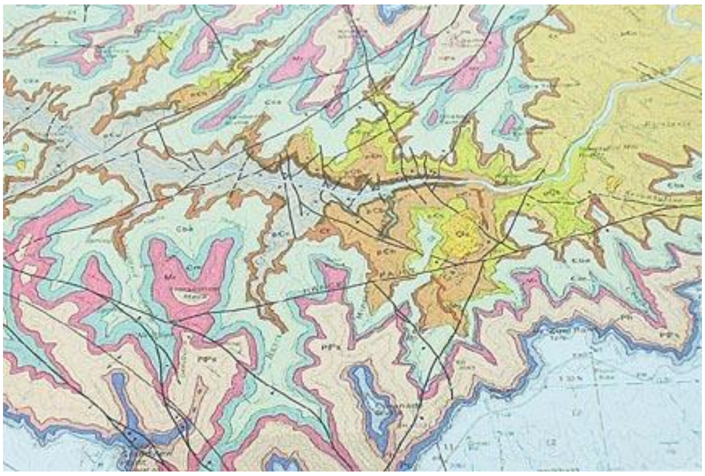
Geological Maps and Interpretation

What is a Geological Map?

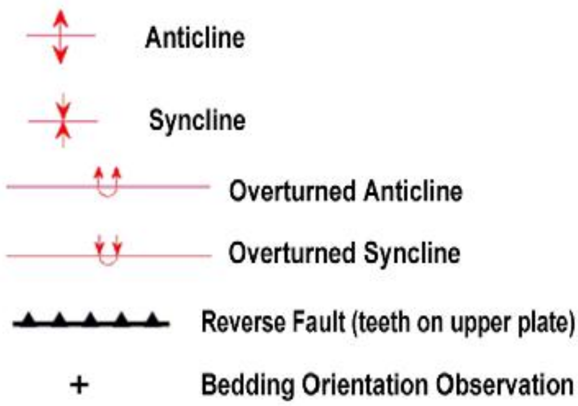
A Geological Map is the illustration of outcrops[1] of different rock types of a region or area, super imposed upon its topography[2].



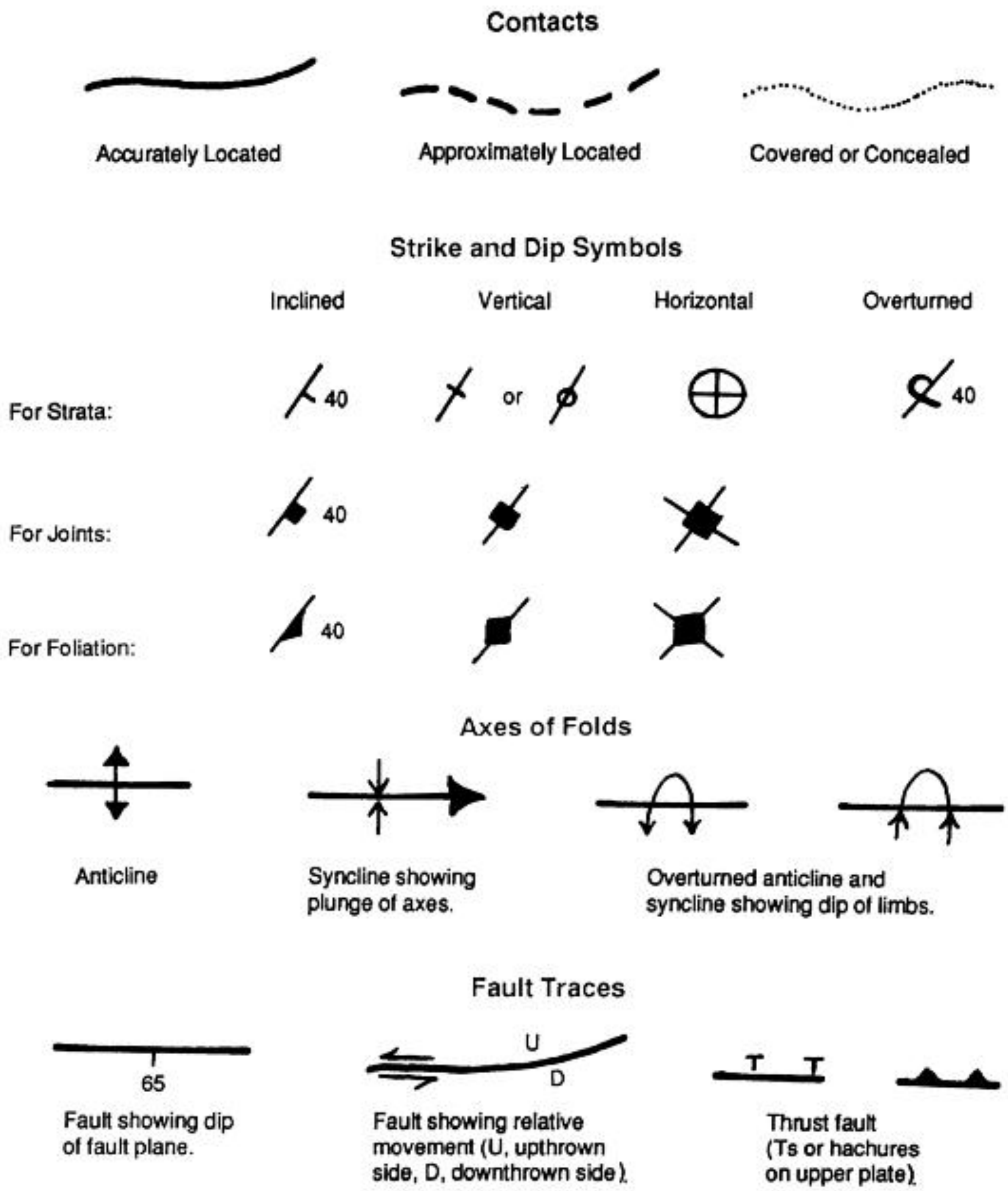
These maps mark accurately the locations & extent of different rock types, their boundary etc. in brief they are expected to offer all the possible data about the geology of the area concerned.

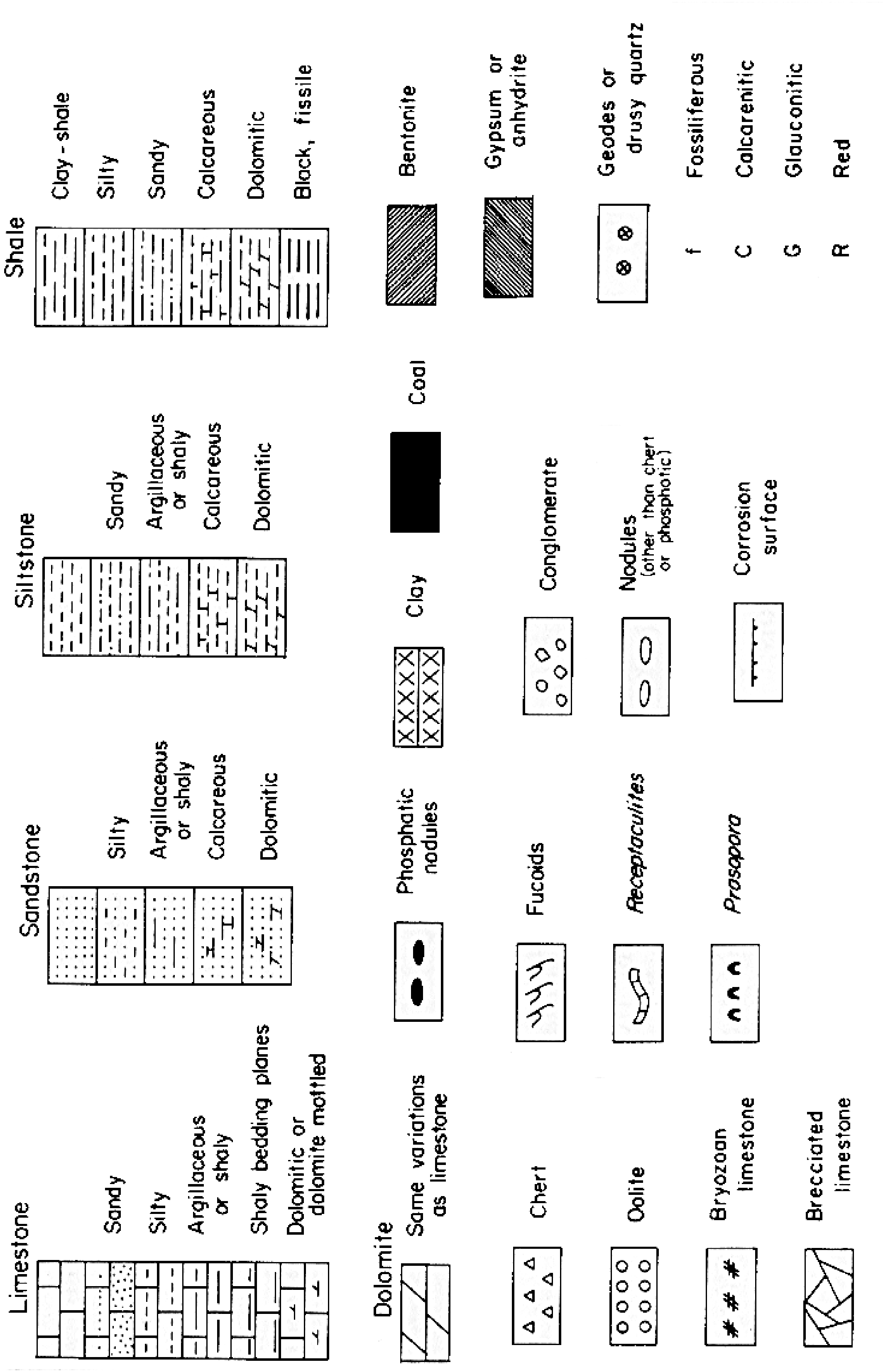
The most use of geological map is to indicate the nature of the near surface bed rock. These are very important to a civil engineer who advice on excavation of road cuttings or on sitting of bridges. For a geographer these maps are very useful tools in the studying of the land for companies in exploiting minerals, whereas an experienced geologist can extract much more from these maps.

