Simple Geologic Maps and Cross – sections

A geologic map gives information about the type and location of bed rock units of various ages, contacts between different rock units, type and location of faults and folds, strike and dip of rock layers.

In addition geologic maps are used:

- **To locate rocks of particular age, lithology or structure.**
- **To construct cross-sections**
- **To reconstruct the geologic history of an area.**
- **To explore for natural resources**
- **To locate water supply and groundwater recharge zones.**

Basic Elements of a Geologic Map

a) Color, pattern & letter symbols

b) Explanation/ Legend/Map Key Explanation:

The series of boxes, suitably colored, patterned and labeled provides the identification of formation name and usually a brief lithologic description.

There are *standard map colors* for different countries.

C) Contact

Each of the formations on a geologic map must be enclosed by a contact.

d) Structural Symbology

Structural geologic maps display abundant structural symbology. *Contacts, bedding, joints, shear fractures, veins, faults, cleavage foliation, lineation and shear zones* are shown

e) Geographic coordinate system:

It can be given either in geographic lat/long or UTM

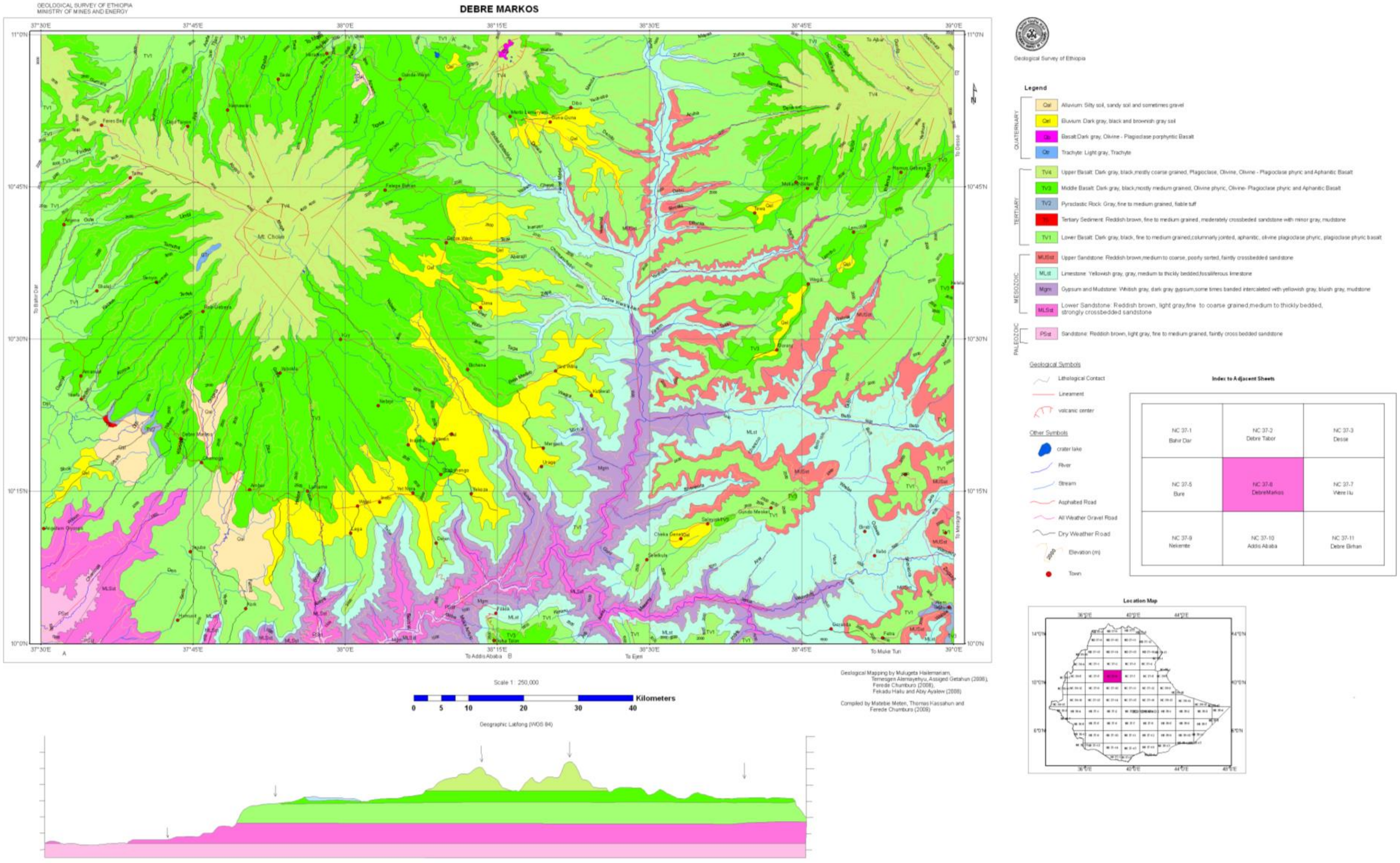
f) Scales and north arrows

g) Borders and Title

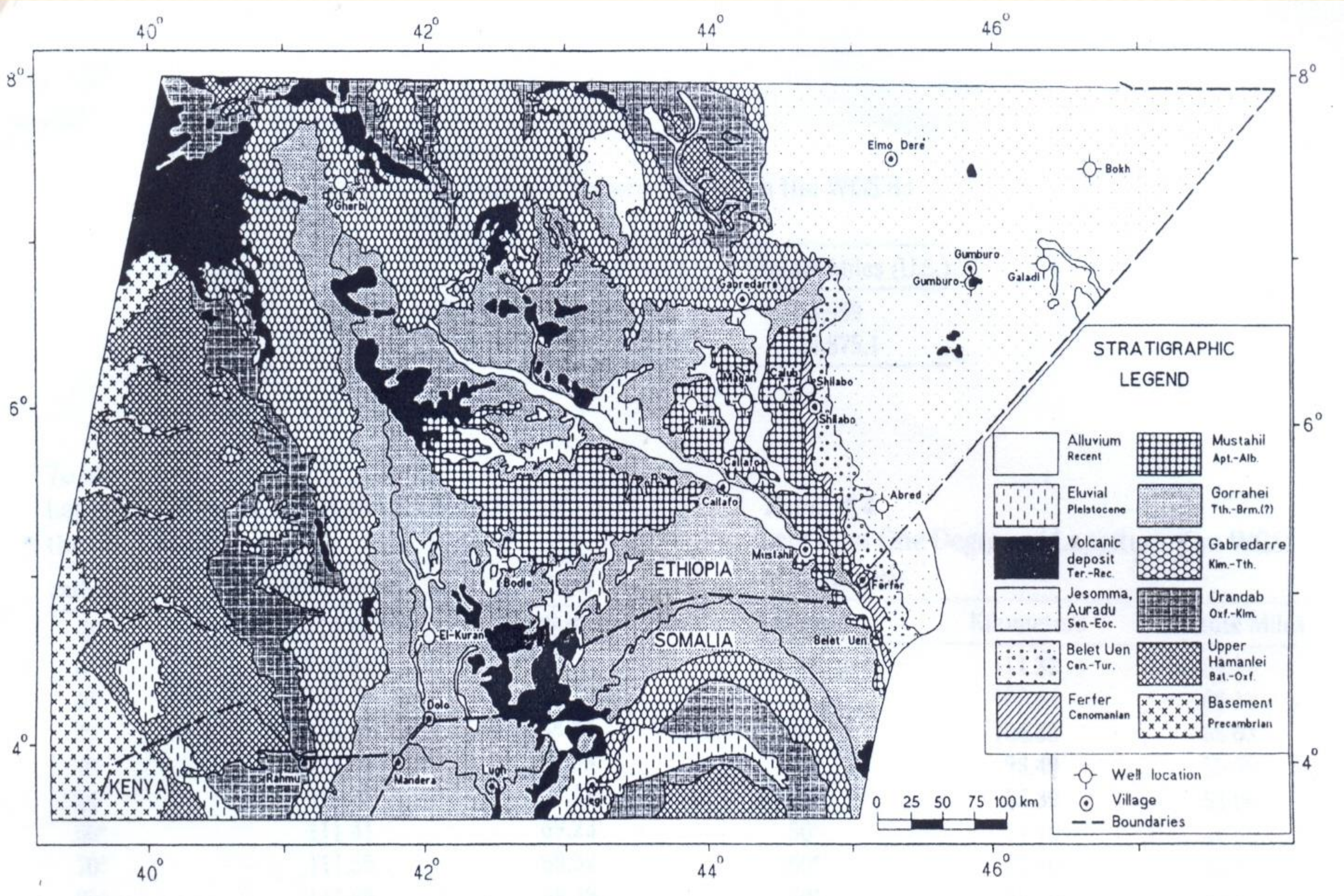
- Are final components of a geologic map
- Most borders are not colored
- The title of the map is mostly placed at the upper margin and the name of the geologist who prepared the map appears at the lower right hand corner.
- The source of the base map should appear in the lower left hand corner.

Map symbols for bedding, foliation and cleavage, and lineation

Bedding	
	Strike and dip of bedding
	Strike and dip of overturned bedding
	Strike and dip of vertical bedding
	Horizontal bedding
Foliation and Cleavage	
	Strike and dip of foliation
	Strike of vertical foliation
	Strike and dip of cleavage
	Strike of vertical cleavage
Lineations	
	Trend and plunge of lineation
	Strike and dip of foliation, and trend and plunge of lineation in the plane of foliation.
	Strike and dip of bedding, and trend and plunge of lineation in the plane of bedding.


