Lesson 7:
Rotating Point Symbols

Lesson Goal: Correctly orient geologic symbols by joining adjusted Azimuth and Bearing data to point data.

What You Will Need: A Pentium class PC with 32 MB of RAM (minimum) and 100 MB of free hard drive space, ArcView GIS 3.1 or higher.

Data and/or Utilities: Sample data for Placitas, New Mexico downloaded from *ArcUser Online*.

This data set is based on the USGS Placitas New Mexico 7.5-minute quadrangle and contains a point file and associated geology polygons.

Many industries are using more complex symbols for representing point data sets. To accurately depict this data, some or all of the symbols may need to be rotated.

This tutorial uses a data set that includes sedimentary Strike and Dip, metamorphic foliation, jointing, and other types of point data that would be used by geologists and others for structural modeling. This data set is based on the USGS Placitas New Mexico, 7.5-minute quadrangle and contains a point file and associated geology polygons.

Prepare the sample data set for this lesson by extracting the 13 files for this exercise from the zipped file. Retain the zipped file in case you want or need to redo some or all of the steps described here. Once the symbols in a project are rotated, they cannot be unrotated. The sample data can be combined with other data available from the USGS site for the Placitas area such as digital line graph, optional format (DLG-O), Drawing Exchange Format (DXF), and Geographic Names Information Systems (GNIS) data. The project data is Universal Transverse Mercator (UTM) projection North American Datum for 1927 (NAD27) Zone 12. Any additional data should be in or reprojected into UTM NAD27 Zone 12.

The sample data set includes a point data file called PLACPNT1 and a polygonal geology file called PLACGEO1. Create a directory for this project call PLACITAS. Unzip and place all the files for this project in the PLACITAS directory.

The Geologic Symbol Palette

Both ArcView GIS 3.1 and 3.2 include a palette of selected geological point and line symbols. This marker and pen palette, named geology.avp, as well as many other special-use symbolsets for forestry, transportation, and other disciplines, come with ArcView GIS. The symbols in the geology set represent many types of geologic point and line features as defined by the USGS in the Open File Report 95-525 and its successors that are the current standards for geologic symbology.

The palette includes 108 marker symbols for minor geologic point types and 168 line types for representing major geologic line features. The point symbols were created as TrueType fonts so they can be scaled and rotated. Line Symbols that have directionally sen-

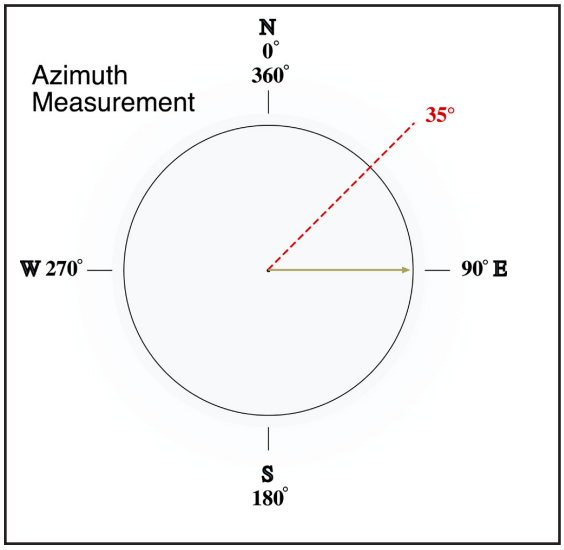


Figure 1: Azimuth system of measurement

Quadrant	Direction of Measurement	Begin/ End
NE	clockwise	N to E
SE	counterclockwise	S to E
SW	clockwise	S to E
NW	counterclockwise	N to E