The main feature that attracts one is the symbols. The different symbols of the geological map are as followed.



1 - An outcrop is a visible exposure of bedrock or ancient superficial deposits on the surface of the Earth.
2 – Topography is the study of surface shape and features of the Earth and other observable astronomical objects

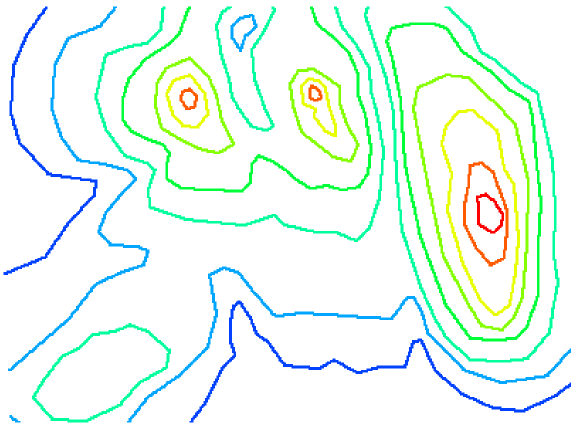

Contacts
Accurately Located
Approximately Located
Covered or Concealed
Strike and Dip Symbols
Inclined
Vertical
Horizontal
Overturned
For Strata:
40
or
40
For Joints:
40
For Foliation:
40
Axes of Folds
Anticline
Syncline showing plunge of axes.
Overturned anticline and syncline showing dip of limbs.
Fault Traces
65
Fault showing dip of fault plane.
U
D
Fault showing relative movement (U, upthrown side, D, downthrown side).
T
T
Thrust fault (Ts or hachures on upper plate).


Limestone
Sandy
Silty
Argillaceous or shaly
Shaly bedding planes
Dolomitic or dolomite mottled
Sandstone
Silty
Argillaceous or shaly
Calcareous
Dolomitic
Siltstone
Sandy
Argillaceous or shaly
Calcareous
Dolomitic
Shale
Clay - shale
Silty
Sandy
Calcareous
Dolomitic
Black, fissile
Dolomite
Same variations as limestone
Phosphatic nodules
Clay
Coal
Bentonite
Gypsum or anhydrite
Chert
Fucoids
Conglomerate
Geodes or drusy quartz
Oolite
Receptaculites
Nodules (other than chert or phosphotic)
f Fossiliferous
Bryozoan limestone
Prasopora
Corrosion surface
C Calcarenitic
Brecciated limestone
G Glauconitic
R Red

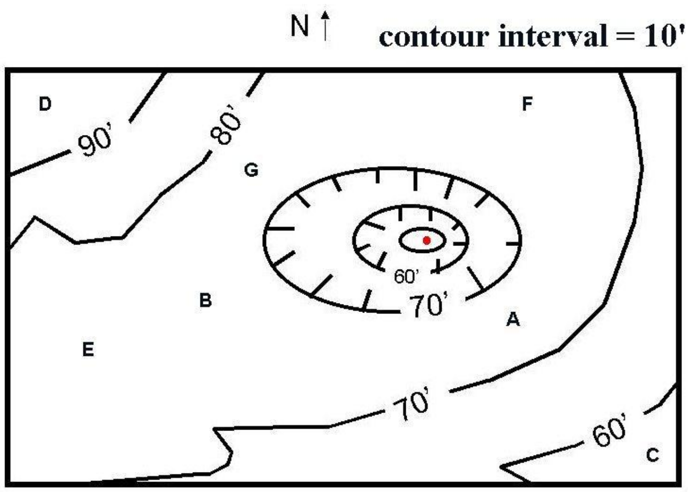
Cleavage Symbols	Boudinage Showing Bearing and Plunge	Oil Well with Show of Gas
Inclined Cleavage, Showing Strike and Dip	Lineation Normal to Minor Fold With Bearing and Plunge	Oil and Gas Well
Vertical Cleavage Showing Strike	**Mine Symbols**	Gas Well with Show of Oil
Cleavage, Horizontal	Inclined Mineshaft, Large Scale Map	Gas Well
Cleavage, Inclined Showing Strike and Dip	Raise or Foot of Winze	Dry Hole
Cleavage, Vertical	Vertical Mine Shaft	Abandoned Oil and Gas Well, Show of Gas
Spaced Cleavage/Strain Slip	Portal	Abandoned Oil and Gas Well
Horizontal Cleavage	Open Pit, Quarry or Glory Hole	Oil Show
Dykes/Veins	Prospect, Pit or Small Open Cut	Oil and Gas Show
Dyke Element	Sand, Gravel, Clay or Placer Pit	Gas Show
Dyke, Showing Dip	Vertical Mine Shaft	Dry Hole
Dyke, Vertical	Vertical Mine Shaft	Abandoned Oil and Gas Well, Show of Oil
Dyke, Horizontal or Sheet	Inclined MineShaft, Small Scale Map	Abandoned Gas Well
Vein	Inclined Tunnel or Adit, Small Scale map	**Contacts/Faults**
Vein, Mineralized Stringers or Veinlets	Trench, Small Scale Map	Contact
Joints	Drill Hole, Inclined Showing Bearing and Inclination	Contact/Fault Showing Dip
Joint, Inclined, Showing Strike and Dip	BH Bore Hole	Contact/Fault, Vertical
Joint, Vertical	Drill Hole, Vertical	Contact/Fault, Inferred
Joint, Horizontal	Drill Hole, Inclined Showing Bearing, Inclination and Position of Hole Bottom	Contact/Fault, Approximate
(F) Fossils	Open Pit, Glory Hole or Quarry, Ticks on Inside	Contact/Fault, Concealed
S Salt Dome	Trench, Ticks on Inside	Normal Fault, Hatches Downside

A little exposure towards geological maps:

1. Elevation: it is the height of the land above mean sea level. Normally the sea level is taken as 0 m or ft. The ground or level above is called elevation and is written +tive. The ground or level below is called depth, written as –tive.
2. Relief: the arithmetic difference between any two elevations is called relief. Relief can be maximum or total relief and local relief.
    a. Total or Maximum relief: It is the difference between highest & lowest elevations on the map.
    b. Local relief: it is the difference between hill top & its adjacent valley.
3. Contours: contours are lines on topographic maps that represent equal elevations above a datum point (standard point). The datum point will be usually the sea level (0ft). These represent the three dimensional features, such as hills, valleys, ridges as lines on paper.

