Activity 8: Topographic Map III - Back Azimuths and Triangulation

Maine Geological Survey

Objectives:

To provide the student with further experience and exercises in mapping, to develop skill in using back azimuths and triangulation. To enhance navigational skills and map usage.

Time:

This activity is designed to last one (1) class period.

Background:

Complex mapping skills are needed by workers in a wide range of occupations, including soil scientists, bedrock and surficial geologists, surveyors, mining companies, and land use planners of all types. These skills become critical in field situations where an immediate decision has to be made before some other activity can take place.

This activity develops the concept of back azimuths; that is, taking an azimuth and proceeding exactly (180 degrees) in the opposite direction. Triangulation extends azimuths from known points into back azimuths such that the azimuth - back azimuth line connects two margins of the map; where three such lines, from three separate points meet you have located, indirectly, a fourth (or unknown) point.

To determine the back azimuth for any given azimuth one does the following. If the original azimuth is less than 180 degrees, you ADD 180 degrees to the original azimuth.

If the original azimuth is 180 degrees or more you SUBTRACT 180 degrees from it. This is shown on Figure 1.

Using back azimuths allows a person in the field to precisely back off from washed out roads, flooded areas, defunct bridges, and similar obstacles while maintaining the accuracy of direction needed for subsequent movements. For example, a person walking a proposed traverse for an oil company pipeline encounters a swamp, the person establishes a back azimuth, moves over a given distance to avoid the swamp (90 degree angle), and goes back to his original azimuth on a parallel line which lets him continue in the same direction while avoiding the swamp (Figure 2).

Triangulation involves plotting 2 or more lines from known azimuths and derived back azimuths and using the point of intersection to determine the position. Triangulation can be used in the field to find one's location with reference to visible landmarks; the field exercise is much easier if students have done triangulation on paper first. This is a good chance to reinforce the practical aspects of geometry with your students. In setting up map triangulations you take the coordinates of at least two known points and extend the azimuth from each point across the map. A back azimuth is established from the original point and a line extended across the rest of the map. When azimuth/back azimuth lines have been drawn for all points, the place where these lines intersect will be the coordinates of the unknown location. Since the triangulation lines may be quite long it is very important that they be plotted from the azimuths/back azimuths as accurately as possible. Note that an azimuth - back azimuth combination always forms a STRAIGHT line. If you wind up with a triangle on the map, the larger the triangle, the greater degree of error in plotting one or more of the lines. A typical triangulation diagram could look like Figure 3.

Materials:

Students will need:

- Their copy of the local, 7.5-minute series, gridded topographic map
- Grid coordinate protractors
- Plastic compass
- Long ruler or meter stick
- Pens and notebooks

Procedure:

Depending on the specific details of your local quadrangle, locate a natural obstacle(s) and choose a specific grid location some distance away; have students follow an azimuth that leads them to the obstacle; let them construct a back azimuth and navigate around the obstacle recording directions and distances. A number of viable solutions usually exist and can form the basis of an excellent class discussion.

Select and give grid coordinates for three points on the map; list azimuths to be followed in the construction of a line through each point. Have students construct an azimuth-back azimuth line through each point until each end of the line hits a map margin. Caution students to draw these lines lightly as they will need to be erased before the next activity; otherwise the map becomes incredibly cluttered with lines. Students should record the coordinates and identify the object located at the intersection point of the three lines.

For groups with lots of skill and patience you can have three sets of primary triangulation lines determine one set of points to be used as starting points for one set of secondary triangulation lines to locate one point on the map.

Follow-Up:

If the local quadrangle permits, take students into an area and "lose" them. Once in the area, pass out maps, compasses and grid coordinate protractors. Let the students find themselves by triangulation from three visible landmarks. NOTE: The magnetic compasses you use for this must be quality instruments (Sylva etc.) and they must be adjusted for local magnetic deviation (about 18 degrees in Maine).

Plot a test traverse using azimuths and triangulation and see if students can "find the treasure" at the end of the traverse. You may vary the complexity depending on the amount of time you wish to spend and the details of your local quadrangle.

You may also be interested in Activity #6: Topographic Map I, #7: Topographic Map II, #9 Surficial Geologic Map of Maine, #10: Bedrock Geologic Map of Maine, and #11: Aquifer maps and Maine Ground Water.

