UNIVERSITY OF ZAMBIA

GEOLOGY DEPARTMENT

GGY3051: ENGINEERING GEOLOGY

INTERPRETATION OF TOPOGRAPHIC & GEOLOGICAL MAPS

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F09 – School of Mines Annex Building

PART I: TOPOGRAPHIC MAPS

PART II: GEOLOGICAL MAPS

INTRODUCTION TO TOPOGRAPHIC MAPS AND PROFILES

Objectives

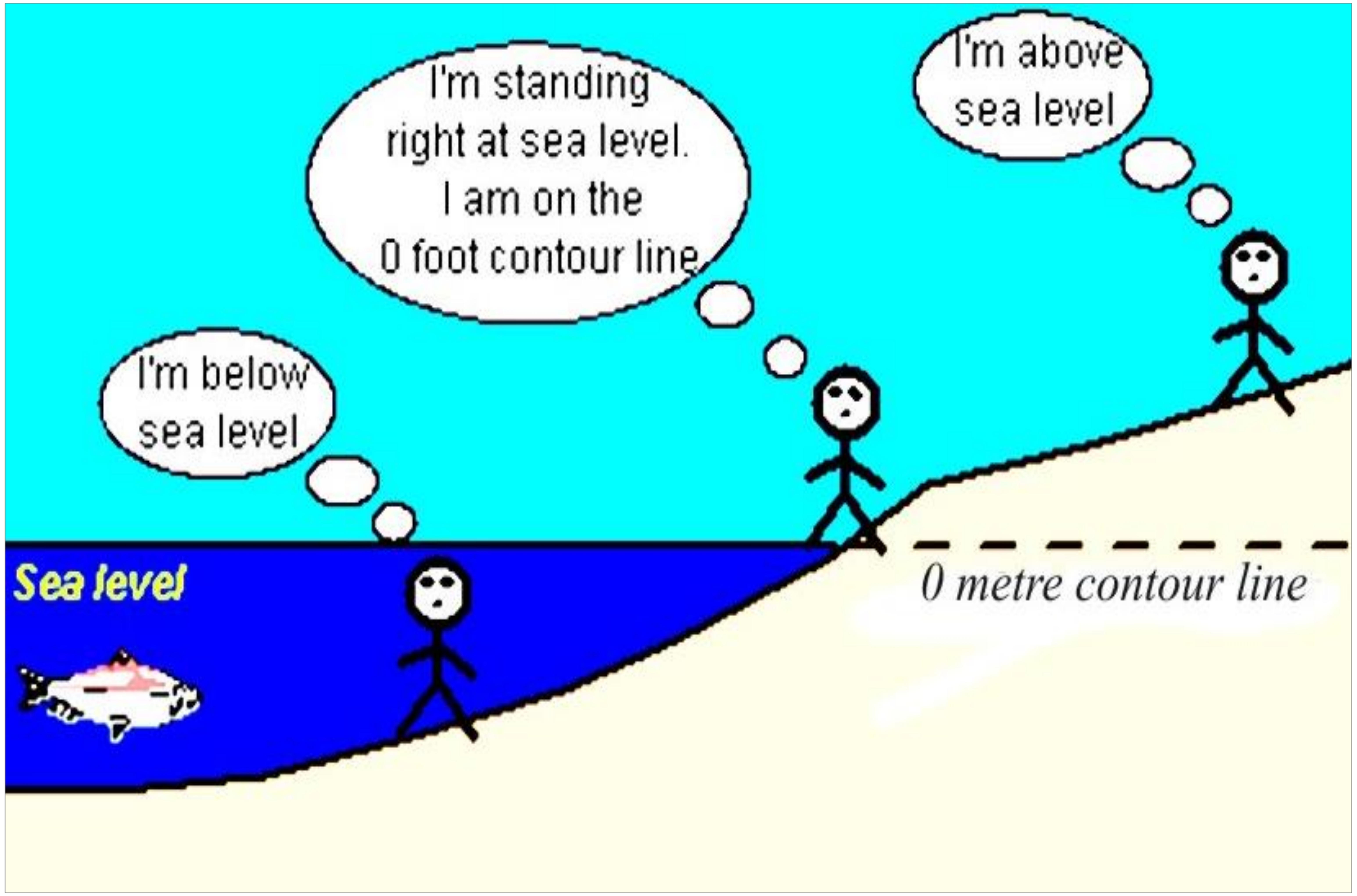
To:

- ✓ **Define** a topographic map and **state its uses**.
- ✓ Describe how **contour lines** show the **elevations**, **shape**, and **slope** of the **land**.
- ✓ Identify the meanings of some **symbols** and **colors** used on **topographic maps**.

What is a Topographic Map?

A **topographic map**:

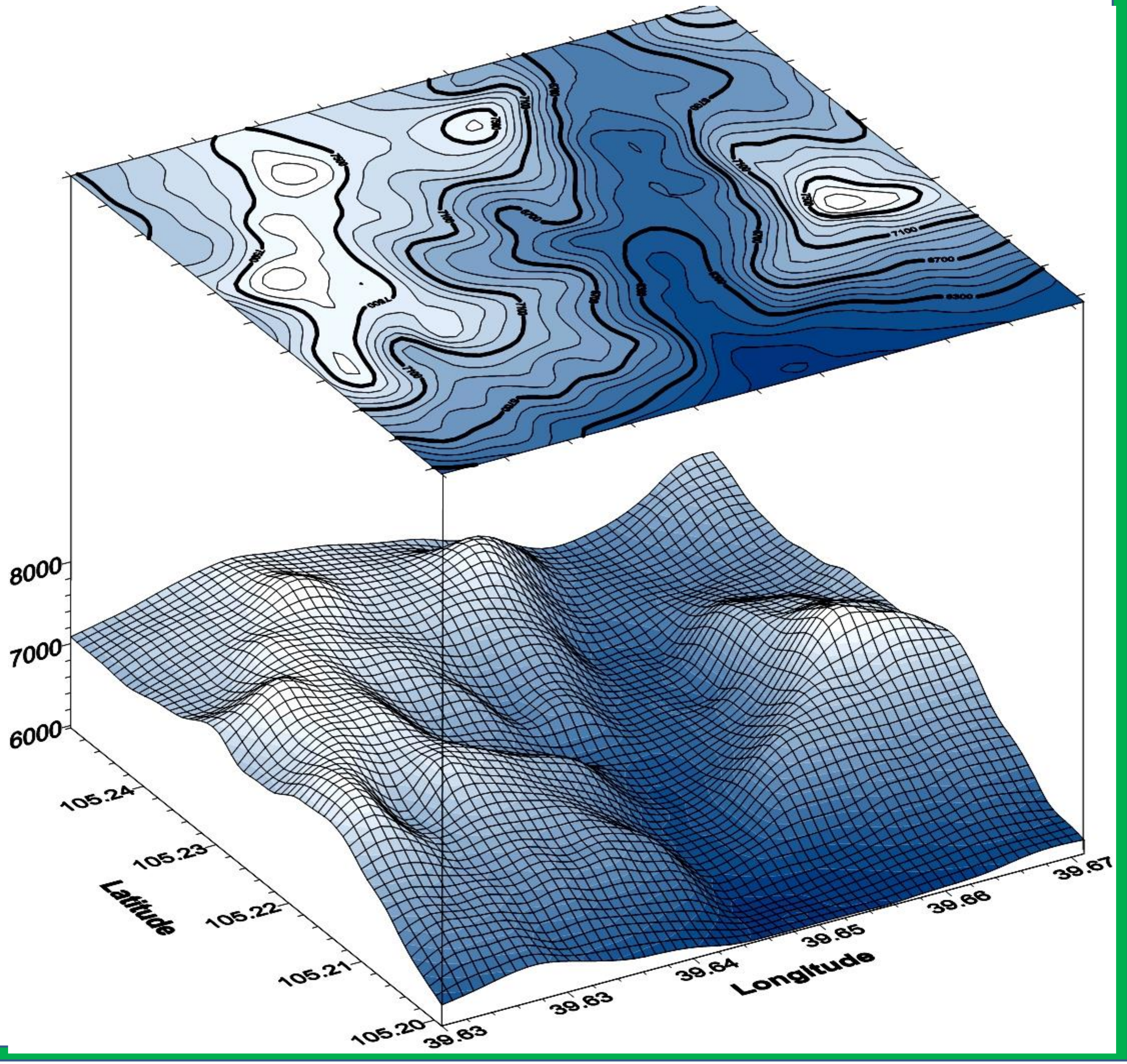
- ✓ also known as a **contour map**.
- ✓ shows elevation of land **above** (or **below**) sea level & its **shape.**



Topographic Map.....contd.

- ✓ Is a **two-dimensional** (flat) **representation** of a **three-dimensional land surface**.
- ✓ Shows three-dimensional information *(relief or height variation)* by **using contour lines** to represent elevations of hills and valleys.

This vertical information is the distinguishing feature of any topographic map.



Topographic Map.....contd.

Topographic map:

- is a large scale representation of a portion of the earth's surface showing;
  - *relief, hydrography* and perhaps *vegetation*.
- shows projections of natural & man-made physical features.

Topographic Map.....contd.

Topographic map:

- differs from the more familiar ***planimetric*** map – e.g. highway map – which does not show relief.
  - This makes topographic maps a valuable tool in geological and engineering studies.
- are also used by anyone who needs to know the three-dimensional aspect of land surfaces.

Topographic Map.....contd.

On topo map, we generally see the following features:

a) SCALE – expresses ratio of **distance between two points** on **map** and **true horizontal distance on the ground**.

For instance:

Scale of 1:25,000 means distance of 1 cm on map = 25,000 cm on the ground.

Or 1 cm = 25,000 cm = 250 m

Thus, the smaller the scale of the map, the less detail can be shown on map.

SCALE 1:50,000

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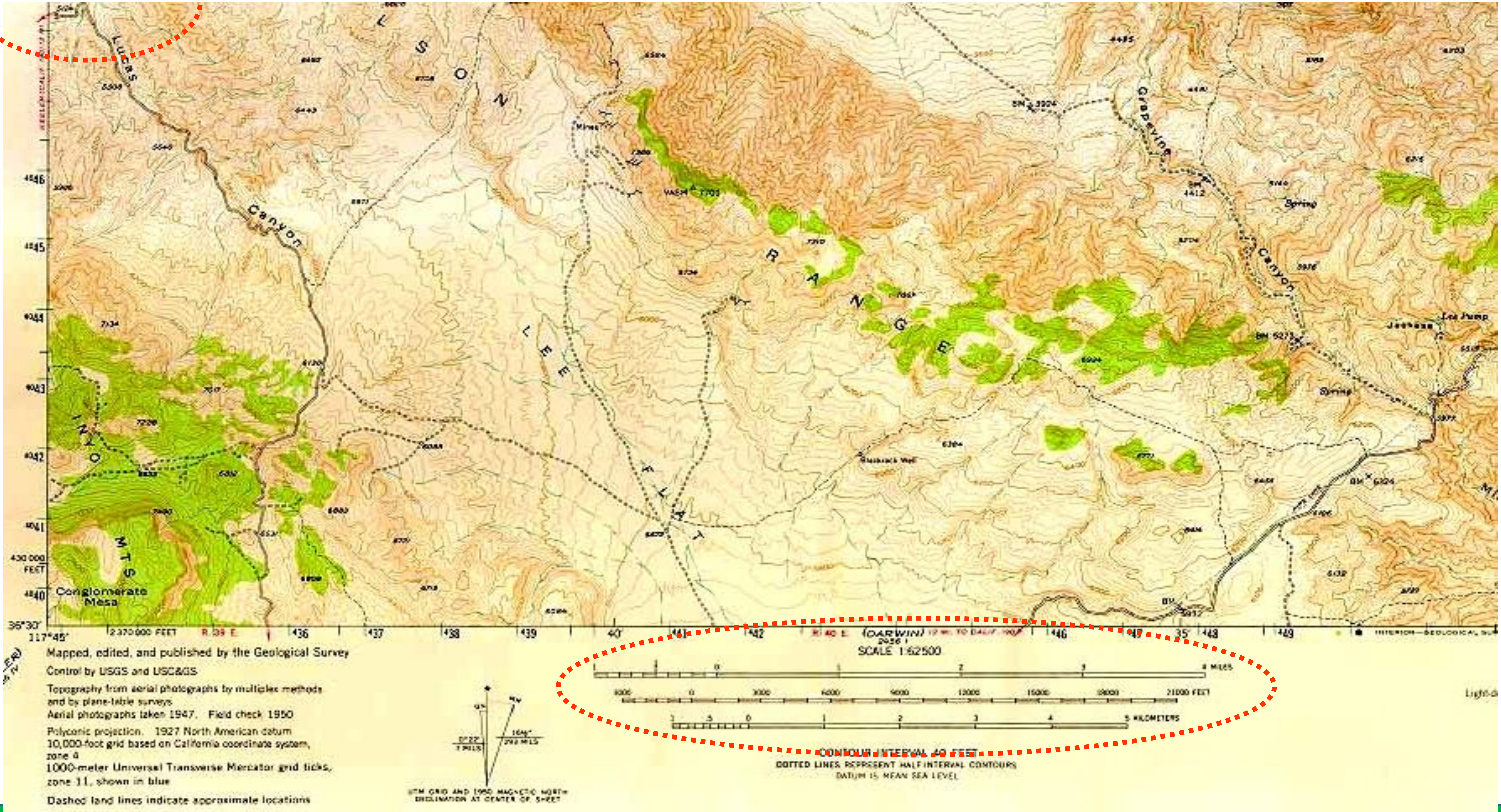
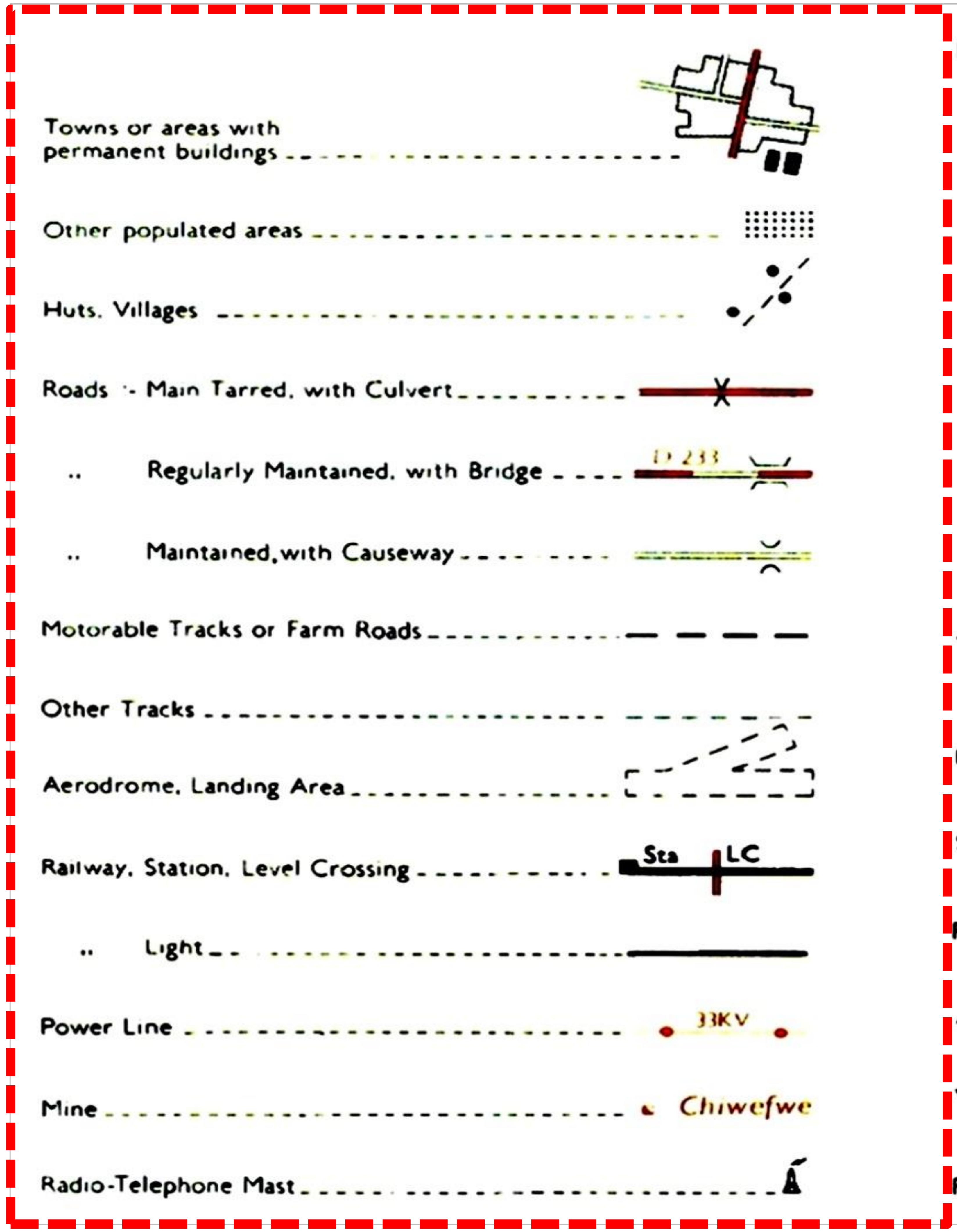
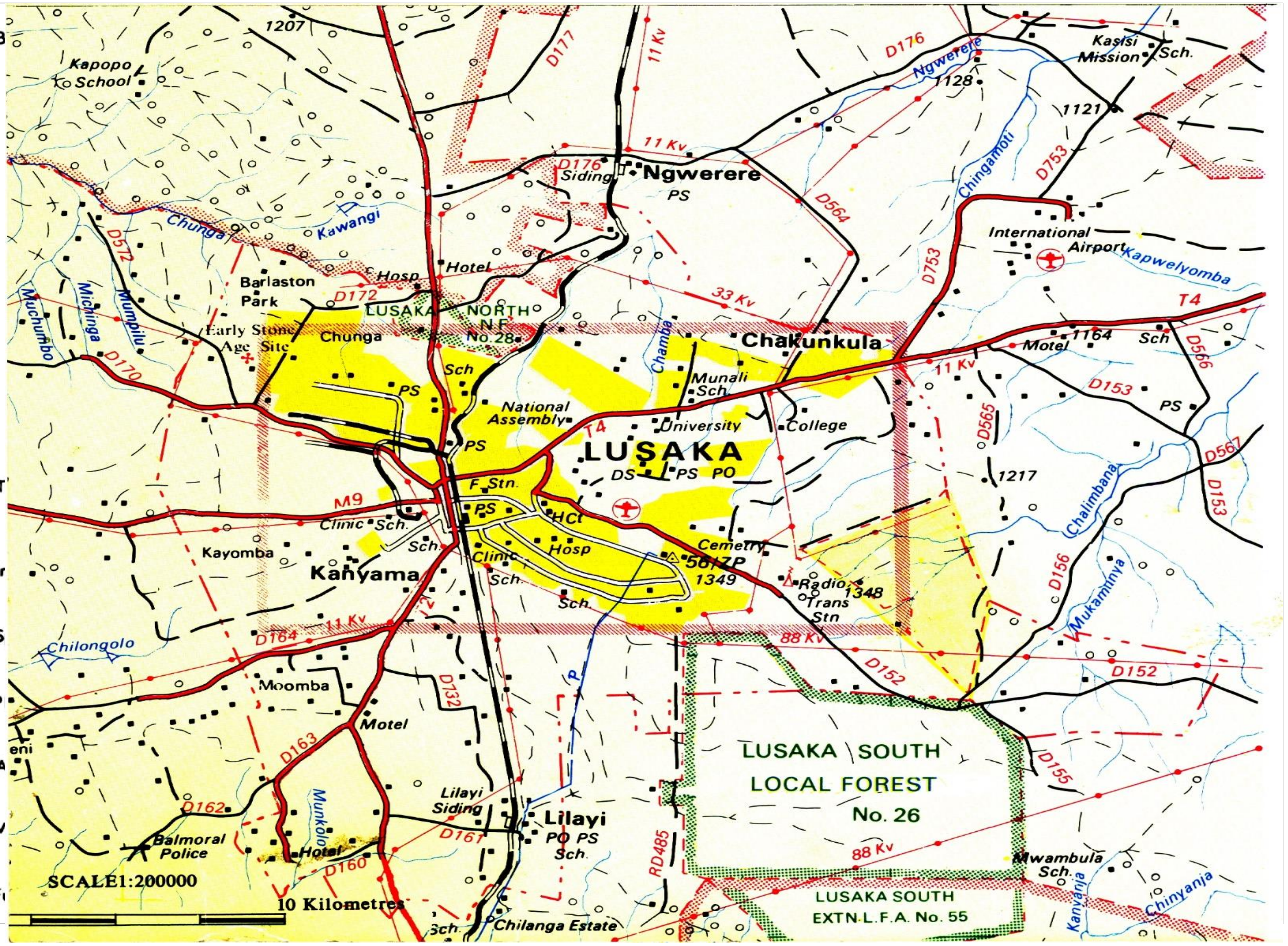


