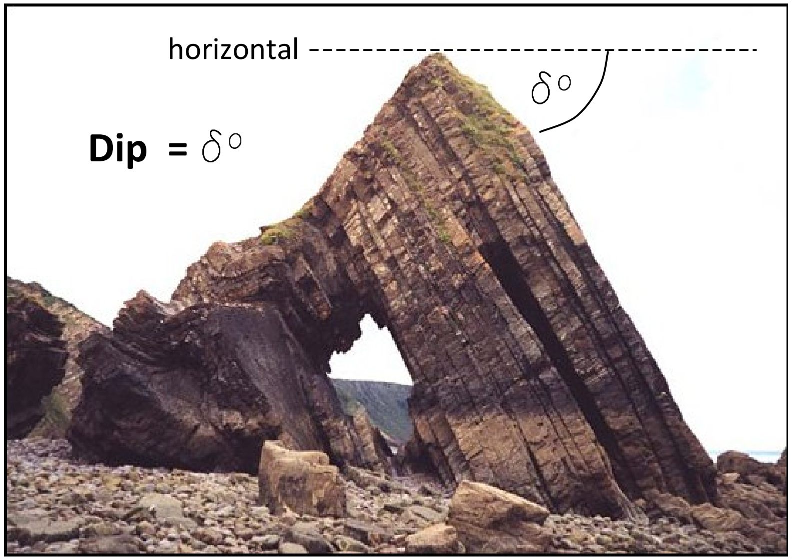
PLANE DIP and STRIKE, LINEATION PLUNGE and TREND, STRUCTURAL MEASURMENT CONVENTIONS, THE BRUNTON COMPASS, FIELD BOOK, and NJGS FMS

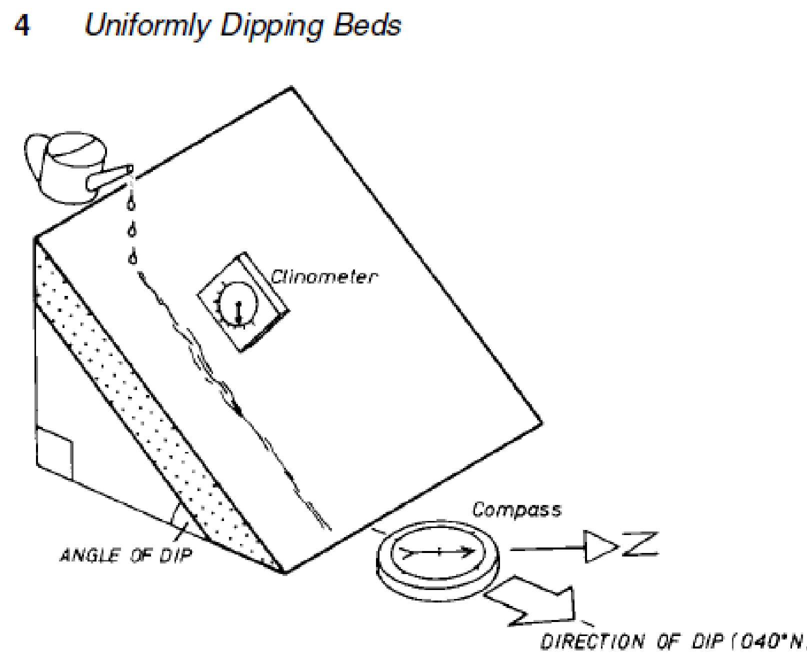
The word *azimuth* stems from an Arabic word meaning "direction“, and means an angular measurement in a spherical coordinate system. In structural geology, we primarily deal with land navigation and directional readings on two-dimensional maps of the Earth surface, and azimuth commonly refers to incremental measures in a circular (0- 360°) and horizontal reference frame relative to land surface.

Brunton Pocket Transit

Sources:
Lisle, R. J., 2004, Geological Structures and Maps, A Practical Guide, Third edition
http://www.geo.utexas.edu/courses/420k/PDF_files/Brunton_Compass_09.pdf
http://en.wikipedia.org/wiki/Azimuth
http://en.wikipedia.org/wiki/Brunton_compass
FLASH DRIVE/Rider/PDFs/Holcombe_conv_and_meas.pdf
http://www.state.nj.us/dep/njgs/geodata/fmsdoc/fmsuser.htm

Plane Dip and Linear Plunge





The concepts of direction of dip and angle of dip.

Bedding and other geological layers and planes that are not horizontal are said to dip. The *dip* is the slope of a geological surface. There are two aspects to the dip of a plane:

(a) the *direction of dip*, which is the compass direction towards which the plane slopes; and
(b) the *angle of dip*, which is the angle that the plane makes with a horizontal plane (Fig. 2.3).

The direction of dip can be visualized as the direction in which water would flow if poured onto the plane. The angle of dip is an angle between 0° (for horizontal planes) and 90° (for vertical planes). To record the dip of a plane all that is needed are two numbers; the angle of dip followed by the direction (or azimuth) of dip, e.g. 74/138 is a plane which dips 74° in the direction 138°.