References:

Activity developed by Duane Leavitt

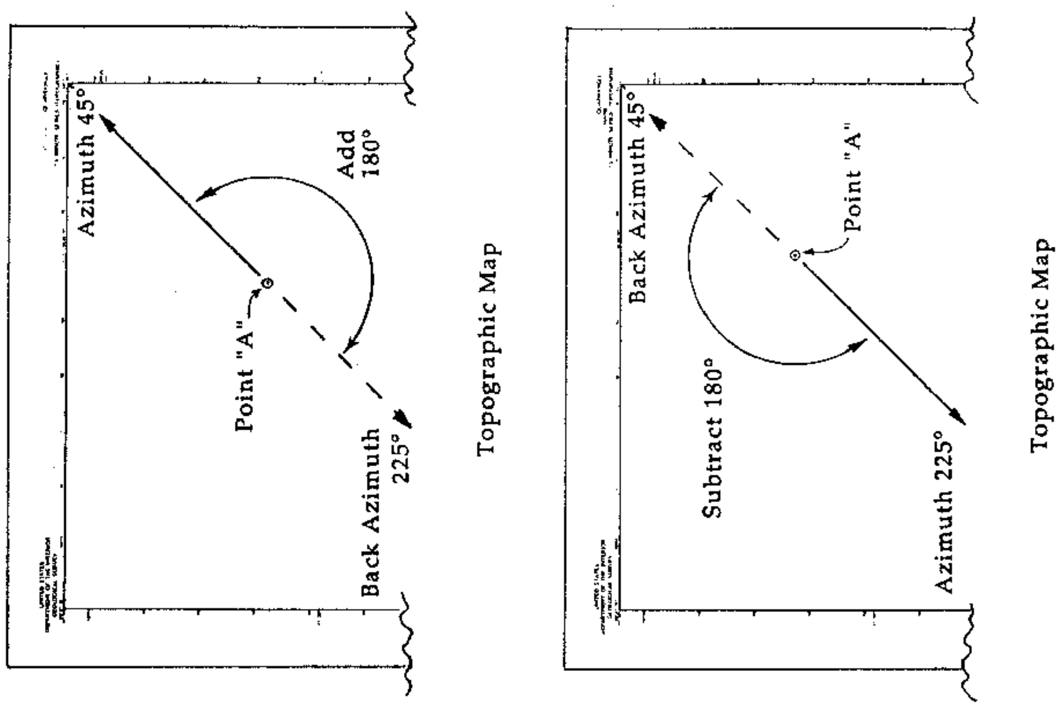


Figure 1. Plotting back azimuths. Top: An original azimuth of 45 degrees becomes a back azimuth of (45+180) 225 degrees. Bottom: Conversely, if the original azimuth is 225 degrees, the back azimuth becomes (225-180) 45 degrees.

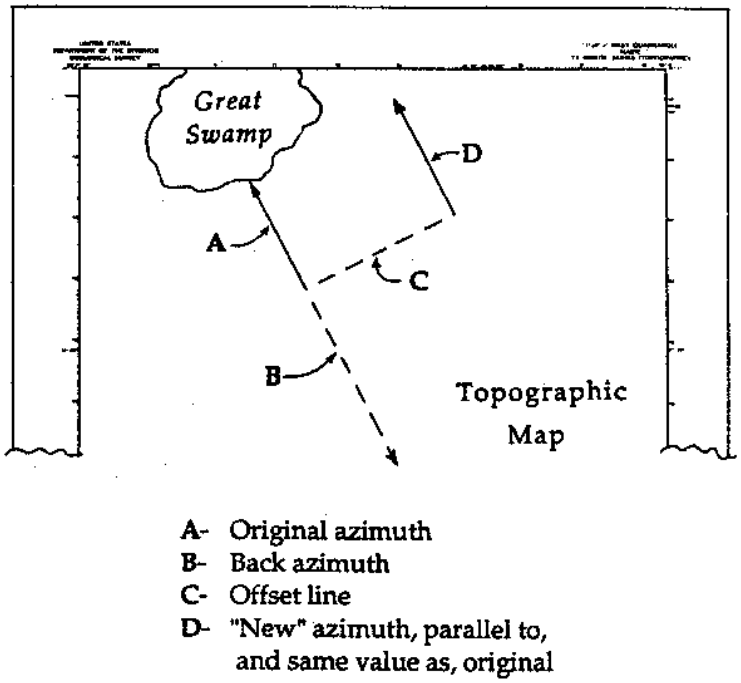


Figure 2. Sample of using a back azimuth to track around a large swamp.

