Indian Institute of Technology, Kanpur

Department of Earth Sciences

ESO213A: Fundamentals of Earth Sciences

Lecture 17. Structural Elements

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Aims of this lecture

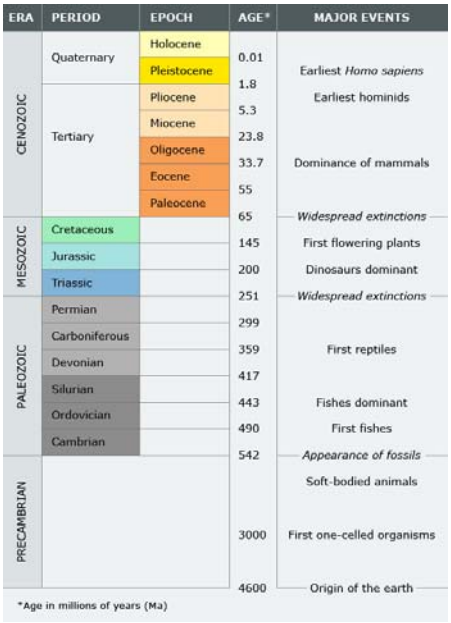
- Basic concepts of geological contacts and there applications in Structural Geology
- Attitudes of Planar, linear and angular features – what to measure and why?
- Concept of structural measurements
- Planar and linear features and their measurements

Structural Measurements – what and why?

- Understanding the structures in field is puzzling. This is mostly because, the exposures are not always continuous, difficult to access and all features are not present everywhere. These unavoidable characteristics of field geology, particularly for the interpretation of large structures, make the subject extremely challenging.
- Most of the geological observations, particularly in large scale (a few 100 meters or more), are generally two dimensional. The observations are usually presented in a map and the third dimension (relief or depression) is considerably negligible. However, geological structures are essentially three dimensional and one has to interpret the 3D geometry of the structures, unless considered otherwise.
- Rocks display various types of geometric elements are different scales. The elements can be broadly classified as planer- and linear-elements. Bedding, foliations, schistosity, cleavage etc. can be considered as ***planes*** whereas geological features like fold axes, mineral lineation, and paleocurrent directions are ***lines***.

Stratigraphic Sequence (geological contacts)

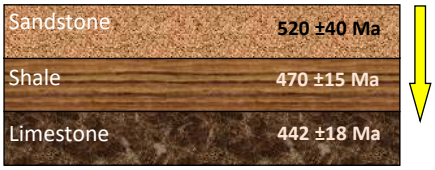
- The establishment of the lithological and/or stratigraphic sequence is a prerequisite in interpreting the large-scale structures and the history of an area.
- Any structural information has little meaning without its lithological (sedimentological or petrological) and age (paleontological or radiometric) context.



Stratigraphic Sequence (geological contacts)

Normal Sequence/Stratigraphy

Unconformity



Inverted Sequence/Stratigraphy

Repetition of Stratigraphic sequence

Stratigraphic Sequence – THINGS TO REMEMBER

- Layering in deformed metamorphic rocks (secondary layering) does not necessarily represent bedding. Thus it is important, wherever possible, to demonstrate the existence of bedding and stratigraphy, which can be obtained by identification of sedimentary structures that define the "way up" of the beds. Selecting a distinctive marker horizon is useful to picture regional structures.
- A deformation structure is necessarily younger than the age of the host rocks.
- An unconformity in stratigraphy marks the time of a major tectonic event.
- Inverted stratigraphy and/or repetition of stratigraphic sequence also suggest a single or multiple deformation events in the host rock.

What to measure?

The sediments are deposited (and/or precipitated) along horizontal planes and subsequently lithified to form rock-strata. After deformation, the horizontal strata do not necessarily remain horizontal.

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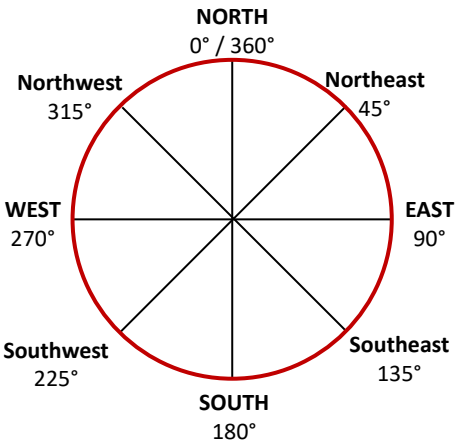
Structural Measurements – Basics