GEOLOGICAL SURVEY OF ETHIOPIA
MINISTRY OF MINES AND ENERGY
DEBRE MARKOS
Geological Survey of Ethiopia
Legend
QUATERNARY
Qal Alluvium: Silty soil, sandy soil and sometimes gravel
Qel Eluvium: Dark gray, black and brownish gray soil
Qb Basalt: Dark gray, Olivine - Plagioclase porphyritic Basalt
Qtr Trachyte: Light gray, Trachyte
TERTIARY
TV4 Upper Basalt: Dark gray, black, mostly coarse grained, Plagioclase, Olivine, Olivine - Plagioclase phyric and Aphanitic Basalt
TV3 Middle Basalt: Dark gray, black, mostly medium grained, Olivine phyric, Olivine- Plagioclase phyric and Aphanitic Basalt
TV2 Pyroclastic Rock: Gray, fine to medium grained, fiable tuff
Tertiary Sediment: Reddish brown, fine to medium grained, moderately crossbeded sandstone with minor gray, mudstone
TV1 Lower Basalt: Dark gray, black, fine to medium grained, columnarly jointed, aphanitic, olivine plagioclase phyric, plagioclase phyric basalt
MESOZOIC
MUSst Upper Sandstone: Reddish brown, medium to coarse, poorly sorted, faintly crossbedded sandstone
MLst Limestone: Yellowish gray, gray, medium to thickly bedded, fossiliferous limestone
Mgm Gypsum and Mudstone: Whitish gray, dark gray gypsum, some times banded intercaleted with yellowish gray, bluish gray, mudstone
MLSst Lower Sandstone: Reddish brown, light gray, fine to coarse grained, medium to thickly bedded, strongly crossbedded sandstone
PALEOZOIC
PSst Sandstone: Reddish brown, light gray, fine to medium grained, faintly cross bedded sandstone
Geological Symbols
Lithological Contact
Lineament
volcanic center
Other Symbols
crater lake
River
Stream
Asphalted Road
All Weather Gravel Road
Dry Weather Road
Elevation (m)
Town
Index to Adjacent Sheets
NC 37-1 Bahir Dar
NC 37-2 Debre Tabor
NC 37-3 Desse
NC 37-5 Bure
NC 37-6 DebreMarkos
NC 37-7 Were Ilu
NC 37-9 Nekemte
NC 37-10 Addis Ababa
NC 37-11 Debre Birhan
Location Map
Mt. Choke
Debre Markos
To Bahir Dar
To Desse
To Addis Ababa
To Ejere
To Muke Turi
Scale 1 : 250,000
0 5 10 20 30 40 Kilometers
Geographic Lat/long (WGS 84)
Geological Mapping by Mulugeta Hailemariam, Temesgen Alemayehyu, Assiged Getahun (2008), Ferede Chumburo (2008), Fekadu Hailu and Abiy Ayalew (2008)
Compiled by Matebie Meten, Thomas Kassahun and Ferede Chumburo (2009)

