tank "team" needs to prepare a set of **two** fluid samples, one with a density of 1.1g/cc and one with a density of 1.2g/cc*, as follows.

Begin dissolving, a little at a time, $MgSO_4$ in 250 ml of water in a beaker or small plastic cup. Stir until completely dissolved. It will take a fair amount of crystals to change the density much.

1. Put an <u>empty</u> measuring cup on the lab balance, power up the balance and press the TARE button. This allows the scale to compensate for the weight of the cup. With the measuring cup still on the scale, carefully pour exactly 100ml of mixture into the cup, and weigh it. The goal is a 100ml sample that weighs 110g. If it does not, pour it back into the mixing cup, add more $MgSO_4$, mix until dissolved, and repeat until the goal density of 1.1g/cc is reached. Pour the 100 ml sample into another container and set it aside, and label it[§].
2. Continuing with the dense fluid, repeat steps 1 & 2 to get a sample with a density of 1.2g/cc.
3. Add 1 small measure (1/4 tsp.) of fluorescein powder to each sample. Mix until dissolved. If you have done this right, the sample will be a red color.

Note:
*We may decide to mix up some other densities as well. Check with your TA.
[§]Once the density of the sample is determined, it no longer matters for this experiment what the accurate volume of the sample is. You can transfer the sample to an unmarked container, and clearly label it.

The basic experiment: The dyed, dense fluid is poured onto the sloping tank bottom and allowed to flow down the slope as a density-modified current. The variables will be density and slope angle. Each tank team will make two experimental runs with two densities of fluid, each at the same angle. The lab section will share all the data. Each student is responsible for analysis of the data collected by all the teams in their lab section.

Procedure:

1. Set up the tank, fill with water, and adjust the slope to the desired angle. Be sure the incline is level laterally. Each team will be given an angle for their runs.
2. Gently but quickly pour the entire 100ml sample of dense fluid at the top of the slope, in the shallow water. Avoid disturbing the water as much as possible.
3. Begin timing the flow at the first mark it passes. Determine the velocity of the flow by timing it over a measured interval. If the flow is slow enough, time it over two intervals, high and low on the slope.
4. Observe and sketch the flow, both from the top, and side view.
5. When the flow stops, the run is over. Drain the water, rinse the tank, and set up for the next run.

***When your team is ready to make an experimental run**, tell your TA, and the class. We will all try to observe every run. The teams are responsible for timing their runs, and will announce their results. For the dense fluids things happen fast, so be ready!

What to look for: The flow will have a pronounced head that has a three-dimensional shape. Note the map view, and the vertical shape, of the flow. Especially note any mixing of the dyed fluid with the clear water. What happens as the fluids mix down-slope? Look carefully at the internal structure of the flow. Watch what happens at the end of the tank.

Results: Your data should enable you to make a series of plots of velocity vs. density. Use these plots to show how:

- Increased density results in increased velocity
- Velocity decreases down-slope with density decrease, as fluids mix.
- Steeper slopes produce greater velocity.

In addition, qualitatively describe what you observed about how these flow behave. Could you see the "head" of the flow? (See textbook description of turbidity currents.) Why does it look like it does? How and where does mixing occur along the flow? Add any other observations that seem applicable.

Please clean up the lab when finished!