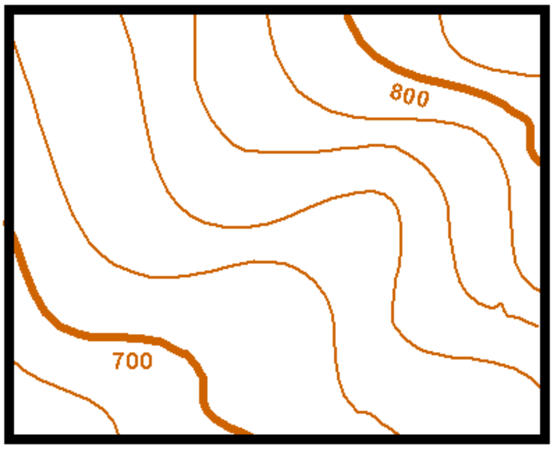


    a. Contour interval: It is the difference in elevation between any two adjacent contour lines. The contour interval once determined on the map, will remain constant through out the map.
    For example, if a map is determined with contour interval of, the contour values would be like 10, 20, 30, --------, 120, 130, --- etc.

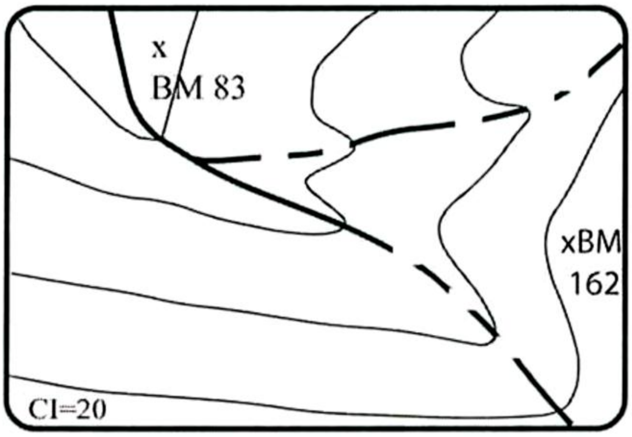


The contour interval selected for a map is dependent on the area.
For example, if the terrain is more mountainous, it will have a larger contour value & vice versa.

b. Index contours: The contours which are marked with elevation (value) & are marked thick are called index contours. Generally every fifth contour line will be an index contour.
For example, if the contour interval is 10ft., the index contour will be 50ft.

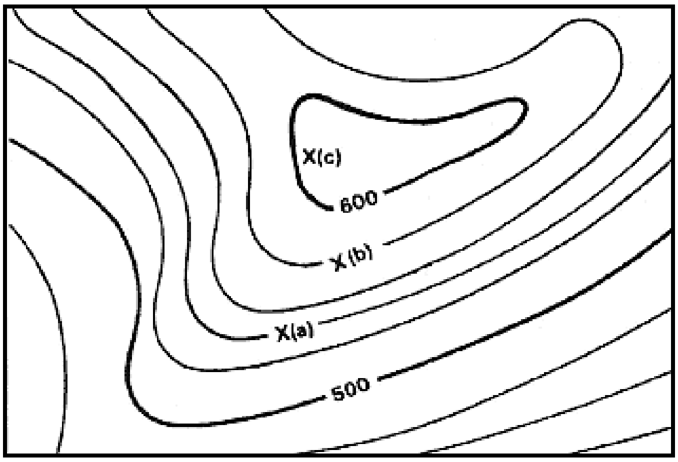


4. Bench Marks: These are the precise accurate measurement of certain locations by any survey department. Normally permanent brass marks are set in the ground at location on map. These are marked as “BM”.



5. Spot Elevations: These are the elevations that have been surveyed in to a given place but are not marked by permanent markers. Spot elevations are indicated on maps by ‘x’ followed by elevations.

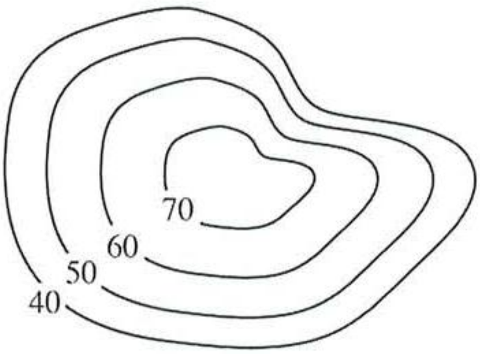
   For example: x250, x520 etc.



Interpretation of contour lines:

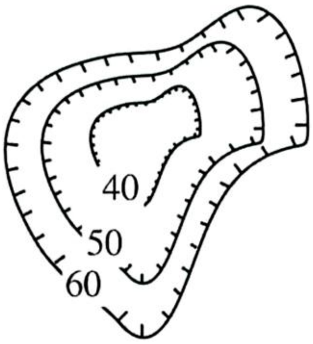
A. Peak or hills and depressions:

   Peaks or Hills and depression in a geological map are represented by closed rings. The rings will be more or less circular, if they represent hill or depression which is regular. The contour lines will be wavy or irregular circles if the represented structure is irregular.



Contours representing Himalayan ranges

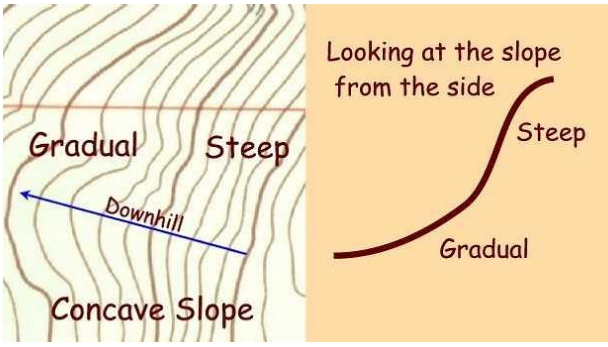
Generally the contour lines representing the depression will be hachured[1].

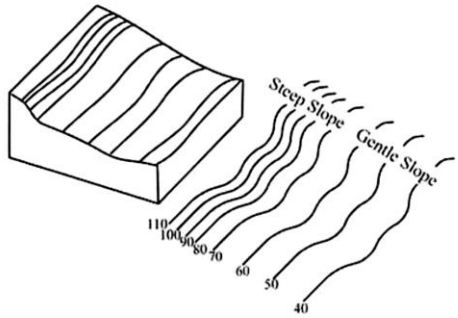


1 - ha·chure: One of the short lines used on maps to shade or to indicate slopes and their degree and direction.

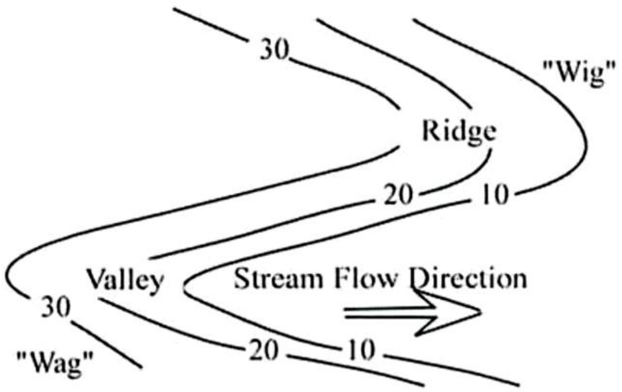
The other interpretation will be, if the multiples of contours (contour numbers) are progressive or ascending, it's a hill or peak and if they are regressive or descending, it's a depression.

B. Slopes: if the contour lines are more are less parallel to each other, they represent slopes. If the slope lines are very near to each other, they represent steep slopes and if they are far from each other, they represent normal slopes.

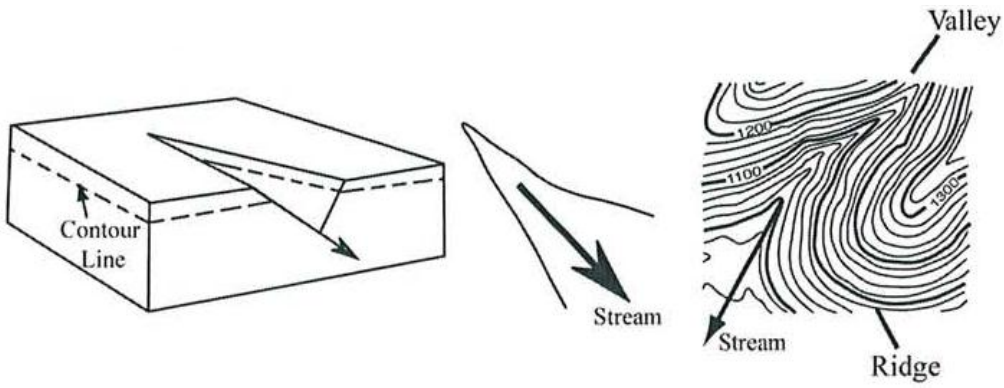




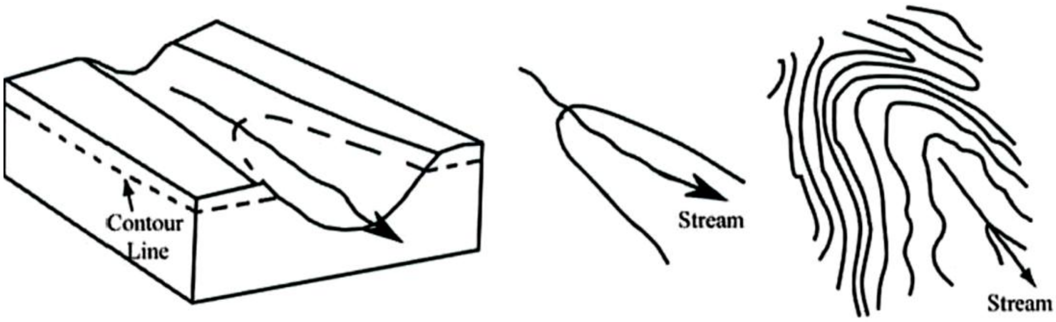
C. Ridges & Valleys: the wavy contour lines bending front and back represent ridges and valleys. If the contour line bends forward, it's called wig. It usually represents a ridge.
If the contour line bend back ward, its called wag, usually represent valley.



