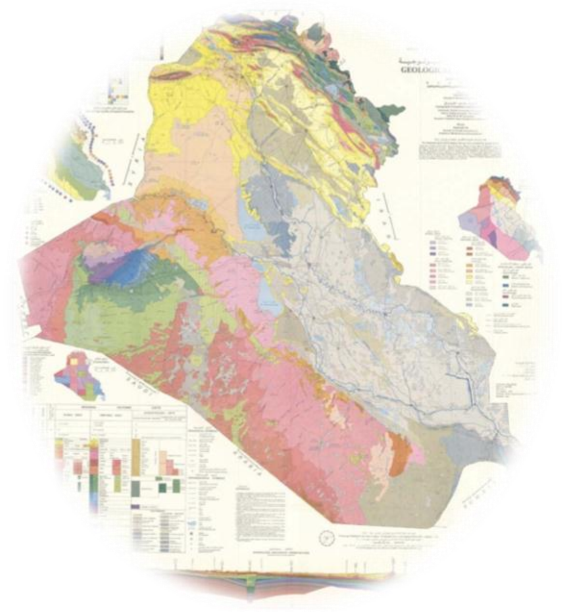
Engineering Geology CE1301

Lecture #8 **Topographic and Geologic Maps**



Muayad A. Al-Sharrad

Ph.D. Geotechnical Engineering

Assist. Prof.- Department of Civil Engineering

University of Anbar

Room 012

Civil Engineering Building

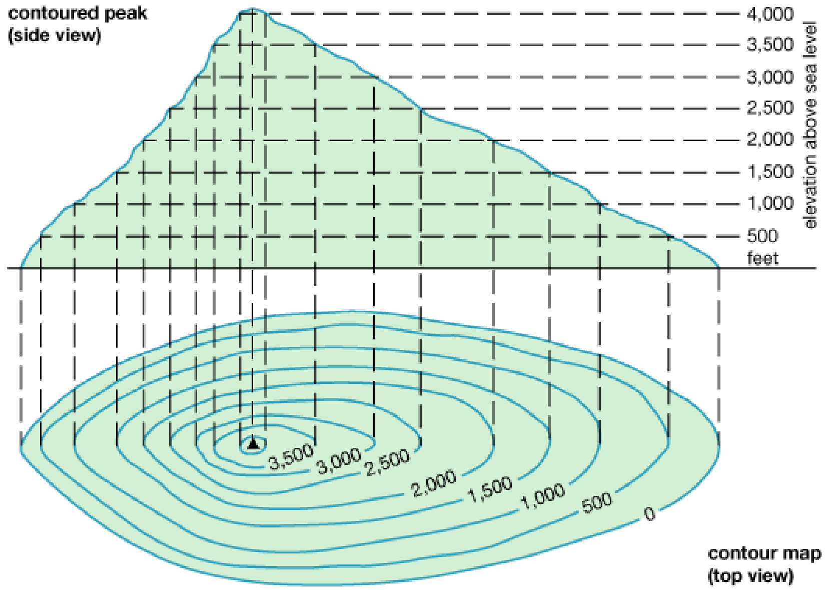
Ramadi 31001

Iraq

Email: muayad.alsharrad@uoanbar.edu.iq

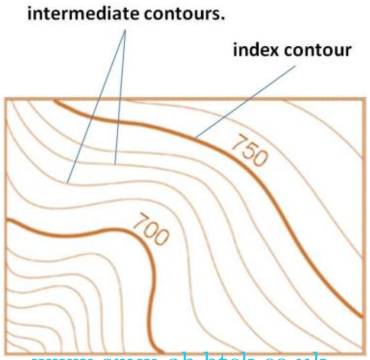
TOPOGRAPHIC MAPS

- **Topography:** general configuration and shape of the land surface.
- **Contour lines:** lines that connect points of equal elevation on a curved surface above or below a reference datum such as sea level.
- **Contour interval:** is the difference between two successive contour lines.
- **Benchmark** (B.M.) is a point of known elevation serves as a reference for other points.
- **Topographic contours:** represents the shape of the ground surface.
- **Structure contours:** represents the shape of the geological surface including bedding planes, fold shapes, fault planes, etc.



