Topographic and Geologic Maps:
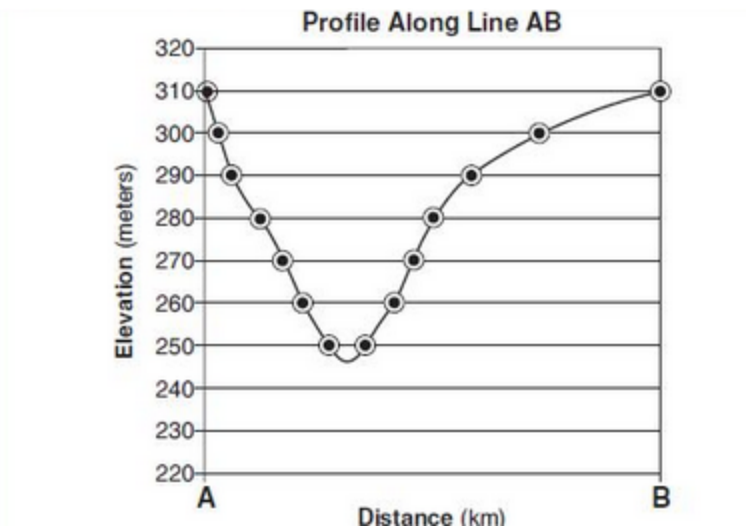
1. Scale: 1:24000, contour interval: 40 Feet

2. 5480-5520 ft acceptable

3. 6040-6080 ft acceptable

4.SE

5.42-45° acceptable

6.

Profile Along Line AB

7. Qaf is quaternary alluvial fill, where silt has been recently deposited by rivers and streams. Quaternary artificial fill, where soil is deposited by human activities, is also acceptable

8. That map symbol represents boudinage, which is when a layer of competent rock is broken up by extension into boudins, and the holes filled by surrounding, less competent rock.

9. Trilobites, a Paleozoic index fossil, would most likely be found in P_zCA, as "P_z" indicates a Paleozoic layer.

10. If the whole earth were covered in water, some areas of the water would be slightly lower than others, due to mass anomalies in the Earth. This theoretical surface is called a geoid. As the geoid is lower at some points than others, a slightly sloped riverbed following the geoid exactly will not flow. This is revelant to map datums because the most common datum is the mean sea level, which varies between points on the globe based on the geoid. Therefore, map datums have to specify where on earth the mean sea level was measured for their datum. For example, the British datum is based on mean sea level in the town of Newlyn, Cornwall.

Tectonics, rock formation, Earth structure and history:

1. True

2. Core

3. Cenozoic

4. Convergent

5. The boundary between the crust and the mantle, accompanied by a change in chemical composition (an increase in Fe and Mg, in particular).

6. coal, sandstone, limestone, shale

7. Carboniferous

8. High Temperature causing melting (for example, an igneous intrusion may cause new magma to melt around it as it rises), lower pressure (as the magma rises) causing melting, and a change in composition of rock to lower its melting point (e.g. the addition of water near subduction zones).

9. The Benioff-Wadati zone is a zone of increased seismicity along the boundary of subducting plates, important in tectonic mapping because it allows us to identify the locations of subducting plates by finding zones with many earthquake foci. The cause of the increased seismicity is most likely the water.