Topographic Map.....contd.

b) **LEGEND** – explains all symbols used on map – **must be studied before you attempt to read map.**

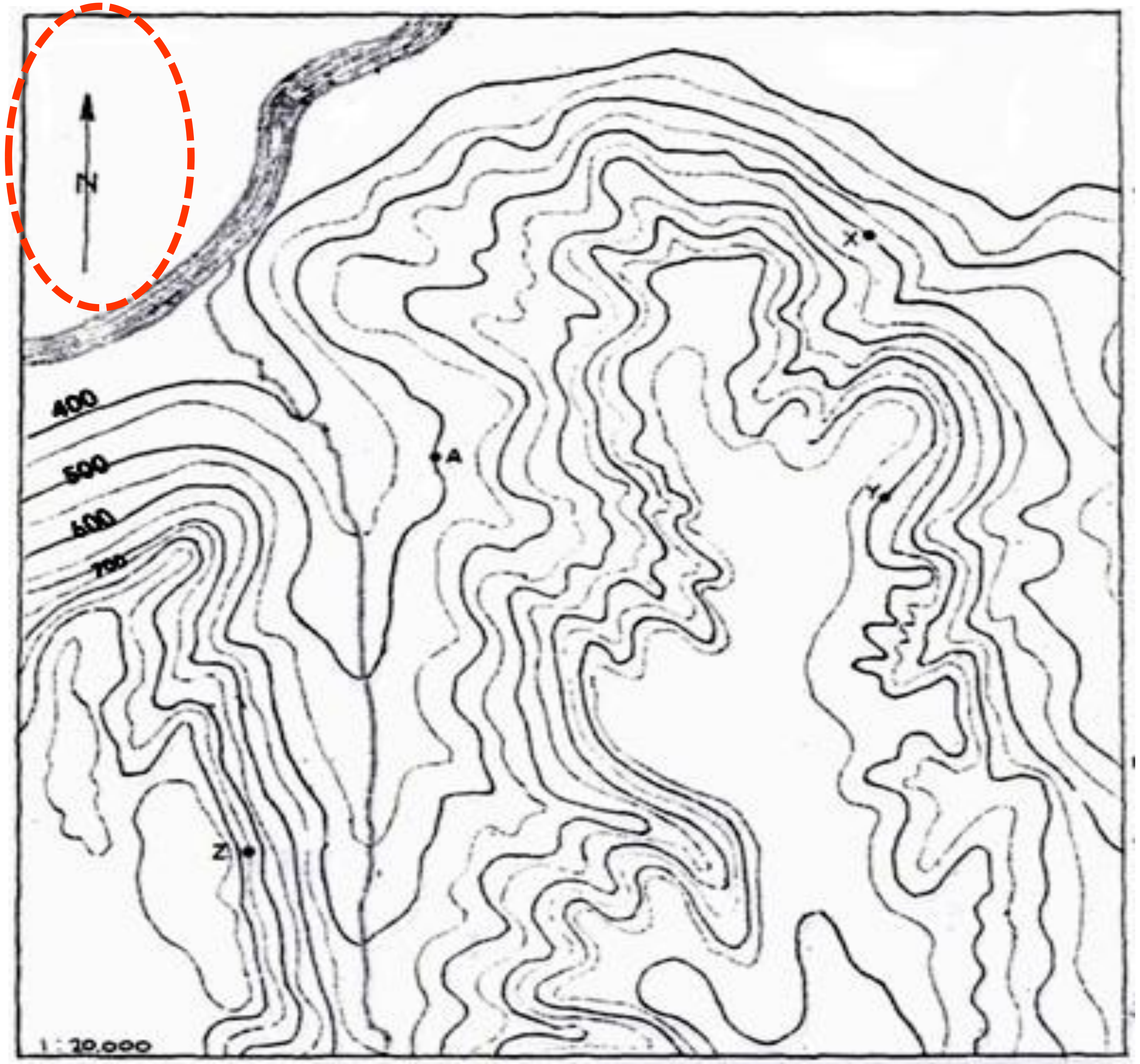




Topographic Map.....contd.

c) **NORTH ARROW** – mark, which points to geographic north.

This **makes it possible to plot and/or read orientations of features** – beds, faults, joints, – on the map (with a protractor).

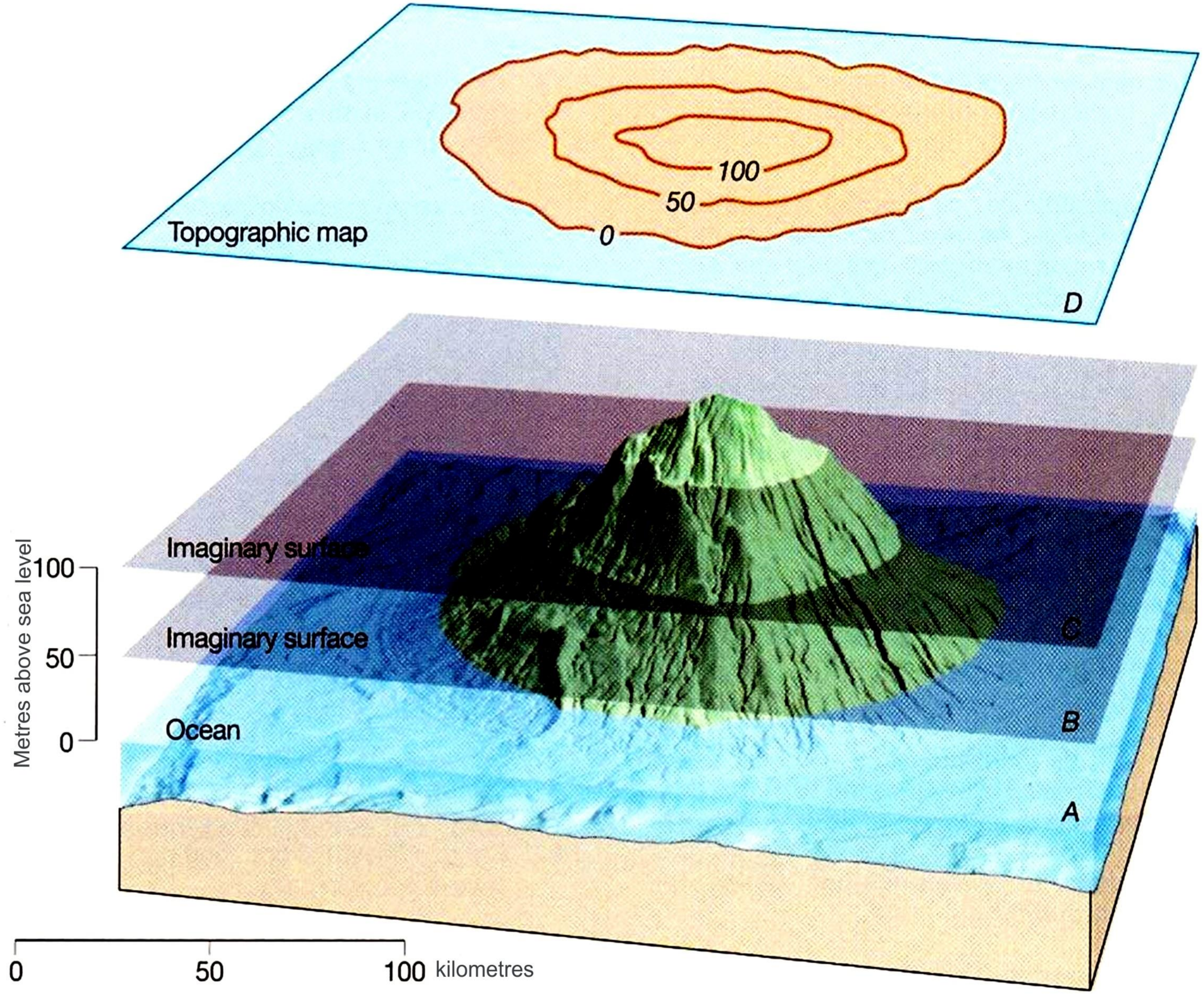


Topographic Map.....contd.

d) CONTOUR LINES –

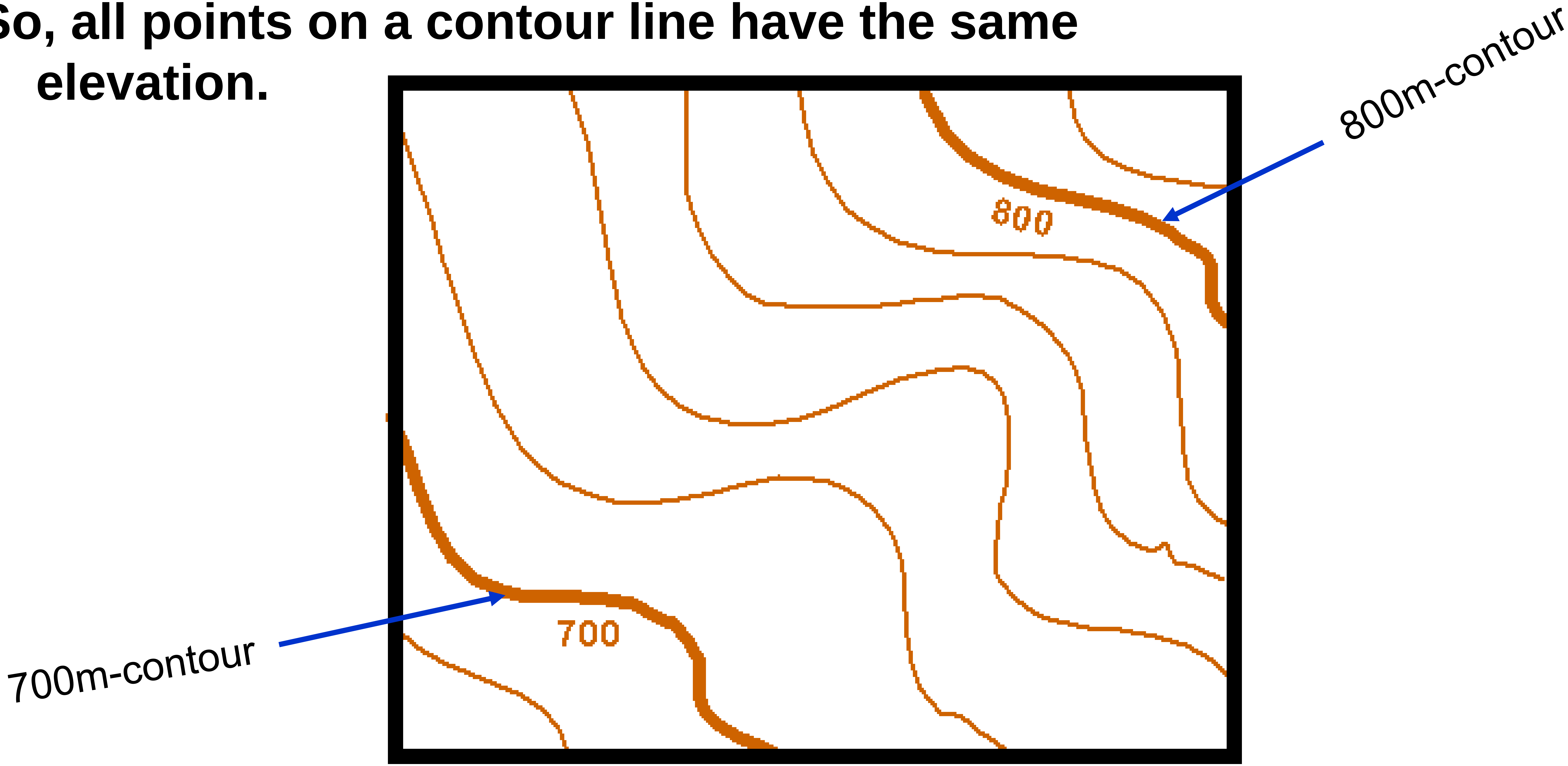
imaginary lines on map representing pts of equal elevation.

- ✓ **Complete series of contour lines** enable map reader to get an impression of topography of whole area of map.



Topographic Map.....contd.

So, all points on a contour line have the same elevation.

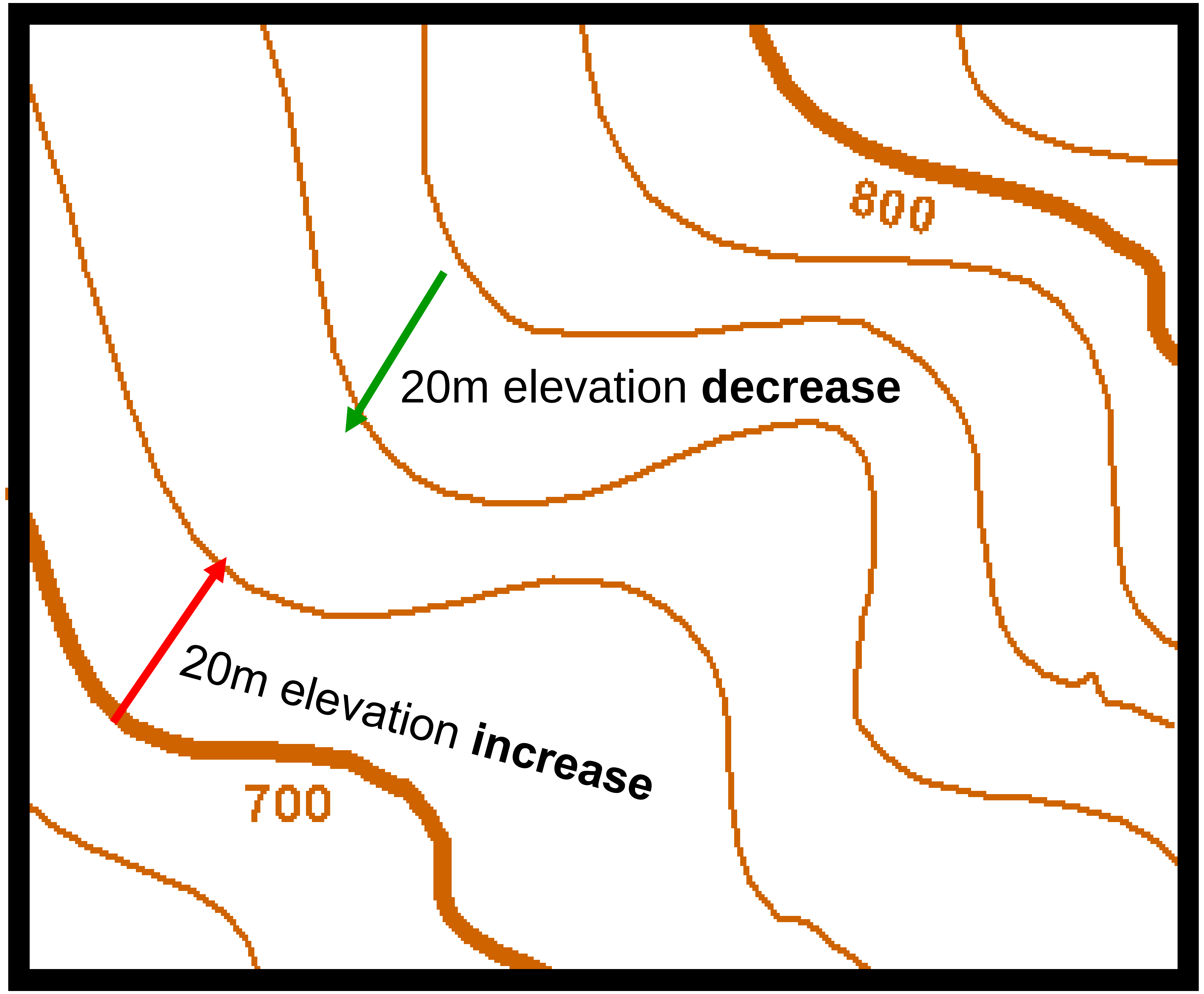


Elements of Topographic Maps

i) ***Contour Interval (CI)*** – elevation difference between contour lines. On map portion shown, CI is 20m.

