Underwater Avalanche: Turbidity Currents
Investigating Density Currents

OBJECTIVE
Students will investigate how changes in density affect the rate at which slurry moves down a slope and what effect changes in slope have on the rate of movement. Students will apply what they learn to ocean floor situations.

LEVEL
Middle Grades: Earth Science

NATIONAL STANDARDS
UCP.2, UCP.3, UPC.5 B.4, D.2

TEKS
6.1(A), 6.2(A), 6.2(B), 6.2(C), 6.2(D), 6.2(E), 6.3(A), 6.3(C), 6.4(A), 6.4(B), 6.6(A), 6.6(B), 6.6(C)

7.1(A), 7.2(A), 7.2(B), 7.2(C), 7.2(D), 7.2(E), 7.3(A), 7.3(C), 7.4(A), 7.4(B)

8.1(A), 8.2(A), 8.2(B), 8.2(C), 8.2(D), 8.2(E), 8.3(A), 8.3(C), 8.4(A), 8.4(B), 8.10(B)

IPC: 1(A), 2(A), 2(B), 2(C), 2(D), 3(A), 4(A), 7(A)

CONNECTIONS TO AP
AP Physics
I Newtonian Mechanics A. Kinematics

AP Chemistry
III Reactions D. Kinetics

TIME FRAME
100 minutes

MATERIALS
(For a class of 28 working in groups of 4)

7 sets of slurry samples, labeled #1-#4	7 long plastic tubes with stoppers
7 ring stands and clamps	tap water
7 protractors	35 150mm standard test tubes
7 test tube racks	7 timers or stop watches
4 600-mL beakers	masking tape
potting clay	pencil or marking pen

TEACHER NOTES

The Turbidity Current Lab demonstrates a density current in the ocean and shows students how the low angle slope of the continental shelf helps to increase the velocity of the sediment laden water. This lab may be taught while teaching about oceans or depositional processes.

Prior to doing the lab you must pre-mix slurries of four different densities and measure the speed of each as they move down a tube. To prepare the four slurries, mix 1/4 pound of clay with one gallon of tap water. Mix together until the clay is suspended in the water. Label the empty beakers #1, #2, #3 and #4. Fill the beakers labeled 1, 2, 3, and 4 with 400, 200, 100, and 50 mL respectively. Add tap water so that the total volume in each beaker is 600 mL. [For each class of 28 you will need 42 samples of slurry 1, or about 600 mL. You will need less of the other three samples, around 200-300 mL.

SAMPLE DATA

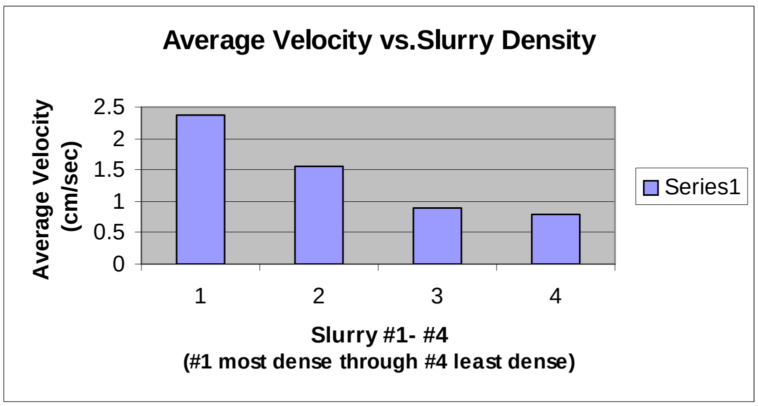
PART I

Data Table 1									
Slurry #1	5 sec	10 sec	15 sec	20 sec	25 sec	30 sec	35 sec	40 sec	
distance (cm)	14	27	39	51	62	73	83	95	average velocity
velocity (cm/sec)	2.8	2.6	2.4	2.4	2.2	2.2	2.0	**2.4**	**2.375**
Slurry #2	5 sec	10 sec	15 sec	20 sec	25 sec	30 sec	35 sec	40 sec	
distance (cm)	21	29.5	33.5	37.5	43.5	50.5	56	62	average velocity
velocity (cm/sec)	4.2	1.7	0.8	0.8	1.2	1.4	1.1	**1.2**	**1.55**
Slurry #3	5 sec	10 sec	15 sec	20 sec	25 sec	30 sec	35 sec	40 sec	
distance (cm)	13	19	24	27	30.5	32	34.5	36	average velocity
velocity (cm/sec)	2.6	1.2	1.0	0.6	0.7	0.3	0.5	**0.3**	**0.90**
Slurry #4	5 sec	10 sec	15 sec	20 sec	25 sec	30 sec	35 sec	40 sec	
distance (cm)	18	20	22	23	25	28	30	32	average velocity
velocity (cm/sec)	3.6	0.4	0.4	0.2	0.4	0.6	0.4	0.4	**0.8**