Linear Plunge and Trend

Any dipping plane can be thought of as containing a large number of lines of varying *plunge* (Fig. 2.4). The strike line is a non-plunging or horizontal line within a dipping plane. The line numbered 5 in is an example of a strike line; it is not the only one but the other strike lines are all parallel to it. If we think of the sloping roof of a house as a dipping plane, the lines of the ridge and the eaves are equivalent to strike lines.

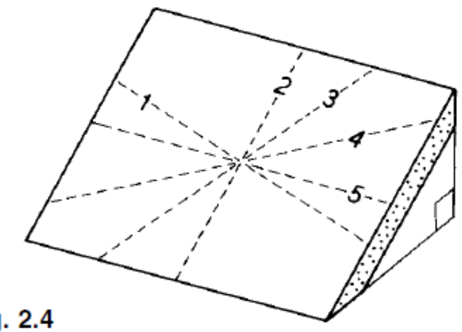
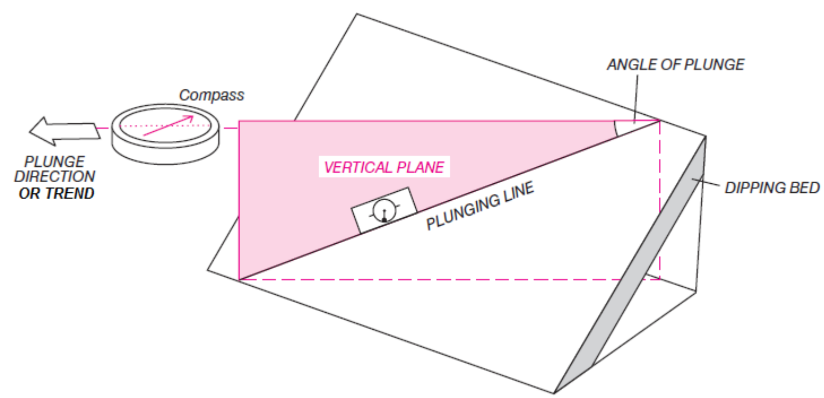


Fig. 2.4
Lines geometrically contained within a dipping plane.

Plunge is used to describe the tilt of lines, the word dip being reserved for planes. The plunge fully expresses the three-dimensional orientation of a line and has two parts:

(a) the angle of plunge, and
(b) the plunge direction or *trend*.

Consider the plunging line on the dipping plane to the right and an imaginary vertical plane containing the plunging line.



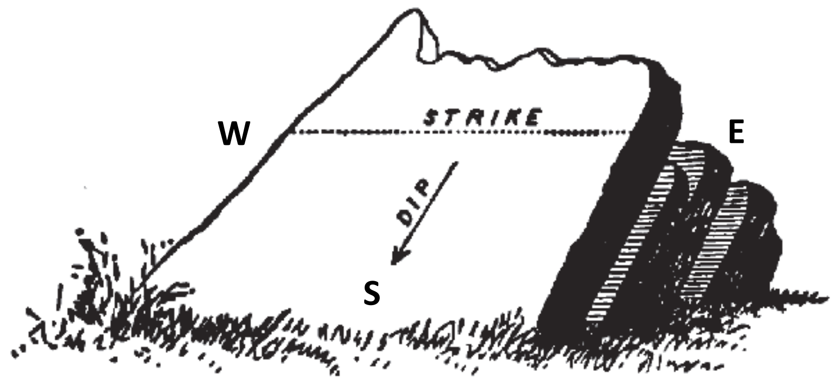
The *plunge direction* is the direction in which this vertical plane runs, and is the direction towards which the line is tilted. The *angle of plunge* is the amount of tilt; it is the angle, measured in the vertical plane, that the plunging line makes with the horizontal. The angle of plunge of a horizontal line is 0° and the angle of plunge of a vertical line is 90°.

Plane Strike and Dip, and Recording Conventions

Within a dipping plane the line at right angles to the strike line is the line with the steepest plunge. The angle of plunge of the steepest plunging line in a plane is equal to the angle of dip of that plane. A strike line is not a polar line (with a unique azimuth), but can be recorded using supplementary angles. For example, the plane to the right is striking E and/or W.

Strike and dip angles are measured using a few different techniques. We will focus on two:

1. Dip and dip azimuth (0-90°/(0-359°), and
2. Strike (0-179°), Dip, and Dip Direction (N,E,S,W)



freepages.rootsweb.ancestry.com/~wakefield/history/35317-h/35317-h.htm

The plane in the example is dipping due south, that is recorded either as 45/180 (using method 1 or 090/45 S for method 2. The dip azimuth and strike are always complimentary.

Two other recording conventions for plane strike and dip that you may encounter include the *quadrant*, and the *right-hand rule*. For the planes sketched above, strike and dip using the quadrant method would be recorded as N90E/45 S. The quadrant system is popular in the US and primarily uses a primary north (N) or south (S) reference, with a secondary direction (E or W). Appended after the bearing. The right-hand rule method requires a unique strike direction (or a polar line), one that has the dip direction lying to the right (clockwise). So for a plane dipping 45° South, the plane recorded using the right-hand rule is 090/45 S. A plane dipping 45° North would be 270/45 N using the same rule.