Choice of **CI** depends upon:

- ✓ **Scale of map**: large-scale maps have small contour intervals.
- ✓ **Relief of area**: areas with low relief will have small contour intervals.

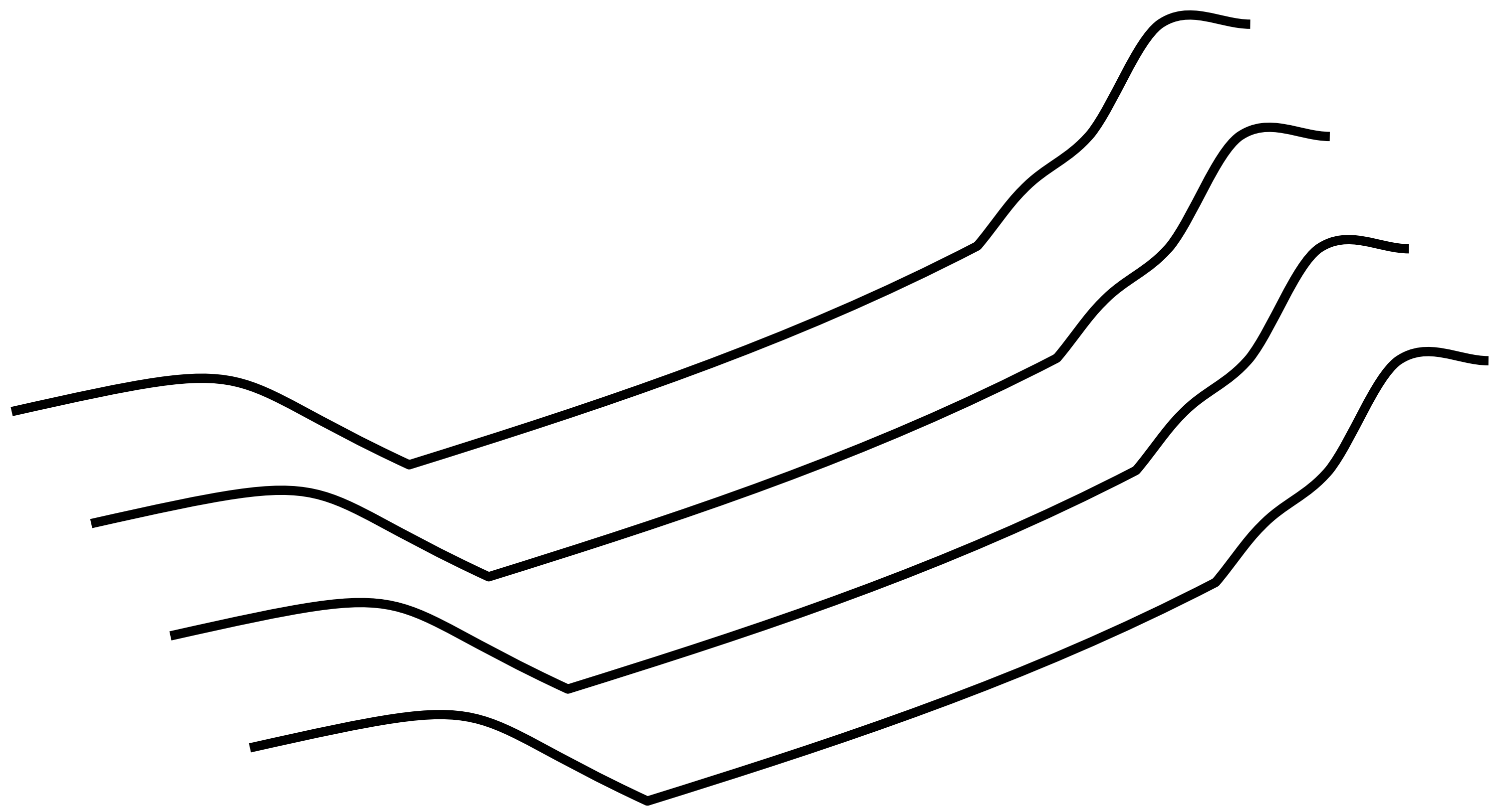


ii) ***Index Contour (IC)*** – is usually every **fifth line** that is **printed 'heavily',** and has an elevation printed on it *(e.g., the 700 and 800 lines in map).*

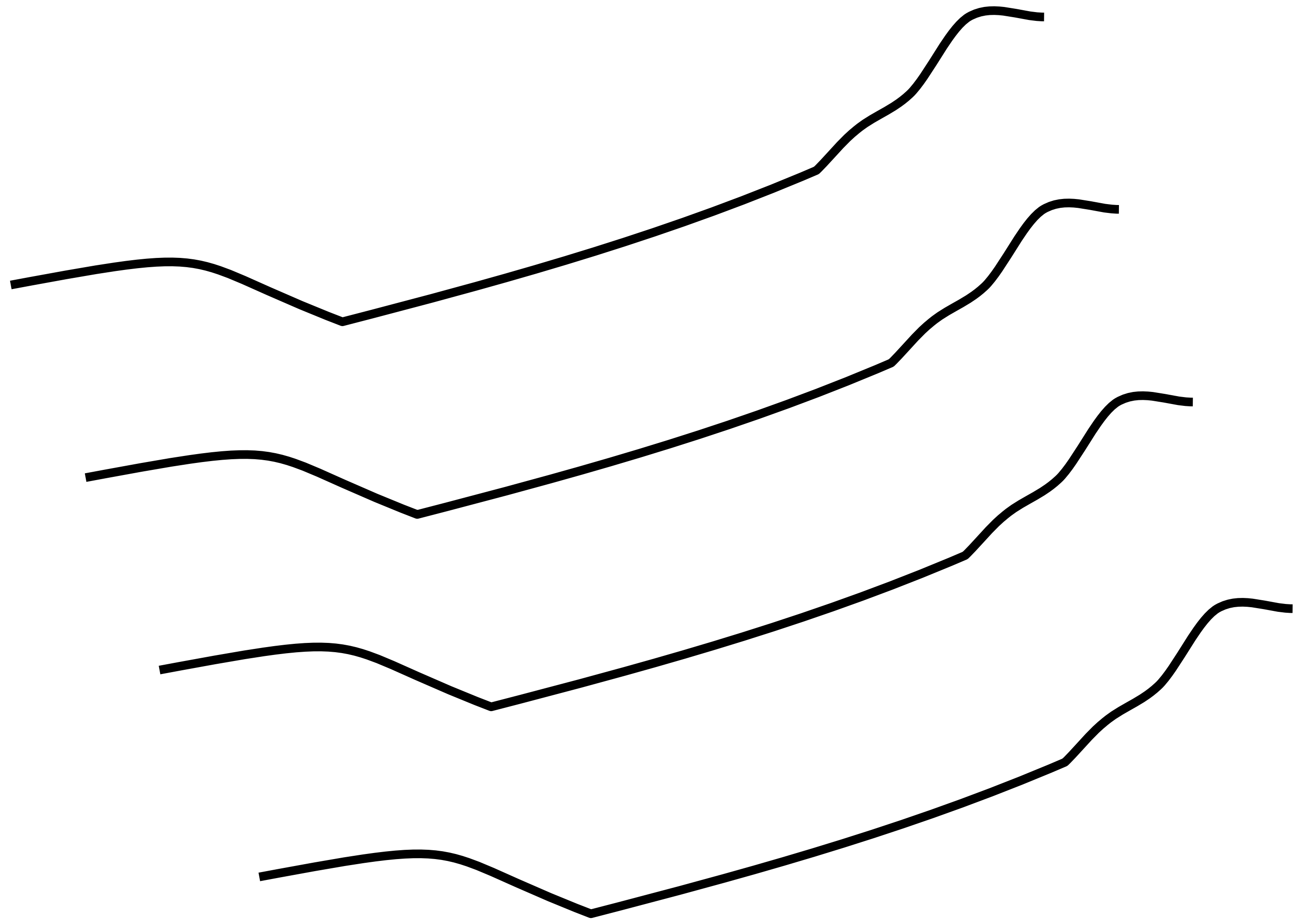
Elements of Topographic Maps.....contd.

iii) Contour Spacing – indicates **steepness of Slope** (**Gradient),** contours:

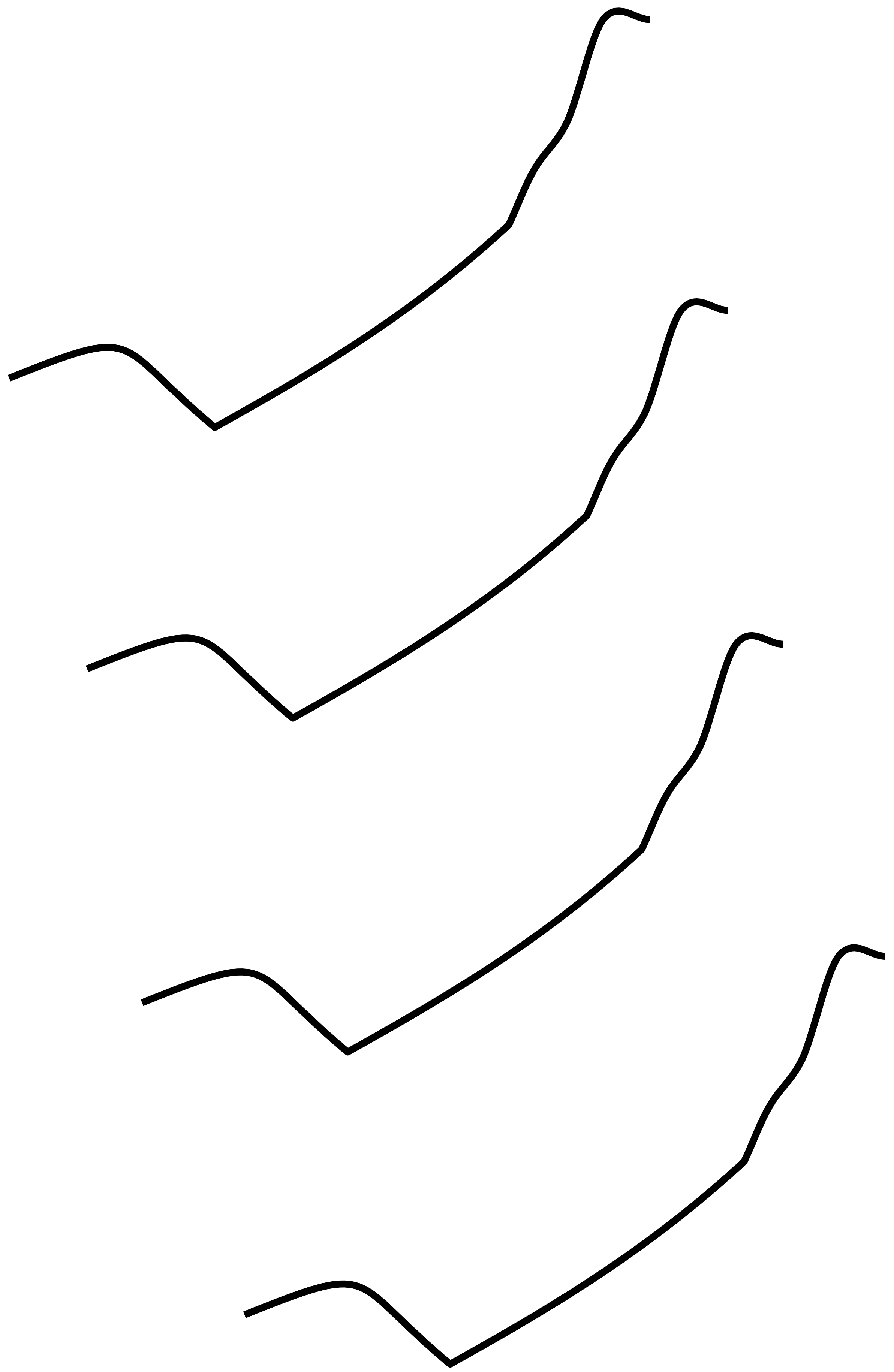
- **closer together**, means a **Steep Slope.**
- **farther apart** indicate **gradual/gentle Slope**



1. Steep Slope



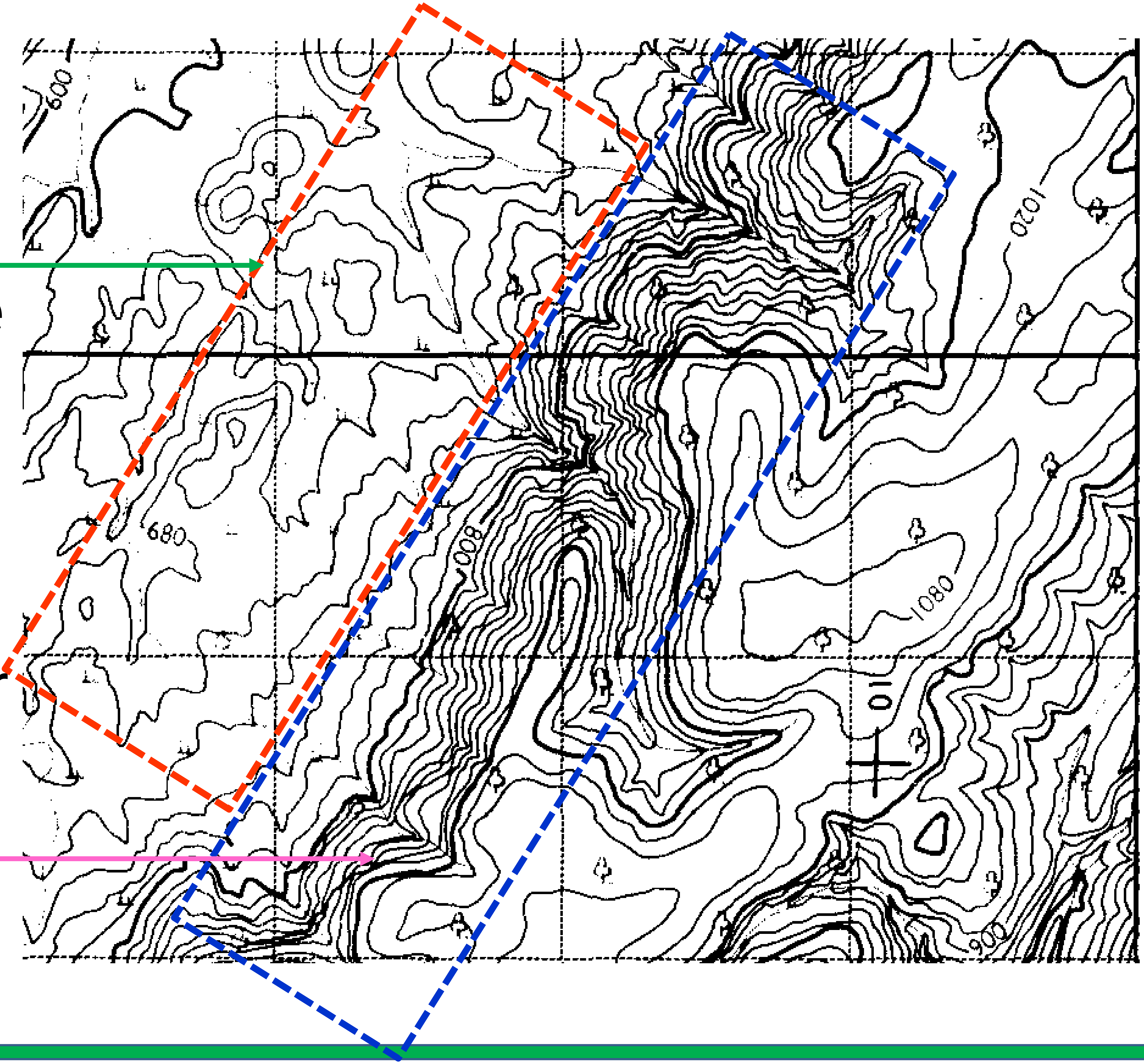
2. Gentle Slope



3. Very Gentle Slope

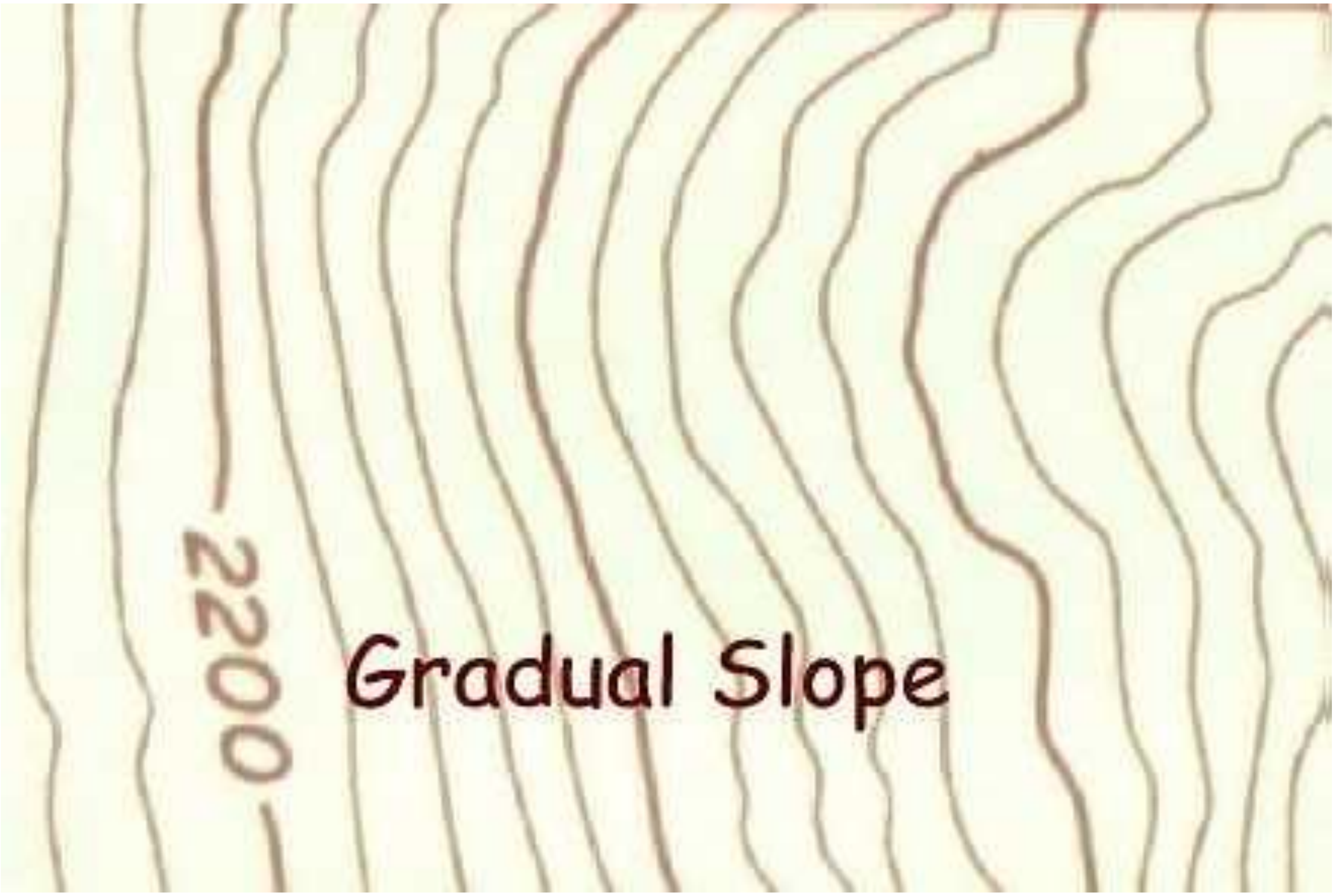
Elements of Topographic Maps…..contd.