<u>Contours have general characteristics such as:</u>

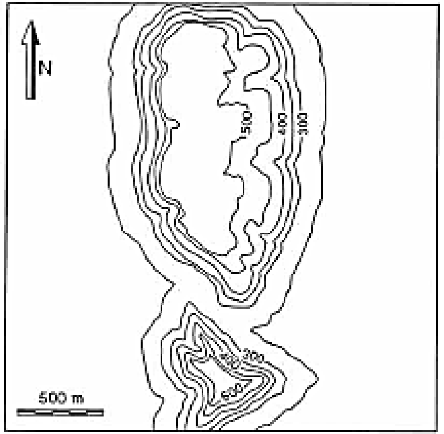
- Contour lines do not cross. Crossing contour lines denote overhanging cliff.
- The spacing of the contour lines reflects the gradient of the slope. The closer the contours, the steeper the ground.
- The difference in elevation between adjacent contour lines is constant on any given map.



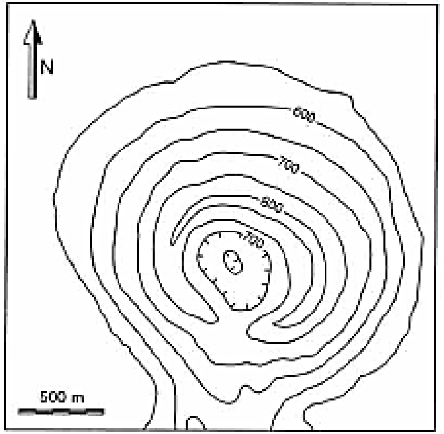
www.smw-ab.btck.co.uk

Example contour maps

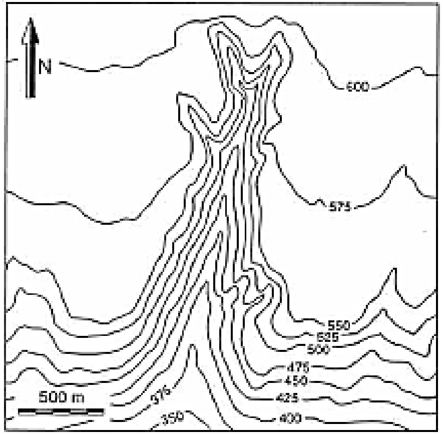
a) Contour map of mesa and butte



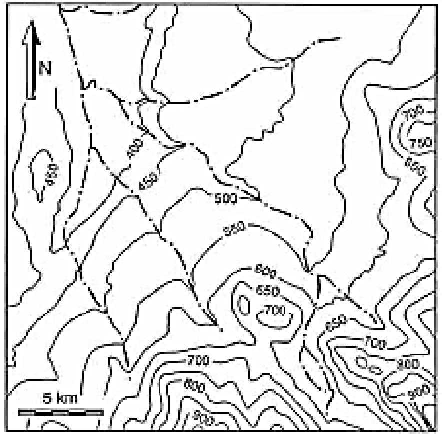
b) Contour map of volcano



c) Contour map of a canyon



d) Contour map of a hillside



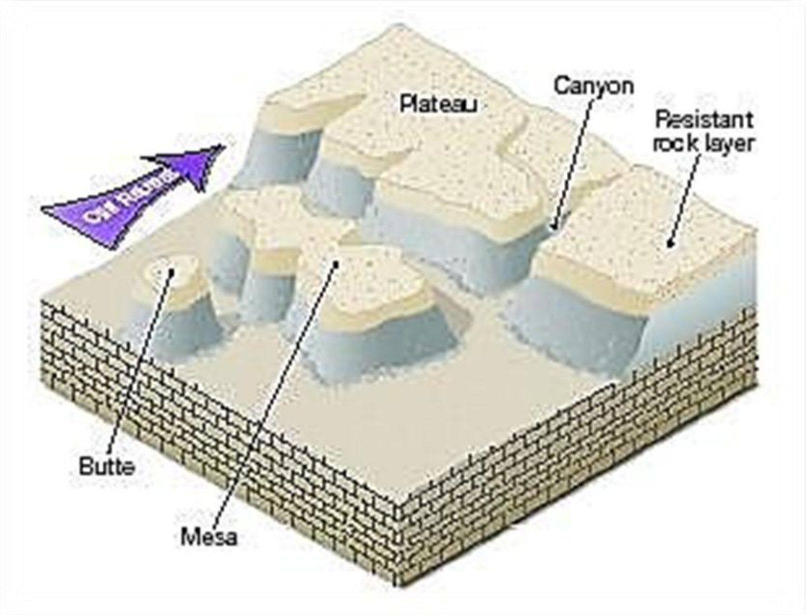


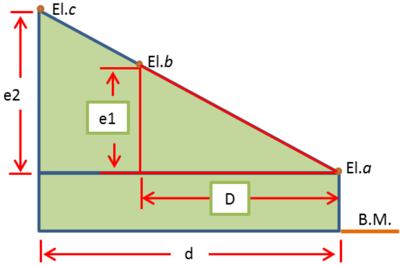
Image source: www.canyontours.com

Constructing Contour lines from 3 elevation points

❖ For the three elevation points, a simple contour map can be plotted as following:

- Connect the three points with a temporary dashed lines;