10. Convection currents in the core create the magnetic field, and shifts in these currents cause magnetic wobbles.

Folds, faults, erosion, intrusion signatures, subsurface geometries, deformation sequences, and sub-surface depositional features
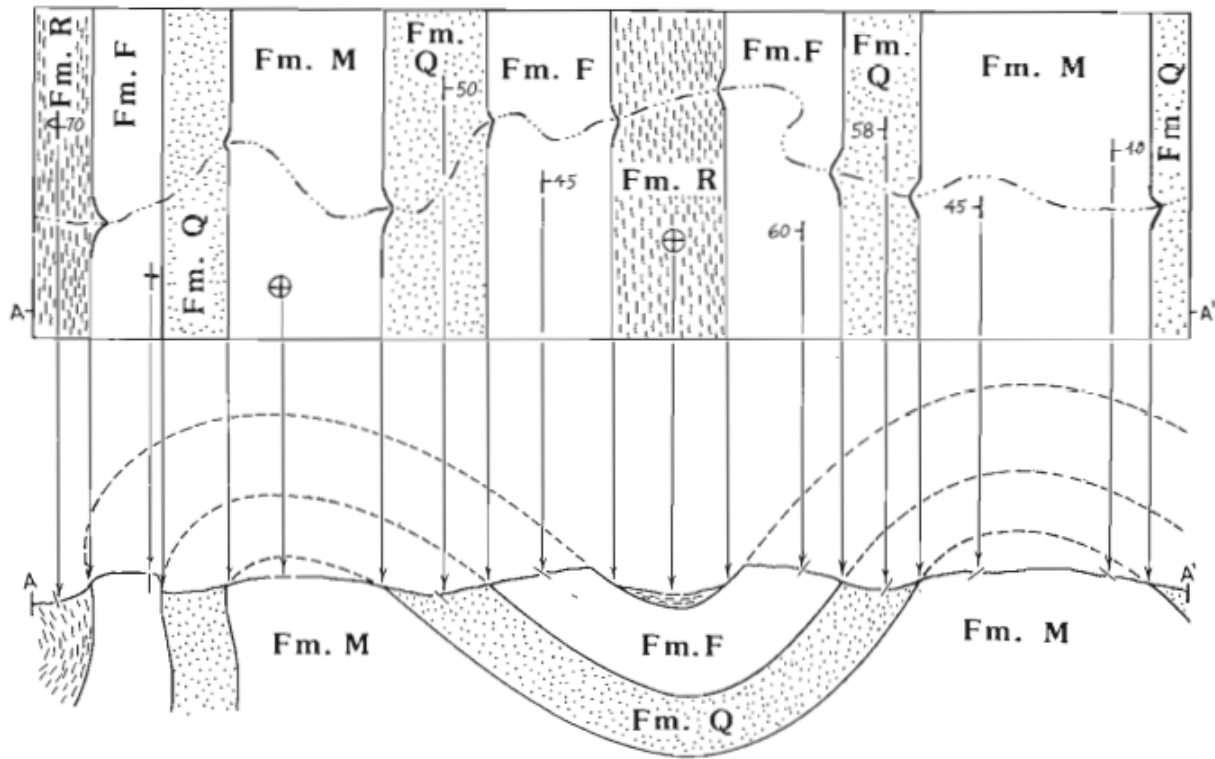
1. older

2. older

3. create

4. f, p, g, b, r, m, h, a, e, x, d, k, j, s

5. A mass of igneous rock which crystallized before the magma reached the Earth

6. rainfall erosion, stream/river erosion, glacial erosion, eolian erosion, coastal erosion, exfoliation, freezing/thawing, lightening strikes, and mass movement are all acceptable.

7.

8. Foliation forms planar features and lineation forms linear features.

9. An axial surface is the surface running through the center of the fold, and the axial plane is a special case of the axial surface for cylindrical folds. An axial trace is the line formed by the intersection of the topography and axial surface. A hinge line is the line of intersection of the two limbs of a fold, and the crest line is the highest point in the fold. For an upright antiform, the crest line and hinge line are the same, otherwise they are different. A trough line is the equivalent of a crest line in a synform.

10. **Basin.** A synclinorium cross-section is more similar to that of a basin than a synform, because both are usually map-scale (as opposed to synforms, which can be outcrop or even specimen-scale). It is more similar to a basin than an antiform or dome because its layers dip down as they approach the center, not up.

11. There is a fold, because points D and B have a bend in the outcrop without an equivalent bend in the topography. It is a synformal syncline, plunging SE. The dashed line is the hingeline, and the solid one the axial trace.
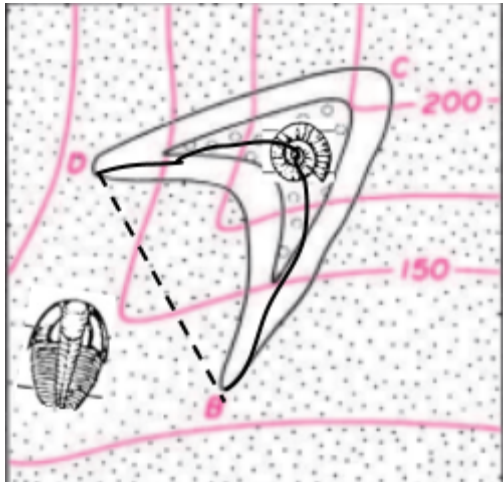

12. sedimentary, as a talus is an erosional formation

13. Solution folding is when minerals in some areas dissolve (into a *solution)*, causing the rock above them to sink down and fold. Being highly irregular, solution folding can produce class 1B, 1C, and 2 ramsay folds.