Figure 2: Direction of measurement

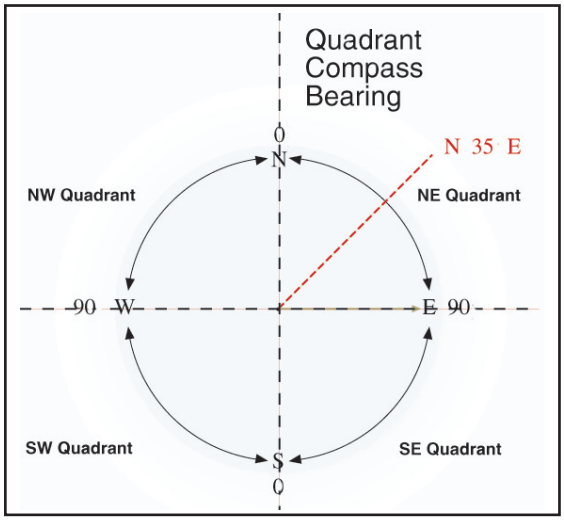


Figure 3: Bearing measurement system

sitive crossing symbology are duplicated in the palette so changes in line direction can be correctly digitized.

Field observation of geologic point sources often includes the following measurements:

- Strike or trend Azimuth or Bearing
- Crossing orientation (e.g., Dip direction)
- Crossing magnitude (e.g., Dip angle)

Points are plotted on maps to represent linear and crossing geometry, and they are often attributed with a value showing the size or magnitude of Dip. Point symbology may be rotated in an ArcView GIS view to display the true orientation of field data. Field geologists and surveyors use one of two methods—Azimuth and Bearing—to measure and record angular field relationships.

Azimuth

Measurements begin at north with 0°, rotate clockwise 90° to the east, then on to 180° due south, next to 270° to the west, and return to 360° at north. The 360° system of Azimuth is shown in Figure 1.

Bearing

Bearing divides the 360° compass Azimuth into four quadrants of 90° each, named northeast (NE), southeast (SE), southwest (SW), and northwest (NW). Angular rotation in each quadrant is measured from the vertical axis (the north-south compass axis). Figures 2 and 3 summarize the concept of Bearing and show the direction of measurement for each quadrant.

Field Mapping Issues

Several important issues must be considered when collecting and recording geologic data. Both Strike orientation and Dip Direction must be represented. Strike is a bidirectional linear measurement describing the intersection of a plane and a horizontal surface. Dip Direction represents the steepest line of fall on the horizontal measured plane; it is the path a marble, influenced by gravity, would follow as it rolled down the plane surface. Dip Direction is a unidirectional measurement and is always perpendicular to Strike.

To simplify field measurements, Dip Direction is often combined with Strike by applying the Right-hand Rule. To use the Right-hand Rule when measuring Strike with a compass, always keep the Dip Direction to the observer's right, as though he was looking at his right hand, palm side up, and his right thumb was pointing to the "down-Dip" side. Using this method of recording data will consistently record the Dip Direction in a clockwise rotation relative to Strike.

If angles are intentionally or accidentally measured using the opposing Left-hand Rule, they can be shifted by adding or subtracting 180° to the Left-hand Azimuth or by swapping north for south

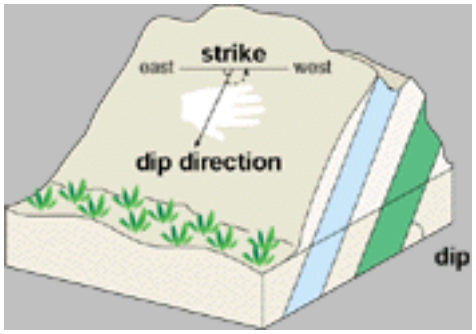
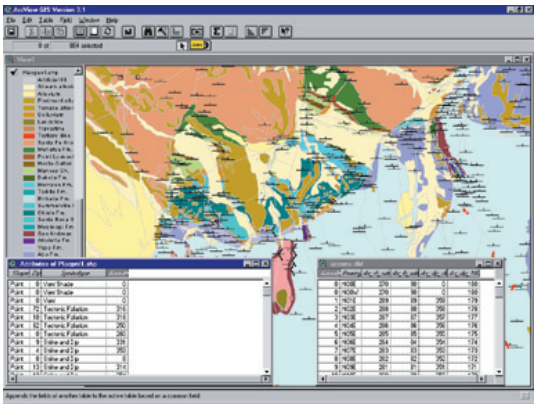