Recording Conventions and Notebook/Computer Notation

When using the Strike, Dip, and Dip Direction convention for recording planes, only measure and record strike azimuth in the 0-179° range, writing strike 1rst, dip 2nd, and dip direction 3rd , in sequence. This helps keep planar readings separate from lineation readings in your field book, and minimizes confusion over what type of feature was recorded that may arise later upon revisiting your notes. Here is a example of some structural measurements:

TYPE OF FEATURE ABBREVIATION FOLLOWED BY STRUCTURAL READING

B 123/45 S J 090/23 N SP 123/66 N SL 66/033 FA 13/002 J 040/88 N

Planes: B - bedding, J - joint, SP – shear plane Lineation: SL - slip lineation, FA – fold axis

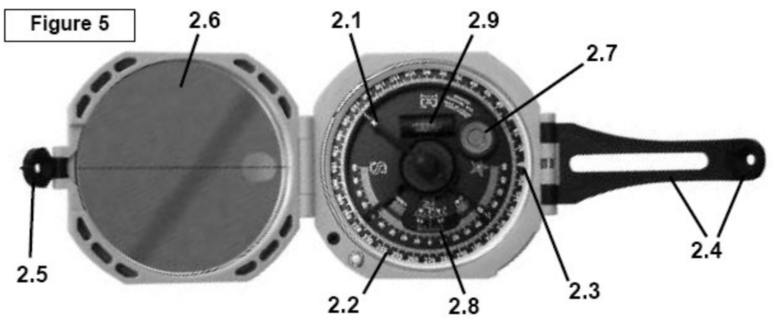
4 planes and 2 lineation are recorded above. Notice how the planes have a three-digit/two-digit format and the lineation have a two-digit/three-digit format.
Also, planes have the alphabet modifier whereas a lineation doesn't.

Measuring strike in the field with a pocket compass is easier than measuring dip azimuth. But the dip azimuth convention is needed when manipulating and using your data with computers. You choose what system you prefer to record your measurements. Ultimately, the system should be easiest for you to remember and use. However, it is expected of you to be able to convert all different methods to one another.

The Brunton Compass

We will be using a Brunton compass to collect field measurements. A Brunton compass, properly known as the Brunton Pocket Transit, is a precision compass made by Brunton, Inc. of Riverton, Wyoming. It was patented in 1894 by David W. Brunton, a Canadian-born Colorado geologist. The Brunton (for short) utilizes magnetic induction damping rather than fluid to damp needle oscillation. The Brunton Pocket Transit is a specialized instrument used widely by geologists, archaeologists, environmental engineers, and surveyors to make accurate degree and angle measurements in the field. The United States Army has adopted the Pocket Transit as the M2 Compass for use by crew-served artillery.

Figure 5



2.2 Graduated Circle (Fig 5)
In combination with the needle, the 1° graduated circle allows accurate 1/2° azimuth readings on both the Degree (0° through 360°) and Quadrant (0° through 90°) graduated circles.

2.3 Zero Pin (Fig 5)
The zero pin is the pointer used for magnetic declination adjustment. If no adjustment is necessary, the pin should point at 0°.

2.4 Large Sight w/ Peep Sight (Fig 5)
The large sight and the attached peep sight are used for precise azimuth measurement.

2.5 Small Sight (Fig 5)
Attached to the cover, the small sight is used for precise bearing and inclination sighting.

2.6 Mirror (Fig 5)
Located on the inside of the cover, the mirror and mirror center line are used for accurate azimuth measurements, when using the transit as a prismatic compass.

2.7 Round Level (Fig 5)
Use the round level to level the pocket transit for azimuth measurement.

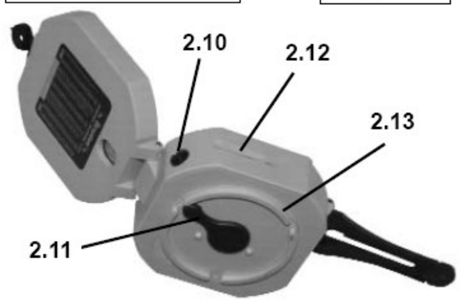
2.8 Vernier (Fig 5)
The adjustable vernier is used in inclination measurements.

2.9 Long Level (Fig 5)
The long level for inclination measurement. Adjust the long level using the vernier adjustment - 2.11.

2.10 Circle Adjusting Screw (Fig 6)
With a screw driver, rotate the graduated circle by turning the circle adjusting screw.

Com-Pro Model Shown

Figure 6



2.11 Vernier Adjustment (Fig 6)
Use the vernier adjustment to adjust the vernier and long level for inclination measurements.

2.12 Ball & Socket Tripod Mount (Fig 6)
The slots on both sides of the body are for mounting to an optional Brunton tripod.

2.13 Alidade Mount -- *Com-Pro Models Only* (Fig 6)
The circular extension with slots, located on the bottom of the body, is for the attachment of an optional Brunton alidade (protractor). Only the Com-Pro models have this feature.