14. Class 3 folds

15. synthetic, reverse. As the allochthon moves down the fault, the dip of the autochthon increases, creating a "bump" that pushes fragments of rock up and back from allochthon.
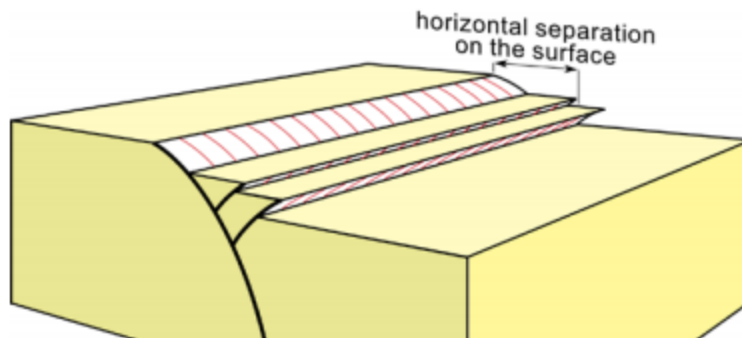

16. antiform, extrado. Antiforms are broader at the bottom than the top, where synforms are broader at the top. When a plane intersects a plunging fold, the plane effectively moves up relative to the fold in the plunge direction. Because the fold is becoming less broad in the direction of plunge, it must be an antiform. An extrado is the exterior part of an arch, which is always exposed in eroded antiforms. (whereas an intrado is the interior part of an arch, exposed on synforms).

17

Neutral surface

Orthogonal flexure
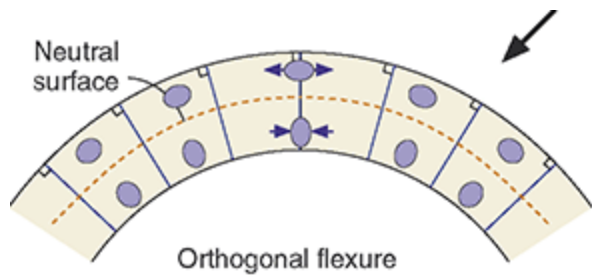
18. It is a normal fault. The rough feel is formed by slickenfibers on the fault plane that have broken off. Because slickenfibers form in the direction of net slip, and slickenfiber crystals break off at high angles to the slickenfibers, a series of ridges is formed pointing in the direction of net slip.

Smooth direction

Slickenfibers on exposed shear plane
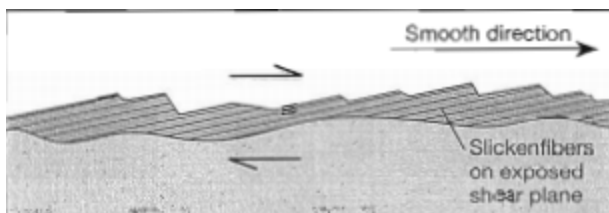
19. NE. Foliation in a rock has the same general orientation as the axial plane of the primary fold. As can be seen in the image below, if the orientation of the hingeline of the primary fold represents N, the vergence of the Z-folds would be towards the NE.