Geological map of the Ogaden Basin and its surroundings (From BEICIP,1985).



Contours and Lithological Boundaries:

1. Horizontal and Inclined Beds

- Lithological boundaries may follow the contours if the area has horizontally stratified/bedded layers and not affected by any tectonic activities.
- In the case of inclined beds, lithological boundaries do not follow the contours.

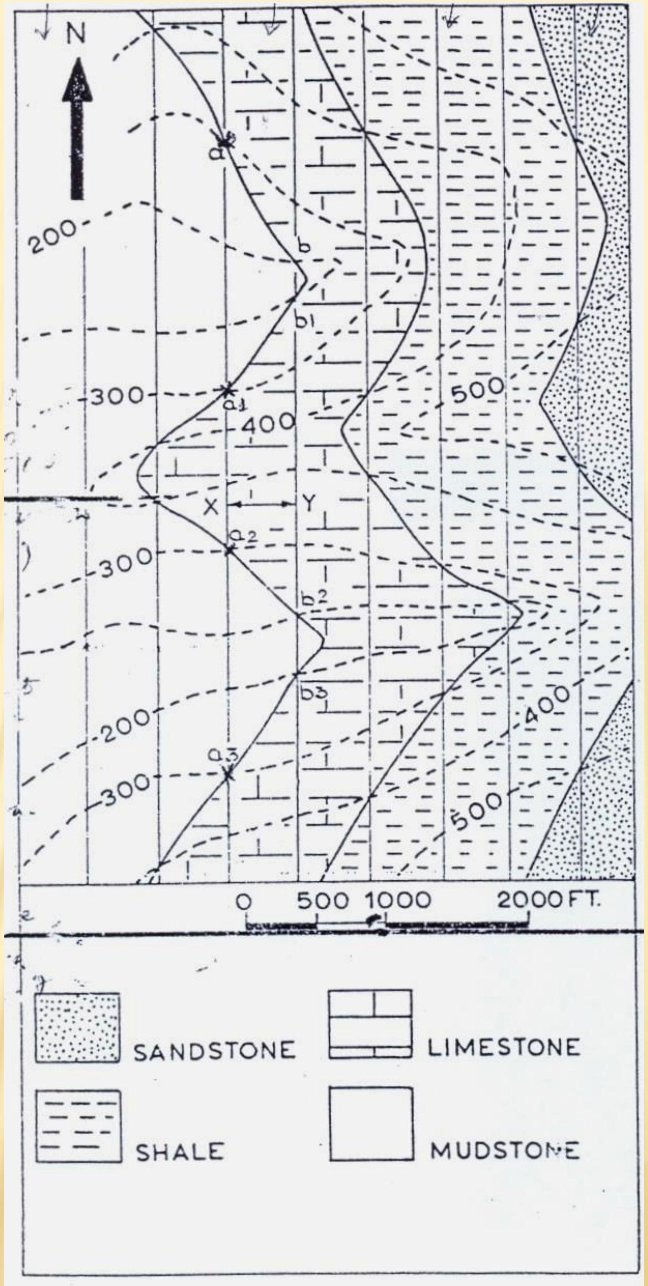
Determination of the Dip and Strike of a Rock Succession

Methods:

a) By Drawing Strike Lines

b) Outcrop pattern of uniformly dipping beds

- **If the strike and dip direction of the map unit is not known, an approximate orientation can be judged from the outcrop pattern of the formation.**
- **The relationship between the dip of the geological surface relative to the topography give the rule of V's**


N
200
300
400
500
a
b
b1
a1
X
Y
a2
b2
b3
a3
0 500 1000 2000 FT.
SANDSTONE
LIMESTONE
SHALE
MUDSTONE

The Rules of V’s are:

1) The apex of the "V” generally points in the direction of dip of the layers.

2) Acute “V” shapes reflect shallow dips.

3) Open "V” shapes indicate steep beds.

4) Horizontal beds always parallel the topographic contours and hence the beds still Vee upstream. In this case, the presence of a "V” pattern does not always show dipping beds.
gradient.

5) Vertical beds have straight outcrop and do not have "Vee”.

6) If the bed is tilted upstream, the beds start to dip upstream and retain a V-shaped outcrop but now the Vee is more "blunt” than the Vee exhibited by the topographic contours.

7) Beds dipping less steeply than the valley floor gives "V”s pointing in the direction opposite to bed dip. In this case the, V-shaped pattern does not indicate the true direction of the dipping beds.