- The further apart the contours, or the larger the interval, the more gradual the slope, or
- The closer together the contour lines, and the smaller the space between them, the steeper the land.

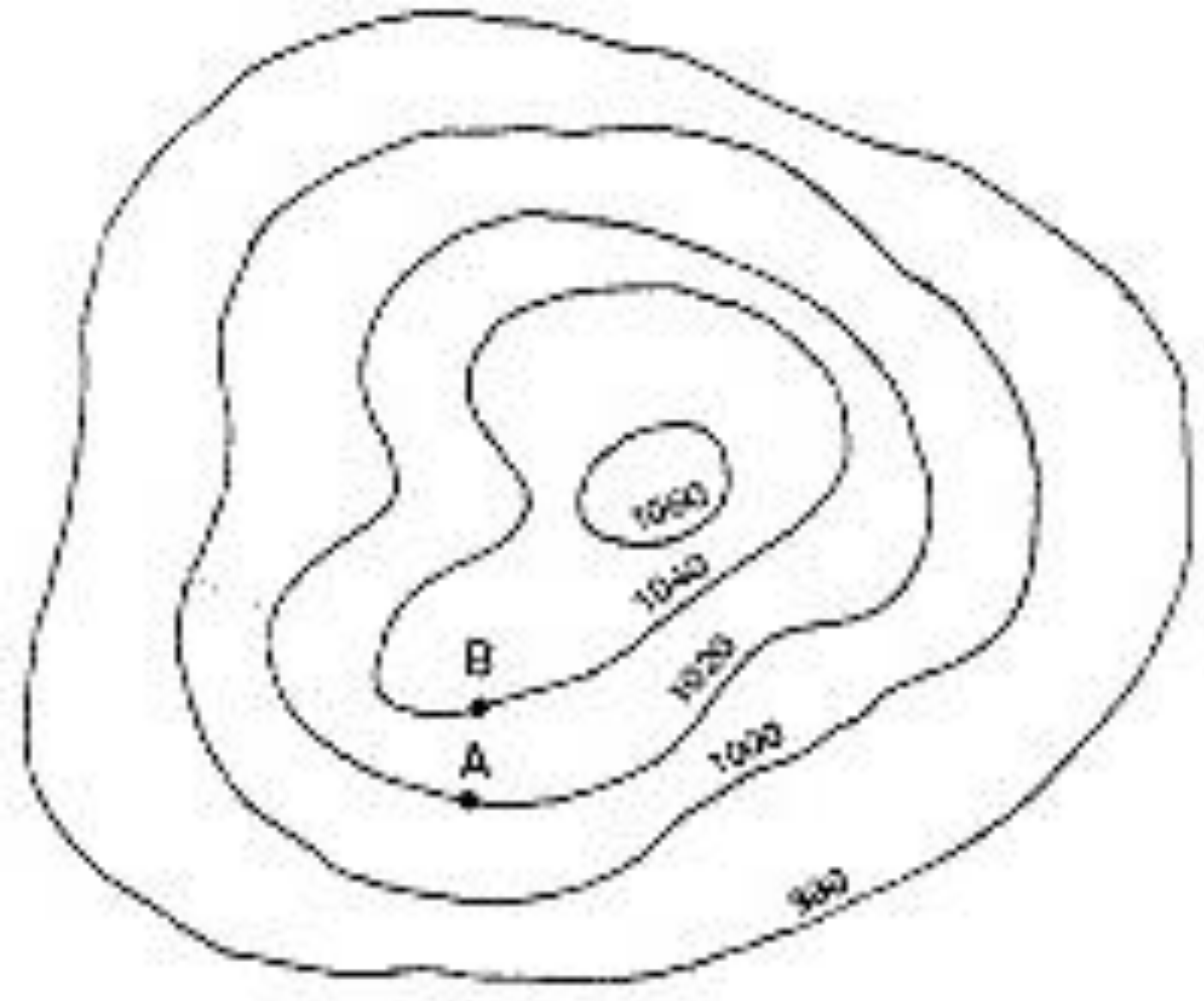


Rules for Contour lines

a) Contour lines never cross

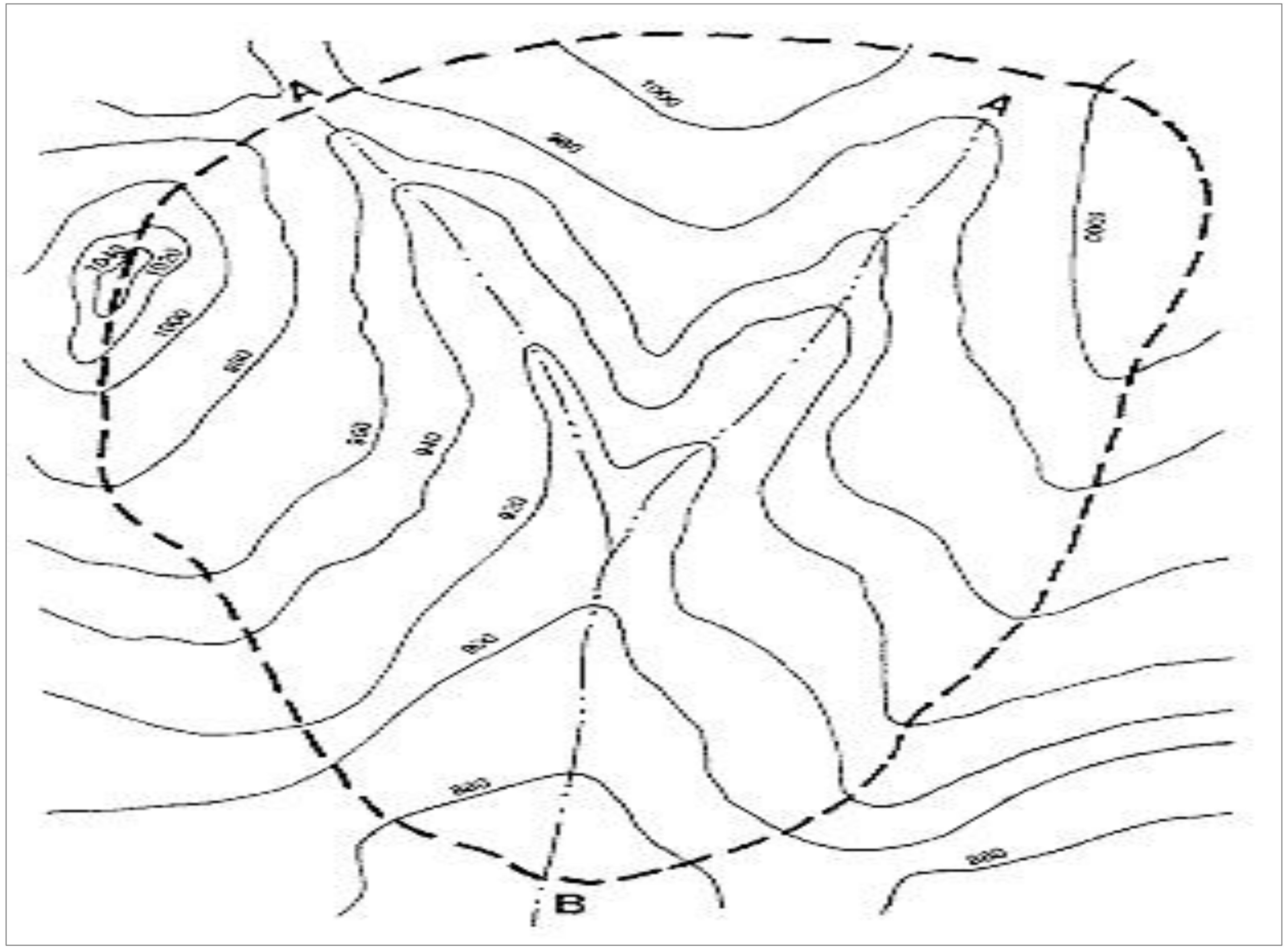


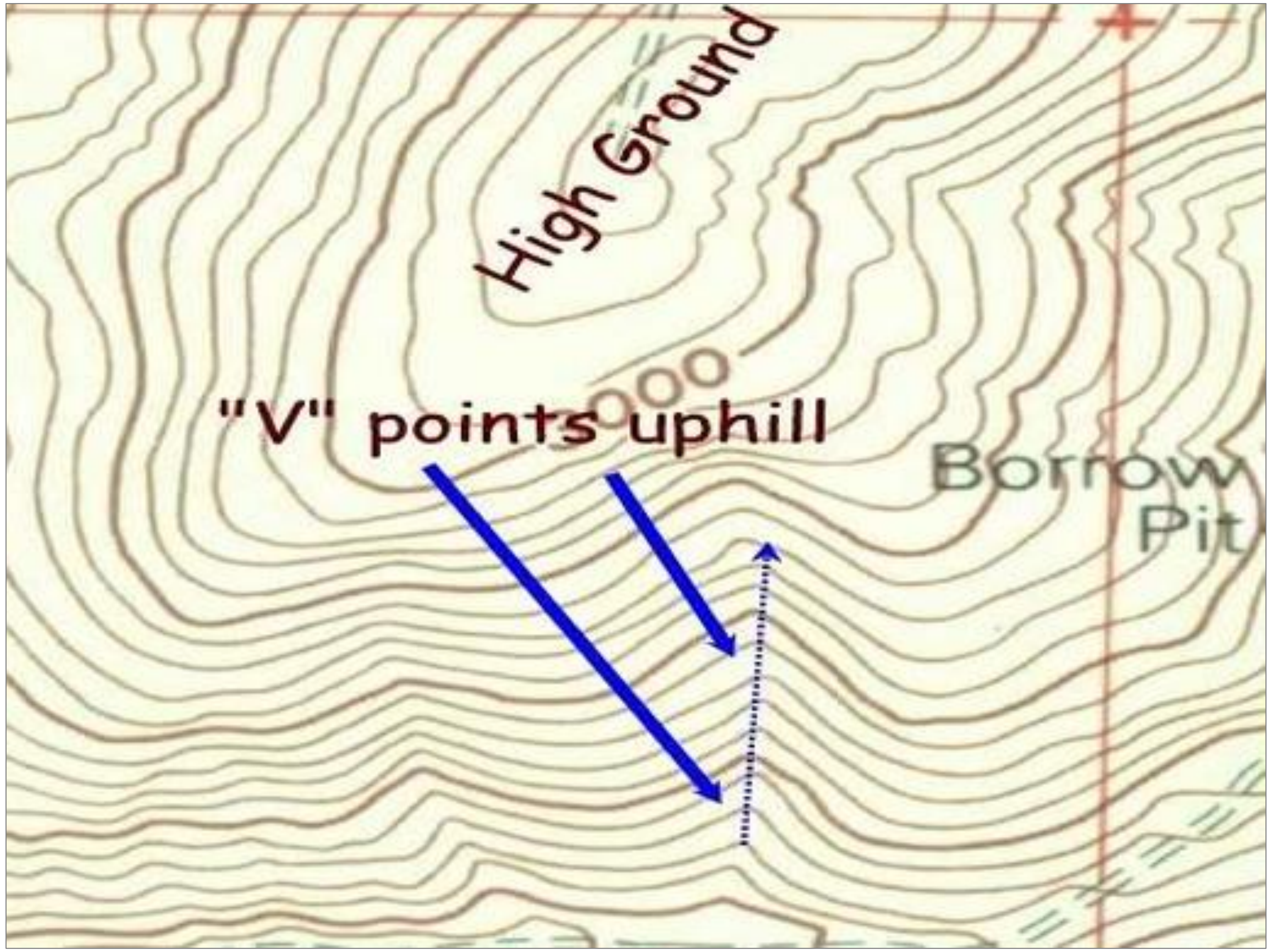
b) Contours form closed loops (even if not shown on the map.



Rules for Contour lines…..contd.

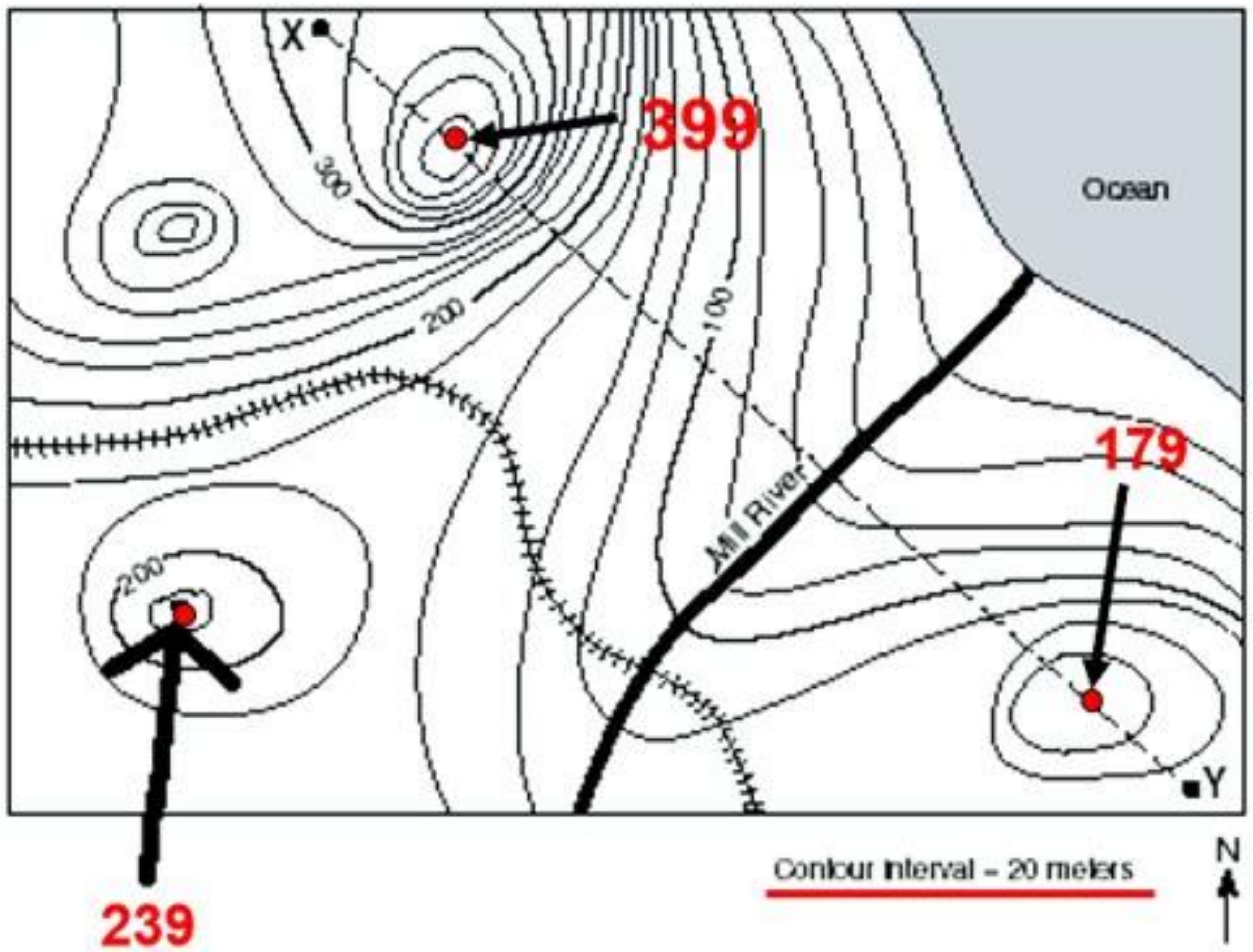
c) contours bend upstream (uphill), when crossing a stream.