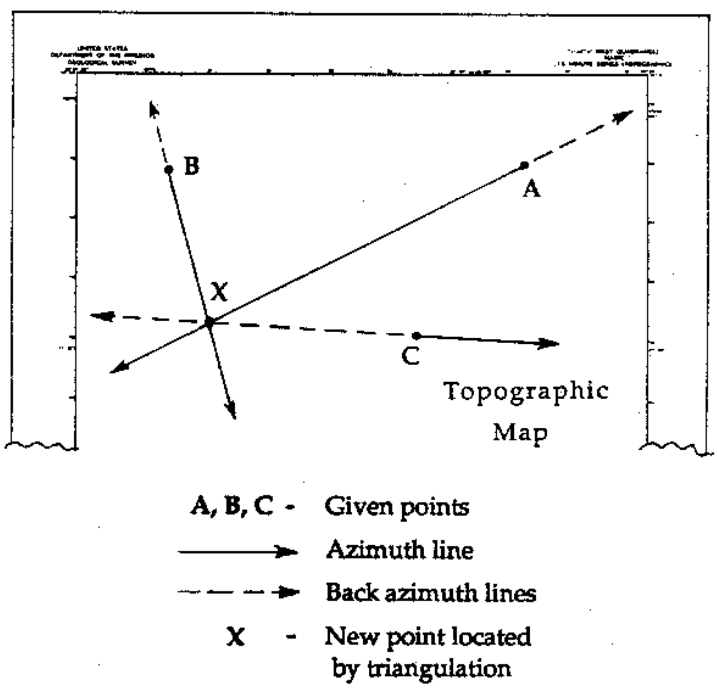


Figure 3. A typical triangulation diagram.

Name___________________________

Activity 8: Topographic Maps III - Back Azimuths and Triangulation

Maine Geological Survey

Student Sheet

Purpose:

To develop two new skills for use in mapping, plotting a back azimuth and triangulation.

Materials:

You will need your gridded 7.5 minute series local topographic map, grid coordinate protractor, a plastic half circle protractor, a long ruler, notebooks, and pens.

Part I. Back Azimuths:

Plotting a back azimuth allows you to go in exactly the opposite direction from your original direction (azimuth) of travel. Back azimuths must be calculated before you can plot them on a map. Back azimuths are calculated as follows:

- If the original azimuth is less than 180 degrees you ADD 180 degrees to the original azimuth, thus an azimuth of 45 degrees (<180) will have a back azimuth of 225 degrees.
- If the original azimuth is greater than 180 degrees you SUBTRACT 180 degrees from the original azimuth. An original azimuth of 265 degrees (>180) will have a back azimuth of 85 degrees.

Practice converting the following azimuths to back azimuths.

Original Azimuth (°)	Back Azimuth (°)
25	
192	
63	
247	
180	

Now take your grid coordinate protractor and plot each azimuth and its associated back azimuth on a piece of blank paper; notice that any given azimuth and its back azimuth plotted from the same point create a straight line. Are all your lines straight ones? If not, check your calculations and plotting.

On the accompanying map segment (see Sample Map 1), locate the gravel pit marked A. Run an azimuth line of 317 degrees from point A to the edge of the map. If you walked this line you would be stopped by the swamp south of Pickerel Pond; calculate the back azimuth, and distance you would have to back track in order to turn south to route 133 and avoid the swamp.

Part II:

In triangulation you construct azimuth and associated back azimuth lines through a minimum of two points until the lines intersect. The intersection indicates the position of the unknown point. Just as you can triangulate from points on a map to find an unknown location, you can also sight known map locations with a compass and a map in the field to find your location. Again, in reference to the enclosed map segment, use points A, B, and C and their given azimuths to construct azimuth/ back azimuth lines and locate the unknown point.