8) Down stream pointing Vees are produced when the beds dip downstream more steeply than the slope of the stream.

If the arc curves in the same direction as the topographic contours, the dip direction is opposite to the down slope direction of the hill.

If the outcrop arc is in the opposite direction to the curve of the topographic contours, the dip direction is the same as the down slope direction of the hill.

In both cases, the openness of the outcrop arc increases as the dip steepens.

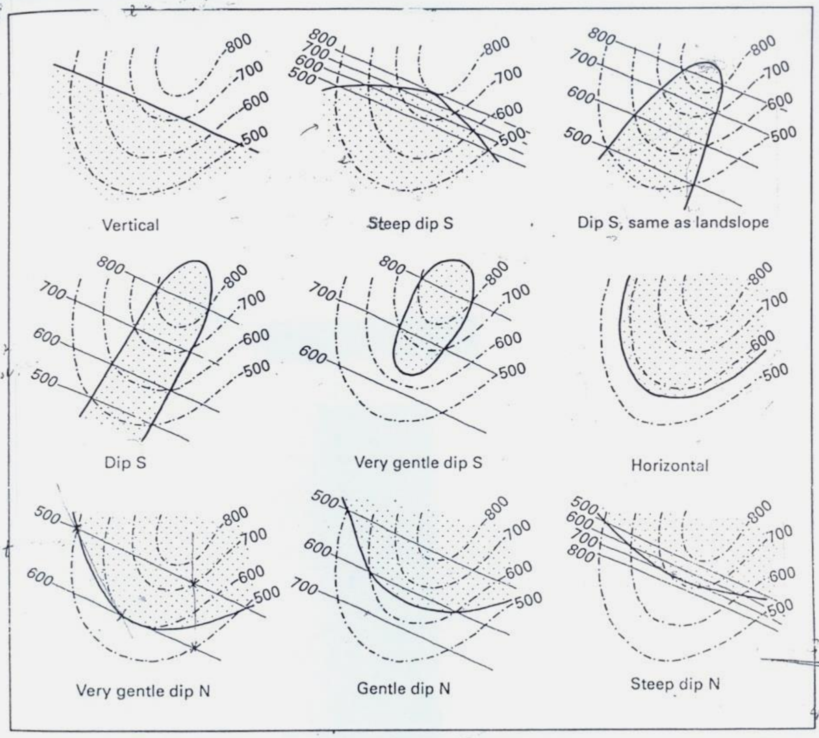
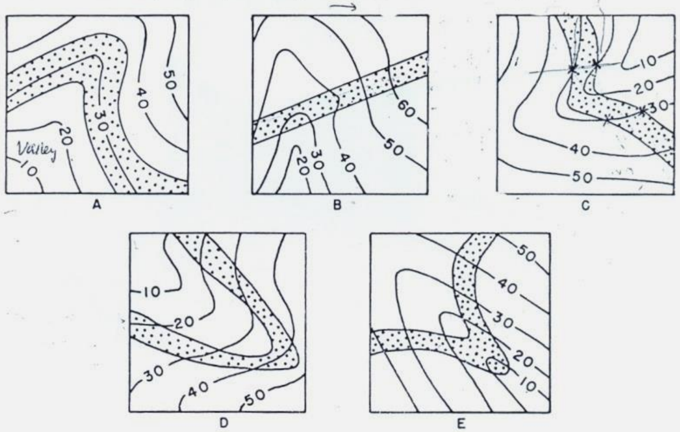


Fig. 3.5 Outcrop shapes made by a uniformly dipping surface crossing a rounded hill. The trace of the boundary between two formations is shown in a heavy line and topographic contours in a dot-dash line. Some structure contours, in light continuous lines, have been added to indicate the differing amounts and directions of dip that produce the different outcrop shapes. North is to the top of the page; south and north below the sketches are approximate directions.

FIG. 5—1 Contoured geologic maps illustrating the "Rules of the V's."