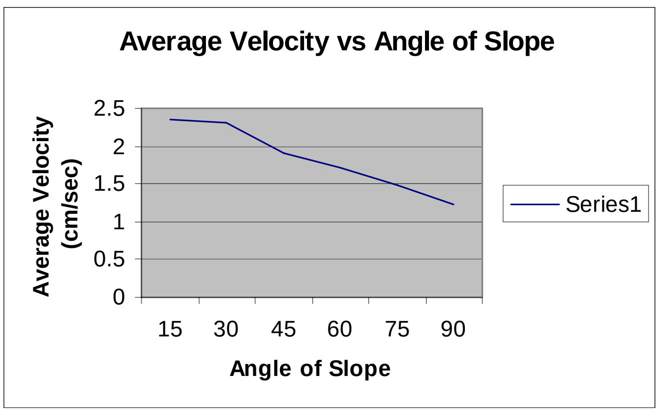
PART II

Data Table 2		
Slope	Travel Time (sec)	Velocity (cm/sec)
15°	**40**	**2.35**
30°	**41**	**2.31**
45°	**42**	**1.9**
60°	**47**	**1.71**
75°	**54**	**1.49**
90°	**65**	**1.23**

Graph for Part I



Graph for Part II



CONCLUSION QUESTIONS

1. From graph #1, what is the relationship between average velocity of a slurry and its density?

- As the slurry density increases the velocity of the slurry increases.

2. Describe any velocity changes that you may have observed in each of the slurries as they traveled down the tube. What factors may have caused these changes?

- The slurry slowed down as it moved down the tube and mixed with the water. The mixing with water decreased the density and caused it to slow down.

3. From the graph for Part II, describe the effect changes in slope had on the velocity of slurry #1. Did the outcome match your hypothesis? Explain why or why not.

- The lower the angle of the slope, the faster the movement of the slurry.

- Answers will vary depending on student hypotheses. Many students may have hypothesized that the greater the slope the faster the movement.

4. Your experiment differed from real density currents in one very important way. Real density currents (turbidity currents) move over the ocean floor collecting loose sediment as they move, thereby increasing in density. Did your samples increase in density as they moved down the tube? Explain your answer.

  - No, samples did not increase in density.
- Samples decreased in density as they moved down the tube because they mixed with the fresh water and became less dense as they moved down the tube.

5. If the density of a turbidity current increases as it continues along its path, predict what happens to its velocity.

- In the ocean, as a turbidity current moves down the continental slope and increases in density the velocity also increases.

6. Use what you have learned about turbidity currents to explain why continental sediment can be found far from continental shorelines.

- On a continental shelf, as a turbidity current rolls across the low degree slope, it picks up more sediment, increasing density and therefore increasing velocity. As it leaves the continental shelf it is moving very fast and shoots over the continental slope. It continues to pick up additional sediment as it moves down the slope and finally it collapses onto the abyssal plain. The low angle of the abyssal plain can allow the sediment to travel long distances before coming to a stop.

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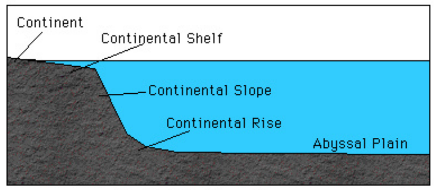

Model of the Ocean Floor

Turbidity currents are undersea flows of muddy sediments that are often triggered by earthquakes. They can also be caused by flooding events in which rivers carry high amounts of sediment into the ocean and by underwater landslides or slumps. Turbidity currents generally occur on the continental slope and rise, areas too deep to be affected by surface waves and tidal currents. As the continental slope flattens at its base into the continental rise and the abyssal plains of the deep sea, the turbidity flows slowly and the sediments settle into graded beds of sand, silt and mud called "turbidites."

Purpose

To investigate how slurry density affects the rate at which slurry moves down a slope and also what effect changes in slope have on the rate at which slurry moves down a slope.

Materials

slurry samples #1,#2, #3, #4	long plastic tube with stopper
ring stand and clamp	tap water
protractor	4 150 mm test tubes
test tube rack	timer or stop watch
pencil or marking pen	

Procedure

Safety Alert

1. Keep your lab table area clean and **dry**.

Part I – Slurry Flow Velocity vs. Slurry Density

1. In the space marked HYPOTHESIS on your student answer page, make a hypothesis as to which slurry will move fastest down the tube. (Slurry #1 is the most dense and #4 is the least dense.)

