# STRUCTURAL GEOLOGY LAB 1: GEOMETRIC and KINEMATIC ANALYSIS in a SANDBOX (instructions during lab)

## Goals:

* Use sketches and structural map symbols to make a geometric description of structures.
* Observe and record kinematic analysis of an analog model.
* Use density, thickness, and strength measurements to determine the real-world scale of an analog structure model.
* Separate descriptions from interpretations in a lab write-up.

## To turn in (at beginning of your lab next week):

* Table summarizing the set-up of your model.
* Table with the measurements needed for the scaling problem**.**
* Scaling calculation (showing enough steps that I can follow it while grading)
* Map- and cross-section-view sketches of your model after deformation.
* Structure map of your final model (with at least 5 qualitative strike & dip symbols, and with fold and fault symbols as appropriate)
* Image from Google Earth, showing the scale of a real-world analog to what you created during lab.
* Write-up (bullets ok), with separate description and discussion/interpretation sections

## Do during lab:

### 1) Select fault type and material (sand or flour).

* Record information about conditions.
* Sketch your set-up. Include:
	+ Shape of base
	+ Arrows showing movement of every part that moves
	+ Concept sketch annotations, explaining the parts of the set-up

### 2) Run your model at least 3 times. Watch for things that are similar in each run, and things that are different each time. Sketch notes for yourself to help you remember your observations.

### 3) After your third run, make three sketches to show the geometry of the surface that resulted from your experiment.

a) Sketch the shape of the surface in map view. After you have made your sketch, compare your sketch with those of other students in your group. Discuss what features you drew in common, and what features are different. Then make a second drawing, showing the features that you think would be most important for communicating the deformation that you observed. Be prepared to show your second drawing to students in the other groups.

b) Sketch a cross-section view of your model. (In your group, discuss which side of your model to draw.)

c) Make a structure map showing the key structural features that resulted from your experiment. (See Appendix for a list of symbols to use.) Your map should include:

* At least 5 qualitative (no numbers) strike and dip symbols, showing the approximate strike and the direction in which the surface is tilted. You don’t need to measure the exact orientation of the surface, but use the same kind of symbols from a geologic map to show the shape of the surface.
* Fold hinge symbols, showing the location of anticline and syncline hinges.
* Fault symbols, showing the location of thrust faults, normal faults, and/or strike-slip faults that cut the surface.

### 4) Use the GoPro to record one final experiment. You will use this last experiment for the rest of the interpretation for your lab, so you can do the recording over if it doesn’t behave in the way that your other experiments did.

### 5) Measure the properties of your sand.

In order to relate an analog model to examples of structures found in the real world, you need to measure the properties of your material and then do scaling calculations. (See the introduction handout for more details.) Make the measurements in the field lab; we will return to the classroom to do the calculations.

#### Density (mass/volume)

* Weigh the container (the plastic weigh boat) before putting sand in it.
* Measure 100 mL of sand. (100 mL = 100 cm3)
* Pour the 100 mL of sand into the weigh boat.
* Measure the mass in grams of 100 cm3 of sand + the weigh boat.
* Subtract the weight of the weigh boat from the total measured weight to give the weight of the sand alone.
* Calculate density = mass/volume (= grams/100 cm3).

#### Thickness

* Use a ruler to measure the thickness of your sand pile in centimeters.

#### Angle of repose:

* Pour sand through a funnel to make a conical hill.
* Measure the slope of the hill with a protractor
* (Check with a different measurement: measure the height of the hill and the width of the hill; use trig to calculate angle)
* Coefficient of friction: height/half width, or tan of angle

#### Cohesion

* Cut a small vertical slope in your sand hill.
* Gradually cut larger and larger vertical slopes, until your sand pile just begins to collapse.
* Measure the height (HC) of the vertical cliff in cm.
* After the cliff collapses, measure the slope angle () (in degrees, using a protractor) of the sand pile that develops from the collapsed cliff.
* Calculate the friction angle B using the following equation:

(1) $φ\_{B}=2\*\left(κ-45°\right)$

* Calculate cohesion using the following equation:

(2) $C\_{B}=\frac{H\_{C}\*ρ\*g}{40}\*\frac{\left(1-\sin(φ\_{B})\right)}{\cos(φ\_{B})}$

CB = bulk cohesion (Pascals)

HC = height of vertical cliff (cm)

= slope angle of the collapsed cliff (degrees)

B = friction angle (degrees)

 = density (g/cm3)

g = acceleration of gravity (980 cm/sec2)

### 6) Jigsaw tour: show your observations to members of other groups.

### 7) Return to the lab classroom to complete the calculations.

* Do the scaling calculation (see instructions below, and additional math in the “Introduction” handout) and find an image on Google Earth that is the correct size to correspond to your model.