3 -- Magnetic Declination

The Earth is completely surrounded by a magnetic field, and an unobstructed magnetized object will orient itself with the earth's magnetic north and south poles. Magnetic declination (variation) is the difference between true geographic north (north pole) and magnetic north (in northern Canada), with respect to your position. It is important to note magnetic declination at your position, because magnetic declination varies and fluctuate slowly at different rates, around the world. (Fig 7, p.5)

The Brunton Compass

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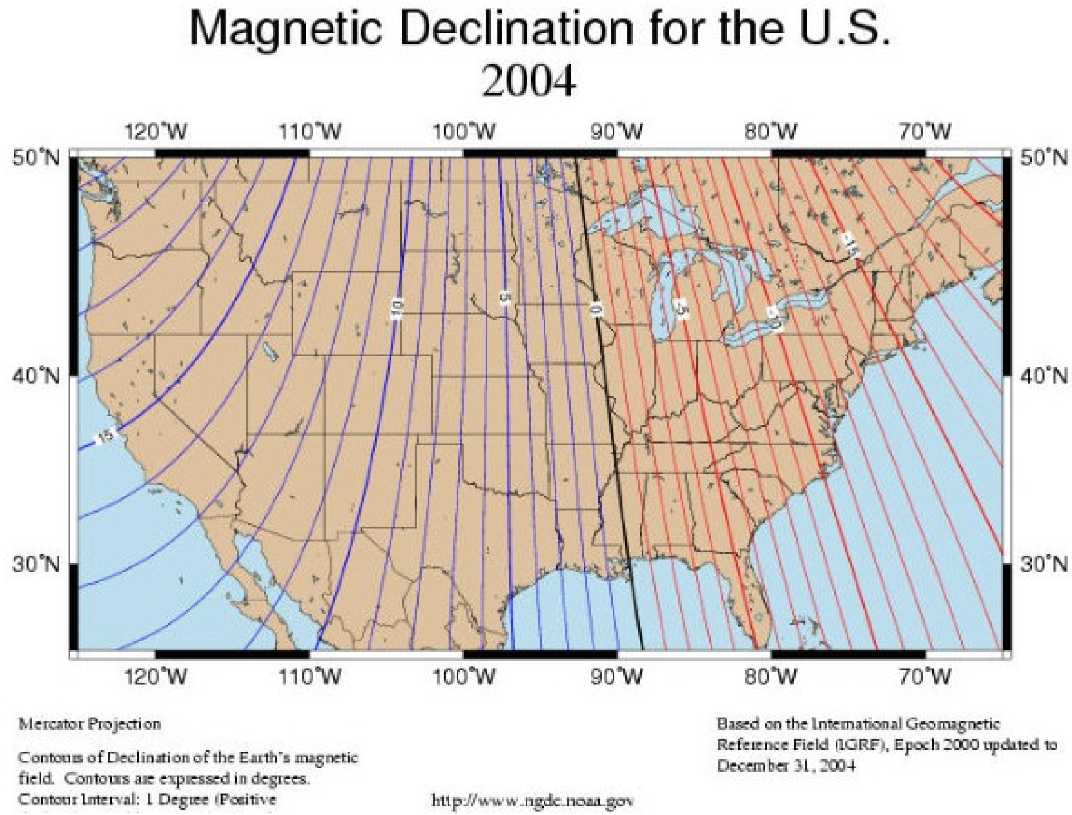
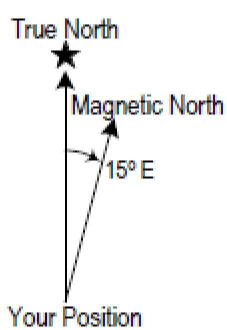
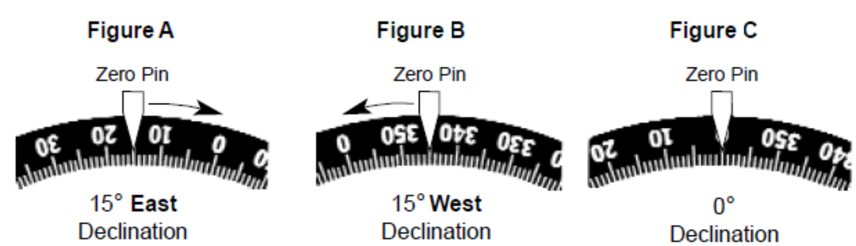


An example of a map legend showing the declination of Magnetic North from True North, and the manual procedure for adjusting the compass for magnetic declination