- Select a sensible contour interval, let's say 5 m;
- Find the relative positions of the subdivisions on each dashed lines and mark them with small lines or circles, etc. This can be done by using the following relationship:

D=d*e1/e2

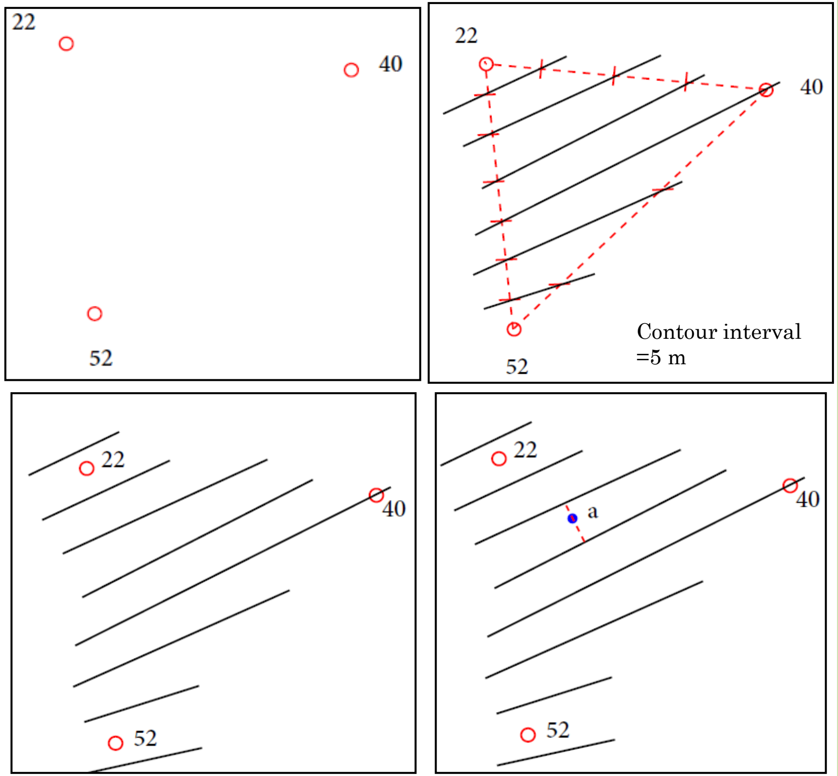


where
D=Distance, on the map, from the smallest elevation;
d=distance between the two elevation points,
e1= difference in elevation between the required elevation and points
e2= difference in elevation between the two points.

For example, to find the relative position on contour line at elev. 45m, passing between the elevations 40m and 52m, and if contour interval is 5 m and *d= 10 cm, then*

D=10(45-40)/(52-40)=4.2 cm from elev.40.*

- Connect points of the elevations with straight contour lines.
- Note that the resulting contour map represents a planner surface just because the elevation points do not offer enough flexibility to represent the actual topography.
- The final contour map is obtained by eliminating the dashed lines.