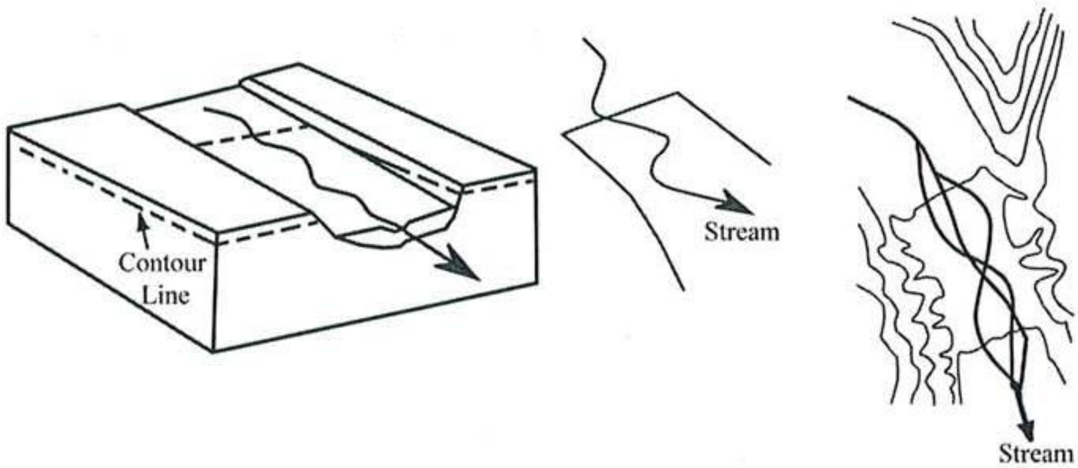
The valley shapes, features will help us to interpret the history of landscapes.
For example, if the contour "wag" terminates as a pointed V or the valley has a V-Shaped transverse profile, it represents the typical streams in youthful stage.



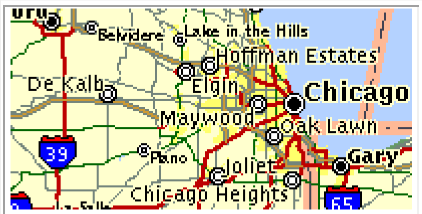
If the contour "wag" terminates as round or the valley has U-shaped transverse profile, it indicate a glacial valley or it is valley which is the result of glacial erosion.



If the contour "wag" is squared or if the valley has flat bottom, it represent a flood plain valley which is in mature stage of erosion.



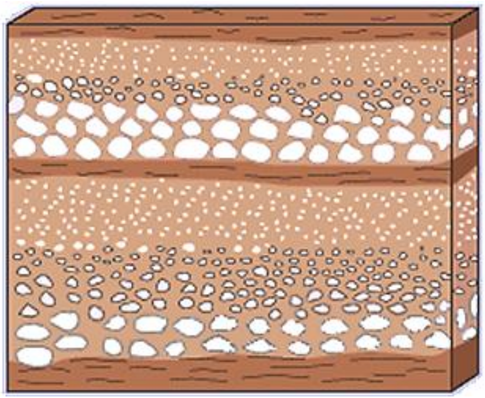
6. Map scale: It is the expression of ratio or proportion between a distance on a map and the actual distance on the land surface. This ratio is called the Representative Fraction (RF). A RF of 1:100,000 indicate that 1 unit of measure on the map represents 100,000 units on the land surface (i.e., 1 inch = 100,000 inches - 1.58 miles). The lesser the scale, the more detail will be on the geological map.

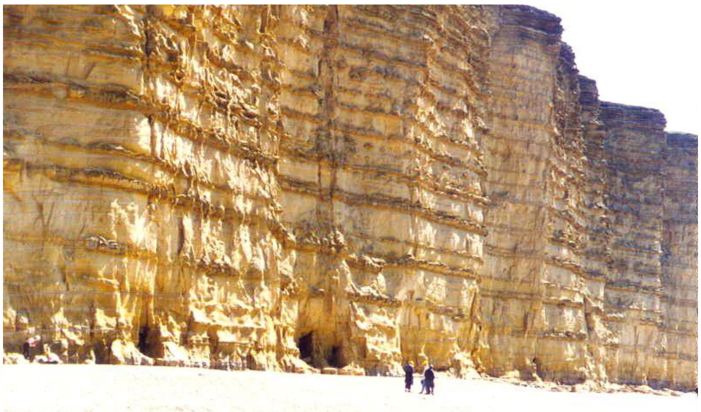


More Detail	<--------------	--------------->	Less Detail
Larger Scale			Smaller Scale
1:24,000	1:100,000	1:500,000	1:1,000,000

Uniformly Dipping Beds:

Beds are the depositions of earth masses layer by layer. This could be due to sedimentation brought by physical erosion or weathering. When more beds of sediment are laid down on top, the structures resemble a sandwich or a pile of pages of book. This stratified structure is known as bedding.





The bedding can be horizontal as shown above or could be dipping at certain angle.

Steeply dipping beds of carboniferous limestone and mud stone.

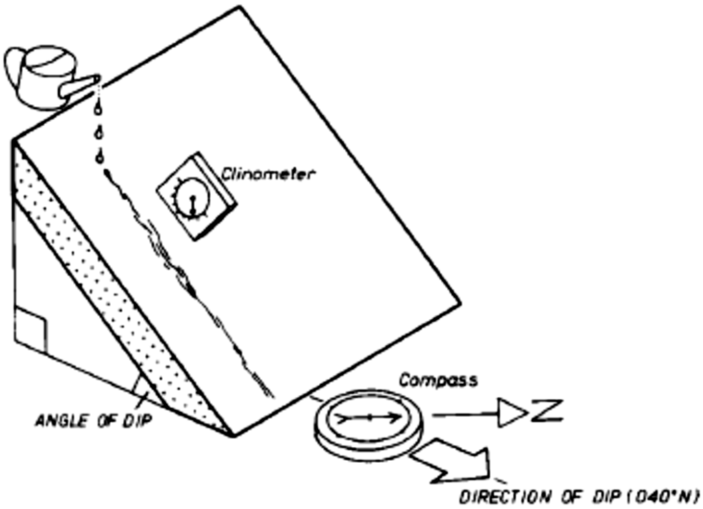
What is Dip?

Beddings that are not horizontal or any stratified structures that are at an angle to plane.

Dip is the slope of a geological surface. There are two aspects to the dip of the plane.

a. The direction of the Dip.
b. The angle of the Dip.

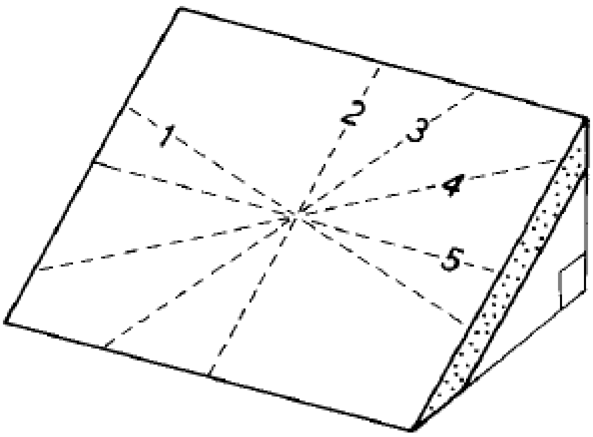
The direction of dip can be visualized as the direction in which water would flow if poured onto the plane. The angle of dip is an angle between 0° (for horizontal planes) and 90° (for vertical planes).