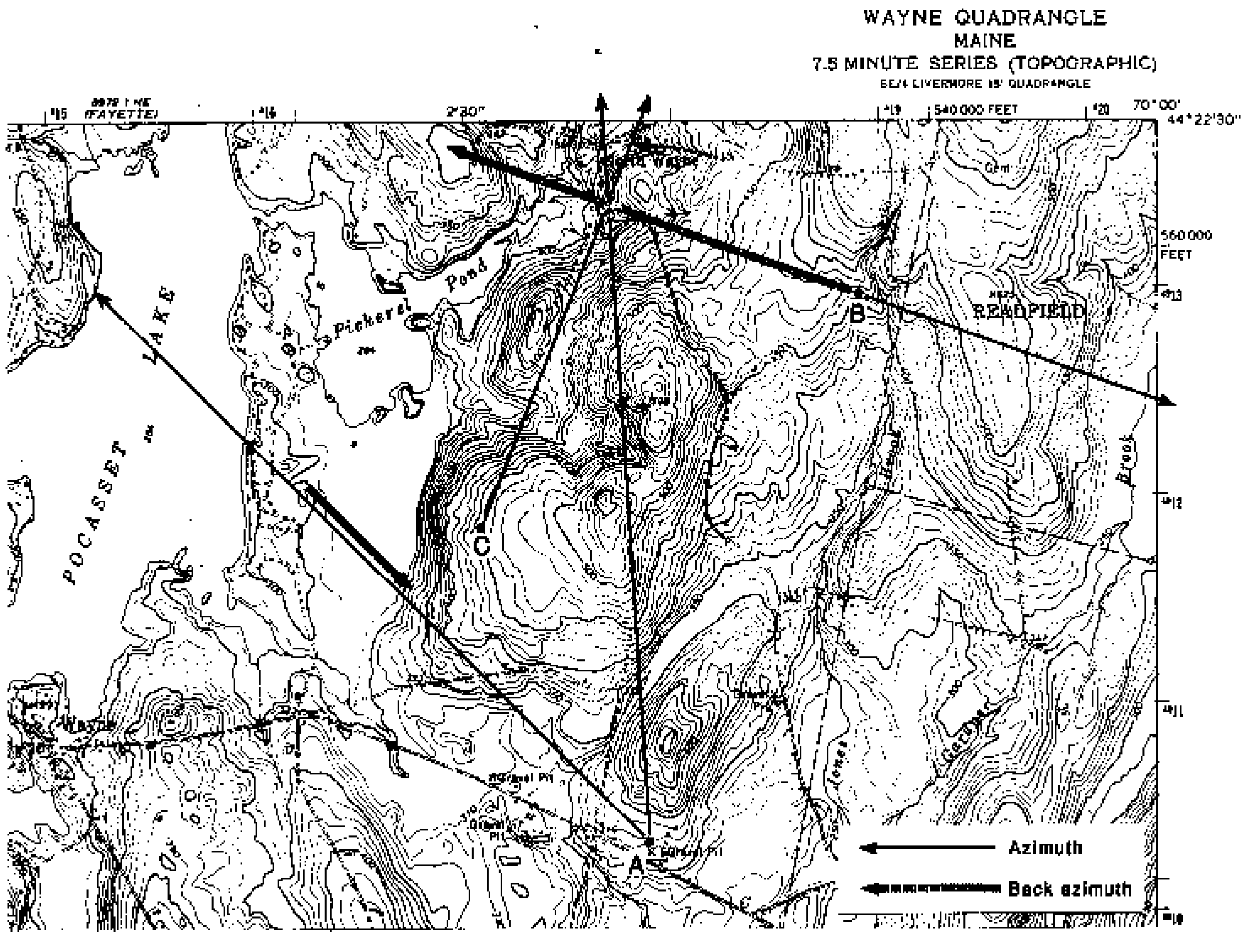
Point	Azimuth (°)	Back Azimuth (°)
A	358	
B	111	
C	022	

The unknown location is a cemetery and it is located in North Wayne.

Your teacher may have additional exercises for you to do on your own quadrangle map; follow these instructions at this point.

Questions:

1. Why is a third azimuth/back azimuth line desirable in locating a point by triangulation?



Sample Map 1. Locate the gravel pit marked A on the map. Run an azimuth line of 317 degrees from point A to the edge of the map. If you walked this line you would be stopped by the swamp south of Pickerel Pond; calculate the back azimuth, and distance you would have to back track in order to turn south to route 133 and avoid the swamp.