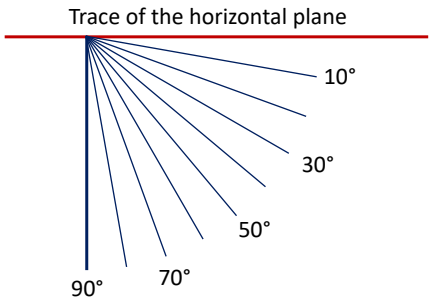
- **POINTS**
  - One set of coordinates
  - Distance and direction from a reference point
  - Intersection of two lines
  - Intersection of three planes
- **LINES**
  - Defined by two sets of coordinates
  - Defined by two points
  - Distance from a reference point & the direction of the line
  - Intersection of two planes
- **PLANES**
  - Defined by three sets of coordinates
  - Defined by three points
  - Defined by distance and direction from reference points/line
  - Defined by two intersecting or two parallel lines

Azimuth (Direction) and Inclination

Azimuth: measured along horizontal plane in degrees (°)

Inclination: measures the angle of tilt/slope at which the plane/line is oriented from the horizontal plane





A few common words of Structural Geologists

TREND

DIP

FRONT-BEARING

PLUNGE

STRIKE

Attitude

APPARENT-DIP

BACK-BEARING

PITCH

RAKE

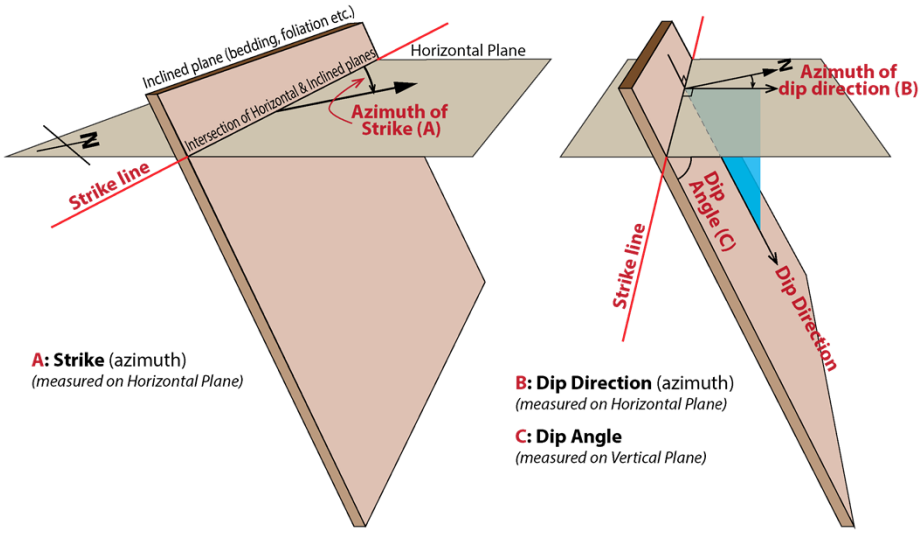
Azimuth

DIP-ANGLE

DIP-DIRECTION

All there are related to measurements of lines and planes

Orientations of Planes



RIGHT HAND RULE FOR MEASURING STRIKE. MAKES LIFE EASY.

Orientations of Planes

STRIKE:
Direction of the line of intersection between an inclined plane and a horizontal plane **OR** the strike is the compass direction of the horizontal line lying in an inclined plane

DIP ANGLE:

Inclination of a plane below the horizontal; 0°≤ dip ≤90° **OR** the dip is the large angle made by the plane with the horizontal

- *The azimuth directions of strike and dip are perpendicular.*

DIP DIRECTION:

The compass direction towards which the plane slopes

APPARENT DIP ANGLE/ DIRECTION:

Any dip angle/direction measured in a vertical plane that is not perpendicular to the strike line

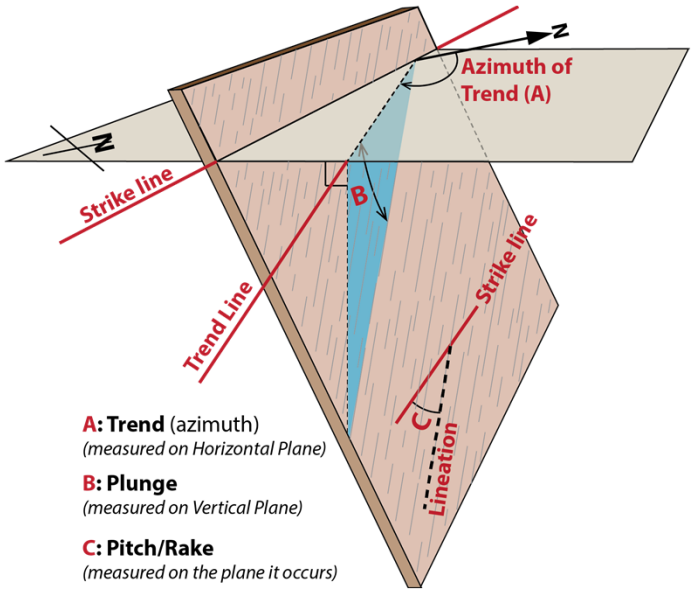
Structural Measurements – what and why?