To record the dip of a plane all that is needed are two numbers; the direction of dip followed by the angle of dip, e.g. 138/74 is a plane which dips 74° in the direction 138°N (this is a direction which is SE, 138° clockwise from north). In the field the direction of dip is usually measured with a magnetic compass which incorporates a device called a clinometer, based on a plumb line or spirit level principle, for the measurement of dip angles.

The Dip is represented as  or  in geological maps.

Plunge of Lines & Strike:
If a dipping plane is imagined as followed.

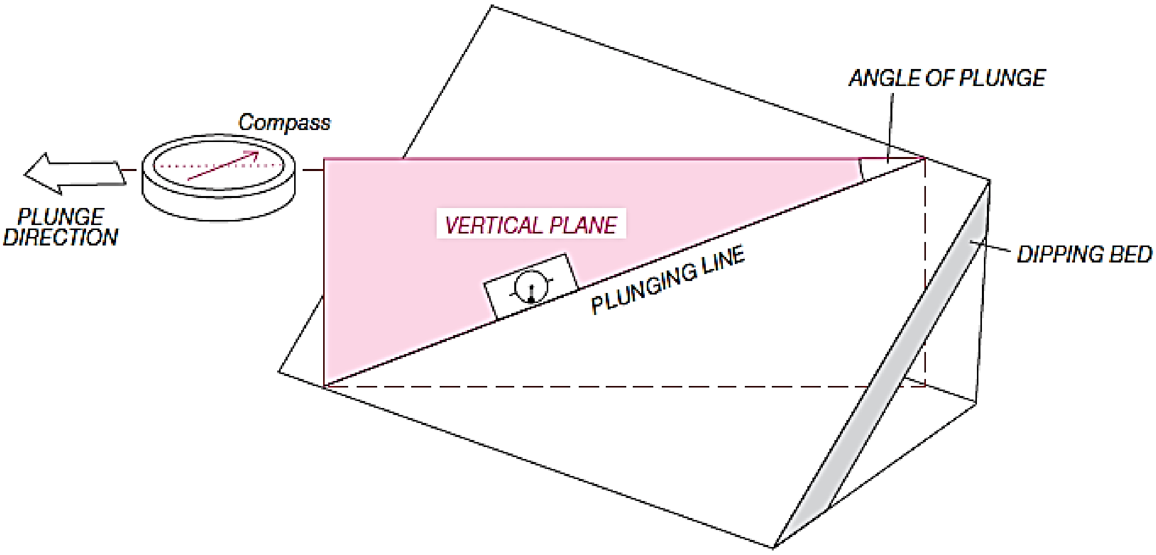


All the lines contained within the plane are not horizontal expect "Line 5". All the lines 1 – 4 are called plunging lines (plunge) & Line 5 is called *Strike*.
Plunge is used to describe the tilt of lines, the word dip describe the tilt of planes. Plunge fully expresses the three-dimensional orientation of a line and has two parts:

1. The angle of plunge, and

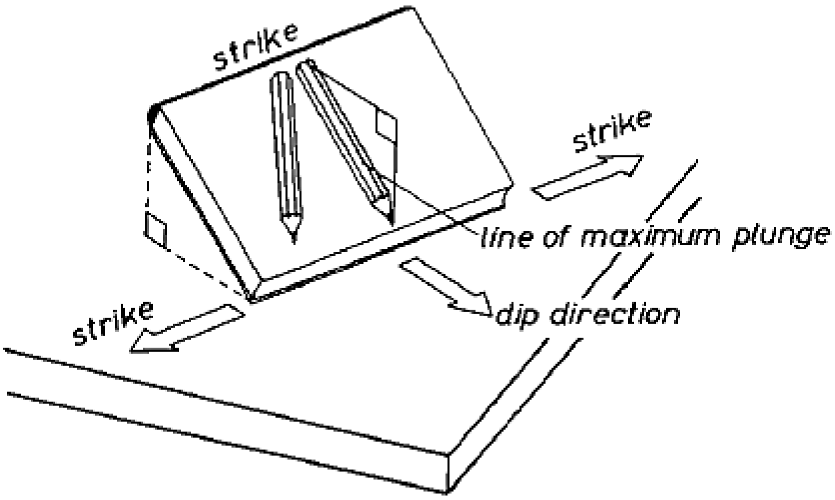
2. The plunge direction.

Consider the plunging line on the dipping plane in the fig. 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°. The plunge of a line can be written as a single expression, e.g. 23–220 describes a line that plunges 23° towards the direction 220°N.

The strike line is a non-plunging or horizontal line within a dipping plane. Within a dipping plane the line at right angles to the strike line is the line with the steepest plunge. Verify this for yourself by tilting a book on a flat table top as shown in Fig.

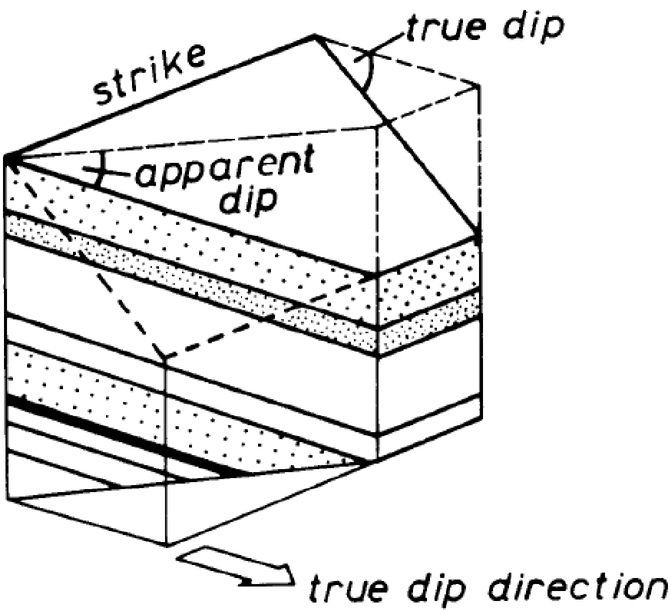


Place a pencil on the book in various orientations. The plunge of the pencil will be steepest when it is at right angles to the spine of the book (a strike line). The angle of plunge of the steepest plunging line in a plane is equal to the angle of dip of that plane.

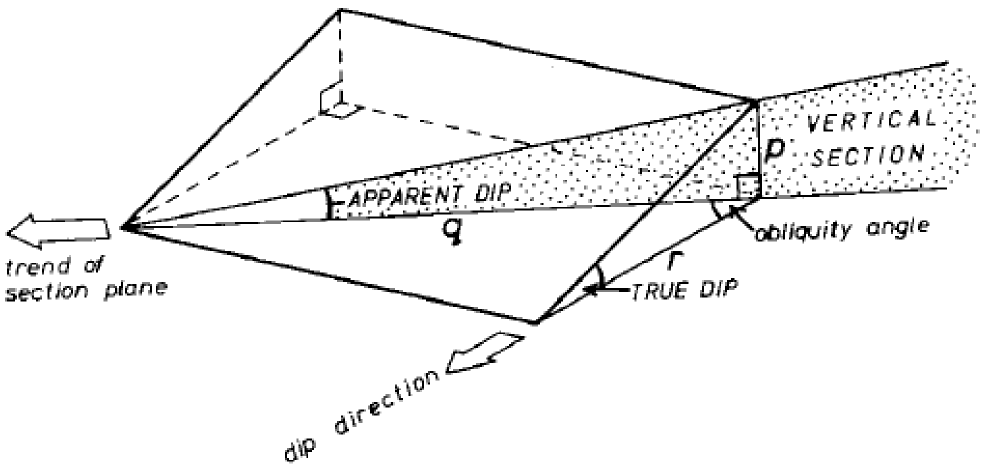
When specifying the direction of a strike line we can quote either of two directions which are 180° different. For example, a strike direction of 060° is the same as a strike direction of 240°. The direction of dip is always at right angles to the strike and can therefore be obtained by either adding or subtracting 90° from the strike whichever gives the down-dip direction.

Dip or inclination is possessed by the geological structures like sedimentary beds, tabular bodies like dykes, sills, lava flows so on. It can be represented as True dip and Apparent dip.

True dip is the maximum inclination of the dipping tubular body. And apparent dip is measured in any direction other than that of the maximum dip.