Figure 4: Application of the Right-Hand Rule

North	**N00E**
East	**S90E**
South	**S00W**
West	**N90W**

Figure 5; Recommended abbreviations for cardinal orientations



Join the PLACPNT1 table and the AZCONV.DBF on the Azimuth field.

or east for west with a Left-hand Bearing. When recording an orientation using Bearing measurements, a cardinal direction may be recorded in two ways (e.g., north can be shown as N00W or N00E). Although the method described in this lesson will rotate symbols using data with either Bearing measurement notation style, the abbreviations for cardinal orientations shown here are recommended.

ArcView GIS and Angles ArcView GIS uses the Radial Coordinate System to manage angular measurements and to orient data. In this system, 0° is oriented to the right along the positive x-axis. Positive angular rotation proceeds clockwise 90° to the positive y-axis, then to 180° on the negative x-axis, then to 270° to the negative y-axis, returning to 360° on the positive x-axis. The Azimuth and Bearing systems may be related to the Radial Coordinate System through complex radial mathematics to convert field data to values used by ArcView GIS to rotate geologic point symbols.

A conversion table for ArcView GIS in dBASE format named AZCONV.DBF has been included with the sample data to simplify the rotation process. Joining field data, recorded as Azimuth or Bearing, to the AZCONV table will assign proper ArcView GIS rotation angles to the field data points. Descriptions for the six fields in the AZCONV.DBF table are shown in Figure 7.

Field Name	Field Type	Description
Azimuth	Short Number	Field Azimuth as whole number decimal
Bearing	Alphanumeric 4	Field Bearing as alphanumeric string
Av_rh_rule	Short Number	Strike conversion angle using Right-hand rule
Av_lh_rule	Short Number	Strike conversion angle using Left-hand rule
Av_dip_dir	Short Number	Dip direction conversion angle
Av_dip_180	Short Number	Dip direction conversion angle rotated 180°

Figure 7: AZCONV.DBF field descriptions

The table contains 365 records, one for each whole number of degree measurement from 0° to 360°, plus four additional records to include alternate Bearings for north, south, east, and west.

Using the Conversion Table

Following is a step-by-step example of how to use the conversion table to rotate point data.

1. With the unzipped sample data and AZCONV table in the PLACITAS directory, begin a new ArcView GIS project and add a new view but don't add any themes.
2. Load the geologic symbol palette by choosing Windows>Show Symbol Window from the menu bar. Click on the Palette icon located in the upper right corner of the dialog box. In the next dialog box, click the Load button and path to

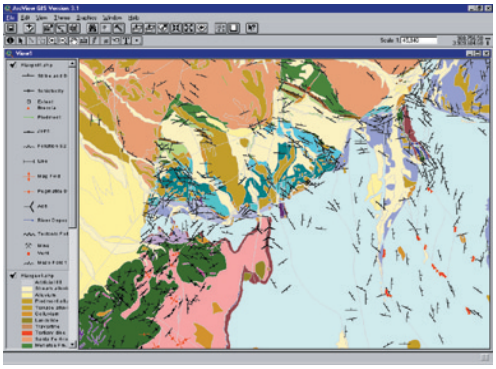
the geology.avp palette, which typically will be located in the ARCVIEW\SYMBOLS subdirectory in the location where ArcView GIS was installed. After loading the palette, click on the marker button icon and scroll down to verify that the geologic point symbols have loaded.