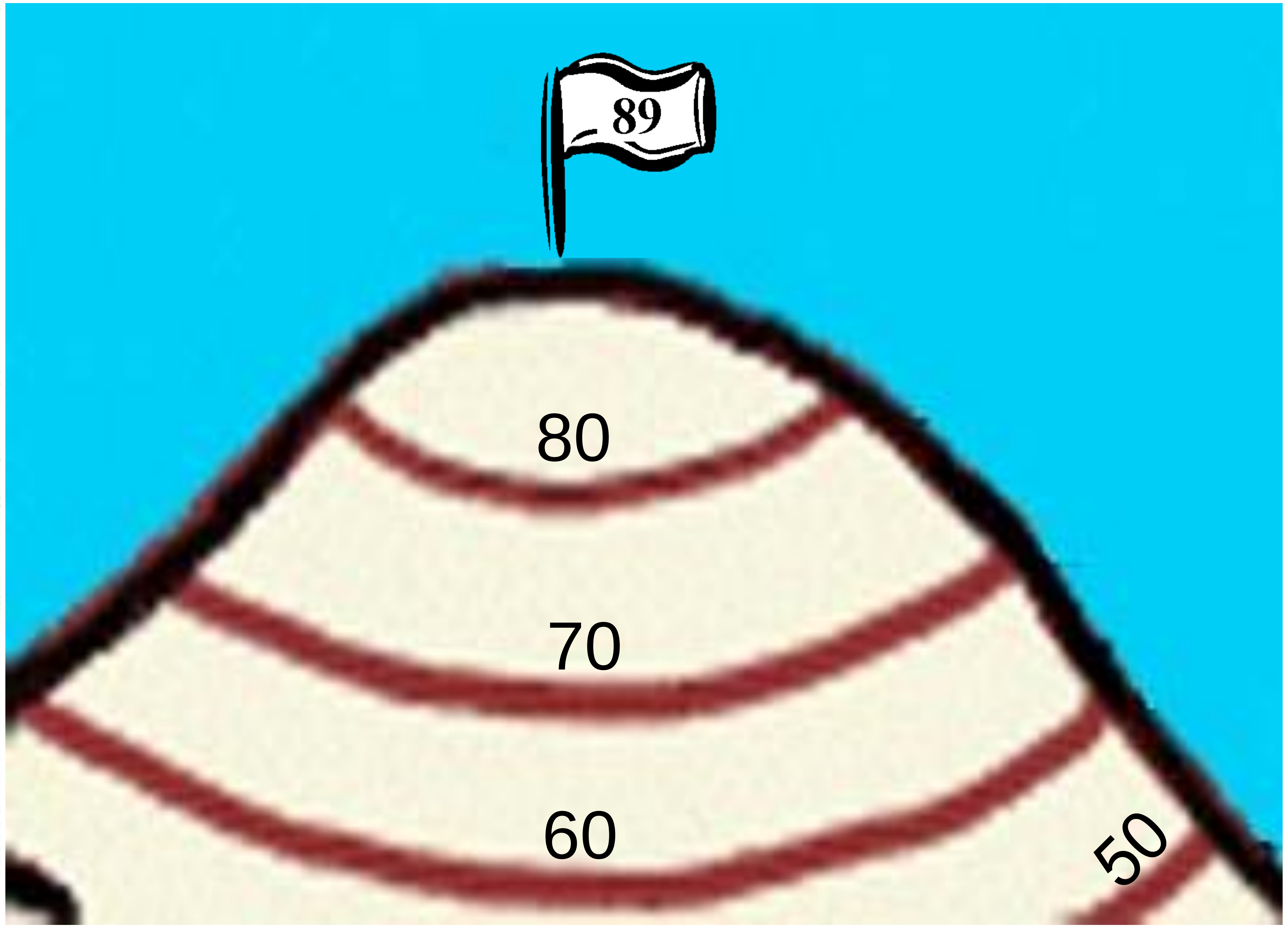




Rules for Contour lines…..contd.

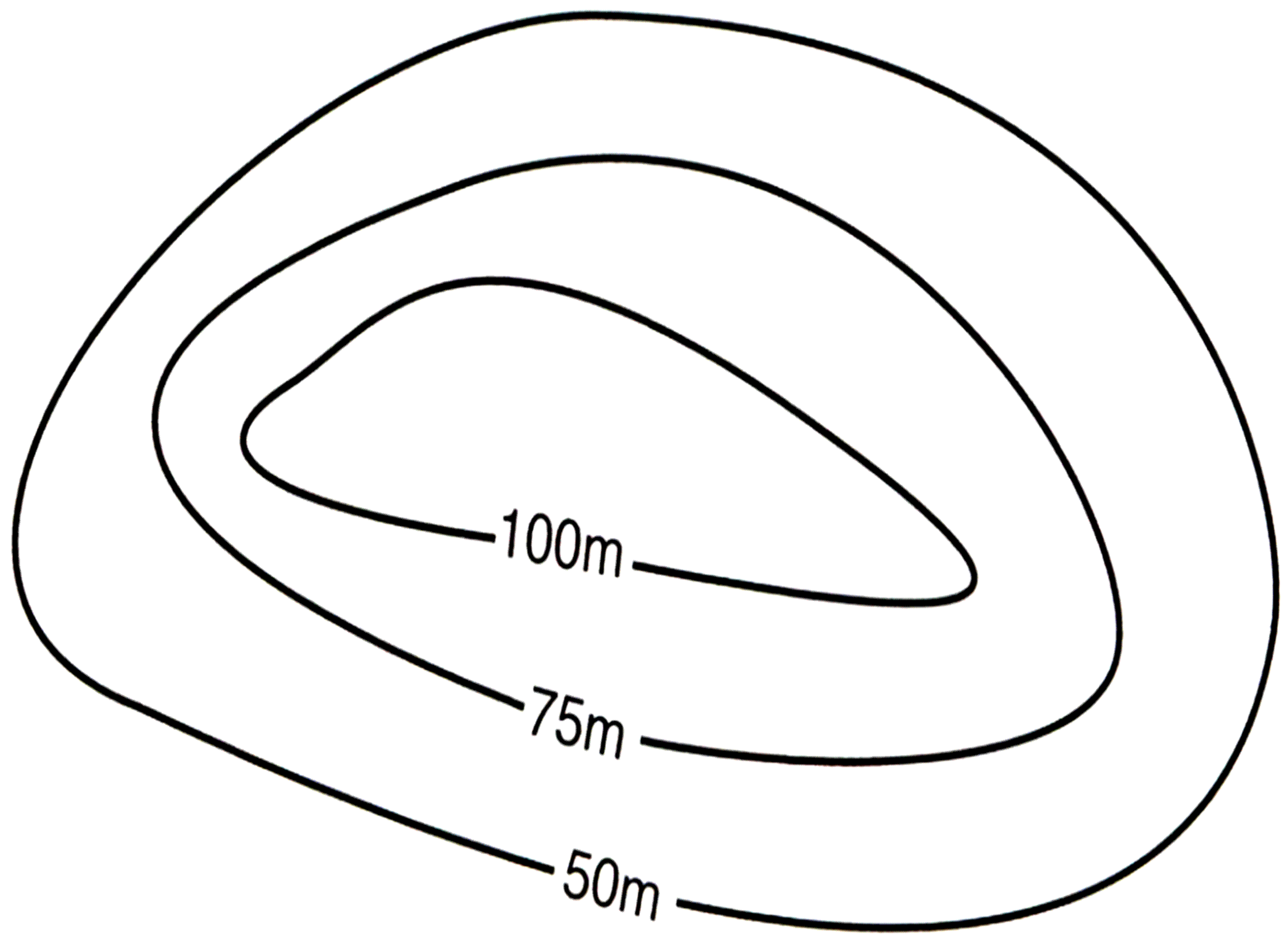
d) The maximum possible elevation for a hill is "1" less than what the next contour "should" be, i.e. highest possible elevation of hill is **just below** the value of next line <u>that is not shown</u>.

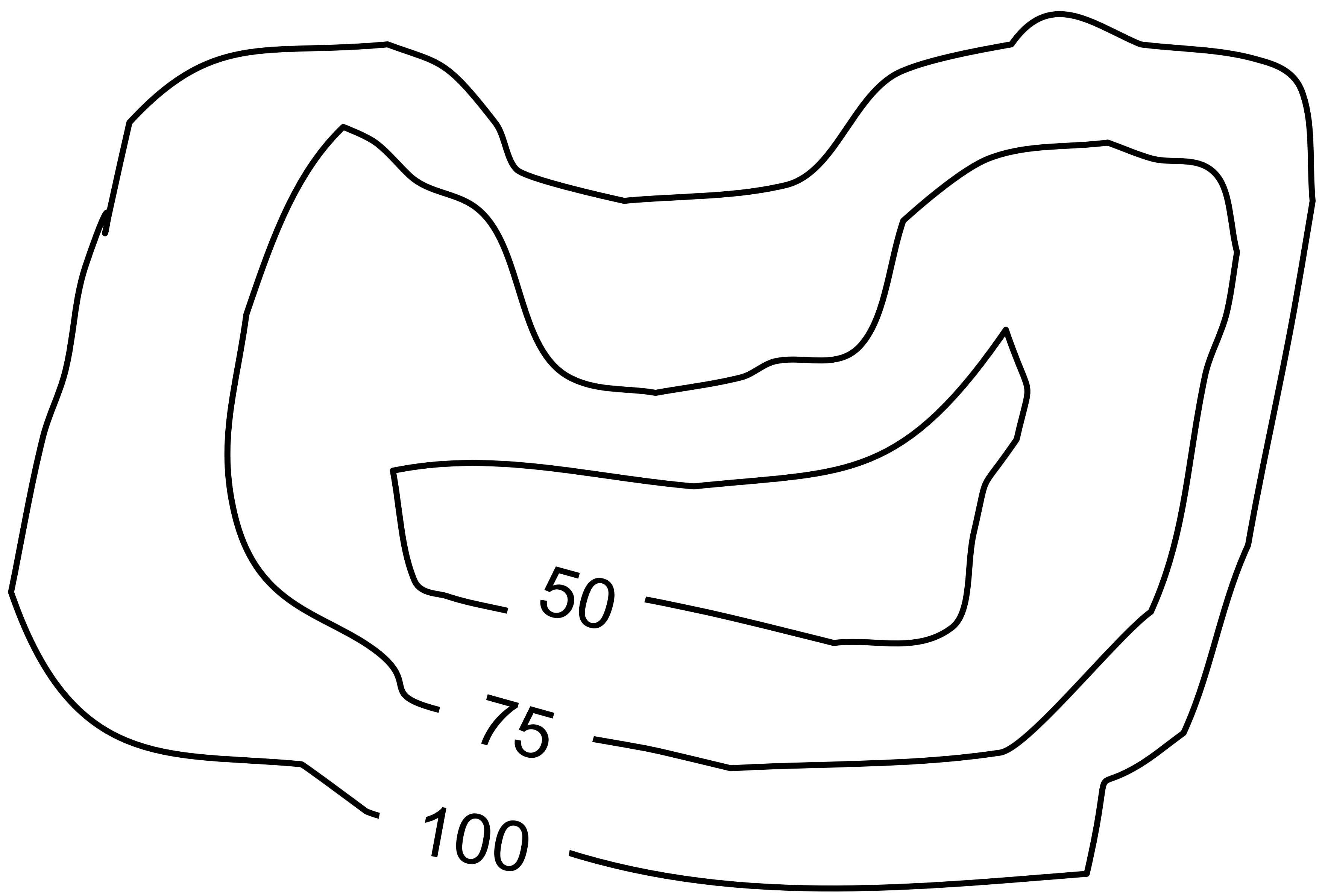




Rules for Contour lines…..contd.

iii) Contours are Closed in domes / basins





a) **Dome/Isolated Hill** – *closed curves decrease in size. Inner curves are at higher elevation than outer curves, and* ***peak is within the innermost curve***

b) **Basin/Depression** – *closed curves increase in size. Inner curves are at lower elevation than outer curves, and* ***depression is within the innermost curve.***

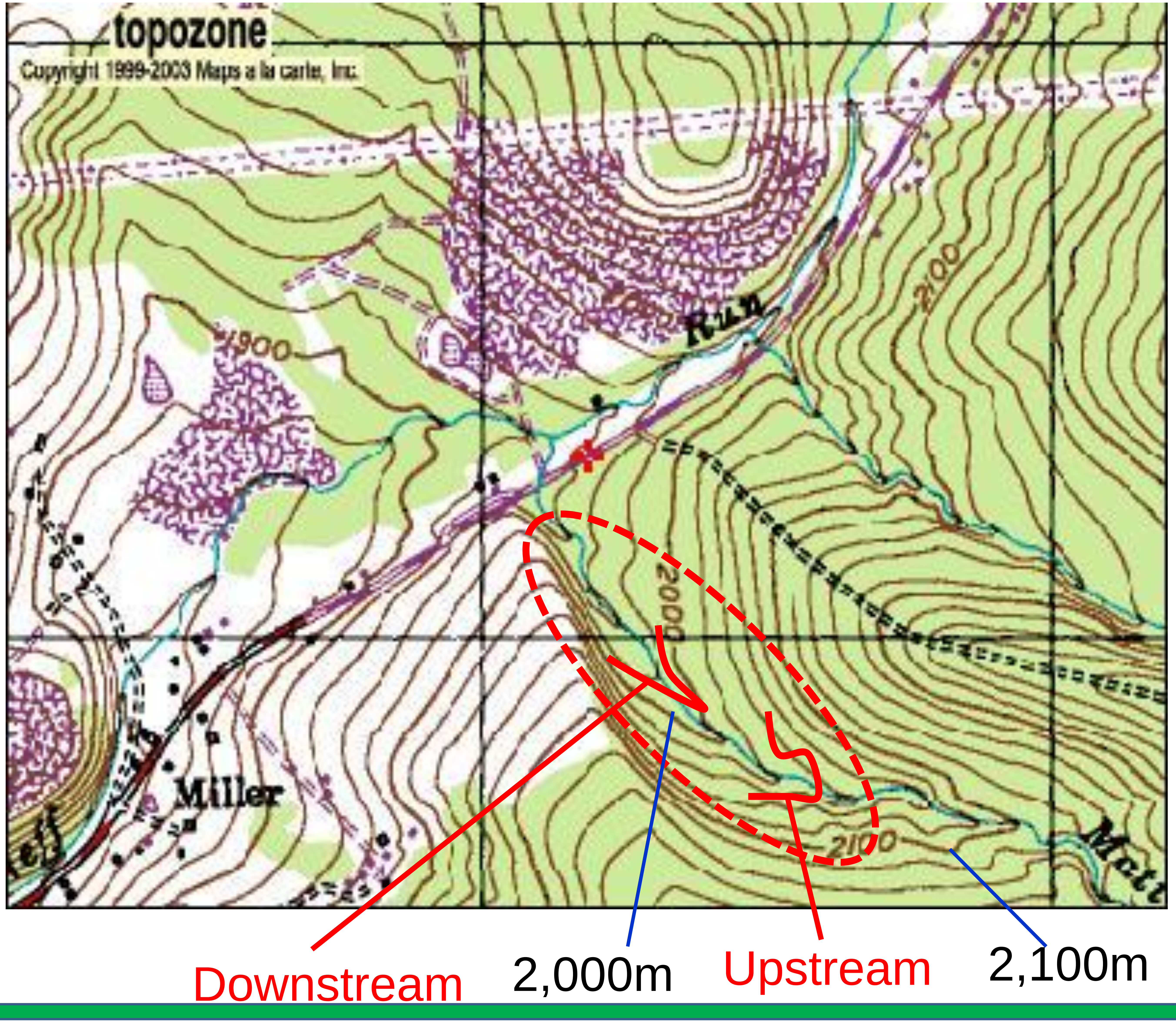
What to Read from a Topographic Map

i) Tracking River Flow direction

a) How does water flow? – usually DOWNHILL

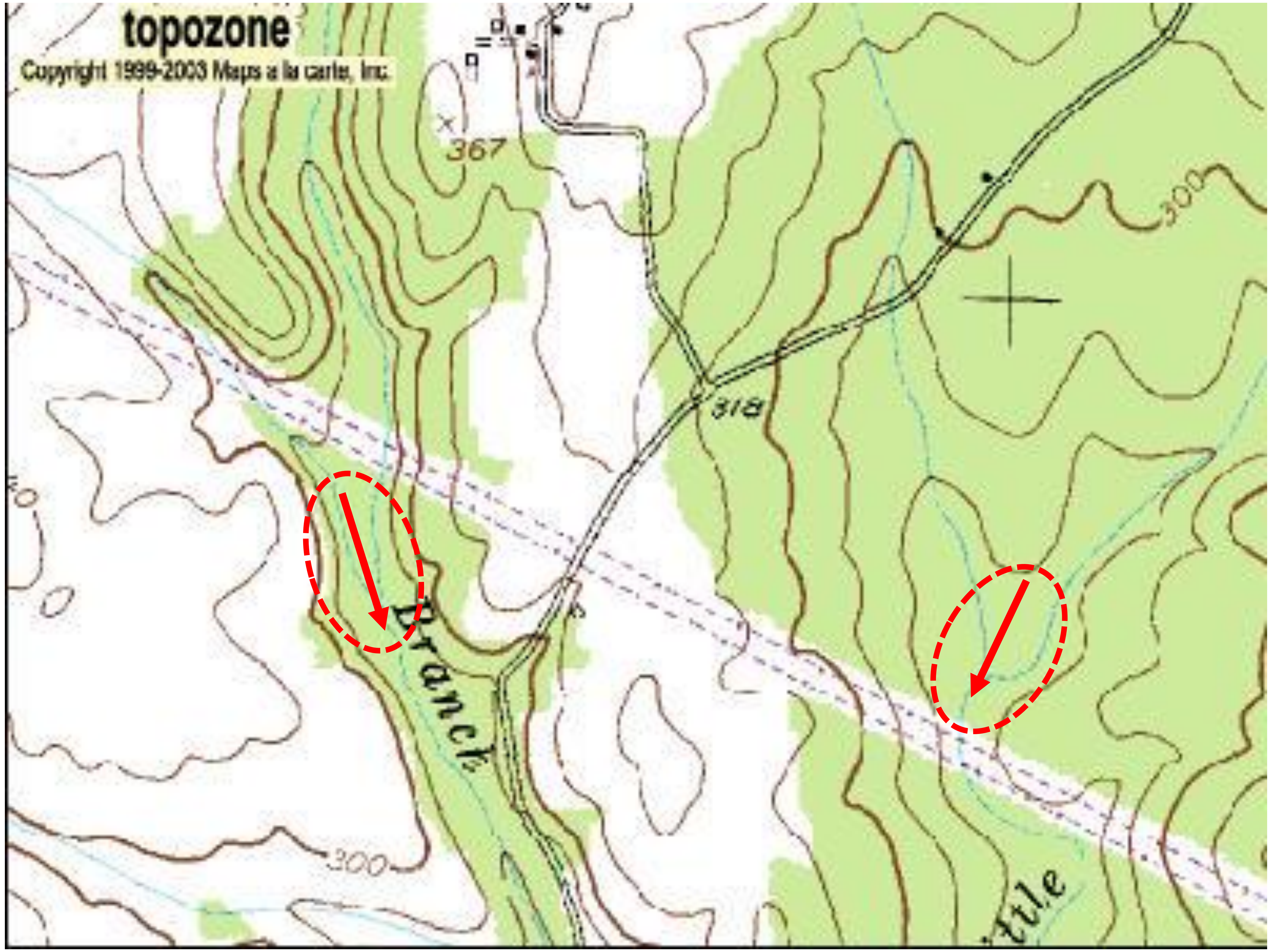
b) How can one tell, what direction (N, S, E,...) is **downhill?**

- Look for elevation changes since water will flow from higher to lower elevations.
- Look at the contour lines as they cross the stream – they always point upstream.