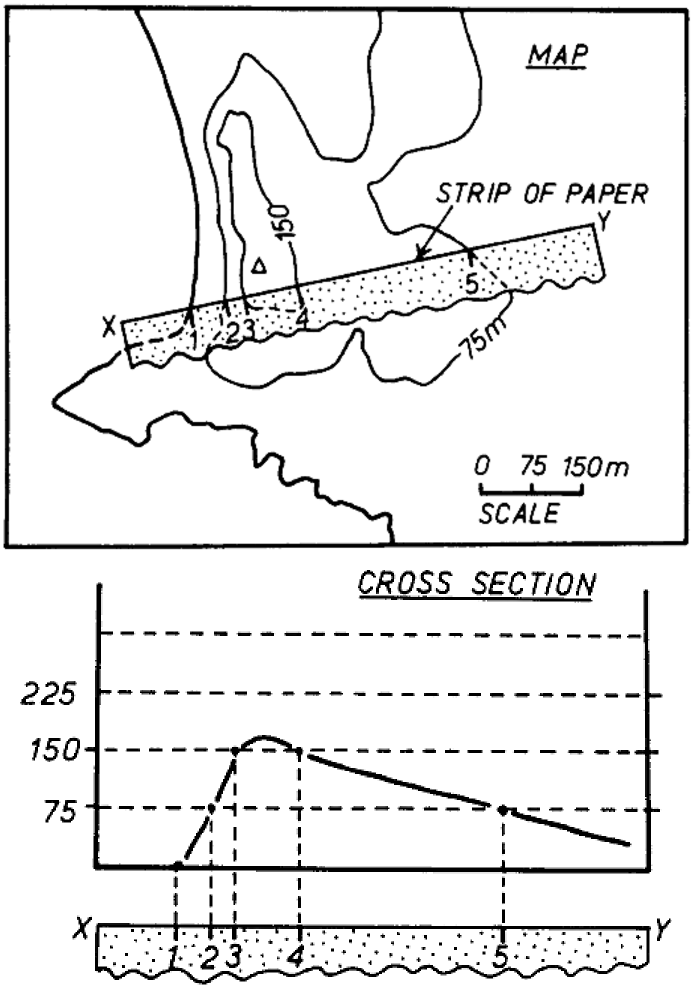
At many outcrops where dipping beds are exposed the bedding planes themselves are not visible as surfaces. Cliffs, quarries and cuttings may provide more or less vertical outcrop surfaces which make an arbitrary angle with the strike of the beds. When such vertical sections are not perpendicular to the strike, the beds will appear to dip at a gentler angle than the true dip. This is an apparent dip.

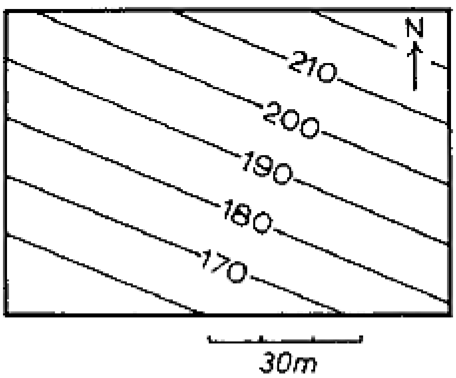


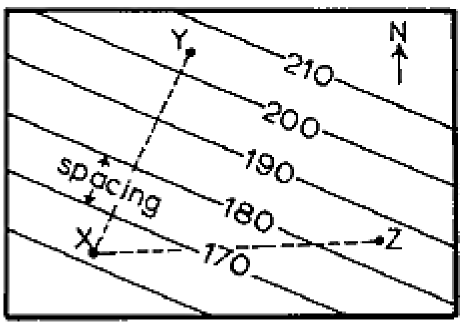
The tangent of the angle of apparent dip = p/q,
The tangent of the angle of true dip = p/r and
The cosine of the obliquity angle = r/q.

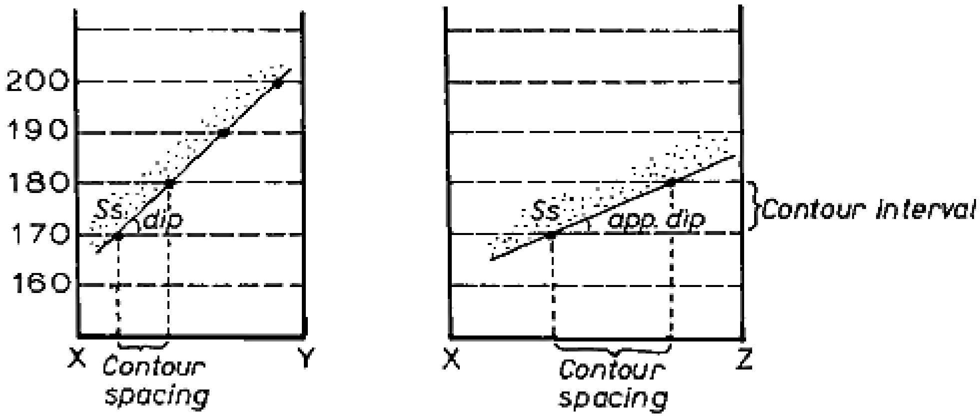
Since it is true that: p/r X r/q = p/q
It follows that:
tan (apparent dip) = tan (true dip) X cos (obliquity angle)

Interpreting Geological Maps:







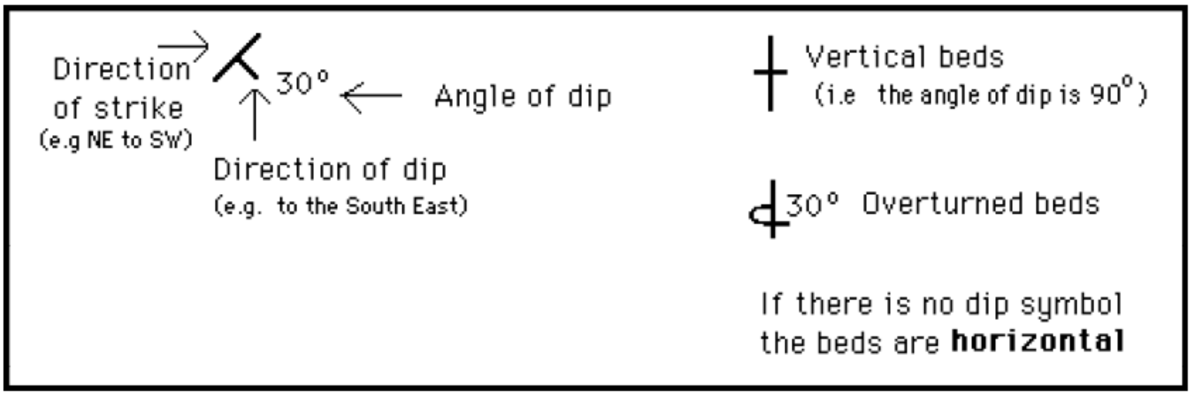


$$Tan(angle\ of\ dip) = \frac{Contour\ Interval}{Contour\ spacing}$$

Or

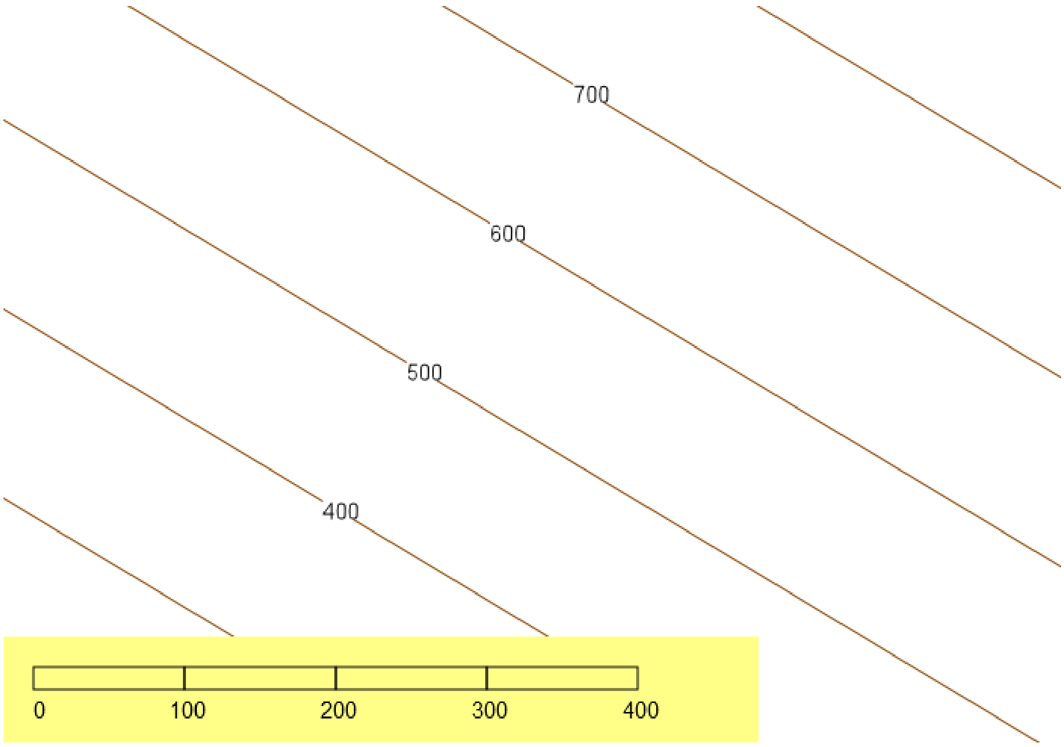
$$Dip = tan^{-1}\frac{Contour\ Interval}{Contour\ spacing}$$