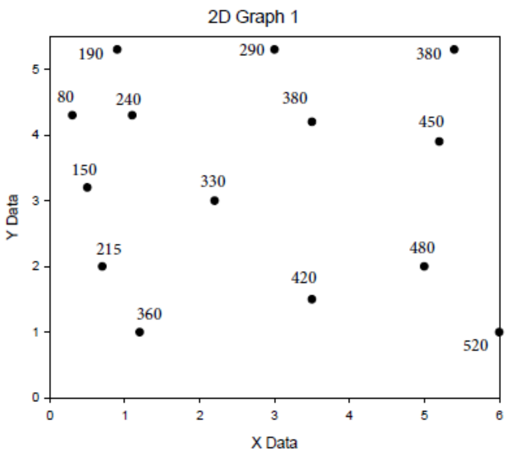


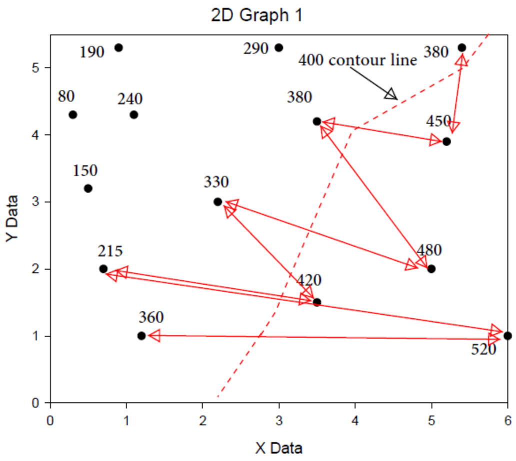
- Elevation of point *a*?

This elevation can be obtained by knowing the relative normal distance of the point between the two successive contour lines 30 and 35 as following:
Let's assume that the length of the dashed line is 1 cm and the distance to point *a* from the contour line 30 is 0.3 cm, then
elevation of point *a*=30 + (0.3/1)*5= 31.5 m.

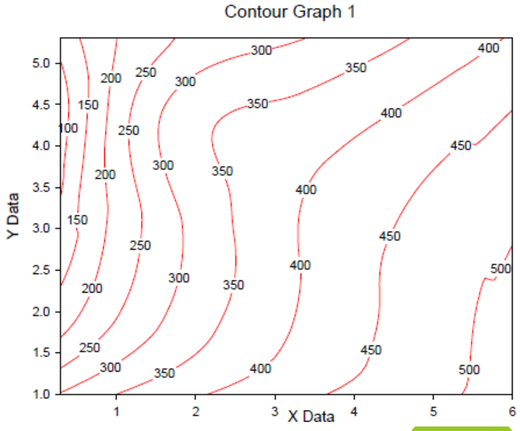
Constructing Contour lines from more than 3 elevation points

- Contour lines are plotted following the same steps described in the previous case.
- A typical fitting exercise is shown for the contour line 400.
- The resulting contour map is no longer planer.





Contour interval=50m



This map was plotted by using [SigmaPlot software](). Many other softwares can also be used such as Matlab, Surfer, etc.

SIGMAPLOT®
Exact Graphs and Data Analysis

Vertical cross-sections through topographical and geological surfaces

Lisle (2004), see the references

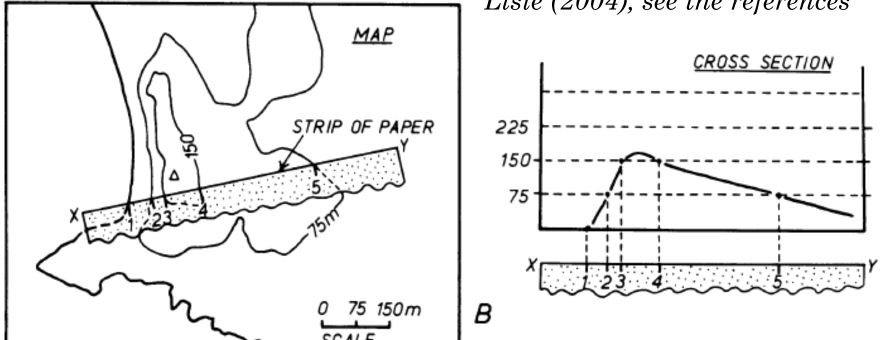


Fig. 2.13 Construction of a cross-section showing surface topography.

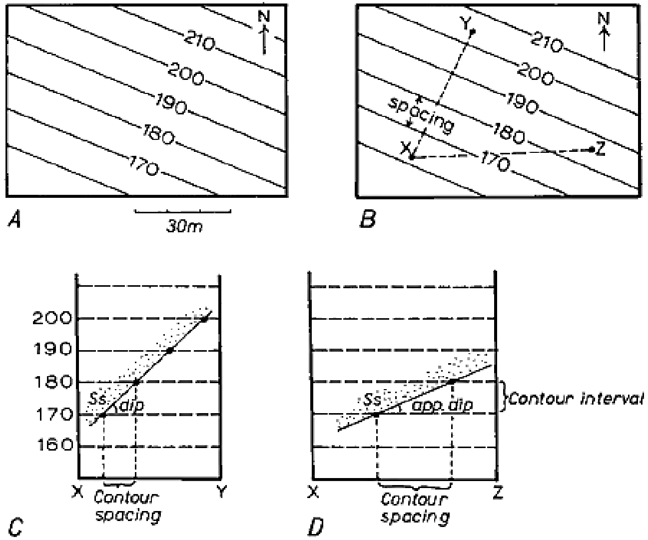


Fig. 2.14 Drawing sections.