What to Read from a Topographic Map…..contd.

c) Also look at where two streams merge. The merge-point will form a V, which **ALWAYS points downstream**.



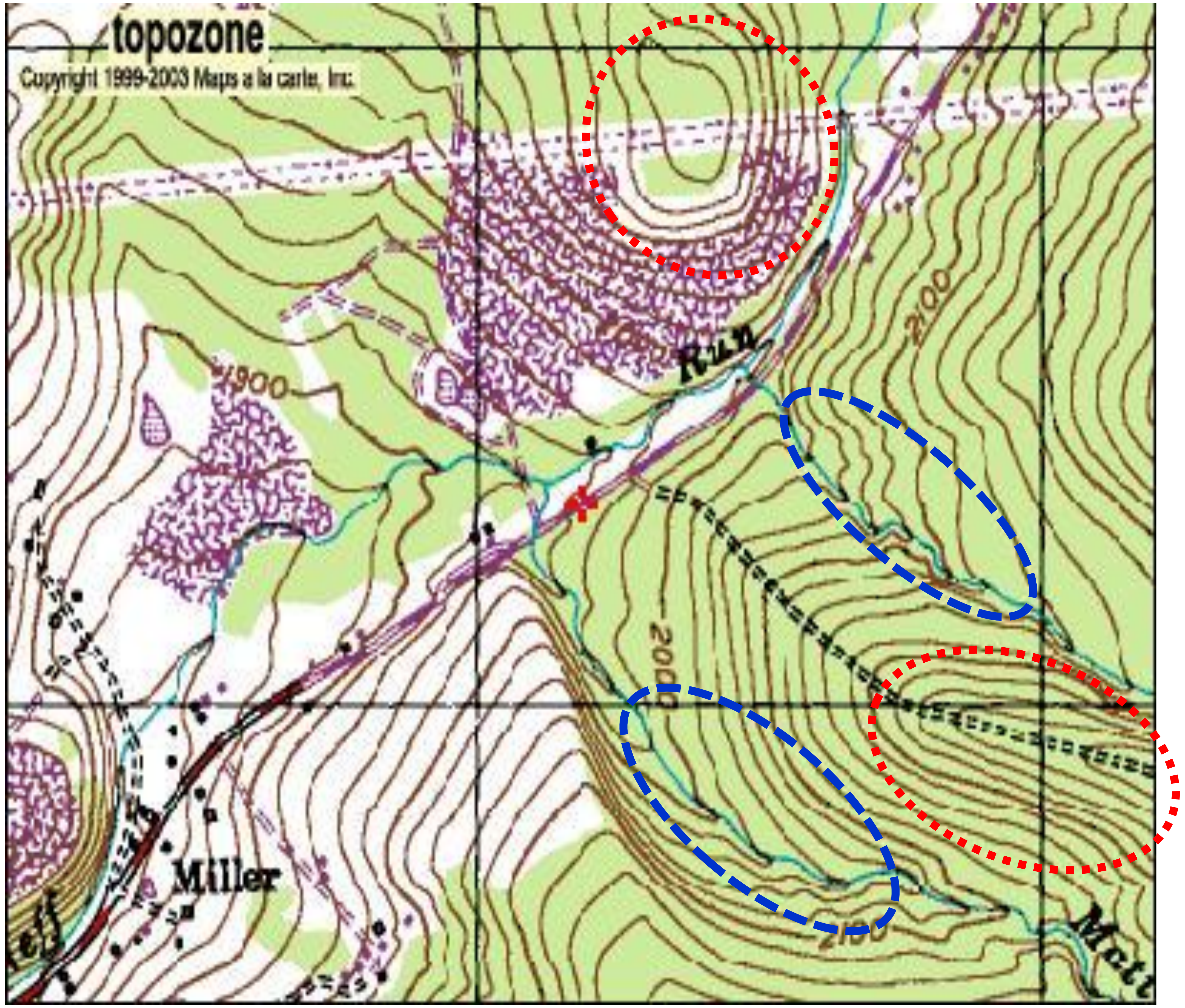
Direction of flow

What to Read from a Topographic Map…..contd.

ii) A 3-D view of topography

This is achieved by noting:

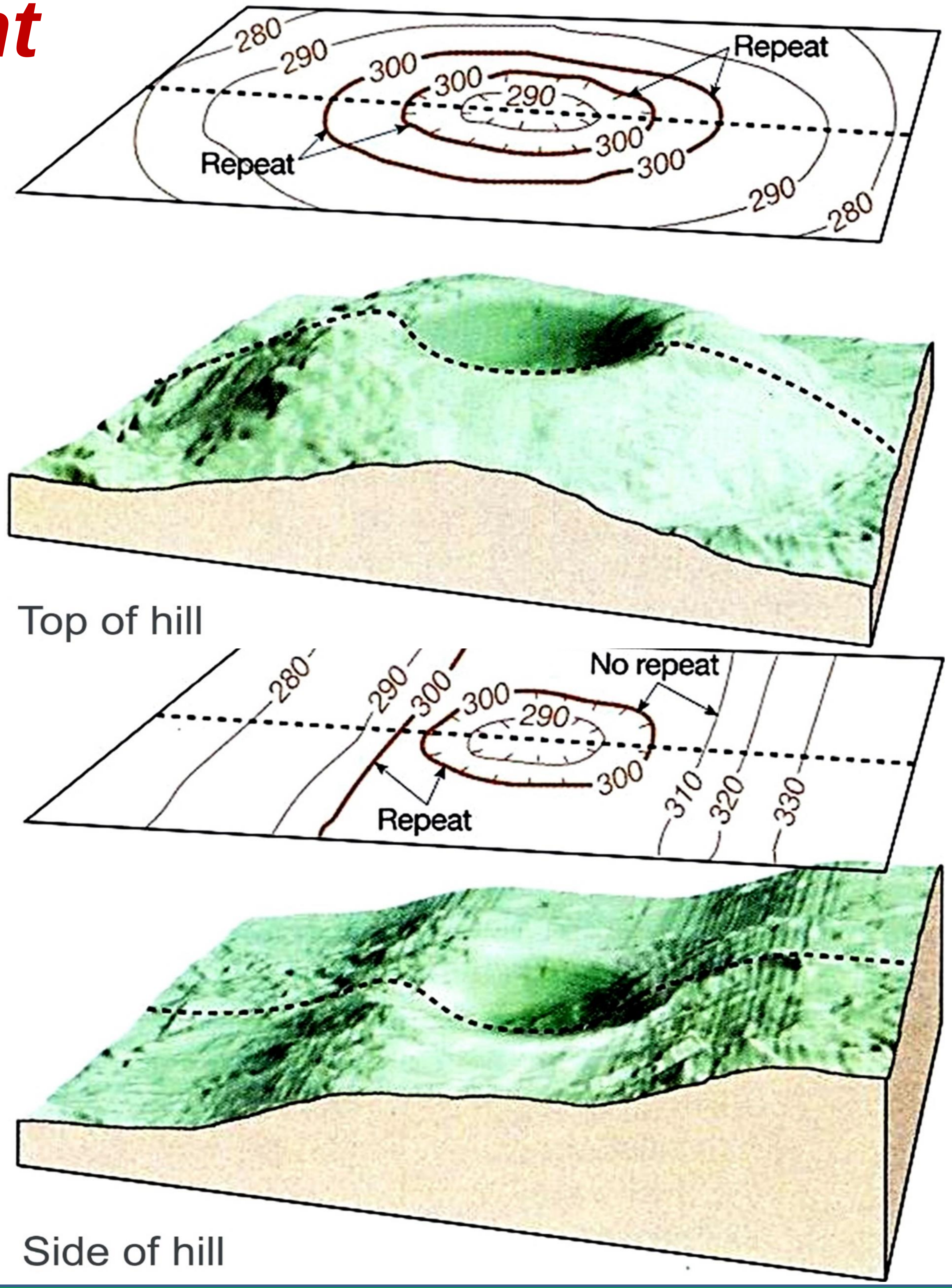
- ✓ spatial distribution of **rises** & **depressions** *for location of hills and valleys + their elevations.*
- ✓ courses of most important watersheds
- ✓ map distances (spacing) between contour lines **noting steep slopes** & **flat country**.



What to Read from a Topographic Map…..contd.

iii) Reading of contour lines in and adjacent to depression…..

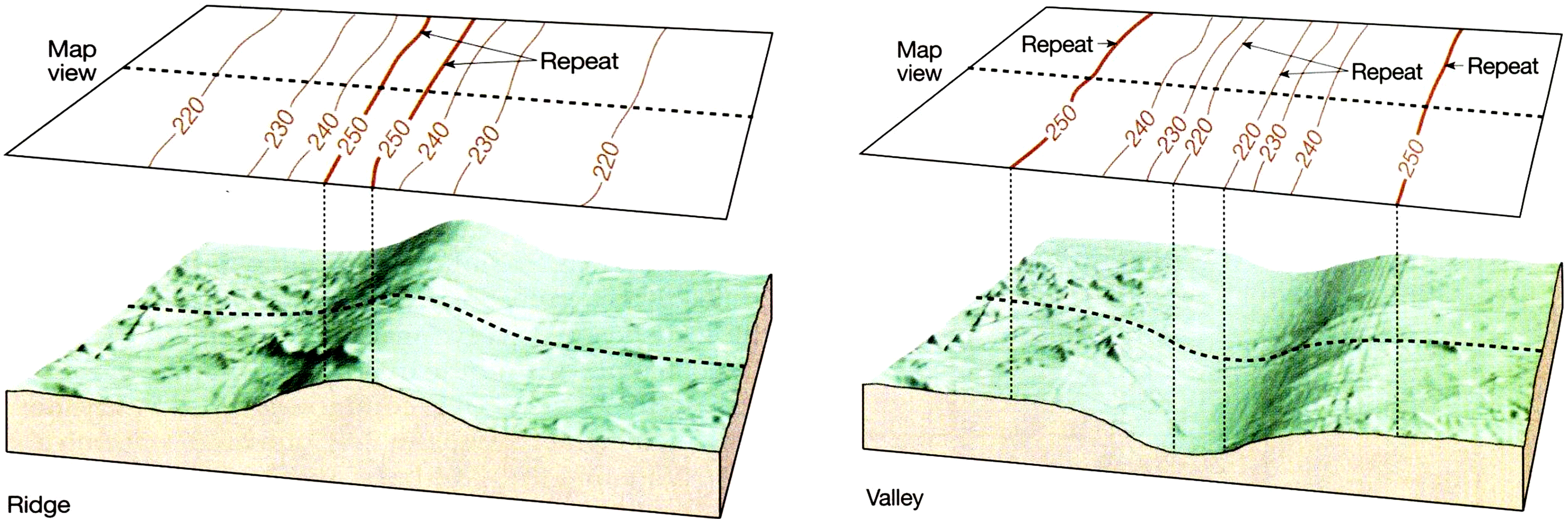
- **Hachure marks** on some contour lines indicate presence of **closed depression**.
    - At **top of a hill**, **contour lines repeat** on opposite side of depression.
    - On side of a hill, contour lines repeat only on downhill side of depression.



What to Read from a Topographic Map…..contd.

…..*and/or adjacent to a domical / basin structure*

Contour lines repeat (occur in pairs) on either side of linear ridges and valleys. *E.g. if you walked the dashed line from left – right, you'd cross 220- 230- 240- and 250-m contour lines, go over crest of ridge, and cross 250- and 240- 230- 220-m contours again as you walk down the other side.*

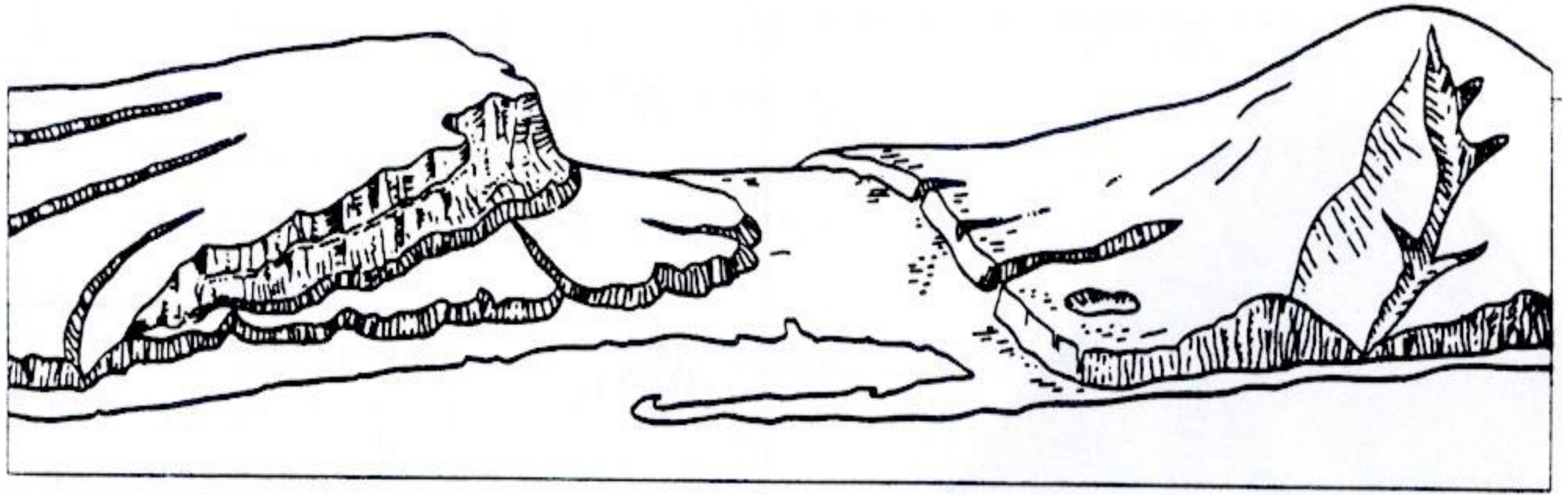


What to Read from a Topographic Map.....contd.

<u>All </u> these observations must be done <u>automatically when studying a map.</u>

It is only with a complete <u>picture of topography </u>in your head that you can start to interpret a geological map!!

A Topographic map



Corresponding landscape morphology

SUMMARY OF CONTOURS

1. Every point on a contour line is of the exact same elevation; that is, contour lines connect points of equal elevation.

2. Contour lines always separate points of higher elevation (uphill) from points of lower elevation (downhill). You must determine which direction on the map is higher and which is lower, relative to the contour line in question, by checking adjacent elevations.

3. Contour lines always close to form an irregular circle. But sometimes part of a contour line extends beyond the mapped area so that you cannot see the entire circle formed.

4. The elevation between any two adjacent contour lines of different elevation on a topographic map is the *contour interval*. Often every fifth contour line is heavier so that you can count by five times the contour interval. These heavier contour lines are known as *index contours*, because they generally have elevations printed on them.

5. Contour lines never cross one another except for one rare case: where an overhanging cliff is present. In such a case, the hidden contours are dashed.

6. Contour lines can merge to form a single contour line only where there is a vertical cliff.

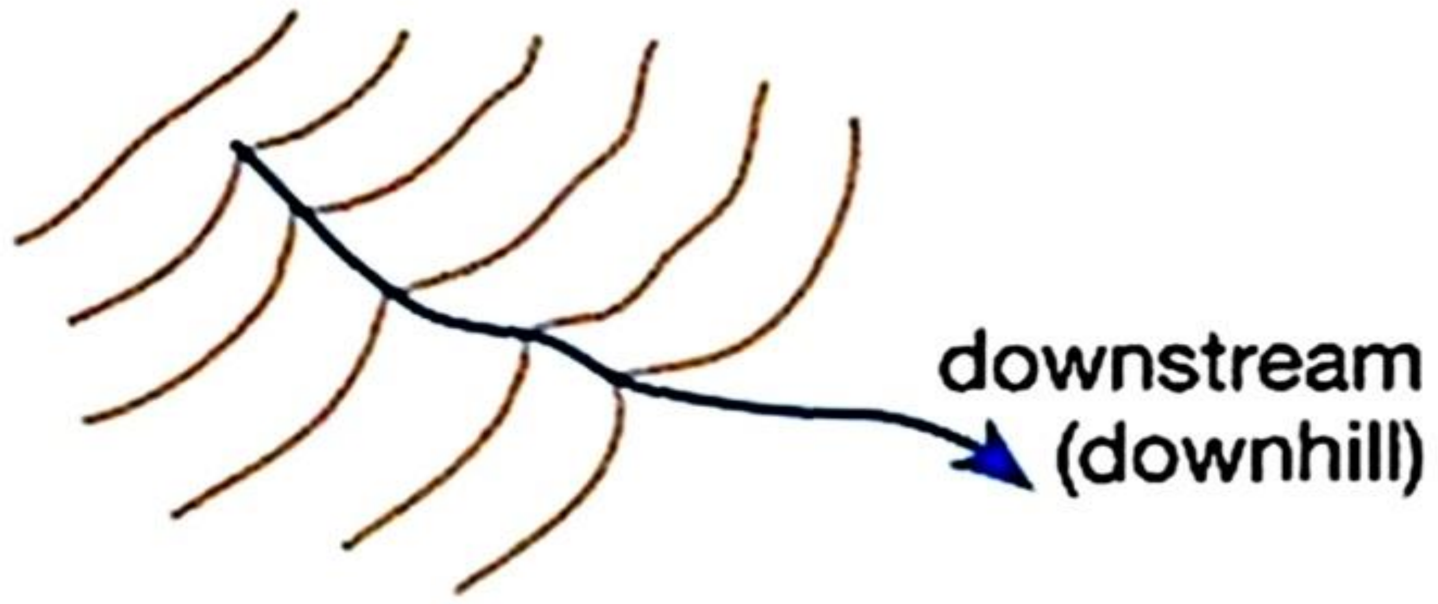
7. Evenly spaced contour lines of different elevation represent a uniform slope.