M-folds

Z-folds

S-folds

Extension

Contraction

Neutral surface
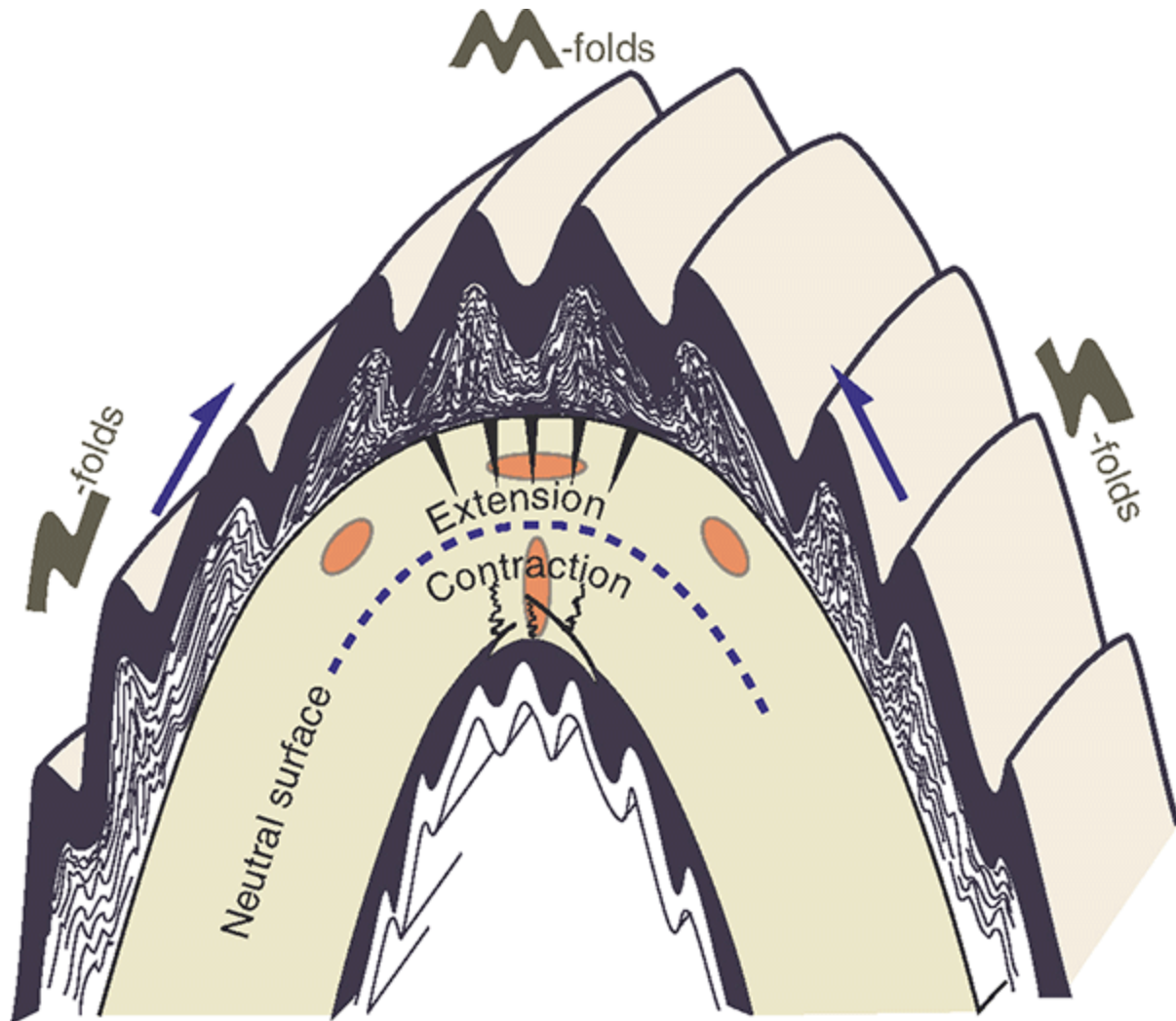
20. reverse, synthetic, normal. Mineral deposits always form at the bottom of amygdules, therefore the block that the dike is contained in must be tilted to the right. If the allochthon is on the east, then listric reverse faulting would produce blocks tilted in that manner (once the allochthon rises above the autochthon, the weight of gravity would produce synthetic normal faults, creating right-tilted blocks, in the allochthon).

21. First, note that, although it is a 6 layer anticline, the borehole went through five equally thick layers. This means that the top layer is fully eroded at, and only at the hinge line (otherwise, the layer below it would be partially eroded and thus not as thick as the others, and a concentric antiform has layers of equal thickness by definition). Next, note that a bluntness of 1 means that the fold is circular, so the radius is equal to the amplitude. As it has 6 layers, each 100 ft (500 ft borehole/5 layers), the radius is 600 ft (6 layers*100ft thickness). Now, we need to find the volume of the top layer that has been eroded, by using the forumla for the area of a circular sector, .5r^2(a-sin(a)). To find the angle *a*, simply set up a right triangle, where side a is distance from center to hingeline, side b is the distance along the hingeline from the center to the edge of the exposed fold (the radius-the thickness of the top layer), and the hypotenuse is the radius of the fold.