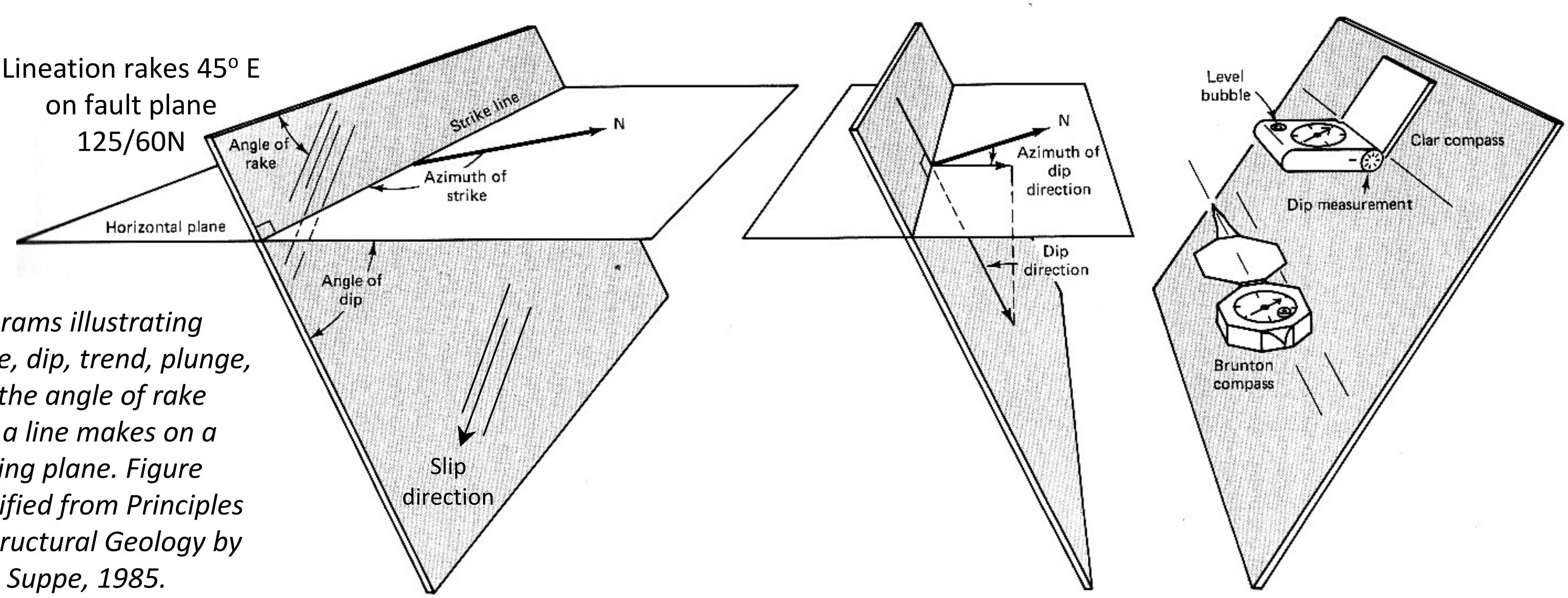
To adjust for magnetic declination, rotate the graduated circle by turning the circle adjusting screw. Begin with the zero pin at 0°. For **East** declination, rotate graduated circle ***clock-wise*** from the zero pin. (Fig A) For **West** declination, rotate graduated circle ***counter-clockwise***. (Fig B) If magnetic declination is 0°, no adjustment is necessary. (Fig C)



Line Rake (or Pitch) on a Plane

Sometimes, it is more convenient to use a different method when measuring the orientation of a line on a plane rather than the trend and plunge. Occasions arise on the outcrop where accessibility factors make it difficult to position oneself properly in order to take a trend reading, or the dip of the plane is to steep and makes trend measurement impractical.

The orientation of the line on a dipping plane can also be defined by the *pitch* of the line. Pitch is synonymous with the US term *rake*. The pitch(rake) of a line is the angle measured in the plane between the strike line and the line of interest. A strike sense direction must also be given to indicate which of the two possible strike senses was used. The orientation of the plane also must be given in order to uniquely orient the line. Pitch angles are in the range 0-90^{o}, with a pitch of 0^{o} being a line parallel to the strike, and a pitch of 90^{o} being a line parallel to the dip line.



Diagrams illustrating strike, dip, trend, plunge, and the angle of rake that a line makes on a dipping plane. Figure modified from Principles of Structural Geology by John Suppe, 1985.

The Colorado School of Mine provides a free Excel application for converting pitch on a plane to linear plunge/trend. See FLASH DRIVE/EXCEL/rake_plunge_calculator.xls. FMS automatically converts values upon data entry in the program.

Using a Field Book for Geological Mapping

You will be recording your field observations, notes and structural readings in a field book that is supplied at the beginning of class. This will be your ledger of activity in the field and laboratory. It will be reviewed but not graded. What you transpose from it will be graded, so it is vital that you keep your observations, notes, thoughts, and readings organized and legible for later reference.

It is advisable to use an indelible marker to personalize you book inside the font hard cover in case it is ever misplaced or forgotten. Provide enough information that you can be contacted for its return. Securing a business card inside, or something similar works too.

I recommend starting a new day's entry on a new page, with a heading stating the date and location. It is always good practice to take your time at a location and describe the location and the type of outcrop or station, in addition to the stratigraphic description and the type of structures that you measure. If you use abbreviations, etc., you should have list of them somewhere in the book, preferably in the front pages, so that your notes become legible by others upon scrutiny.