8. The closer the contour lines are to one another the steeper the slope. In other words, the steeper the slope the closer the contour lines.

9. A concentric series of closed contours represents a hill:

10. *Depression contours* have hachure marks on the downhill side and represent a closed depression:

11. Contour lines form a V pattern when crossing streams. The apex of the V always points upstream (uphill):



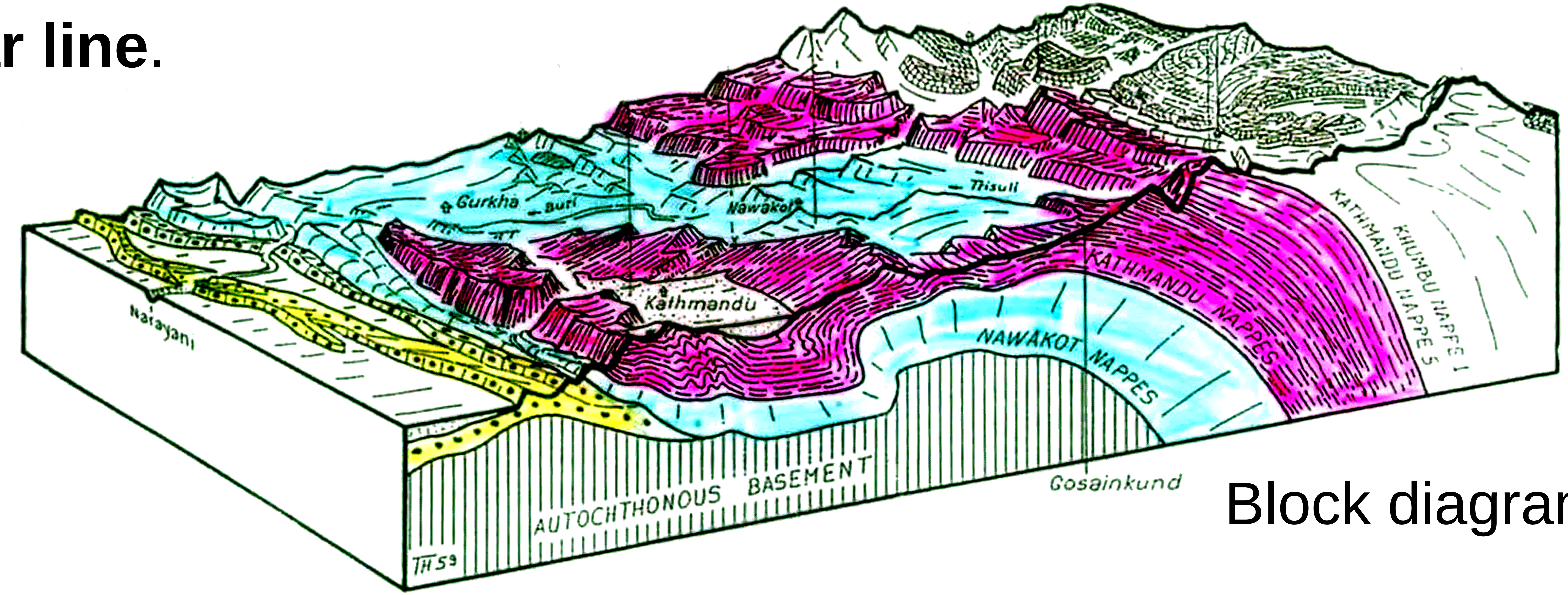
12. Contour lines that occur on opposite sides of a valley always occur in pairs.

13. Topographic maps are contoured in metres referenced to sea level

Construction of a Topographic Profile

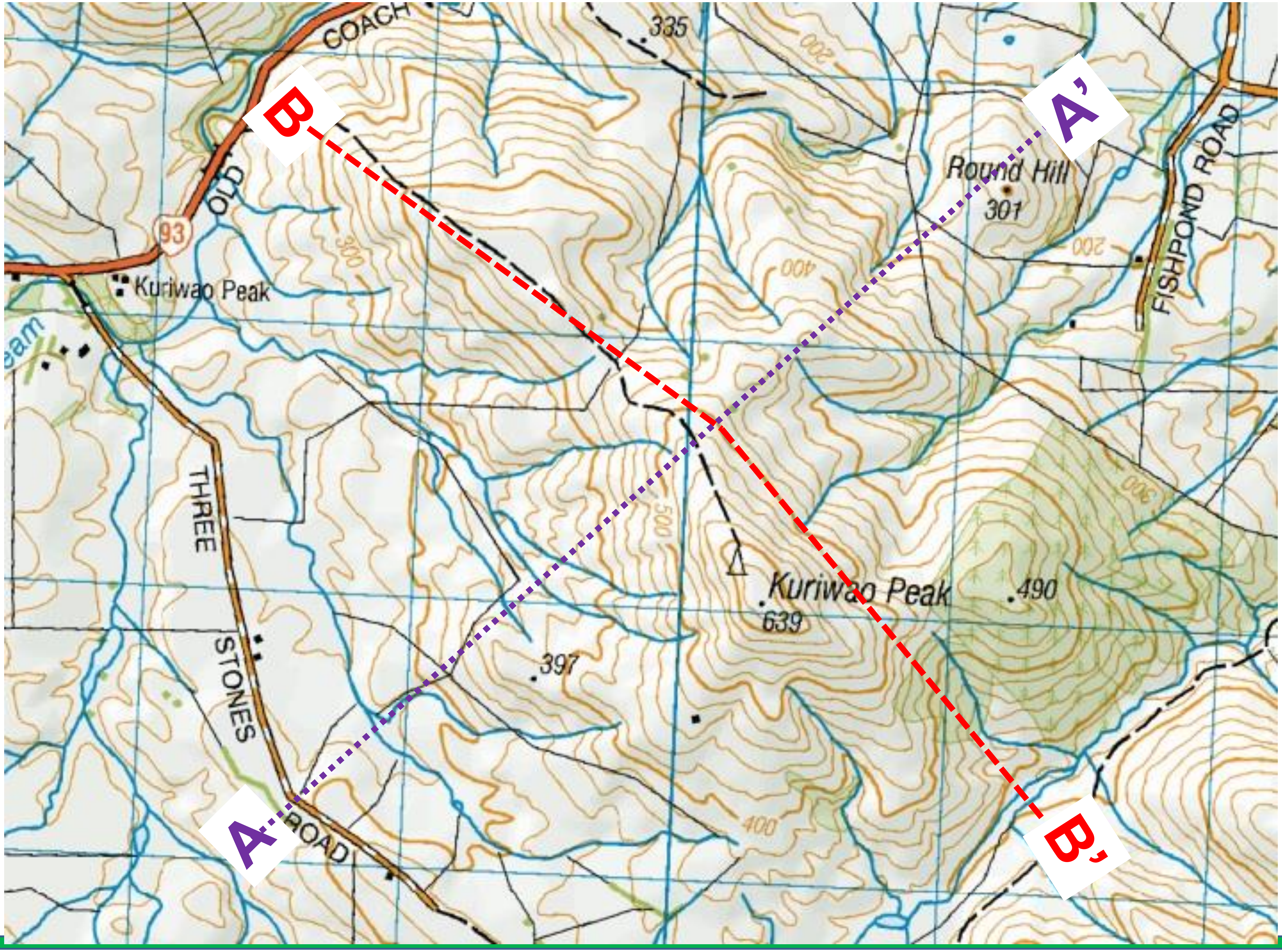
A Topographic Profile:

- is an **outline of land** as it would appear in a **vertical slice** along a **particular line**.



Block diagram

Construction of a Topographic Profile…..contd.

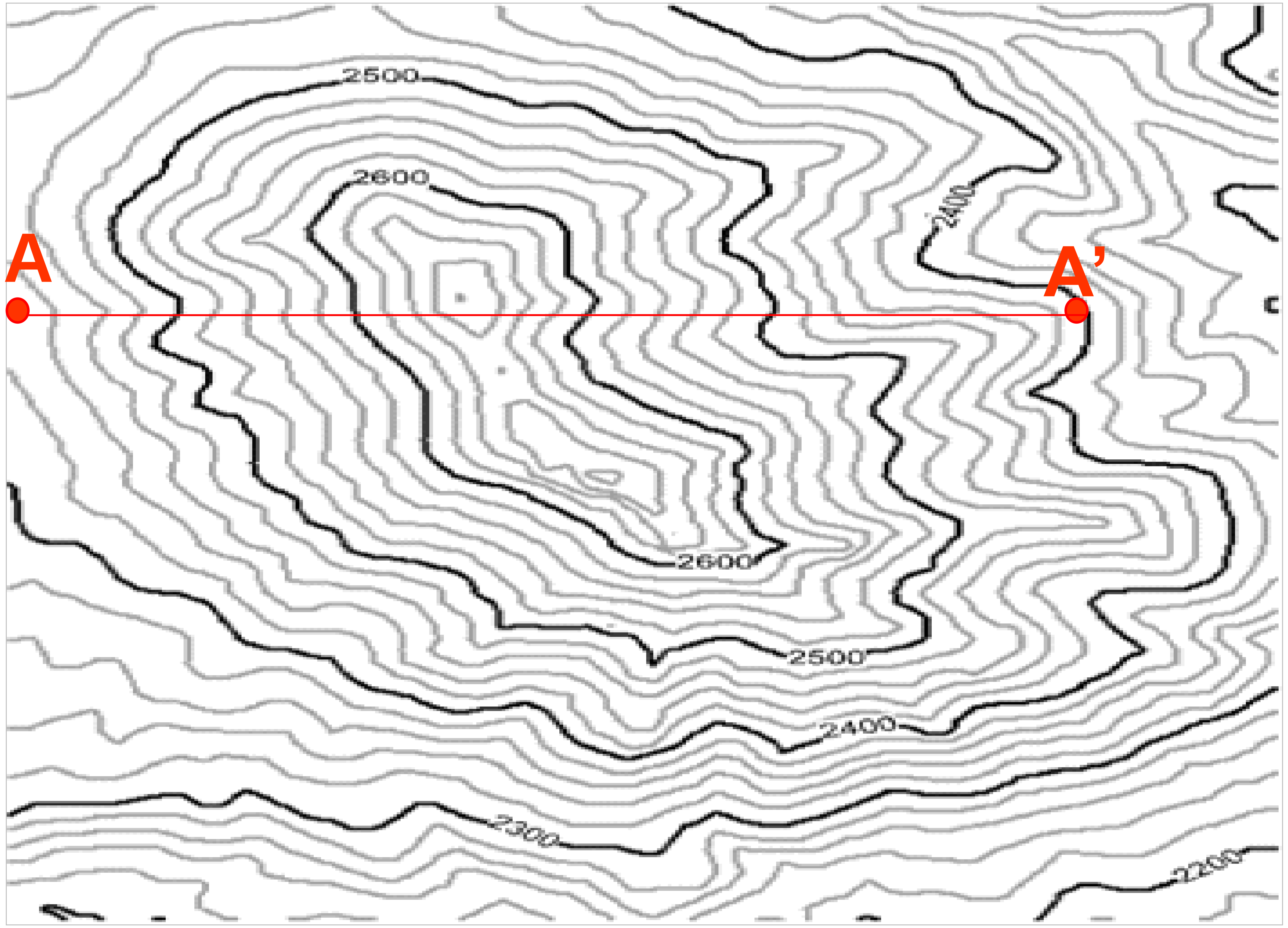


Construction of a Topographic Profile…..contd.

Example in drawing profile:

Step 1

1. On map, draw a line of section along which profile is to be constructed.
2. Label the section line. A-A‘
3. Be sure that line intersects all features of interest (ridges, valleys, streams, etc.) that you wish the profile to show.

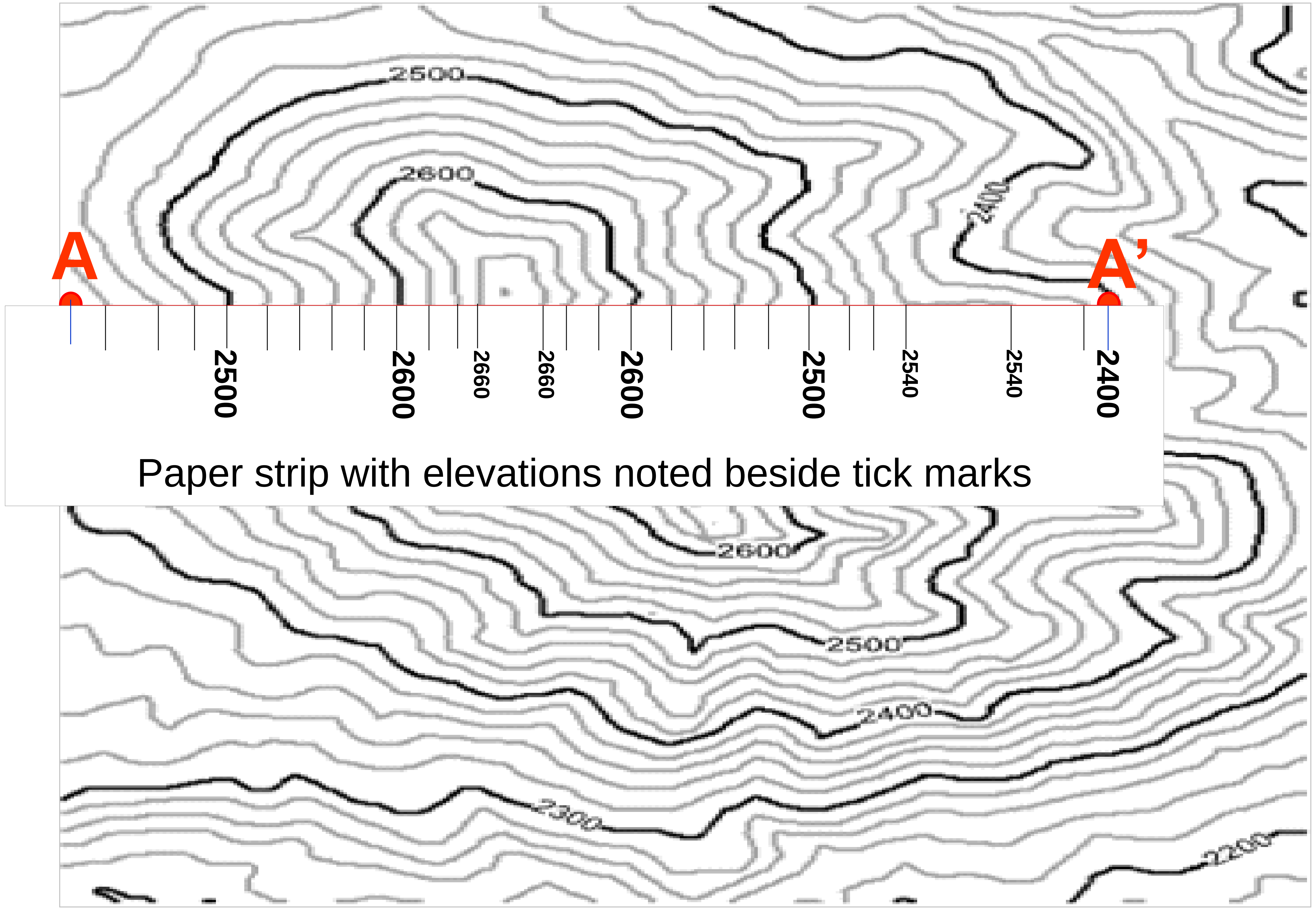


Construction of a Topographic Profile…..contd.

Step 2:

On a **strip of paper** placed **along the section line,** A-A‘:

- make **tick marks** at each place where a **contour line intersects** the section line, and **note**;
  - ✓ <u>elevation</u> at the tick marks.
  - ✓ location and elevation of points A and A' and any streams crossed.



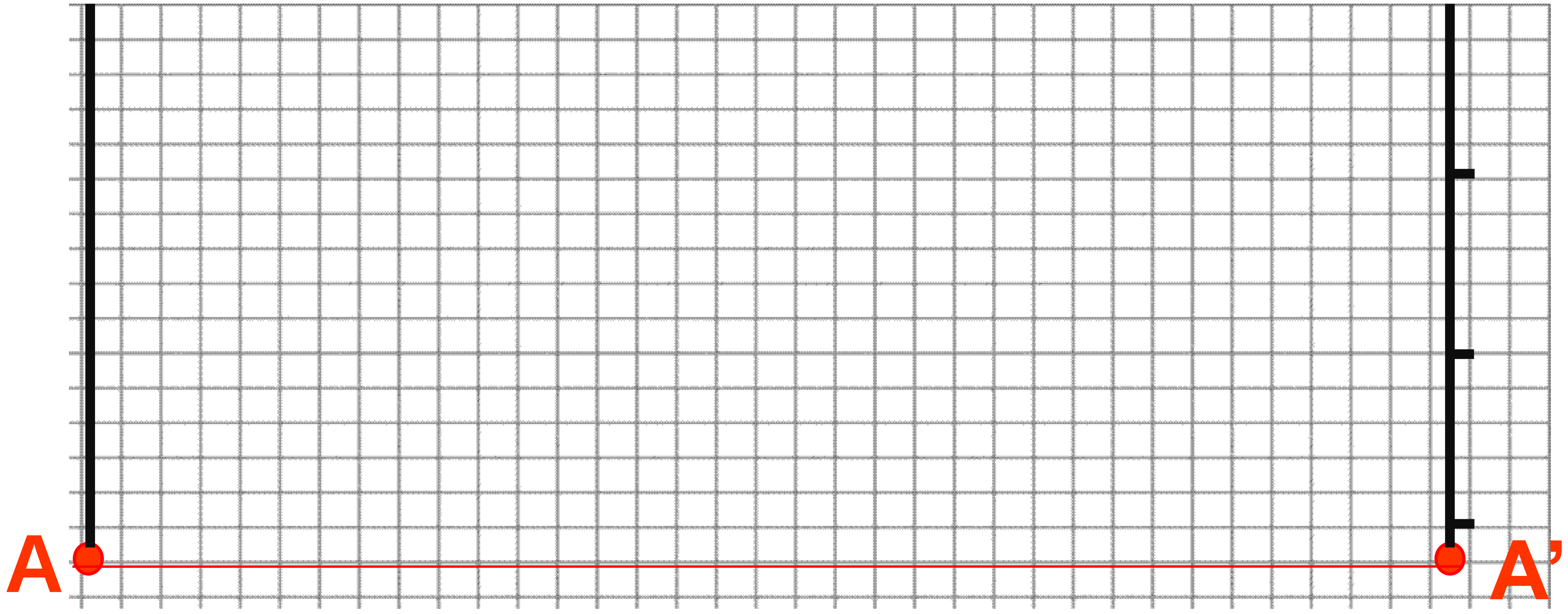
Paper strip with elevations noted beside tick marks

Construction of a Topographic Profile.....contd.

