Analysis & Probability/Geometry: Geologist (Mining)

Bureau of Land Management

Job Description: Assessment of mineral resources, oversight of active mining operations, geologic and mineral resource investigations.

Problem:

Acme Mining Company is considering developing a small phosphate mine in southeastern Idaho. The area has been explored, geology has been mapped, and two drill holes (DH1 and DH2) were drilled. A vertical, east-west oriented cross section of the area has been drawn, as shown below. Note that the phosphate bed (a sedimentary layer) is not flat, but is inclined. The angle of inclination from a horizontal plane is known as the "dip" (d on the cross section).

The drill holes were drilled vertically and rock samples were collected. The geologist on the drill rig recognized the change in rock types as the hole was drilled downward. The following drill data is given:

Drill hole depth (feet)

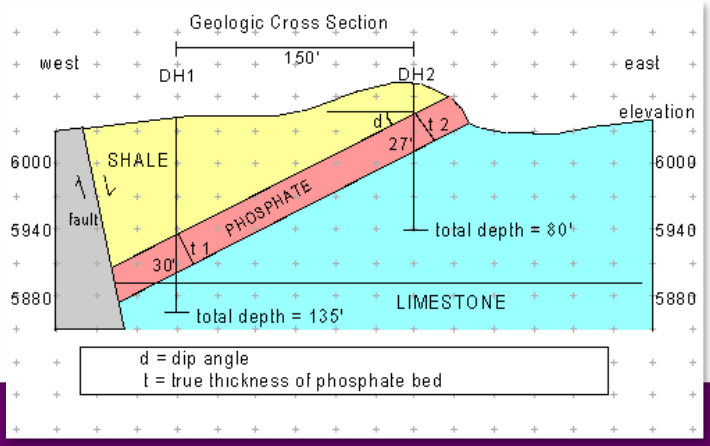
Rock type	**DH1**	**DH2**
Surface, alluvium	0 - 3'	0' - 3'
Shale	3' - 75'	3' - 15'
Phosphate	75' - 105'	15' - 42'
Limestone	105' - 135'	42' - 80'

Since mining is expensive, it is important to the company to obtain an accurate estimate of phosphate resources in this area to assess the economic feasibility of developing a mine.

If the resource is poor, the costs of mining could well exceed the profits generated, thus the company would go broke (and the geologist lose his or her job!).

As a first step in estimation of the volume and tonnage of resource, the geologist needs to determine the average true thickness of the phosphate bed. True thickness (t, on the cross section) is measured perpendicular to the phosphate bed. Since the drill holes were drilled vertically (at an angle to the inclined bed), the thickness observed from the drill hole data is not true thickness, but is "apparent" thickness.

Assuming the ground level of DH1 is the same level as the highest phosphate level of DH2, determine the dip angle (d) and the average true thickness (t) of the phosphate bed between the two drill holes.



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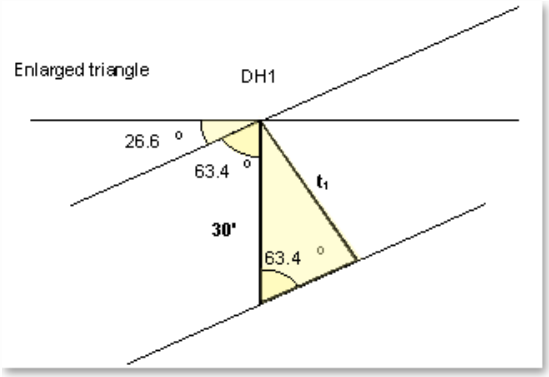
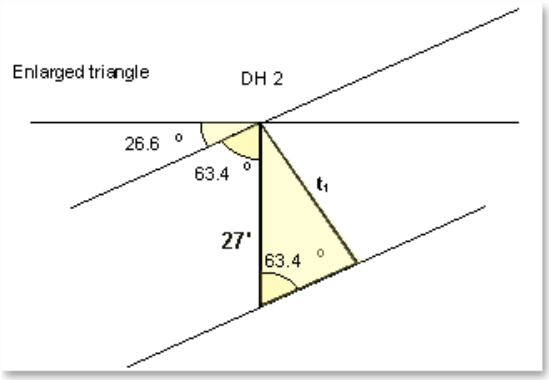
See problem for details.

Solution:

1. Determine the dip angle of bed (d)
d = angle of true dip
(inclination of bed from horizontal)
A right triangle is formed as shown, thus trigonometry can be used to solve the problem.
tan d = opposite/adjacent = 75 ft./ 150 ft. = .500
Using a calculator to determine angle: tan-1 ≈26.6°



2. Determine the true thickness (t) of phosphate bed (average of "t" from PH1 + PH2).
True thickness can also be calculated using trigonometry. A right triangle is formed as shown.
For DH1: "Apparent" thickness from drill-data = 105' - 75' = 30'
sin 63.4° = opposite / hypotenuse = t / 30'
t = 30sin 63.4° = 26.8 feet for t_1



For DH2: "Apparent" thickness from drill-data = 42' - 15' = 27'
sin 63.4° = t/27'
t = 27 sin 63.4° = 24.1 feet for t_2

3. Average thickness = (26.8' + 24.1') / 2 ≈ 25.5 feet

Note: *This problem could also be solved graphically as an alternative. The result of 25.5 feet average thickness is significantly different from an average of (30 +27)2 = 28.5 feet that would have been determined from averaging the apparent thickness from drill-hole data. A difference of 3 feet is significant when the volume of the entire resource block is calculated.*