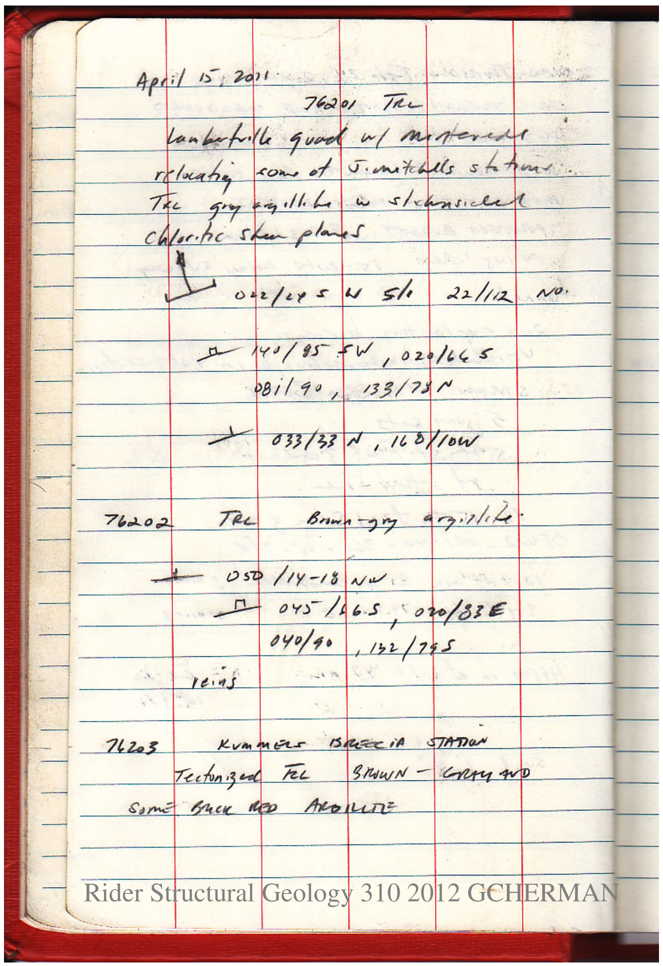
I prefer to use a mechanical pencil for recording my notes. Others prefer to use ball-point pens. Whatever you use, it should not bleed when wetted. Mistakes will happen, and it is helpful if you can erase a mistake and fix it.

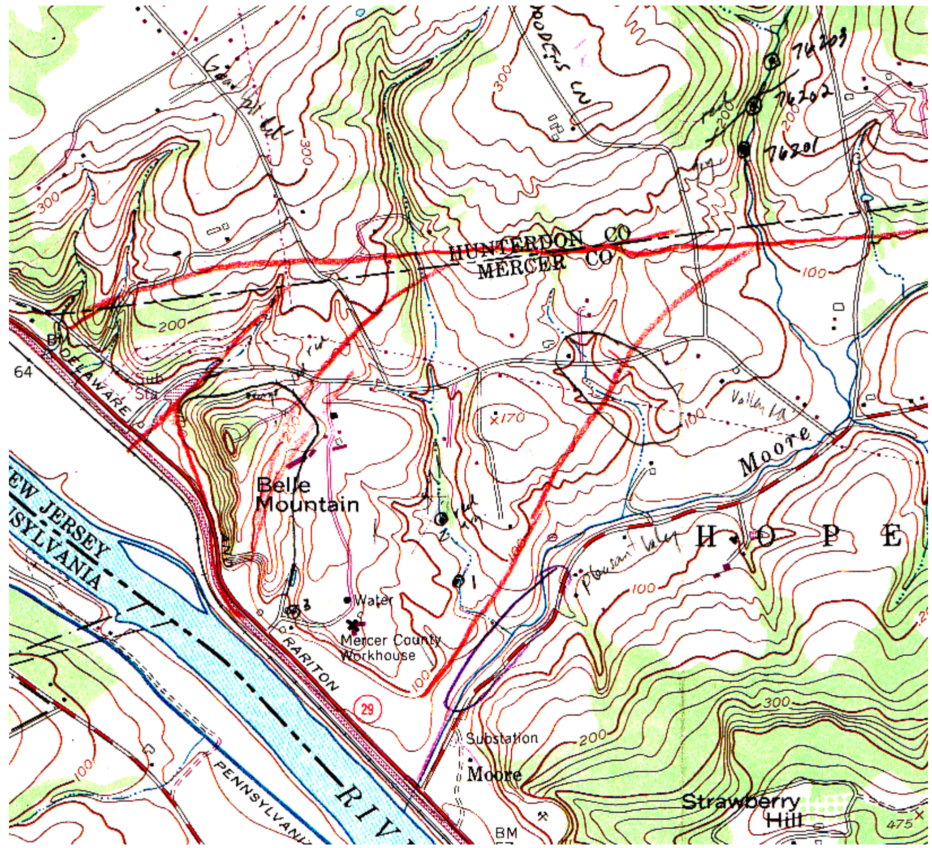
Field-station identification is key. You may use different schemes throughout the semester, but you will need to become familiar with that used by the NJGS as part of cataloguing data throughout northern New Jersey using the Field data Management System (FMS - see FLASH DRIVE/GCH_310_Lab_Supplement_2012.doc).

There will be assignments and examples used throughout the semester of data that are archived in the NJGS FMS. Their station numbering scheme uses a five-digit integer. The first two numbers refer to the USGS quadrangle number (0-99) awhile the remaining 3 digits correlate to field station (1-999 or less). For example field station 17456 refers to the 456th station in quadrangle No. 17 (Newfoundland 7-1/2' Topographic quadrangle).