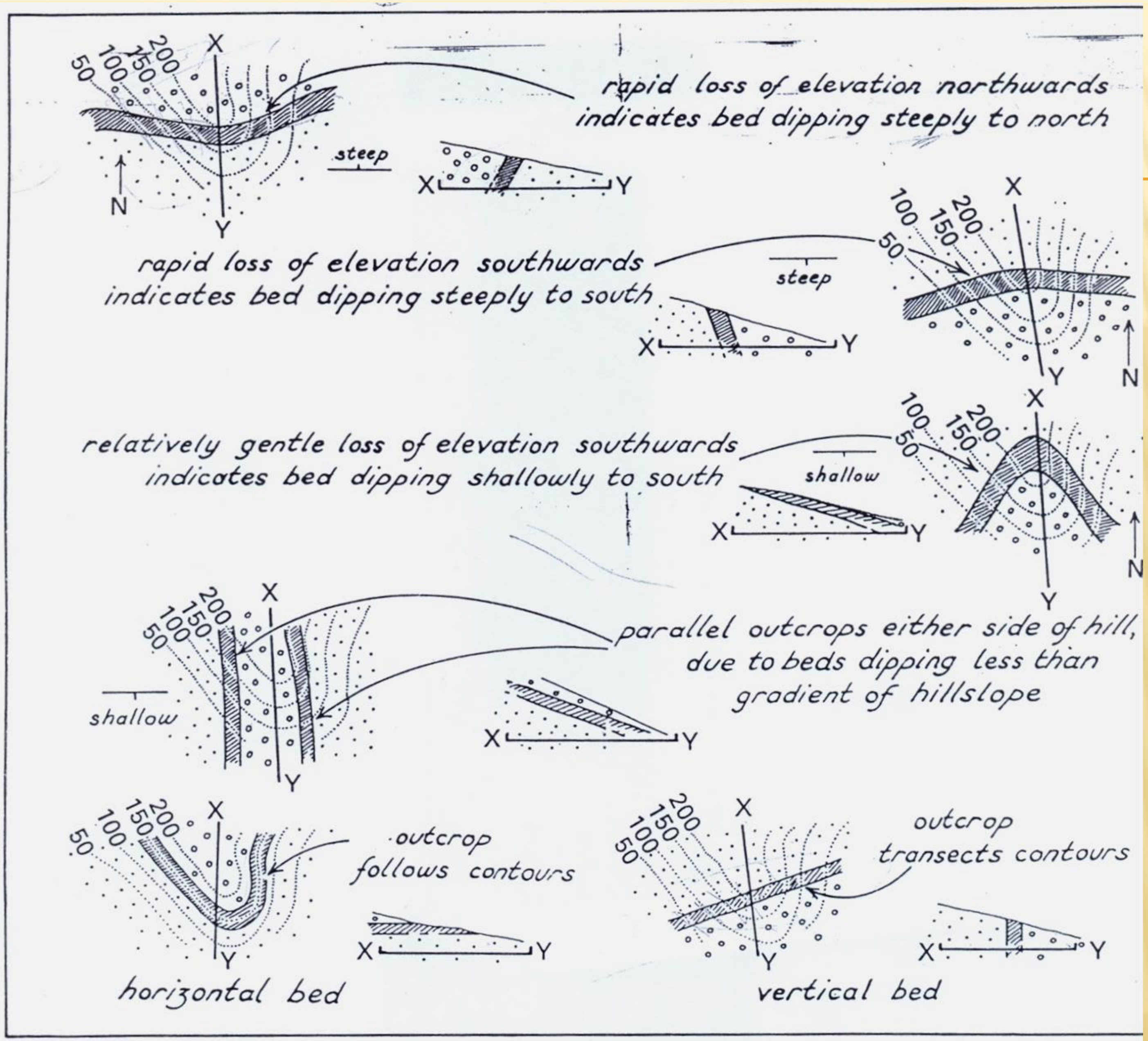


Fig. 6.2 Some examples of the visual assessment of outcrops crossing hills. In each example, the formation is regularly dipping and the hillside of roughly uniform gradient. In practice, less regular outcrops are likely.

The "Three – Point Method"

Accurate values of strike and dip direction can be derived by plotting some structure contour.

Given a regularly dipping unit and its elevation at three points, various aspects of its orientation can be derived.

The first step is to view the three points. Each can be underground or at the surface.

Procedures

- Connect the three known points to form a triangle.
- Divide sides of triangle
- Join two points of same elevation.
- This line is the structure contour for this value, which indicates strike direction.
- Dip direction is given by any line perpendicular to strike direction towards decreasing elevation.

- **Tan dip angle = Difference in elevation between X and Known points.**
- **Horizontal distance between X and Known point.**

Structure Contours (Strike Lines)

Straight structure contours

Straight structure contours are sometimes referred to as *strike lines*. This is because structure contours everywhere parallel the strike of the surface.

Straight structure contours represent a smooth geological surface.

The even spacing of structure contours reflects a uniform angle of dip.

Dip direction is perpendicular to the strike line, in the direction where elevation is decreasing

Curving structure contours show the variation of strike direction.

Strike lines will be straight, parallel and if dips are constant – equally spaced.

Important points for structural contour interpretation are:

- A contour line should never divide or split.
- A contour line must represent one and only one elevation.
- A contour line may never intersect other contour line.
- Closely spaced contour lines indicates a steep slope, widely spaced lines indicate a gentle slope.

Knowing the elevation of a unit at three points – from outcrop at a known altitude, elevation in a drill core, etc., or some combination of these, the geologist can:

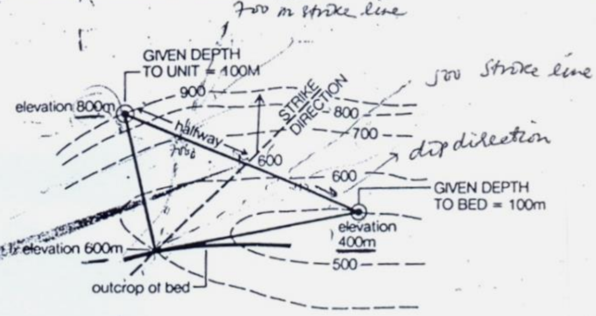
i FIND THE STRIKE DIRECTION

① Connect the three known points to form a triangle. Indicate elevations of unit at corners for clarity.

② Divide side of triangle connecting biggest elevation difference to find point of same value as third corner of triangle, of intermediate elevation.

Here, point halfway between 800m and 400m points will be 600m

③ Join two points of same elevation. This line is the structure contour for this value, which indicates strike direction

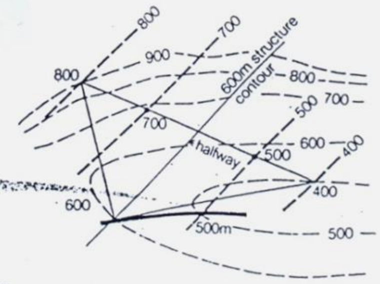


ii CONSTRUCT STRUCTURE CONTOURS

④ Make further subdivisions of triangle sides to find other intermediate elevations (if there are any). Connect with any other known elevation points.

Here, point halfway between 600m and 400m will be 500m; can connect to point of outcrop at 500m topographic contour

⑤ Parallel to derived structure contours, can add tentative contours through single points of known elevation.