Evaluate 2arccos((b)/(c)) to find the angle *a*. Then, evaluate the circular sector formula using the value obtained for angle *a* and the radius:

Eq. 1: .5*(600^2)(2arccos(5/6)-sin(arccos(5/6)) = 111348 ft^3

Now, we need to find the total volume eroded in the area owned by the railroad. To do that, simply multiply the area of the circular sector by the length of the zone.

Eq. 2 <Eq. 1 value>*800 = **89,078,441 ft^3 eroded**

Now, we simply need to find the volume of the mineral layer in the uneroded anticline and subtract out the volume eroded to find the total volume of the mineral layer owned by the railroad company. The volume is equal to the area of the mineral layer in a cross-section multiplied by the length of the zone owned by the railroad. The cross-sectional area of the mineral layer is equal to the area of the entire fold cross-section (a semicircle with radius 600) minus the area of the rest of the cross-sected layers (a semicircle with radius 500).

Eq. 3: ((pi*600^2 - pi*500^2)/2)*800 = 44000000 pi

Now, subtract the value of Eq. 2 from Eq 3 to obtain the final result.

Eq 4: <Eq. 3 value> - <Eq. 2 value> = 49,151,635

The railroad company owns 49,151,635 ft^3 of ore in this anticline. They're rich!

Structure ID
1. antiform
2. dome
3. normal fault
4. monocline
5.
       a. graben
       b. horst
6.
       a. klippe
       b. nappe
       c. fenster/window

7.

      a. listric fault (normal listric fault acceptable)

      b. listric fan/imbricate fan

8. boudinage

9. volcanic neck, sill, batholith/plug, laccoolith, dike

10. sheath fold

Applications

geohazards:

1. G is the most likely to flood, being in a riverbed, and C is the least likely to flood, being on high ground J is the most likely to be buried, as it is on the side of a steep cliff, and C is the least likely to be buried, because it is at a high point (so there is no chance of mass wasting from above it).

2. A and F are, as they are the closest to the discharge path of the spring.

3. Thixotropic clay is a clay that can lose viscosity under pressure, thus causing landslides (the geohazard it's related to).

4. 90°

5. Dip Direction: 74-77 degrees acceptable

   Dip Angle: 34-36 degrees acceptable (use formula distance between contour strike lines = contour interval / tan of the dip angle.

6. N73W-N75W, or 285-287 degrees acceptable

7.
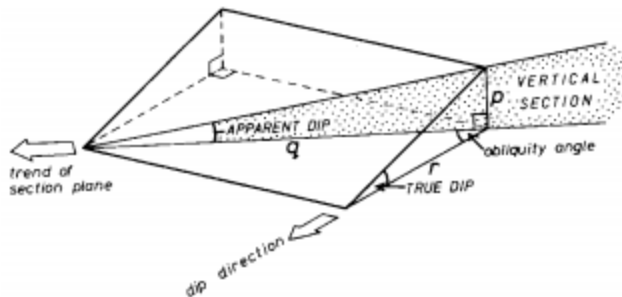
take arcsin(230/350)

The wheelchair ramp dips 41°

8.

Use the formulae:
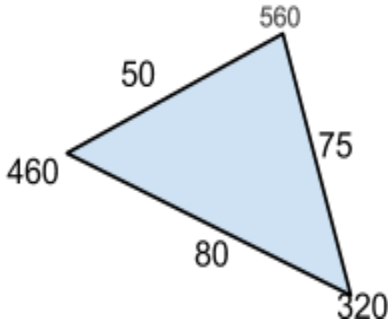
1. tan(angle between A1 and TD lines)=csc(angle between A1 and A2 lines)*(cot(A1)*tan(A2)-cos(angle between A1 and A2 lines))

2. tan (true dip) = tan(app. dip)/sin(angle between bed strike and trend of app. dip), where A1 is the smaller apparent dip, A2 is the larger apparent dip, and TD is the true dip.

First, find the dips on each of the legs of the triangle starting at the highest point.

arctan(2)=63.4349°

arctan(16/5)=72.64598°

Now, we need to find the angle between A1 and A2 lines:

$$c^2 = a^2 + b^2 - 2ab\cos\gamma$$

80^2 = 50^2 + 75^2 - 2*50*75*cos(c)

c = arccos((-80^2+50^2+75^2)/(7500)) = 76.70293°

The angle between A1 and TD lines:

arctan(csc(76.70293°)*((cot(63.4349°)*tan(72.64598°))-cos(76.70293°))) = 54.612°

Make sure that you plug in the smaller apparent dip for A1.