Example Figure 2.14A shows a set of structure contours for the surface defined by the base of a sandstone bed. **Find the direction of strike, the direction of dip and the angle of dip of the base of the sandstone bed. What is the apparent dip in the direction XZ** (Fig. 2.14B)? Vertical sections.

- **Strike direction:** the strike of the surface at any point is given by the trend of the contours for that surface. On Fig. 2.14A the trend of the contours (measured with a protractor) is 120°N.
- **Dip direction and dip angle:** 90° different from the strike direction; giving 030° and 210° as the two possible directions of dip. The heights of the structure contours decrease towards the southwest, which tells us that the surface slopes down in that direction. The direction 210° rather than 030° must therefore be the correct dip direction.

Angle of dip of the base of the sandstone: we must calculate the inclination of a line on the surface at right angles to the strike. A constructed vertical cross-section along a line XY on Fig. 2.14B will tell us the true dip.

From the cross section in (Fig. 2.14C) :

Tangent (angle of dip) =contour interval/ spacing on map between contours

=10m/10m= 1

Angle of dip = $\tan^{-1}(1)$ = 45°.

Apparent dip in direction XZ: is the observed inclination of the sandstone bed in true scale (vertical scale = horizontal scale) vertical section along the line XZ. The same formula can be used as for the angle of dip above except 'spacing between contours' is now the apparent spacing observed along the line XZ.

Geological map: a map on which is recorded geologic information, such as the elevation, distribution, nature and age relationships of rock units, structural symbols and features (folds and faults), etc.

Please click here to watch this illustrative video on geological mapping

The use of geological map

The most obvious use of a geological map is to indicate the nature of the near-surface bedrock.

- To study the geological history of an area and to gather information about forms of common geological structures such as faults and folds;
- For civil engineers to advise on the excavation of road cuttings or on the siting of dams and bridges;
- To study the use of land and minerals exploiting.

Outcrop patterns of geological surfaces exposed on the ground

- A geological surface crops out at points where it has the same height as the ground surface.
- The line of outcrop of a geological surface crosses a structure contour for the surface only at points where the ground height matches that of the structure contour.

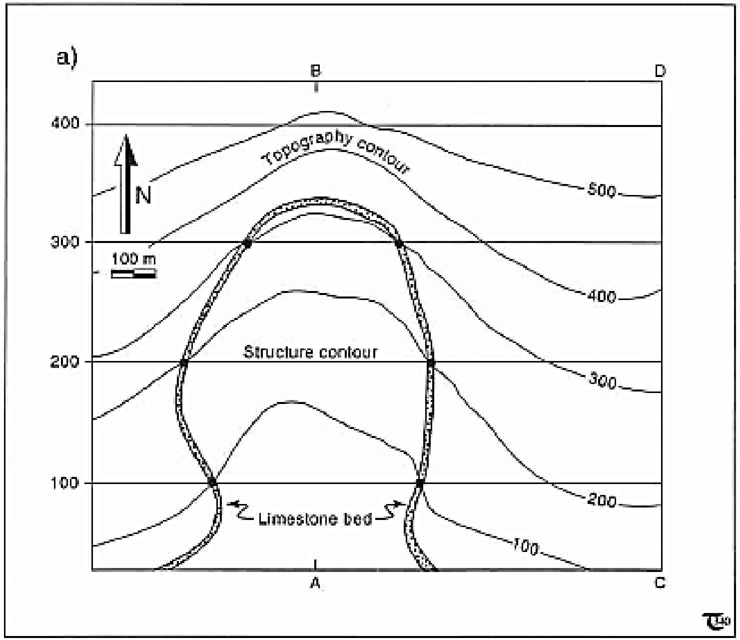


Figure 5-7a: Geological map, including three types of contours: elevation contours, structure contours, and contours outlining the outcrop pattern of a limestone bed. Contours are in meters.