3. Add the PLCAPNT1 and PLACGEO1 shapefiles, stored in the PLACITAS directory, as themes to the view. When displayed, these themes should have custom legends that have already been classified. The PLACPNT1 theme has the correct geologic symbol assigned to each type of data. Notice that all these point symbols are oriented in an east-west direction, and the Dip is pointing to the north. This does not accurately represent the data and needs to be corrected.
4. Make the PLACPNT1 theme active and display its table. Verify that the fields for Strike and Dip data are present and determine if the measurements are in Azimuth or Bearing. In the PLACPNT1 table all measurements in the Strike field are in Azimuth.
5. In order to use the AZCONV table to correct the orientation of the symbols for the PLACPNT1 theme, the AZCONV table must be joined to the table for the PLACPNT1 theme. Go to the project window, highlight Table, click the Add button, and path to the PLACITAS directory containing AZCONV.DBF to add it to the project.
6. With both the AZCONV and PLACPNT1 tables open, make AZCONV active and select the Azimuth field. Next make the PLACPNT1 table active and select the Strike field. Choose Tables > Join from the menu bar to join AZCONV to PLACPNT1. AZCONV should close, and PLACPNT1 will contain the fields from both tables. Inspect the Join to verify that all point records have a corresponding conversion. When joining data sets that use Bearing measurements, carefully check north, east, south, and west points to verify that they are complete and remember to enter north as N00E, east as S90E, south as S00W, and west as N90W.
7. Now the Strike and Dip symbols can be properly oriented to the mapped points. Return to the view and open the Legend Editor for the PLACPNT1 theme by double clicking on that theme in the view legend. The geologic points data has been classified using Unique Value applied to the Symboltype field. Click on the Advanced Options button on the Legend Editor dialog box and assign Av_rh_rule (Right-hand Rule rotation) as the rotation field. The symbols will now be correctly rotated in the view.
8. Save the model. Explore the characteristics of the data used for this example. Study the relationship of Strike and Dip in sedimentary areas. Review the orientation of jointing and foliation in old metamorphic terrain. Note the relationships between point and polygon data. Strike and Dip symbols are

Open the Legend Editor for PLACPNT1, select the Advanced options button, and apply Av_rh_rule as the Rotation Field.

ArcView GIS Tip

To make a custom legend load with an ArcView GIS theme, use the Legend Editor to save the legend with exactly the same name as the theme's shapefile.



After applying the Right Hand Rule rotation to the symbols they will display the correct orientation.

most numerous in areas where sedimentary rocks, joints, and foliation are mapped in metamorphic and igneous terrain, and fluvial features are mapped in young river sediments. Look for breccia pipes and mine adits. Check out the fluvial directions observed in young Rio Grande Trough sediments in the northwest portion of the map.

Using Other Data Sets

The sample data set's prebuilt legend has been classified, and the appropriate symbols are associated with each data type. To use other geologic point data, thematically symbolize each individual data type by using the Legend Editor to classify the data set using Unique Value and the field in the data set that identifies the type of data. Assign the appropriate symbol from the geology.avp palette.

Many digitized geologic maps contain several Left-hand points mixed with Right-hand points because the data was recorded with the wrong orientation in the field or was improperly digitized. Data that has a mix of Right-hand and Left-hand points can be handled in one of two ways. If there are just a few entries with Left-hand data, the simplest solution is to correct individual fields in the table by editing them.

If a substantial number of records contains Left-hand data, a query can be used to correct the data. Create a new field in the point data table to flag which type of data is in each record. Choose Theme Properties from the menu and create a query to separate the two orientation types. Duplicate the point theme, symbolize each set, and apply Av_rh_rule to the Right-hand points and Av_lh_rule to the Left-hand points.

To learn more about classifying legends and building queries, see *Getting to Know ArcView GIS* from ESRI Press, which is available from the GIS Store at the ESRI Web site.

Surveyor's Trick

To obtain a back-sight Azimuth or to reverse your path of travel and head home, add 180° to a forward compass Azimuth that is less than or equal to 180°, or subtract 180° from an Azimuth that is greater than 180°

Summary

This procedure will correctly orient geologic symbols in ArcView GIS 3.1 and 3.2 by joining adjusted Azimuth and Bearing values to point data that may have been incorrectly collected or digitized.

This lesson is based on an article written by Mike Price of ESRI that originally appeared in the October–December 1999 issue of *ArcUser* magazine.