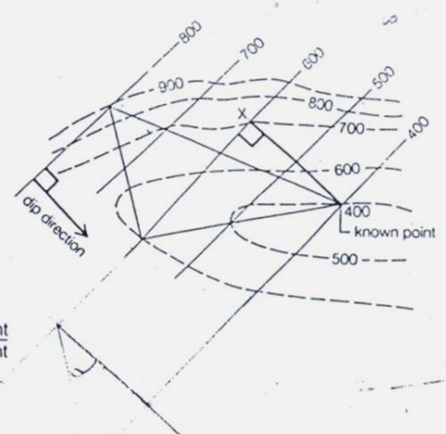


iii FIND DIP DIRECTION AND ANGLE

⑥ Dip direction is given by any line perpendicular to strike direction (structure contours) towards decreasing elevations.

⑦ Draw line from either greatest or least of the three known elevation points to meet structure contour derived in i, above, at right angles. (These points are the most closely known – should give greatest accuracy). Label intersection with structure contour, say x.

$$\text{tan dip angle} = \frac{\text{elevation difference between} \times \text{and known point}}{\text{horizontal distance between} \times \text{and known point}}$$



iv FIND FORMATION DEPTH

⑧ Derive strike direction (i, above) and dip angle (iii, above). Measure horizontal distance, at right angles to strike, between point at which depth required and any point where formation elevation is known (structure contour, outcrop, given point) From formation depth = horizontal distance × tan dip angle (fig. 4.9), find depth difference from point of known formation elevation.

Fig. 3.18 Some applications of the 'three-point method'.

Fig.

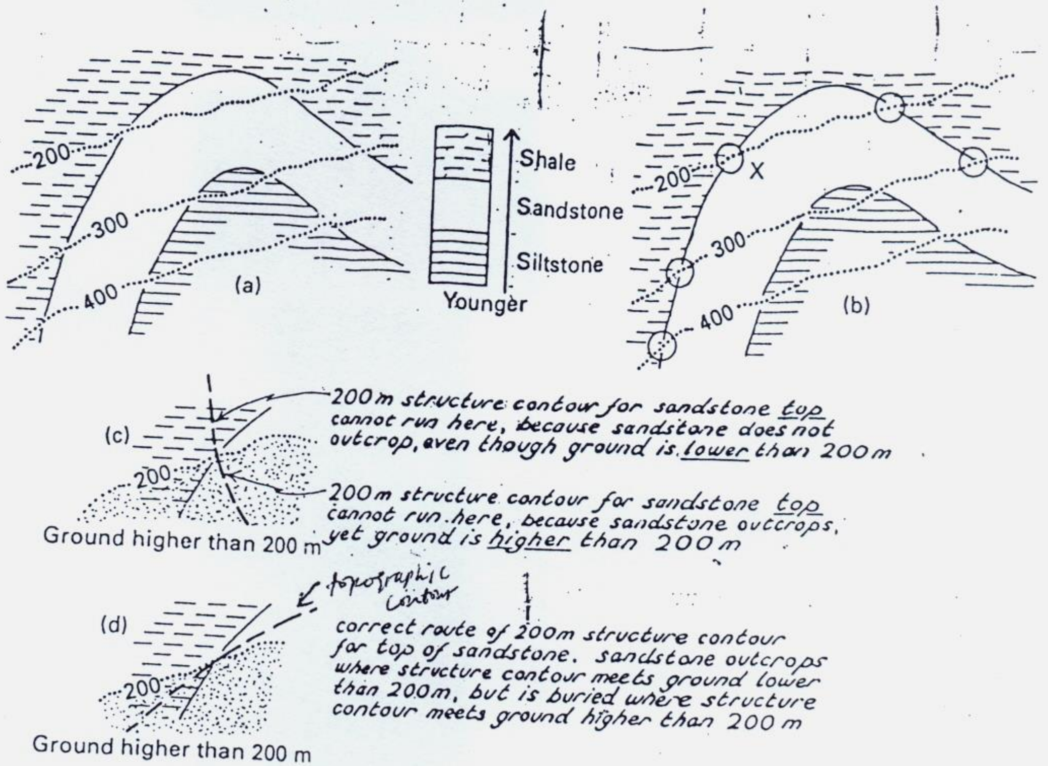
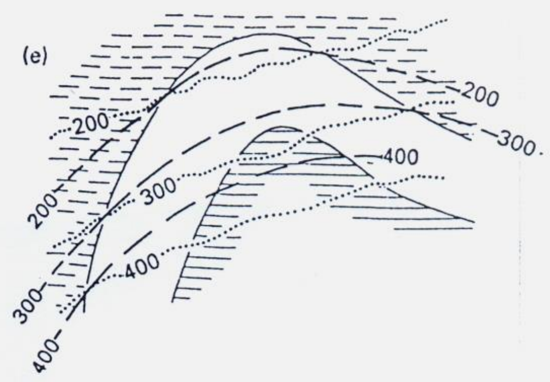


Fig. 3.6 Constructing structure contours from topography and outcrop. (a) Portion of a hypothetical geological map, showing topographic contours (dotted) and the outcrop of a sandstone unit. The top of the sandstone is to be contoured. (b) Preliminary steps. Reference to the stratigraphic sequence shown in the key enables the *top* of the sandstone to be located on the map. Circles indicate where the altitude of the top of unit is known, from intersections with topographic contours: the structure contours will pass through these circles. Consider the circle at X. At first it may seem that there are two possible routes for the 200 m structure contour to pass through the outcrop/200 m topographic contour intersection, as illustrated in (c) and (d). However, the route shown in (c) is not compatible with the map information, and only the route shown in (d) can be correct. (e) shows the 200, 300 and 400 m structure contours completed from the map information.



True and apparent dip of inclined beds

If the slope of a geological boundary or bedding plane is measured in any direction between the strike direction and the direction of maximum dip, the angle of dip in that direction is known as an *apparent dip.*

Its value may range between 0° and the value of the maximum or true dip.