Reference: Weijermars (1997), see the references

GEOLOGICAL MAP

Outcrop patterns of geological surfaces exposed on the ground

Prediction of the map outcrop pattern of the coal seam from the map in Figure 2.16a.

- The thin coal seam in the example only occurs at the ground surface along a single line. The surface at other points on the map (a point not on the line of outcrop) is either buried (beneath ground level) or eroded (above ground level).
- The line of outcrop in Fig. 2.16B divides the map into two kinds of areas:
  - (a) areas where height (coal) > height (topography), so that the surface can be thought to have existed above the present topography but has since been **eroded** away, and
  - (b) areas where height (coal) < height (topography) so that the coal must exist below the topography, i.e. it is **buried**.

The boundary line between these two types of areas is given by the line of outcrop, i.e. where height (coal) = height (topography).

- The red shaded area is the part of the area underlain by coal, see Figure 2.16C.
- A geological surface is buried below the topographic surface when height (topography) > height (geological surface). The difference (height of topography minus height of geological surface) equals the depth of burial at any point on the map. **Depths** of burial determined at a number of points on a map provide data that can be contoured to yield lines of equal depth of burial called ***isobaths***, as shown in see Figure 2.16D.

Lisle (2004), see the references

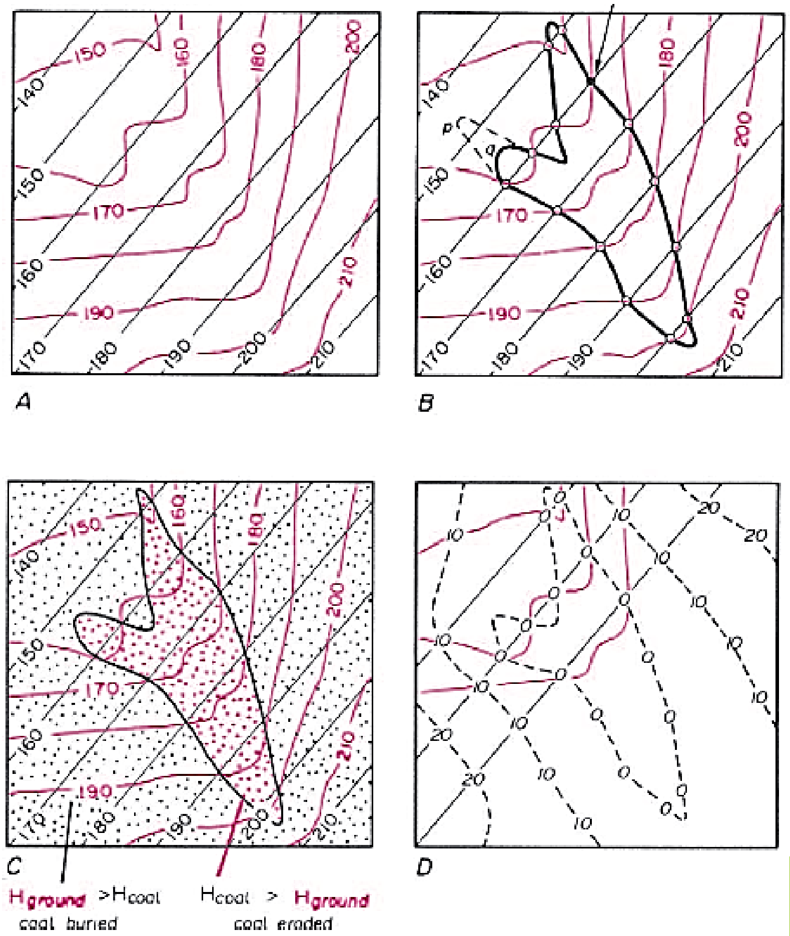


Fig. 2.16 Predicting outcrop and isobaths from structure contour information. Topographic contours are shown in red; structure contours for the coal seam are black.

Lisle (2004), see the references

Structure contours from outcrop patterns

A map showing outcrops of a surface together with topographic contours can be used to construct structure contours for that surface.

- ❖ where a surface crops out, the height of the surface equals the height of the topography.