2. Apply a piece of masking tape down the vertical length of the long plastic tube so that it may be used for marking traveling distances. Set the long plastic tube in the ring stand as shown in Figure 1. Use your protractor to set the tube so that it forms a slope at a 15^{o} angle with the tabletop (Figure 2).

3. Fill the long plastic tube with fresh water to within 10 cm of the top of the tube.

4. Label your test tubes #1-#4. Obtain samples of each slurry from your teacher. Stir each sample before pouring into your test tube.

5. Place your thumb over the end of test tube #1 and shake to mix. Quickly pour slurry #1 into the plastic tube of water. Use a pencil to mark the distance the slurry travels in 5 second intervals. Mark directly on your masking tape.

6. Measure the distances and record them in your data table on the student answer page.

7. Empty the long tube into the sink and refill the long tube with fresh water. For the next trial you may use the same piece of masking tape by either changing colors of marker for each trial or by labeling your marks for each trial prior to starting the next trial.

8. Repeat steps 1-7 for slurry #2, #3 and #4. Record the results in the data table for Part I.

PART II – SLURRY VS. SLOPE

1. In the space marked HYPOTHESIS on your student answer page, make a hypothesis as to which slope angle will cause the slurry to move fastest down the tube.

2. Use your data from Part I for the 15^{o} category. (You do not have to repeat this trial.)

3. Rinse the test tubes used in part I and remove their labels. Only slurry #1 will be used for this part of the experiment.

4. Refill the long tube with fresh water. Readjust the tube so that it forms a slope of 30^{o}.

5. Obtain five more samples of slurry #1. Shake the slurry test tube and again add the slurry to the long tube. Measure the total time (in seconds) that it takes for the slurry to reach the end of the long tube. Record your measurements in data Table 2 on the student answer page.

6. Empty the long tube into the sink and refill the long tube with fresh water.

7. Repeat the procedure for 45^{o}, 60^{o}, 75^{o}, and 90^{o} angles. Record your data in Table 2 on the student answer page.

Name ________________________________

Period ________________________________

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HYPOTHESIS: PART I

HYPOTHESIS: PART II

DATA AND OBSERVATIONS

PART I

Data Table 1									
Slurry #1	5 sec	10 sec	15 sec	20 sec	25 sec	30 sec	35 sec	40 sec	
distance (cm)									average velocity
velocity (cm/sec)									
Slurry #2	5 sec	10 sec	15 sec	20 sec	25 sec	30 sec	35 sec	40 sec	
distance (cm)									average velocity
velocity (cm/sec)									
Slurry #3	5 sec	10 sec	15 sec	20 sec	25 sec	30 sec	35 sec	40 sec	
distance (cm)									average velocity
velocity (cm/sec)									
Slurry #4	5 sec	10 sec	15 sec	20 sec	25 sec	30 sec	35 sec	40 sec	
distance (cm)									average velocity

velocity (cm/sec)									

Part II

Data Table 2		
Slope	Travel Time (sec) (for entire length of plastic tube: 95 cm)	Velocity (cm/sec)
15°		
30°		
45°		
60°		
75°		
90°		

ANALYSIS

PART I

1. Calculate the velocities for each interval. Record them in the data table for Part I.

2. Draw a bar graph comparing the average velocities of the slurry and the slurry density, using your data in Part I. Average velocity should be your *y*-axis and the four slurry samples should be on your *x*-axis.

PART II

1. Calculate the velocity for each angle of slope by dividing the centimeters traveled by the time it took in seconds. Record your answers in your data table.

2. Draw a line graph comparing the velocity of the slurry's vs. the angle of the slope of the tube. Average velocity should be your *y*-axis and the angle of the slope of the plastic tube should be on your *x*-axis.

Graph for Part I

Graph for Part II

CONCLUSION QUESTIONS

1. From the graph for Part I, what is the relationship between average velocity of a slurry and its density?

2. Describe any velocity changes that you may have observed in each of the slurries as they traveled down the tube. What factors may have caused these changes?

3. From the graph for Part II, describe the effect changes in slope had on the velocity of slurry #1. Did the outcome match your hypothesis? Explain why or why not.

4. Your experiment differed from real density currents in one very important way. Real density currents (turbidity currents) move over the ocean floor collecting loose sediment as they move, thereby increasing in density. Did your samples increase in density as they moved down the tube? Explain your answer.

5. If the density of a turbidity current increases as it continues along its path, predict what happens to its velocity.

6. Use what you've learned about turbidity currents to explain why continental sediment can be found far from continental shorelines.