TREND:
Direction (azimuth) of a vertical plane containing the line of interest.

The trend "points" in the direction a line plunges

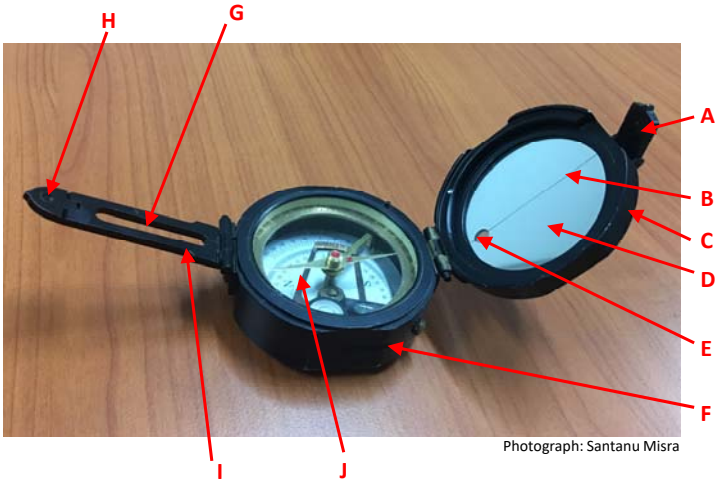
PLUNGE:
The inclination of a line below the horizontal

PITCH:
The angle, measured on a plane of specified orientation, between one line & a horizontal line (strike)



The tool to measure the orientation data

BRUNTON COMPASS *(there are many other compasses, you will be using Brunton)*



Photograph: Santanu Misra

A: Folding Sight

B: Axis Line

C: Lid

D: Mirror

E: Sighting Window

F: Base

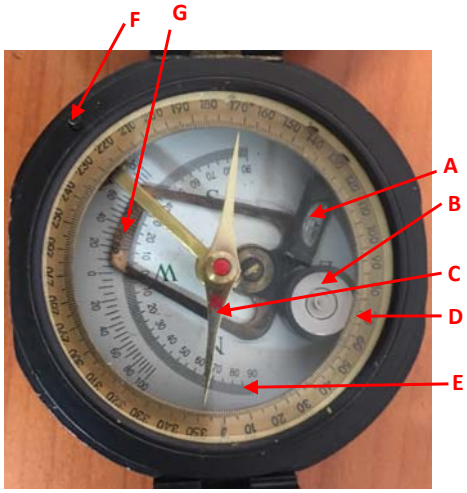
G: Open Slot

H: Peep Sight

I: Sighting Arm

J: Dial *(next slide)*

Parts of Brunton Compass



Photograph: Santanu Misra

A: Long Level – Use for taking azimuth measurements of strike and dip.

B: Circular (Bulls Eye) Level – Use for taking angle measurements of dip.

C: Iron Needle – Points to magnetic North and it is damped using the magnet below the pivot point. But the bearing can be adjusted accordingly by rotating the declination zero pin.

D: 360-degree Graduated Circle – Use for azimuth readings that are accurate to half of a degree.

E: 90-degree Dip Circle – Use for measuring dip using the long level on the vernier.

F: Needle Pin – Helps to lock the needle in place in order to take a reading.

G: Vernier – The vernier is used for inclination measurements with an accuracy to 30 minutes.

How to note Strike and Dip

- There are many styles, geologists use to note dip and strike. Sometimes confusing.
- Usual convention is: STRIKE / DIP ANGLE / DIP DIRECTION *[if you follow the right hand rule, you do not have to mention the DIP DIRECTION; adding 90 with the strike will give you dip direction]*
- Strike must be written in 3-digit numbers (e.g., 078, not 78)
- Assume a bedding plane has a strike 120° (measured following right hand rule); dip angle 45°.