#### Scaling instructions:

What did you just make?

a) Use the following equation to calculate the scaling ratio ($\frac{z\_{p}}{z\_{m}})$ of your model.

$$\frac{z\_{p}}{z\_{m}}=\frac{ρ\_{m}}{ρ\_{p}}\*\frac{σ\_{p}}{σ\_{m}}$$

Use the following values:

m : Density of your sand (from your measurement)

p : Density of typical crustal rock (2.7 g/cm3 – this is a reasonable density for granite, sandstone, shale, and limestone, and is the number that is most often used to represent continental crust in density problems)

m : the cohesion (CB ) that you measured for the sand

p : 50,000,000 Pa (= 50 MPa) (Cohesion of real rocks varies from 15 to 110 MPa, Schellart, 2000; 50 MPa is close to the cohesion of Tennessee sandstone, Weber sandstone, and Blair dolomite)

b) Multiply your scaling ratio by the length of your model to figure out how big your model would be in the real world. (Don’t forget to convert cm to km.)

c) Use Google Earth to find an image with a scale that makes sense for your model. (Some starting points are in the attached .kmz files, but you will need to zoom in or out in order to get your feature to the correct scale.)

Save a picture of the image at the correct scale, and turn that in on the course management system.

### 8) Examine the recordings and complete the write-up. The write-up should include:

* Observations (could be a bulleted list for this lab; in the future, this will be a paper, written in well-organized and grammatically correct sentences and paragraphs)
	+ Geometric description of the final surface of the sandbox
		- Refer to sketches and structure map
	+ Kinematic description of the development of the surface while you observed it
		- Refer to sketches with arrows that show the movement of various parts of the model
* Discussion/interpretations
	+ How did the final shape of the surface develop? (Relate the kinematic observations to the geometric observations.)
	+ What stresses seemed to cause the kinematic development of the model? (Sketches could help your explanation.)
	+ What scale of feature did you model? (Refer to your scaling calculations to back up this interpretation.)
	+ How did the edges of the model behave? Why did the edges behave in that way? How far into the model would you need to look to get away from the edge effects?

**Sandbox lab data sheet**

#### Model conditions:

|  |  |
| --- | --- |
| **Options** | **Your conditions** |
| Type of fault (strike-slip, bend in strike-slip, thrust): |  |
| Modeling material (e.g. sand or flour): |  |
| Thickness of material at start of model: |  |
| Length at start of model: |  |
| Width at start of model: |  |

**Density data:**

|  |  |
| --- | --- |
| **Variable** | **Data** |
| Mass of empty weigh boat (g): |  |
| Volume of material (mL, same as cm3): |  |
| Total mass of material (material + weigh boat) (g): |  |
| Mass of material (g) (= total mass – empty weigh boat): |  |
|  = Density of sand (g/cm3) (= mass/volume) |  |

**Rheology data (follow instructions in lab handout):**

|  |  |
| --- | --- |
| **Variable** | **Data** |
| Angle of repose (degrees): |  |
| HC (Maximum height of vertical cliff, cm) |  |
|  (slope of collapsed cliff, degrees) |  |
| B (friction angle, degrees)$$φ\_{B}=2\*\left(κ-45°\right)$$ |  |
| CB (bulk cohesion, Pascals) $$C\_{B}=\frac{H\_{C}\*ρ\*g}{40}\*\frac{\left(1-\sin(φ\_{B})\right)}{\cos(φ\_{B})}$$ |  |

**Scaling calculation:**

**Sketch of base of model:**

**Map-view sketch of model after deformation (after discussing most important characteristics with your group):**

**Sketched structure map (with appropriate symbols) of model after deformation:**

**Cross-section view sketch of model:**

**Common geologic map symbols**

|  |  |
| --- | --- |
| **Description** | **Map Symbol** |
| Contact (identity and existence certain, location accurate) |  |
| Contact (identity and existence certain, location approximate) |  |
| Contact (identity and existence certain, location concealed) |  |
| Bedding |  |
| Horizontal bedding |  |
| Vertical bedding |  |
| Overturned bedding |  |
| Foliation |  |
| Vertical foliation |  |
| Joint |  |
| Vertical joint |  |
| Lineation |  |
| Anticline |  |
| Syncline |  |
| Overturned anticline |  |
| Overturned syncline  |  |
| Normal fault |  |
| Thrust fault |  |
| Strike-slip fault |  |
| Fault with dip amount | *65* |
| Steep fault (where difficult to tell if normal vs reverse, but relative offset can be observed) | UD |