LABORATORY 7: Thickness and Depth Problems

I. Thickness of Strata

a) *True Thickness*- distance measured perpendicular to the upper and lower contact of a tabular unit.

b) *Apparent Thickness*- vertical distance between an upper and lower contact in a non-horizontal unit. The apparent thickness is equal to the true thickness only when the attitude of the unit is horizontal.

c) *Outcrop Width*- distance on the map between the bounding contacts of a tabular unit measured along an azimuth perpendicular to strike.

d) *Apparent Width*- distance on the map between the upper and lower contacts of a tabular unit measured in a direction other than perpendicular to strike.

e) Special attitudes:

1. Vertical strata: if the map surface is relatively horizontal, the distance measured perpendicular to the contacts is the true thickness.

2. Horizontal strata: the elevation difference between the upper and lower contacts is the thickness.

f) Inclined strata on a horizontal map surface, traverse taken perpendicular to strike.

1. Map outcrop width is an apparent thickness termed the outcrop width (w).

2. Trig equations

sin(dip angle) = (opposite side)/(hypotenuse) = thickness/width **(1)**

g) Inclined strata below a horizontal topographic surface; traverse taken oblique to strike:

stratigraphic thickness = sin(dip angle) * (outcrop width)

1. First step must correct the apparent outcrop width (w') to the true outcrop width (w):

$\cos(\beta) = (w) / (w')$ **(2)**
$(w) = \cos(\beta) * (w')$

where beta is equal to an angle less than 90° between true dip direction bearing and traverse direction. In the below equations, (w) will represent true outcrop

width, whereas (w') will represent apparent outcrop width.

2. Second step may be solved graphically by constructing a cross-section using the calculated true map outcrop width (w) as is demonstrated below, or mathematically using equation **(2)**.

h) Inclined strata on sloping map surface, traverse taken perpendicular to strike.

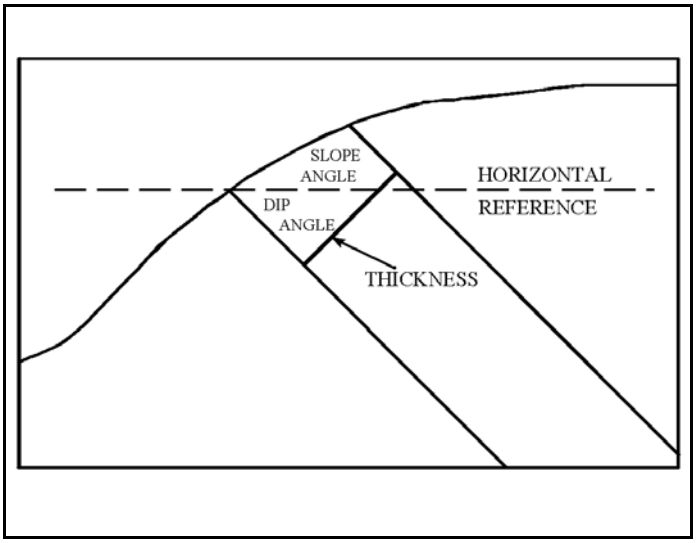

Figure 7-1: Cross-section of thickness problem.

1. Graphically construct the sloping map surface profile on the cross-section view. Then plot the dipping upper and lower contacts according to the outcrop width (w) obtained from the traverse. Note that (w) is the distance actually traveled on the sloping surface- not the distance between traverse endpoints measured from a map.

2. Trig formula will vary according to the relationship of the slope and dip directions. The best way is to inspect your graphical cross-section and decide whether the dip and slope angles are added or subtracted to form the correct geometry.

3. As an example, given that the dip and slope are inclined in opposite directions:

Thickness = sin(dip angle + slope angle) * (w) **(3)**
Sin(dip angle + slope angle) = thickness / (w)

4. Note that in the special case where the slope surface is perpendicular to the stratigraphic contacts, the sum of the dip angle and slope angle will equal 90, therefore the outcrop width is equal to the true thickness.

i) Inclined strata on a sloping ground surface, traverse taken oblique to strike (this is the

most general case).

- The first step is to plot traverse on map, and then plot the strike of the upper and lower contacts on the map. The slope distance component (w) is then calculated by measuring the line perpendicular to the contacts.

  $w = (w') * \cos(\beta)$ **(4)**

  The true thickness can then be solved graphically or trigonometrically as described above. Note that one should measure the slope angle in the direction of (w), or estimate it from the topographic map before proceeding to the next step.

- After the outcrop width (w) is calculated, a cross section view is constructed using the measured slope and dip angles along with the (w) value calculated in the above step.