Contour Spacing is the horizontal distance between the contours) exaggerated to actual with the map scale).

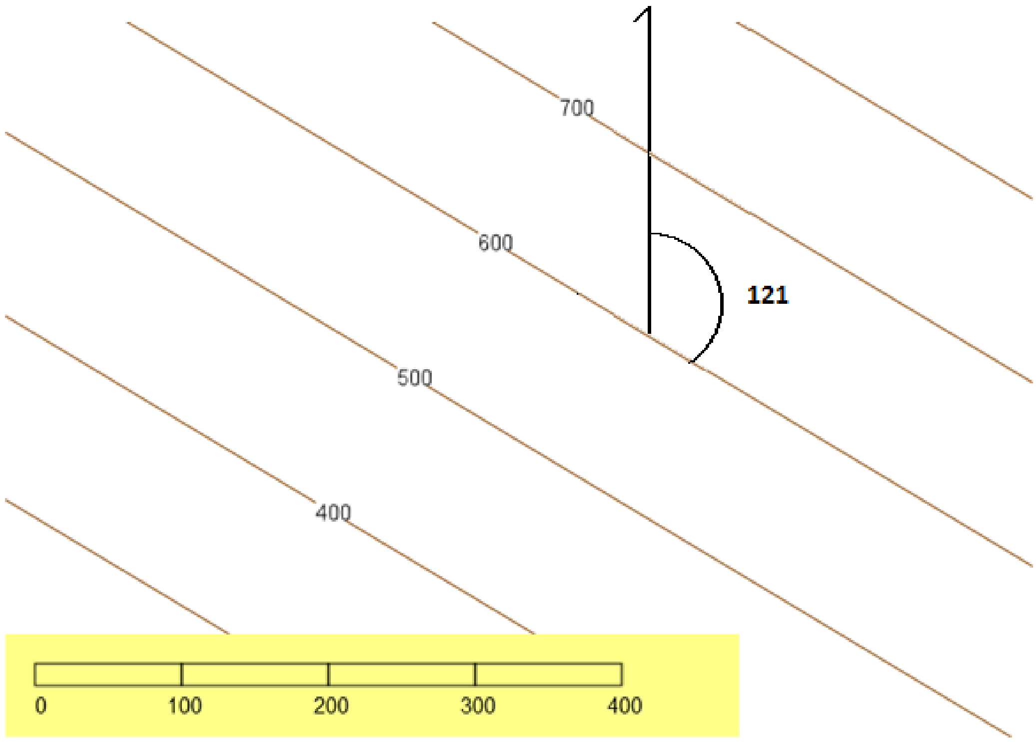


Calculation of dip & strike from contours:

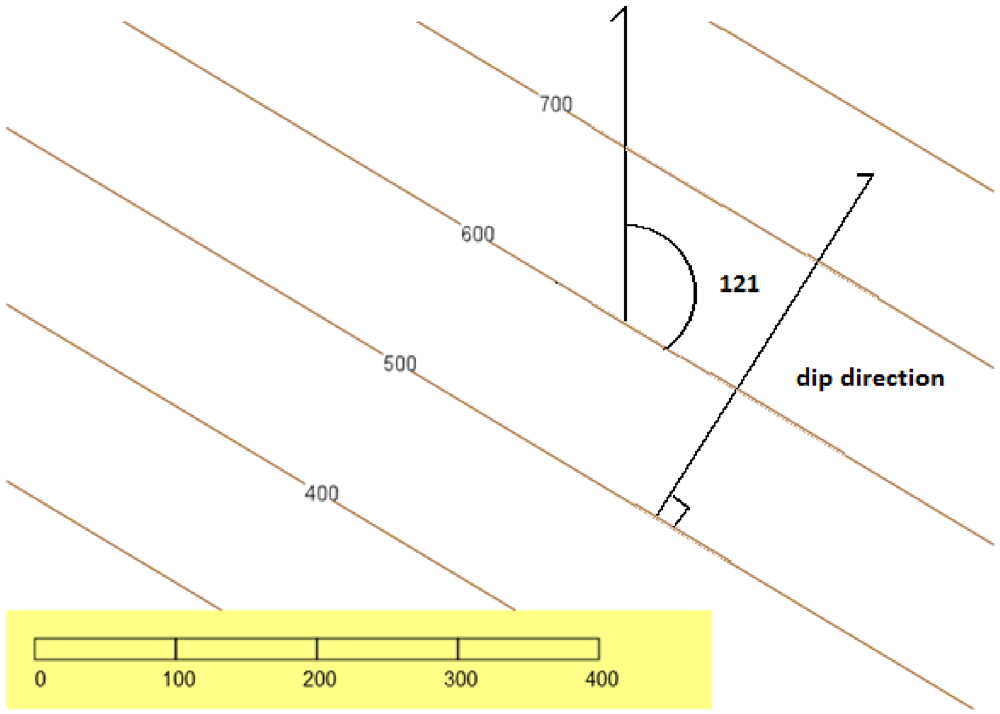
Let the contours of a geologic map be as followed.



Strike is simple. Measure the azimuth of a structure contour clockwise from north. The Strike is 121. We can see from the contours the dip direction is SW

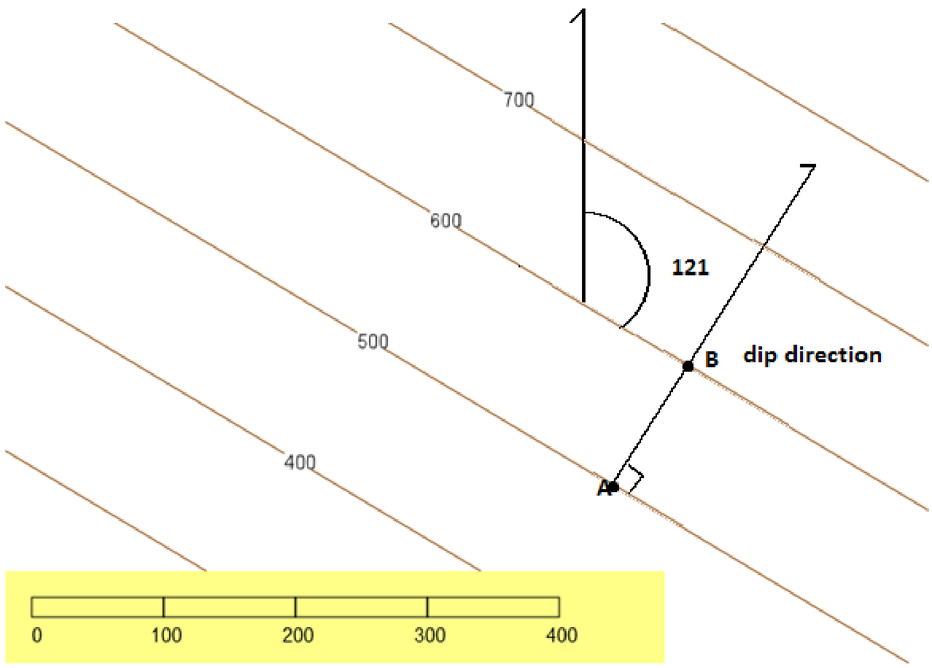


From the figure it is evident that each contour line is tilted from the normal (121^o). From this it can be inferred that all are strike lines of a geological structure. Now Dip is always perpendicular to strike. So drawing Perpendicular (⊥) to any Strike or contour line will give the dip direction.