120/45

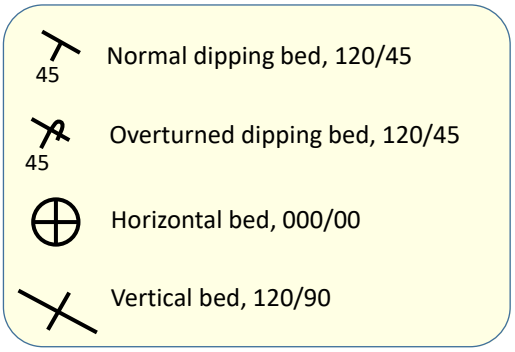
Or,

120/45→210

Or,

120/45 SW

[3-digits/2-digits format]



How to note (write) Trend and Plunge

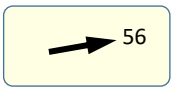
- Fortunately, and unlike dip-strike, geologists follow unique style in mentioning Trend and Plunge.
- Usual convention is: PLUNGE / TREND
- Trend must be written in 3-digit numbers (e.g., 078, not 78)
- Assume a linear element has a trend 080° and plunge 56°.

56/080

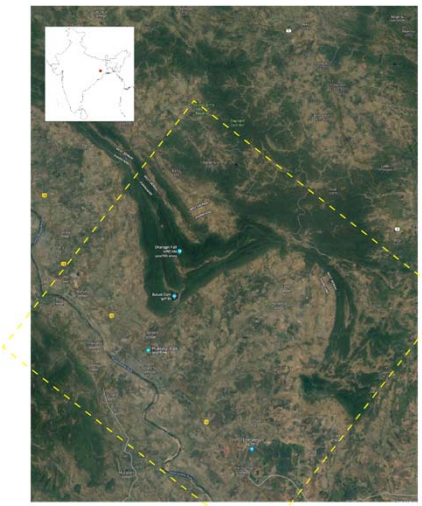
Or,

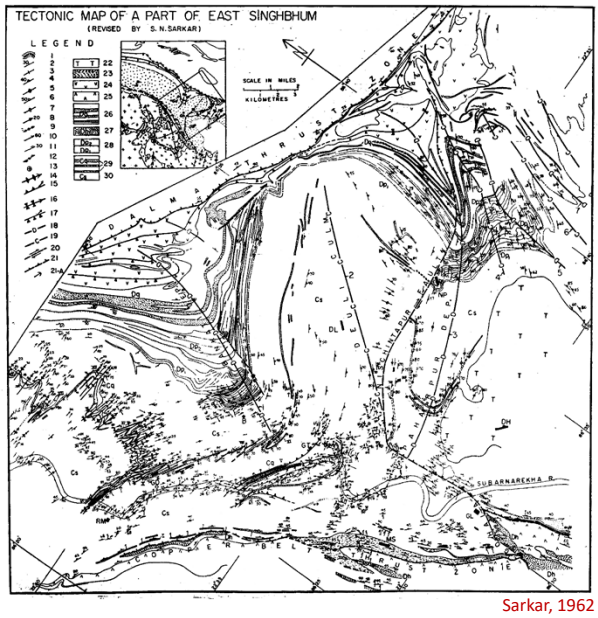
56 → 080

[2-digits/2-digits format]



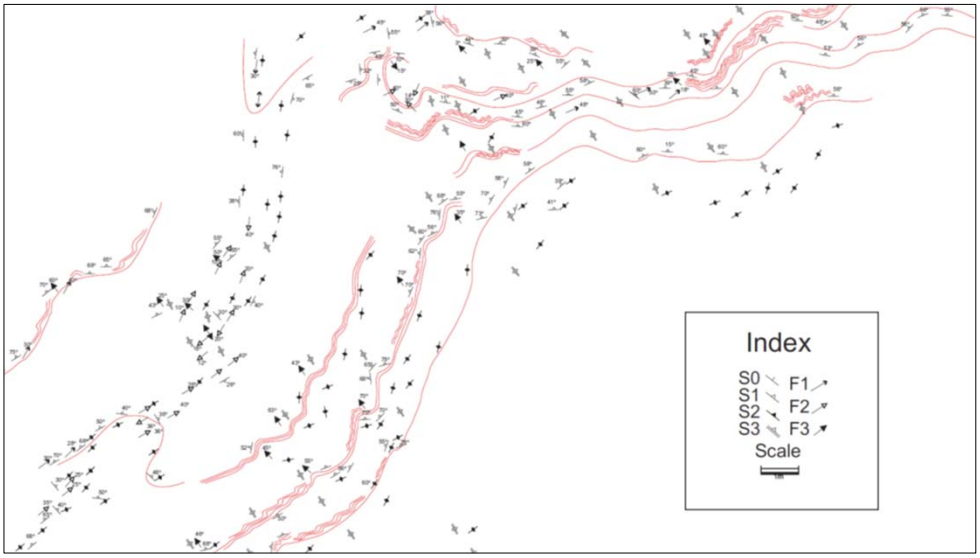
A structural map with measured Structural data





Sarkar, 1962

A structural map with measured Structural data



Next Lecture

Estimating the Deformation: STRAIN