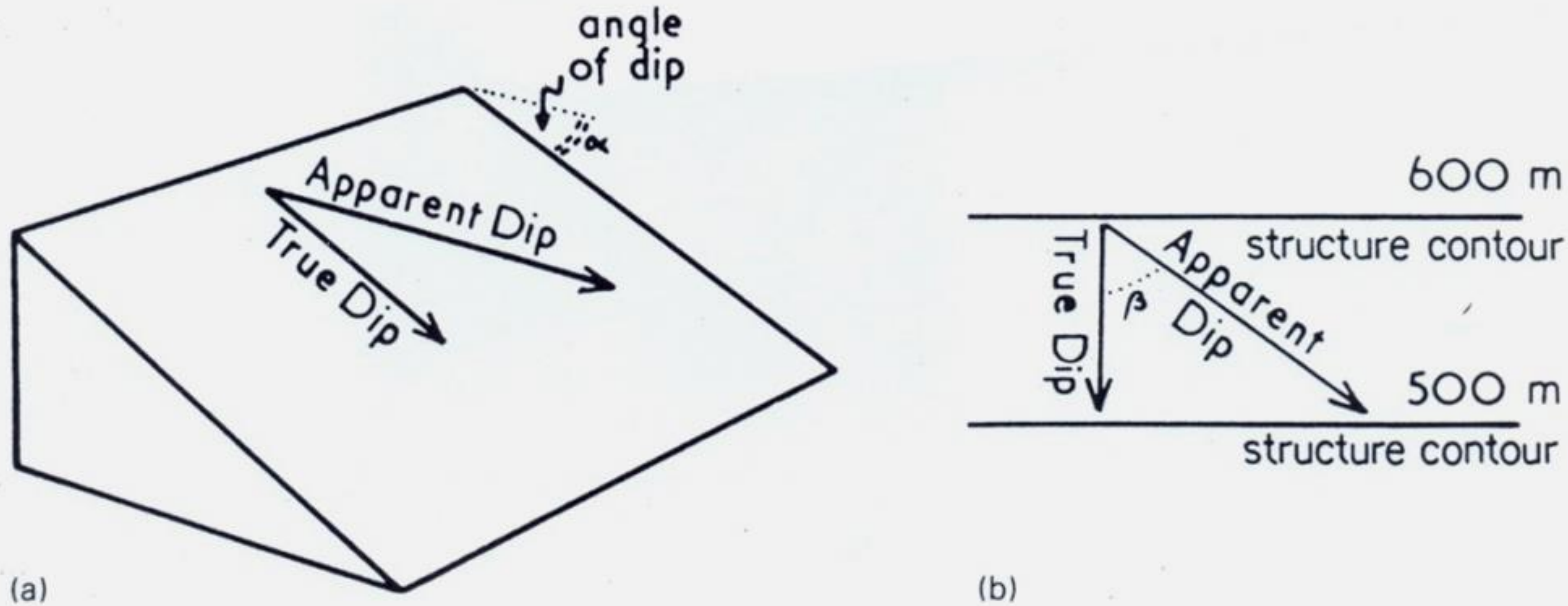


Fig. 6 (a) Diagram and (b) plan or map of structure contours to illustrate the relationship between true and apparent dip.

Naturally occurring or man made sections through geological strata (cliffs, quarry faces, road and rail cuttings) are unlikely to be parallel to the true dip of the strata.

What may be observed, is the dip of the strata in the direction of the section i.e. an apparent dip less than the true dip angle.

Tan apparent dip = Tangent true dip x Cosine β

Width of Outcrop, true and vertical thickness of beds

Width of outcrop

If the ground surface is level, the width of outcrop is a measure of the dip.
Generally, beds outcrop on sloping ground and *width of outcrop* is a function of *the dip of the beds* and *the slope of the ground*.

In the case of horizontal strata the geological boundaries are parallel to the topographic contours.

In dipping strata the geological boundaries cross the topographic contours and with irregular topography the steeper the dip the straighter the outcrops.

In vertical strata, outcrops are straight and unrelated to topography.

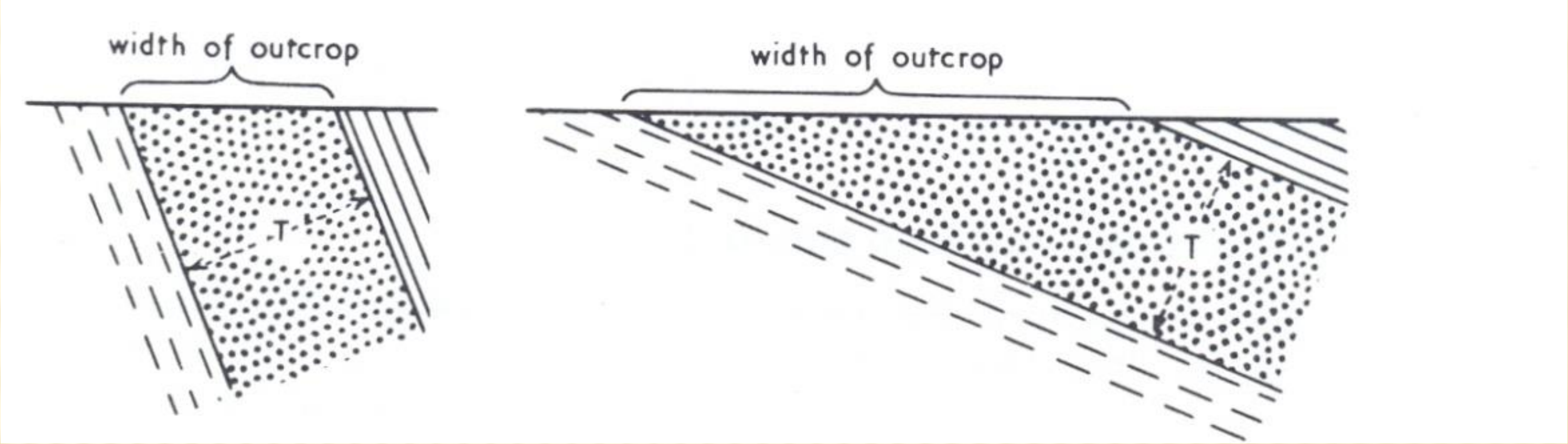


Fig. section showing the different widths of outcrop produced by a bed of the same thickness with high dip and low dip.