II. Apparent thickness in a drillhole (Vertical apparent thickness or Depth)

a) It is often desirable to calculate the apparent stratigraphic thickness encountered in a drill hole. In these calculations it is often assumed that the drill hole is perfectly vertical. The graphical value is then found by measuring on the cross-section the vertical distance between the upper and lower contacts.

b) Trigonometric
cos(dip angle) = thickness / depth
depth =thickness / (cos (dip angle)) **(5)**

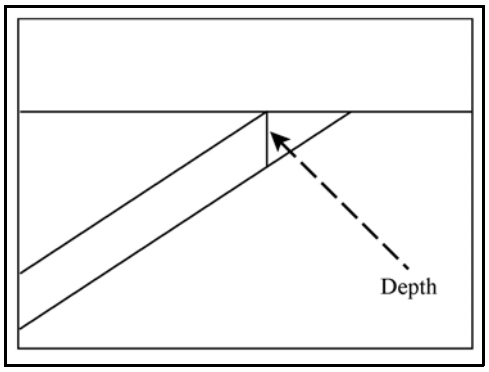

Figure 7-2: Cross-section of depth problem.

EXERCISE 7A: Thickness and Depth Problems

You may want to review the fundamentals of sin, cos, tan, etc. before reading the above pages in the lab manual. When you construct a cross-section for any of the below problems make sure that you label the direction of the line of cross-section (ex. NW-SE). These problems should be completed using graphical methods but check your answer with trigonometric equations.

Problem 1: A bed possesses a true dip amount and direction of 55°, N0°E. The surface of the ground is level, and the distance between the upper and the lower contacts of the bed measured perpendicular to strike is 250'. Find the thickness of the bed.
SCALE: 1" = 50 feet.

Problem 2: Find the thickness of a bed if the outcrop width between the upper and lower contacts is 175', as measured perpendicular to the strike direction. The ground surface slopes 15° opposite the true dip direction. The bed possesses a true dip amount and direction of 35°, N90°E. Find the true thickness of the bed.
SCALE: 1"=50 feet.

Problem 3: The attitude of a sandstone unit is N55°E, 30°SE. A horizontal traverse with a bearing of S20°E, taken from the lower stratigraphic contact to the upper stratigraphic contact, measured 106 meters. What is the true thickness of the unit? Assume that the unit is not overturned by deformation.
SCALE: 1" = 75 meters.

Problem 4: A limestone formation is exposed along an east facing slope. Its attitude is N25°W, 36°SW. The traverse length from the lower contact to the upper contact along a bearing of N80°W was 623 meters. The slope angle measured perpendicular to strike was 15°. Determine the true thickness of the limestone.
SCALE: 1" = 400 meters.

Problem 5: The width of the Red Mountain sandstone near Birmingham, Alabama, was found to be 175' measured along an S67°E direction from a lower elevation to a higher elevation. The slope measured 20° perpendicular to the strike of bedding. The slope face exposed Red Mountain formation with the ends of the traverse being the contacts with an underlying limestone unit and an overlying shale unit. A strike and true dip of bedding are not available, but two apparent dips along bedding planes have been measured: 33°, N47°E and 46°, S56°E. Find the true thickness of the Red Mountain unit. Use any preferred method to solve for the strike and true dip of the unit.
SCALE: 1" = 100 feet

EXERCISE 7B: Thickness and Depth Problems

You may want to review the fundamentals of sin, cos, tan, etc. before reading the above pages in the lab manual. When you construct a cross-section for any of the below problems make sure that you label the direction of the line of cross-section (ex. NW-SE). These problems should be completed using graphical methods but check your answer with trigonometric equations.

Problem 1: A bed dips at an angle of 35 degrees east. The surface of the ground is level, and the distance between the upper and lower contacts of the bed measured at right angles to strike is 200 feet. Find the thickness of the bed. SCALE: 1 inch = 50 feet.

Problem 2: Find the true thickness of a bed if the width of the outcrop between the upper and lower contacts is 150 feet, as measured at right angle to strike. The ground surface slopes 20 degrees opposite the dip. The bed dips 45 degrees east. SCALE: 1 inch = 50 feet.

Problem 3: The attitude of a sandstone unit is N65E, 35SE. A horizontal traverse with a bearing of S10E, taken from the lower to the upper contact, measured 126m. What is the true thickness of the sandstone bed? SCALE: 1 inch = 75m.

Problem 4: A limestone formation is exposed along an east-facing slope. It has an attitude of N15W, 26SW. The traverse length from the lower contact to the upper contact along a bearing of N90W measures 653m. The slope angle was +15 degrees (ascending) measured in the true dip direction. What is the true thickness of the limestone formation? SCALE: 1 inch = 400m.

Problem 5: The width of the Silurian Red Mt. Formation sandstone near Birmingham, Alabama, was found to be 150 feet measured in the S70E directional bearing beginning at the lower stratigraphic contact and terminating at the upper stratigraphic contact. This west-facing slope was found to have a topographic slope of 20 degrees. Also discovered along the traverse was an older limestone unit, the Ordovician Chickamauga limestone, and the younger Devonian Frog Mt. Sandstone. Although exposure was not sufficient for a direct strike and dip measurement, two apparent dips were recorded on the Red Mt. - Chickamauga contact: 24, N47E and 36, S26E. Find the thickness of the Red Mt. Formation. SCALE: 1 inch = 100 feet.