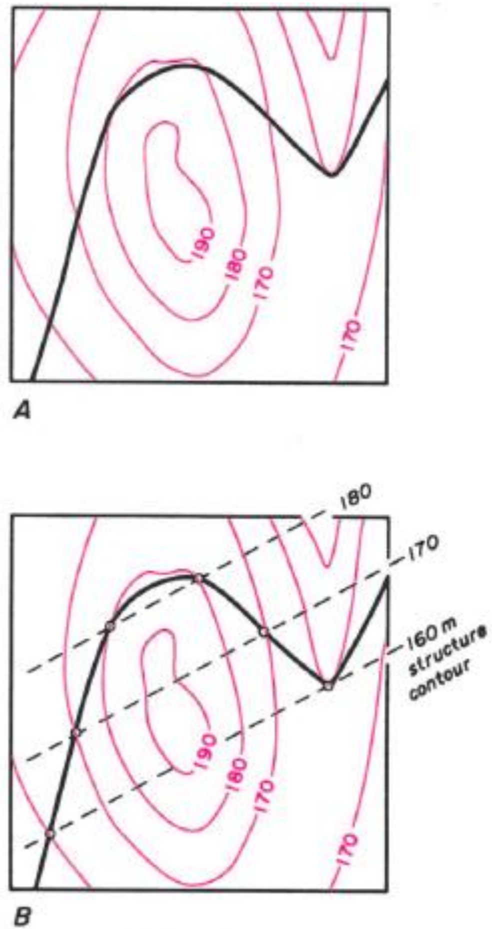


Fig. 2.20 Drawing structure contours.

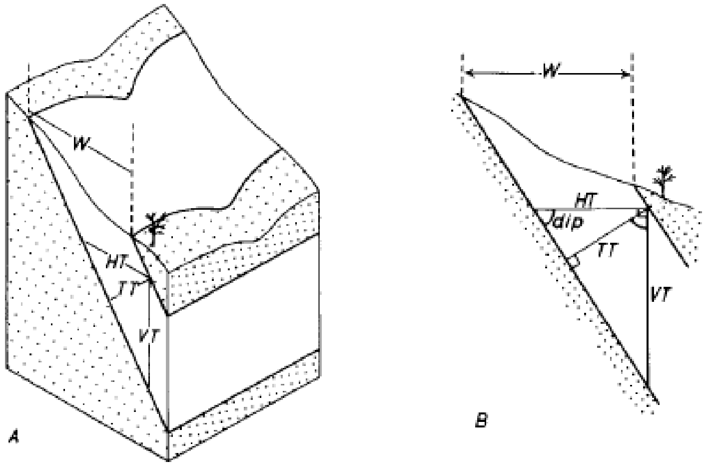
Example

Draw strike lines for the limestone bed in Fig. 2.20A. What assumptions are involved?

- Join points on the outcrop which share the same height. These join lines are structure contours for that particular height (Fig. 2.20B).
- Draw as many structure contours as possible to test the assumption of constant dip (planarity of surface).

The structure contours in Fig. 2.20B are parallel and evenly spaced. This confirms that the limestone bed has a uniform dip.

Lisle (2004), see the references



. .g. 2.21 Bed thickness and width of outcrop.

Stratigraphic thickness

- The *true* or *stratigraphic thickness* of a unit is the distance between its bounding surfaces measured in a direction perpendicular to these surfaces (TT in Fig. 2.21).
- The *vertical thickness* (*VT*) is more readily calculated from structure contour maps. The vertical thickness is the height difference between the top and base of the unit at any point. It is the vertical 'drilled' thickness, and is obtained by subtracting the height of the base from the height of the top.
- Depending on the angle of dip, the vertical thickness (*VT*) differs from the true thickness (*TT*), because from Fig. 2.20B:

$\cos(\text{dip}) = TT/VT$

therefore:

$$TT = VT\cos(\text{dip})$$

- The *horizontal thickness* (*HT*) is a distance measured at right angles to the strike between a point on the base of the unit and a point of the same height on the top of the unit.

- From Fig. 2.21B is can be also seen that

$\sin(\text{dip}) = TT/HT$

therefore,

$$HT = TT/\sin(\text{dip})$$

If *VT* and *HT* are both known, the dip can be calculated from

$$\tan(\text{dip}) = VT/HT$$

Notes

- The *width of outcrop* of a bed ***W*** on Fig. 2.21) **=** the horizontal thickness ***HT* when the ground surface is horizontal**.
- Vertical thickness ***VT*** will be correct in any vertical section but the true thickness will only be visible in cross-sections parallel to the dip direction of the beds.