The dip direction line form the contours can be used in determining dip using trigonometry.

First calculate the spacing between the two strike line (contours), called Contour spacing. Here in the fig. it is AB. Then exaggerate it with the scale on the map given.



The distance between AB (Contour Spacing) on map, can be extrapolated with the scale. The scale shows 2.42:100 and the distance between AB on map is 2.6(cm. aprox). Upon extrapolation, the contour spacing will be 107 m. (2.42:100=2.6:x, where x=107.438).

Now once the contour spacing is determined, dip can be calculated by trigonometry.

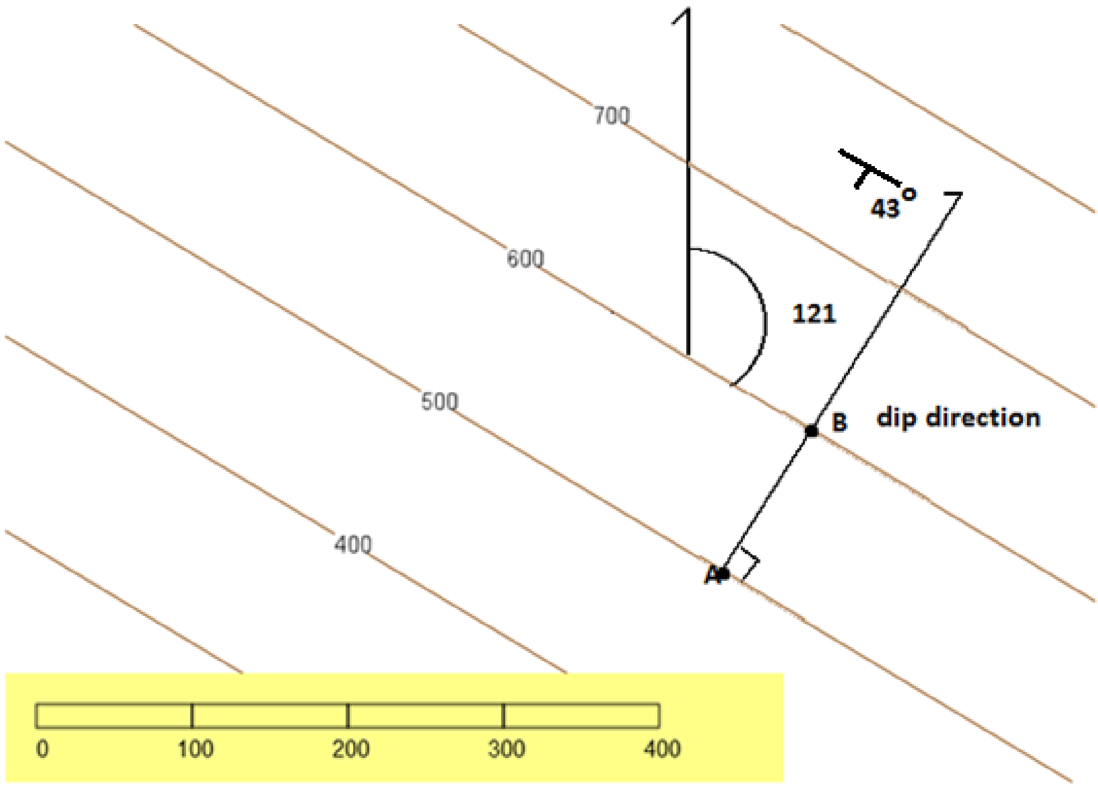
$$Dip = Tan^{-1}\frac{Contou\ Intervel}{Contour\ Spacing}$$

$$Dip = Tan^{-1}\frac{100}{107.438}$$

$$Dip = Tan^{-1}(0.9307)$$

$$Dip = Tan^{-1}(0.9307)$$

$$Dip = 42.944 => 43^o$$



Calculation of Dip and Strike when apparent dip is given.

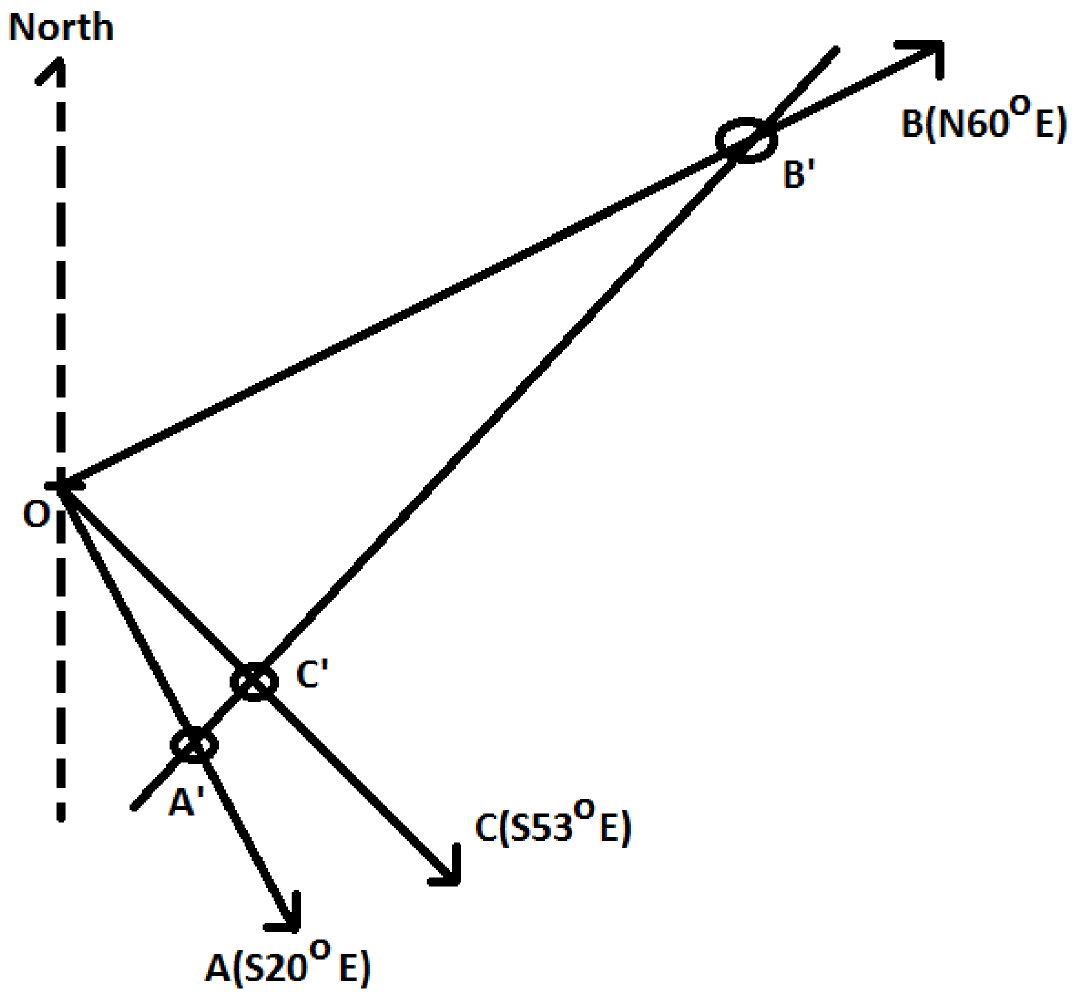
Problem1.

The apparent dips were recorded in a sand stone quarry are 1:5 due S20°E & 1:11 due N60°E. Find the direction and amount of true dip.

Procedure:

1. Let O be the point on normal.
2. From point O, lines OA and OB are drawn due S20°E & N60°E respectively (as shown in fig.).

3. The amount of the apparent dips (given in problem) are marked as OA' – 5" and OB' – 11".
4. A line is drawn joining points A' & B', this represents the horizontal plane.
5. Perpendicular OC is drawn from O which is perpendicular to A'&B'.
6. The Perpendicular OC cuts A'B' at C'. This will be line representing true dip. & OC' represent the amount of Dip.



OA	=	Apparent dip direction, S20^{o}E.
OA'	=	Amount of Apparent dip along OA – 5 Units (5Cm).
OB	=	Apparent dip direction, N60^{o}E.
OB'	=	Amount of apparent dip along OB – 11 Units (11Cm).
A'B'	=	True Strike line.
OC	=	True dip direction, S53^{o}E.
OC'	=	True dip amount along OC – 4.2 Units (4.2Cm).