Using a Field Book and Topographic Map for Geological Mapping

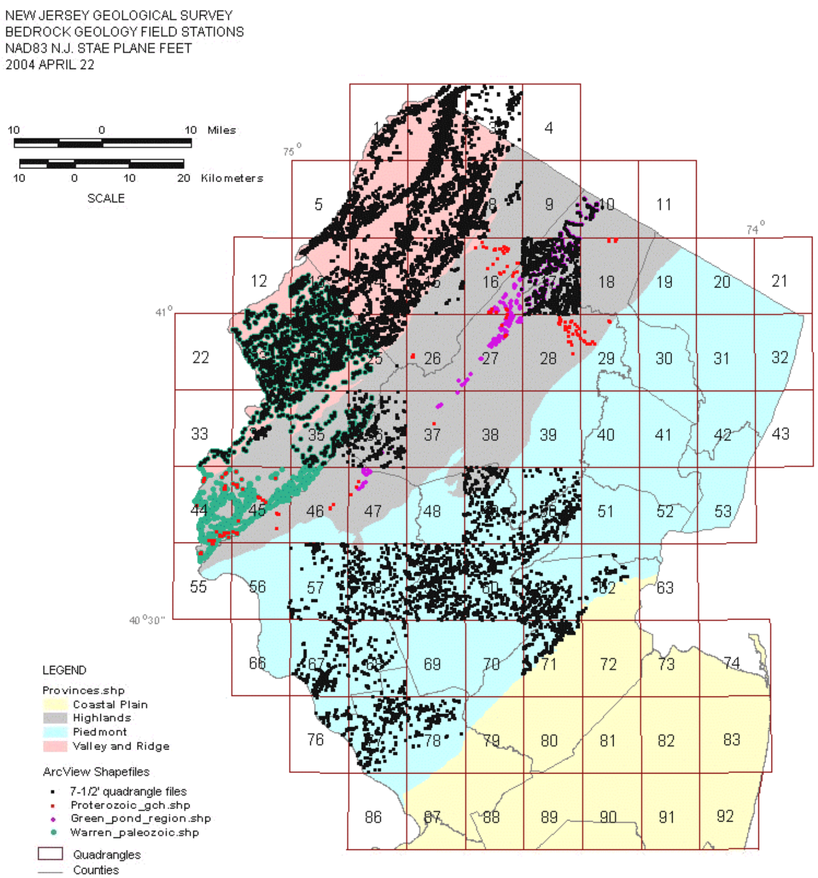
If you use a GPS receiver to locate yourself in the field, recording the location coordinates in the book at a station is also helpful, especially because batteries die, and digital data can be easily lost, overwritten, or inadvertently deleted. It’s also a good idea to mark your position on a hard copy map in the field. USGS 1:24,000 scale topographic quadrangles provide a standard base that can be used for this task. Custom base maps are also popular, such as Google Earth printouts, or local surveys.





Scanned field book page and correlative field map (Lambertville, NJ-Pa 7-1/2’quadrangle). Red-pencil lines are faults mapped at the 1:100K scale. The names of local roads were written on the map. Station numbers reflect two different excursions.

The NJ Geological Survey Field data Management System (FMS.exe)



FIELD STATION POINT LOCATIONS

ESRI ArcView Shapefiles

green_pond_region.dbf	22846	2003-12-10
green_pond_region.sbn	14028	2003-12-10
green_pond_region.sbx	796	2003-12-10
green_pond_region.shp	17768	2003-12-10
green_pond_region.shx	5148	2003-12-10
nj001_stations.dbf	11962	2003-12-01
nj001_stations.sbn	4092	2003-12-01
nj001_stations.sbx	388	2003-12-01
nj001_stations.shp	4356	2003-12-01
nj001_stations.shx	1316	2003-12-01
nj002_stations.dbf	49153	2003-12-01
nj002_stations.sbn	12596	2003-12-01
nj002_stations.sbx	1380	2003-12-01
nj002_stations.shp	17880	2003-12-01
nj002_stations.shx	5180	2003-12-01
nj003_stations.dbf	13762	2003-12-01
nj003_stations.sbn	8292	2003-12-01
nj003_stations.sbx	604	2003-12-01
nj003_stations.shp	7268	2003-12-01
nj003_stations.shx	2148	2003-12-01
nj005_stations.dbf	13656	2003-12-01

