GEOL 101 Lab: Introduction to Deformation

Some of the most dramatic evidence that great forces have shaped the Earth are the rocks that one finds deformed in mountain belts. Rocks can be deformed by body forces, nothing more than gravity acting on them. Slumps and landslides are some familiar results of the effect of gravity. But gravity driven deformation can be vastly bigger than we are accustomed to, especially when aided by additional processes, some of which we will explore in this lab. Alternatively, rocks can be deformed by tectonic forces that push them together and crumple them up, forming most of the world’s great mountain ranges, including the Alps, the Himalaya, and the Andes.

In this lab, we will perform two experiments to investigate both of these kinds of deformation. In one, you will deform layers of sand in front of a horizontally driven piston, simulating tectonic deformation that one sees in many mountain ranges. The structures that you create are not unlike those that have been responsible for recent earthquakes in southern California and elsewhere. In the other experiment, you will observe some of the key mechanical features that allow great landslides to travel tens or hundreds of kilometers over very gently sloping land surfaces.

The Sandbox Experiment

A sandbox is a plexiglass-sided box with a moveable piston at one end. You will fill the box with layers of sand, placing markers of loose white plaster at intervals up the sides.

Procedure

1. Pour sand into the empty sandbox until about 4 cm (~1.5 inches) thick and smooth out the top surface. Sprinkle a narrow strip of white plaster just along the glass walls (do not spread across the entire surface of the sand. Repeat four or five times, ending with a layer of sand with no plaster on the top. Smooth out the top surface. The total thickness of sand should be 15 to 20 cm (~6 to 8 inches) thick.

2. Making sure the hydraulic car jack is collapsed all the way, position it with the handle pointing upward at the back end of the model. Be sure that the small turn screw that you use to release the pressure is shut or else it won’t work.

3. Measure and write down the initial dimensions of the model: thickness of the sand, length of the model.

4. Move the piston by pumping the car jack. At the intervals specified below, make the following observations.
**Observations to Make**

Fill in the following table as you carry out the experiment:

<table>
<thead>
<tr>
<th>Displ. of Piston (cm)</th>
<th>Length of model (cm)</th>
<th>Slope of surface</th>
<th># of Faults</th>
<th>Dip angle of faults</th>
<th>Total Horizontal component of slip on all faults</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 cm</td>
<td>0°</td>
<td>0</td>
<td>N/A</td>
<td>0 cm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>N/A</td>
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</tr>
</tbody>
</table>

**Questions to Answer**

1. As you move the piston, does the sand shorten and thicken uniformly or is the deformation of the sand localized along discrete planes?

2. How much displacement of the piston is required before the first fault forms? What is the angle that the fault makes with respect to the horizontal (i.e., the dip)?

3. Do the fault angles change during the experiment? If so, do they get steeper or shallower?
4. Observe and describe the surface of the model as the deformation proceeds. Is it smooth or lumpy? If there are surface irregularities, can you explain them in terms of the deformation that you observe on the sides of the model?

5. How does the width of the deformed zone change with time?

6. How does the length of the model compare to the horizontal component of slip on the individual faults observed? Should they be the same? If they are different, discuss some reasons why.

The "Beer Can" Experiment

The "Beer Can" experiment was first proposed by the French fluid mechanics expert M. A. Biot to illustrate how certain factors can substantially affect the friction between a mass and the slope on which it rests.

Procedure

1. Take the glass plate provided and place the empty(!) beer can on one end. Tilt the plate by raising the end on which the can rests. Record the angle of the plate at which the can begins to slide down the tilted glass. [A table is provided, below, for recording the observations.]

2. Cover the plate with a film of water (if the plate is dirty you will have to clean it with mild detergent first). Repeat step one. Again, record the angle at which the can slides down the plate.

3. Now chill the can by placing it in the cooler with dry ice [Safety note: Do not handle the dry ice with your bare hands or you run a serious risk of rapid frostbite. Use gloves to place or remove the can from the cooler. Dry ice — or frozen carbon dioxide — is much colder than ice made from water!].

4. After three to five minutes, remove the can from the cooler and place the can on the wetted glass plate with the open end facing up. Tilt until the can slides and record the angle as before.

5. Finally, cool the can again, briefly, and place it on the wetted plate, open end down. Tilt until the can slides and record the angle

Observations
<table>
<thead>
<tr>
<th>Condition of Beer Can (besides empty!)</th>
<th>Condition of plate</th>
<th>Angle of plate when can slides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room temperature</td>
<td>Dry</td>
<td></td>
</tr>
<tr>
<td>Room temperature</td>
<td>Wet</td>
<td></td>
</tr>
<tr>
<td>Cold, open end up</td>
<td>Wet</td>
<td></td>
</tr>
<tr>
<td>Cold, open end down</td>
<td>Wet</td>
<td></td>
</tr>
</tbody>
</table>

**Questions to Answer**

1. Discuss the results of your experiment. What are the important factors that are related to how easily the can moves down the slope? Why is the result for the last combination of factors (cold, open end down, wet) so different from the others?

2. The mechanics of this experiment are shown in the diagram, below. The coefficient of friction is defined as the tangential force divided by the normal force ($\frac{F_t}{F_n}$). Calculate the coefficient of friction for each of the four cases that you investigated above and discuss your results.

\[
\begin{align*}
\text{normal force} &= F_n = mg \cos(\theta) \\
\text{tangential force} &= F_t = mg \sin(\theta)
\end{align*}
\]