Vertical thickness and true thickness

Since the beds are inclined, the vertical thickness, penetrated by a borehole is greater than the true thickness measured perpendicular to the geological boundaries (interfaces).

The angle α between VT (vertical thickness) and T (true thickness) is equal to the angle of dip.

Cosine α = T , T = VT x Cosine α

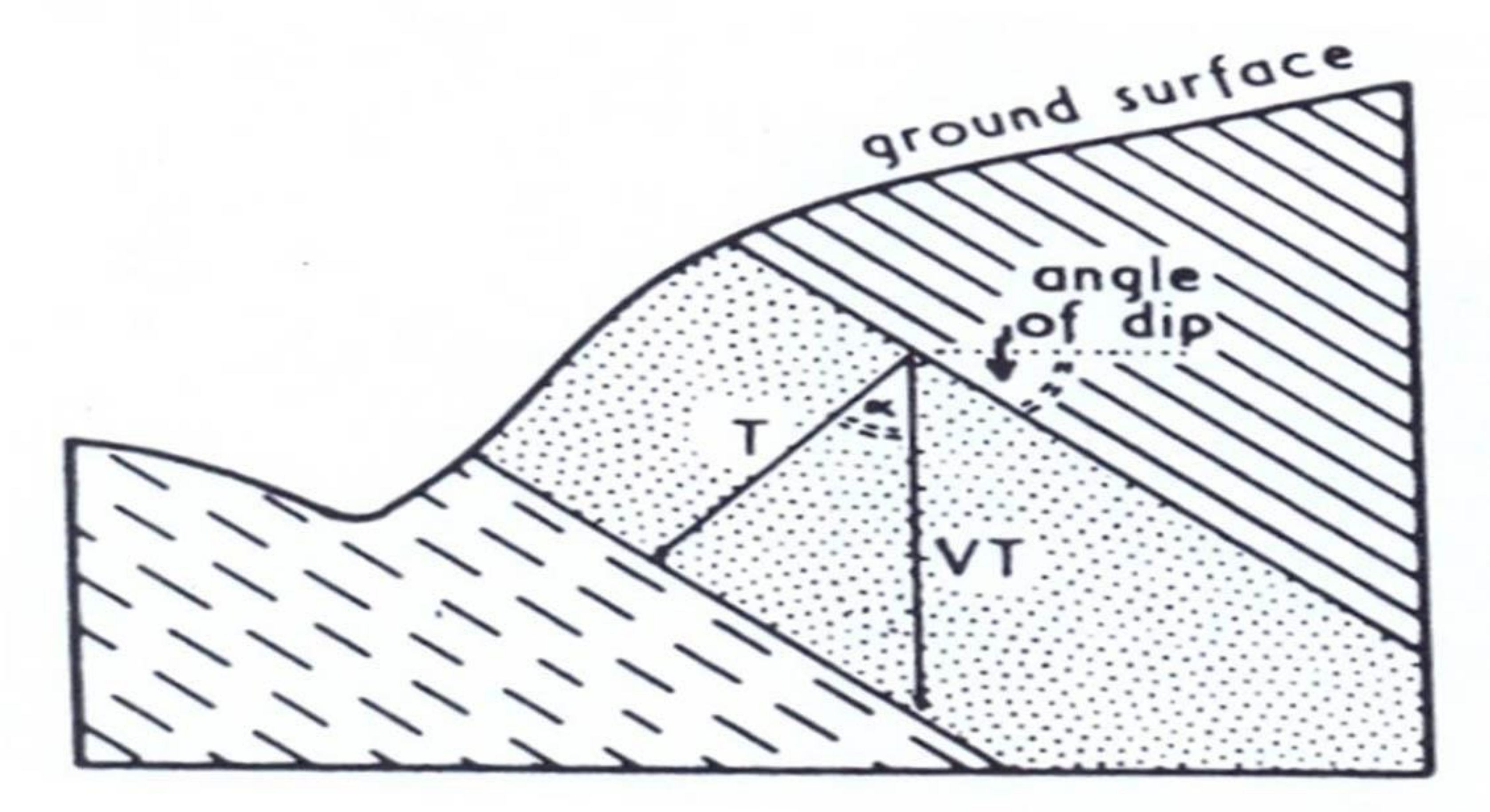


Fig. Section showing the relationship between vertical thickness (VT) and the true thickness (T) of a dipping bed.

The true thickness of the formation is measured at right angles to its bounding surfaces.

It is the shortest distance between the top and bottom boundaries. Measurement at any angle will give a greater value called the apparent thickness.

When the beds are vertical their outcrop width equals their true thickness. Outcrops of vertical formations ignore topography and tend to be straight.

Formation thickness encountered in a borehole or well will be vertical apparent values.

Only in the case of horizontal beds will these equal to the true thickness.

Steeper beds make narrower outcrops than shallower beds of the same thickness. Greater width at the surface is explained by lower dip.