FIELD DATA ASCII FILES

Comma and space delimited FIELDATA (*.fd) and FDARRAY (*.txt) files

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Nj001.txt	15884	2000-12-15	10:18
Nj005.fd	14485	2000-06-16	11:24
NJ005.TXT	27638	2000-06-16	11:24
NJ006.FD	39449	2000-06-16	12:33
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Nj007.fd	46254	2000-06-16	12:47
NJ007.TXT	93982	2000-06-16	12:47
NJ008PA.FD	28678	2000-06-16	12:54
NJ008PA.TXT	63210	2000-06-16	12:55
Nj009.fd	4817	2000-06-16	13:44
NJ009.TXT	11035	2000-06-16	13:44
Nj010.fd	3759	2000-06-16	13:57
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Nj012.fd	4212	2000-06-16	14:30
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 13001,PKFS      ,OMR  ,J  ,        ,155,78,N
 13002,PKFS      ,OMR  ,B  ,        , 35,32,N
 13002,PKFS      ,OMR  ,J  ,        ,130,45,S
 13003,MPS       ,SSG  ,B  ,        , 36,24,N
 13003,MPS       ,SSG  ,J  ,        , 15,75,S
 13004,PKFS      ,OMR  ,B  ,        , 49,13,N
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 13008,MPS       ,SSG  ,J  ,        ,172,50,N
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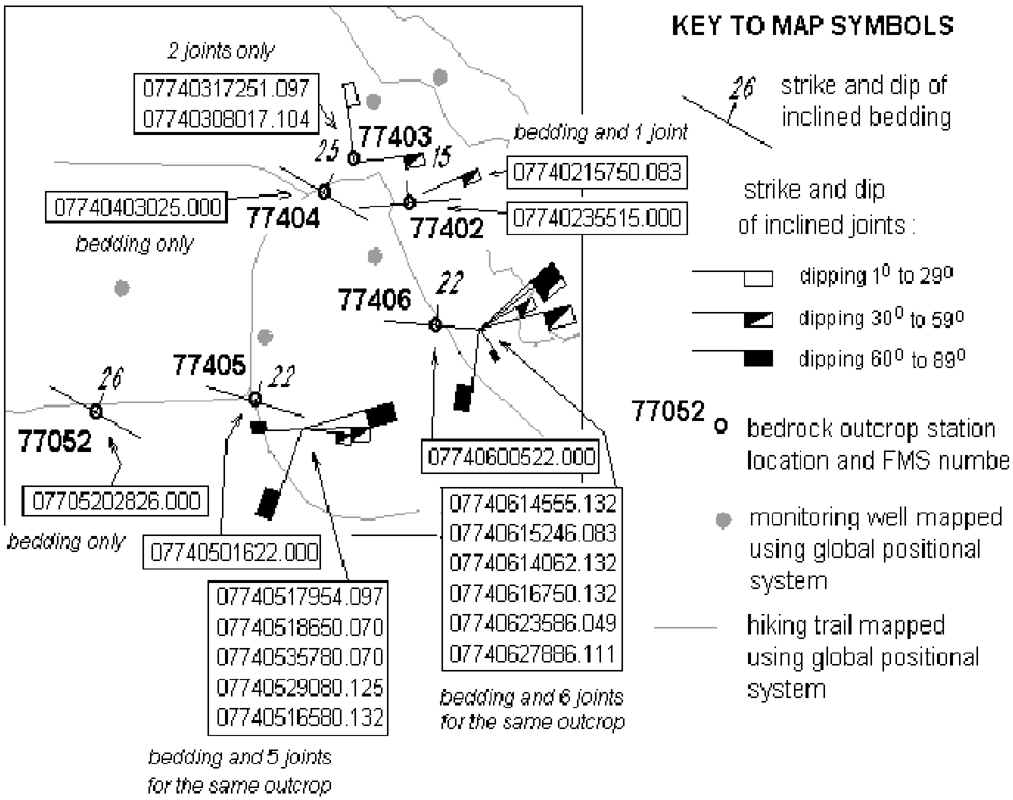
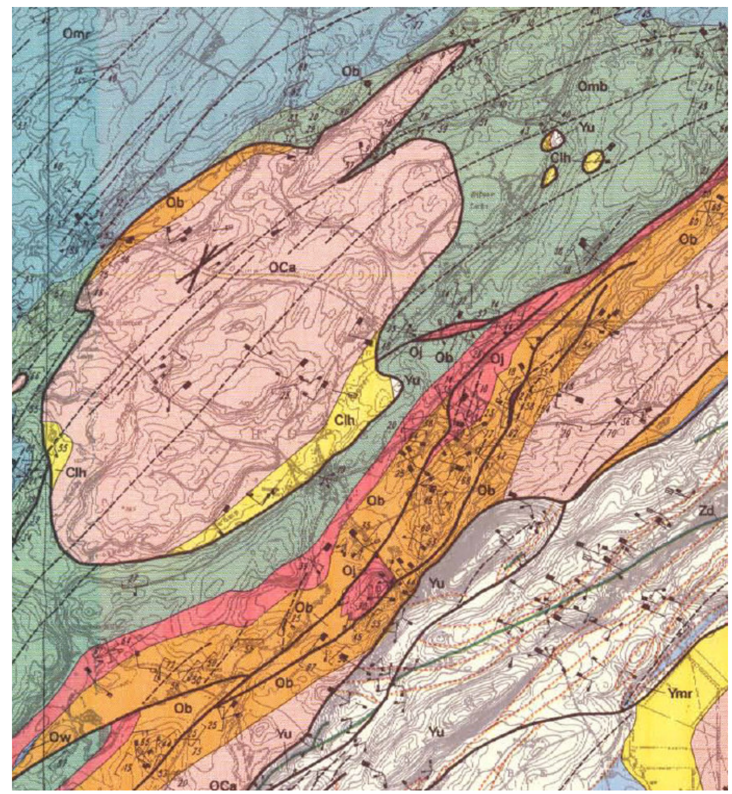
Herman, G. C., 1993, French, M. A., Monteverde, D. H., 1993, Automated mesostructural analyses using GIS, Beta test: Paleozoic structures from the New Jersey Great Valley region: Geological Society America Abstracts with Programs, v. 25, no. 2, p. 23.

The NJ Geological Survey Field data Management System (FMS.exe)





Herman, G. C., Monteverde, D. H., Volkert, R. A., Drake, A. A., Jr., and Dalton, R. F., 1994: Environmental map of Warren County, N. J. ; Bedrock fracture map: N.J. Geological Survey Open-File Map 15B, scale 1:48,000, 2 sheets.