To find strike, just subtract 90 from the dip:

54.612 - 90 = -35.388°, where the bearing of the A1 line is 0°

Now, use formula 2:

true dip = arctan(tan(app. dip)/sin(angle between bed strike and trend of app. dip))

true dip = arctan(tan(63.4349°)/sin(35.388°))

true dip = 74°

9. D = 350°, 80° C = 280°, 45° B = 220°, 10° A = 45°, 60°

10. trend = 62°, plunge = 34°

11. plunge = 40° Rake = 75° from NE

12. 41°

13. 100 ft

14. 30 ft. The bed must dip 90° because its thickness is constant across the terrain, and a horizontal measurement of a vertical bed will always give the true dip of the bed (because true thickness is measured at right angles to the bed).
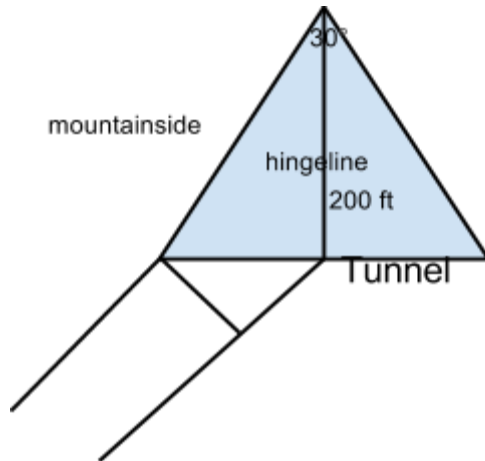
15. 180°

16. 836-844m

17. 10.482

18. As a bluntness of 1 means that there is no rounding at the hingeline, the hingeline, side of the mountain face, and tunnel from the outside to the hingeline form a right triangle on either side of the hingeline (the height of the triangle is 800 ft/4 layers = 200 feet):

As can be seen from the above diagram, the tunnel length is simply 2(200/tan(15°)), **or 1493 feet.**

19.
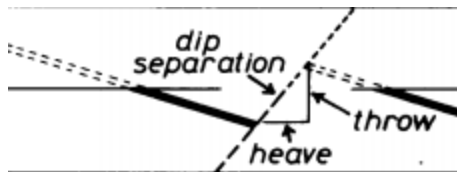
Draw the structure contours for the bed contact on either side of the fault and the thrust plane, and draw the line of intersection on each side of the fault. These lines are the footwall and hanging-wall cutoffs of the contact along the thrust line, and the measured distance between them is the heave, in this case, 15 meters.

The throw is heave*tan(dip):

15cos(31)= 12.857m

The minimum net slip magnitude is minimum total distance that the fault has moved (i.e. the distance between the halves of a theoretical pebble split by the fault), and can be found by the formula $\frac{s \cdot d}{\sqrt{d^2 + s^2}}$, s = strike separation, d = dip separation. The strike separation may be directly measured from the map (it is 36m here), and the dip separation is sqrt(heave^2+throw^2), or 19.756. Thus, the minimum magnitude: (19.756*36)/sqrt(19.756^2+36^2), or 17.319.

Heave: 15m

Throw: 13m

Minimum Net Slip Magnitude: 17m

20. First, we must find the true dip of the bed. We know from the outcrop pattern that the dip direction is either east or west, but because Bob hit coal on the east side of the outcrop, the bed must dip east (90°). The apparent dip is arctan(20/600), and the obliquity angle is (90-65°).

The true dip is:

TD = arctan(tan (apparent dip) / cos(obliquity angle))

= arctan((1/30)/cos(25°)) = **2.106°**

The true thickness of the bed:

TT = 2000sin(2.106°) = 73.497m

Now, to find the azimuth range of the passages, we need to find the maximum net dip of the passage (passage dip - apparent bed dip) that will allow the passage to intersect the bed for 1800 ft. To do this, assume the bed is flat and solve for the dip of the passage:

arcsin(73.497/1800) = 2.340°

This means that the passage can dip 2.340° more than the bed does and still intersect the bed for sufficiently long. As the actual passage dips at 3°, the bed must dip at least .57° for the passage to intersect the bed for sufficiently long.

The required obliquity angle:

OA = arccos(tan(.57°)/tan(3°)) = 79.1

Thus, the range of azimuths is 90° +/- 79°:

11° - 169°