Step 3 – Drawing profile

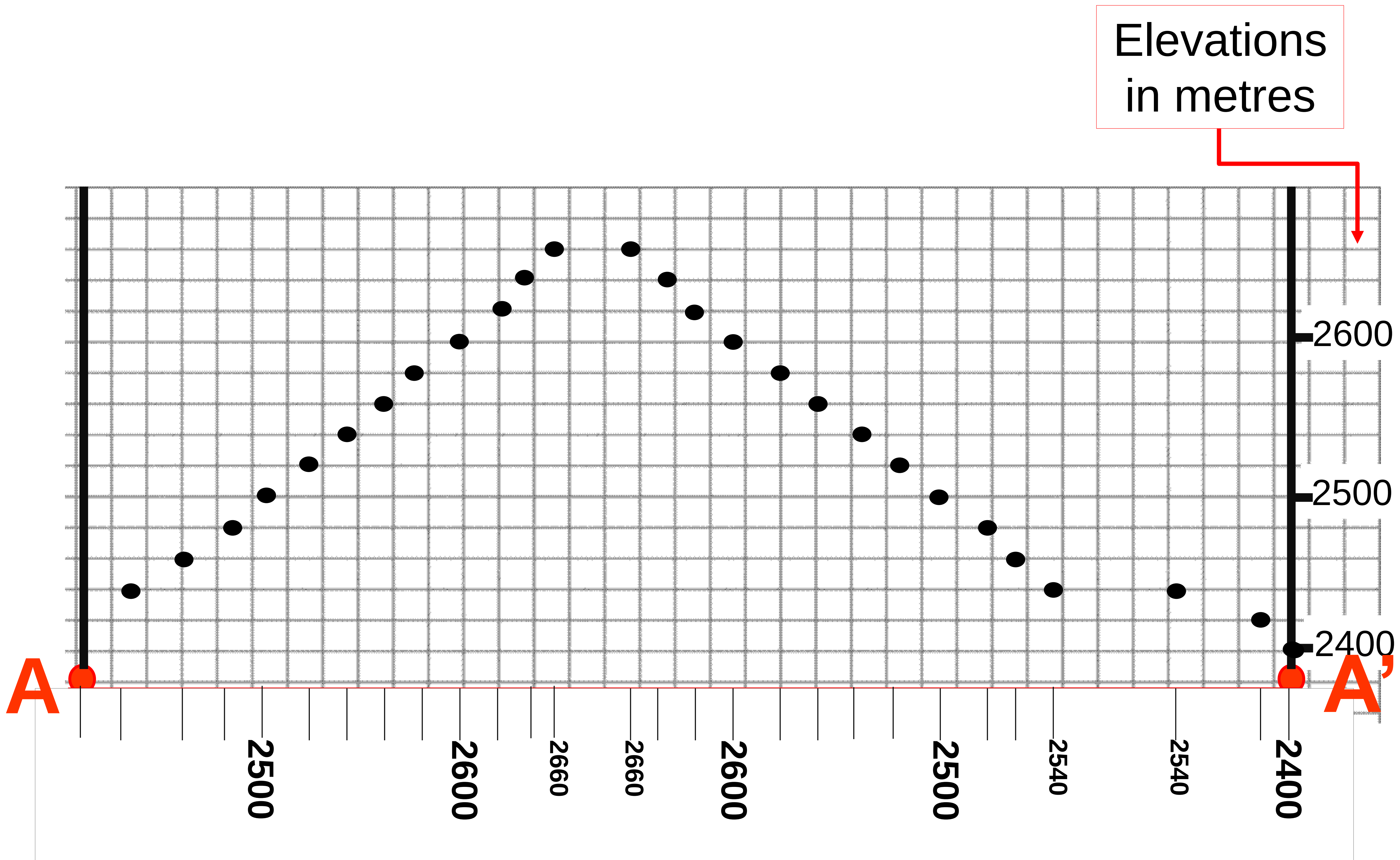
On a **separate sheet** of paper, **preferably graph paper:**

- Mark equally spaced points, with each representing a **constant elevation**, and thus **corresponding** to a contour line - total number of points needed and their elevations depend on:
  - total relief along line of section, and
  - space between lines equal to **contour interval**, or **multiples** of it (vertical exaggeration)



Construction of a Topographic Profile…..contd.

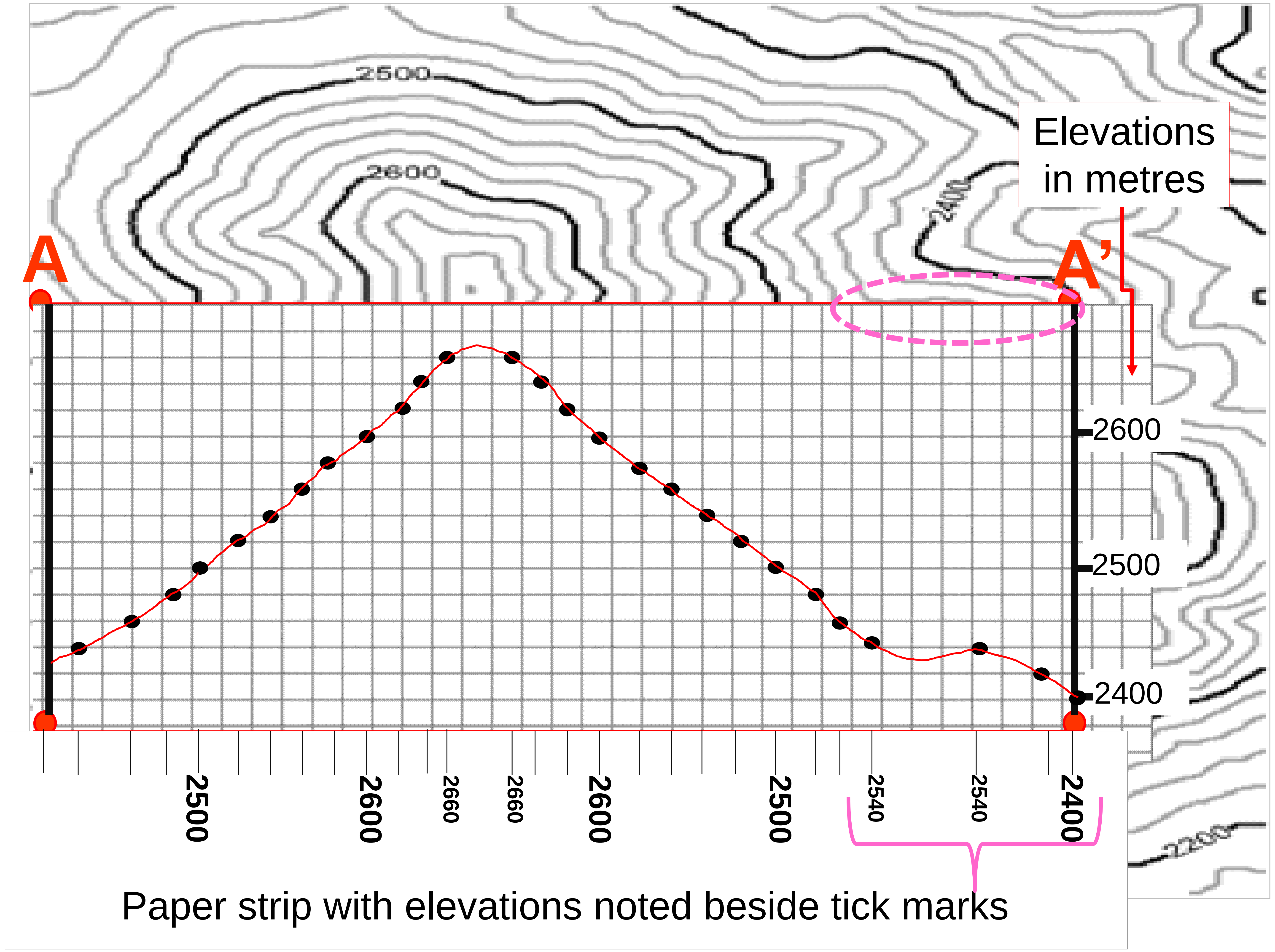
- ✓ Label your lines so that the highest and lowest elevations along the line of section will be within the grid.
- ✓ units on vertical axis should bracket highest & lowest elevations to be shown on profile, and should be at same scale as the horizontal scale, which is that of the map.
- ✓ Then, take the strip of paper you marked in **Step 2**, and place it along the base of your profile.
- ✓ Mark a dot on the grid above it for each elevation.



Paper strip with elevations noted beside tick marks

Construction of a Topographic Profile…..contd.

Smoothly connect these dots to complete the <u>topographic profile.</u> (This line should not make angular bends…..Make it a **smoothly curving line that reflects the relief** of the land surface along the line of section)



Paper strip with elevations noted beside tick marks

Construction of a Topographic Profile…..contd.

The most realistic representation of topography is obtained when:

- ✓ The **vertical scale** for the profile **is the same as horizontal scale**, but
  - ✓ it is common practice to **exaggerate** vertical scale, especially in areas of low relief,
    - ✓ in order to make features stand out more clearly.

Construction of a Topographic Profile.....contd.

Step 4 – Vertical Scale

The **Vertical scale** of your profile **will vary greatly**, depending on how you draw your grid. It almost certainly will be larger than horizontal scale of map. This difference causes an EXAGGERATION in the vertical dimension.

Such exaggeration is almost always necessary to construct a readable profile, for **without vertical exaggeration**, the profile might be so shallow that only the **highest peaks** would be visible.

Construction of a Topographic Profile.....contd.

For example: If:

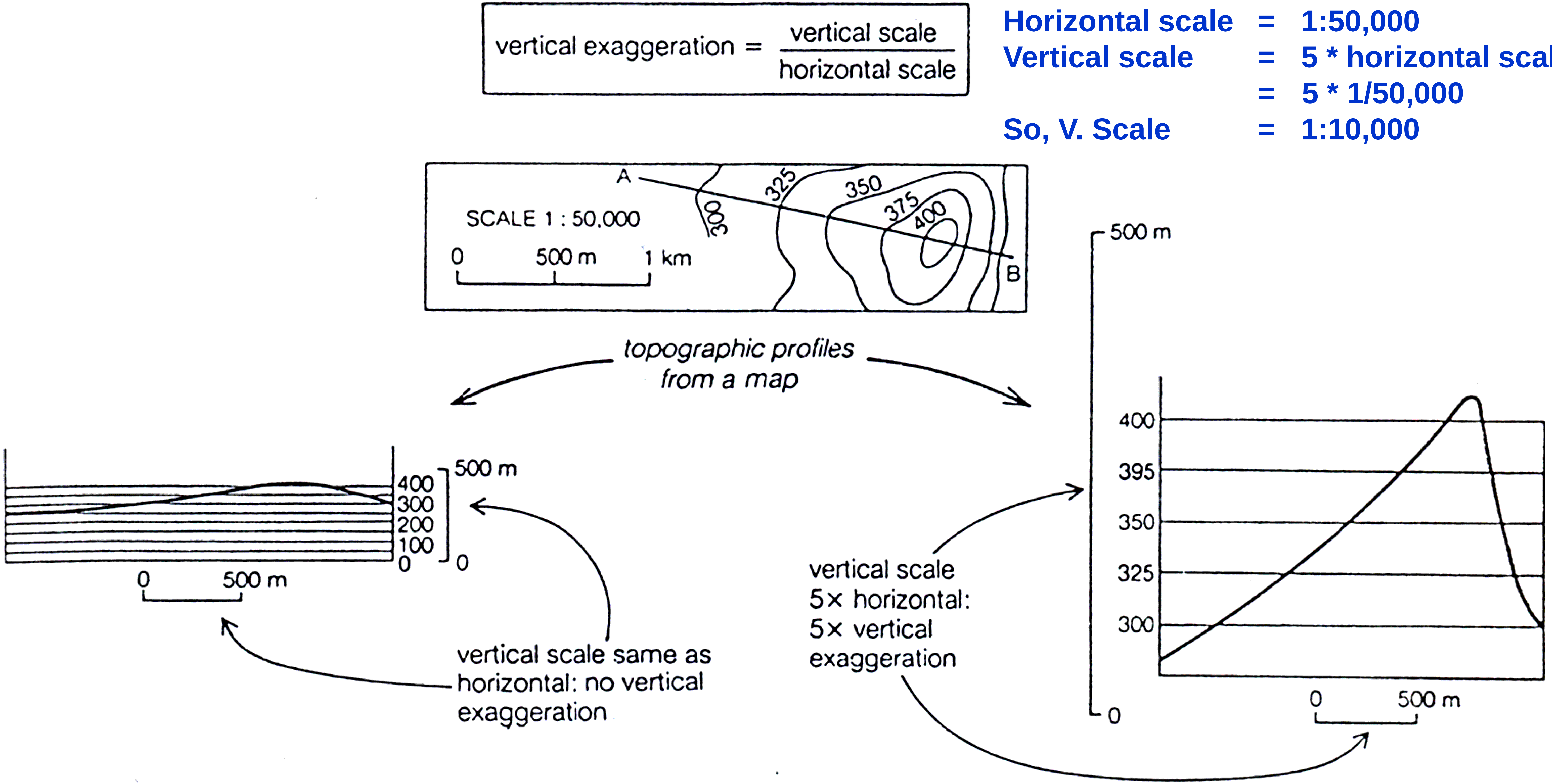
- The **vertical scale** is **1:1,440**, and
- **Horizontal scale** is **1:24,000**, then;

Vertical Exaggeration is determined by **dividing the vertical fractional scale (1/1440) by the horizontal fractional scale (1/24,000)** giving a value **16.7.**

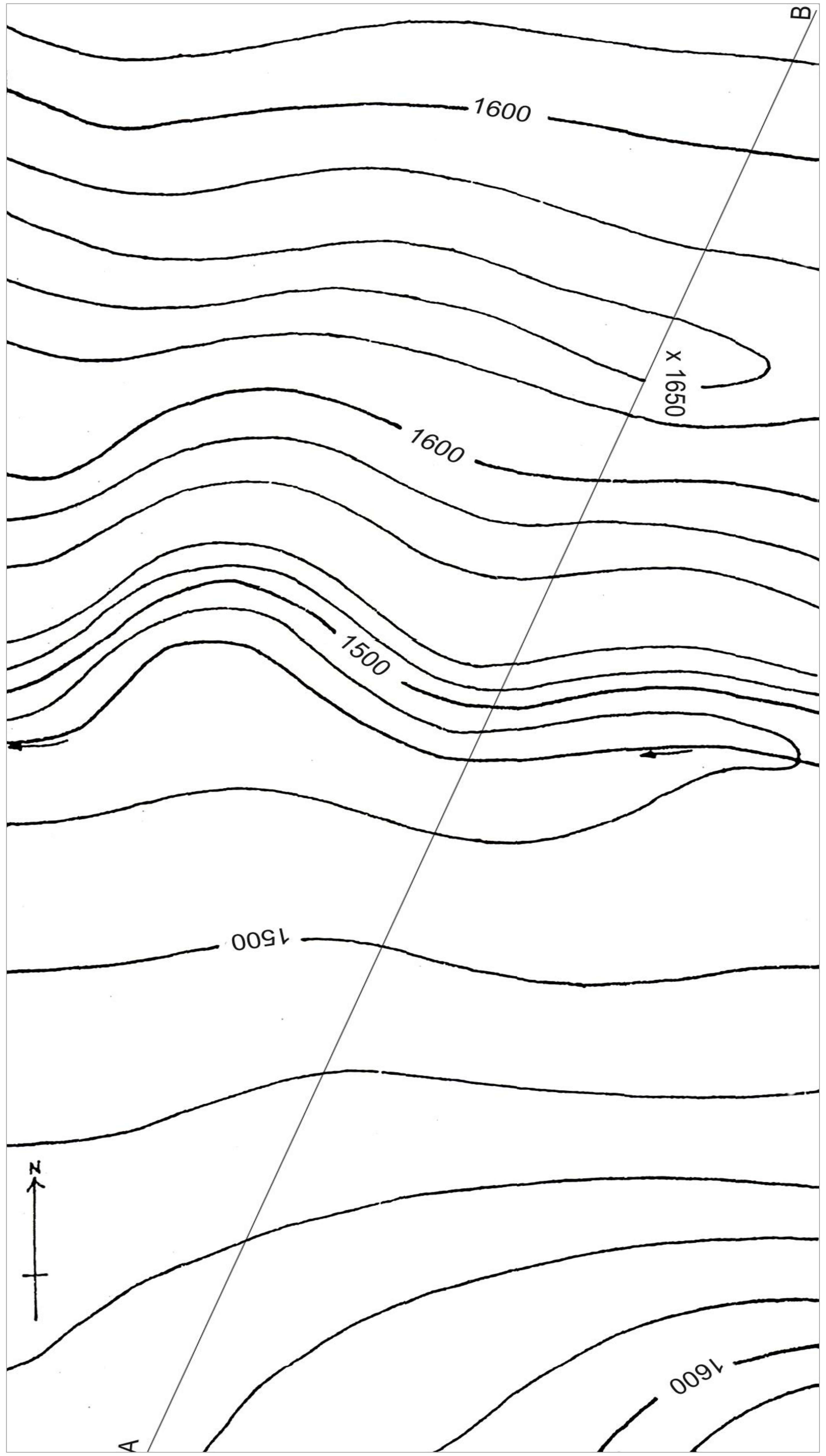
This number (sometimes written as **16.7x**) indicates that the relief shown on profile is **16.7 times > the true relief**. This makes slopes on the profile 16.7 times steeper than corresponding real slopes on ground.

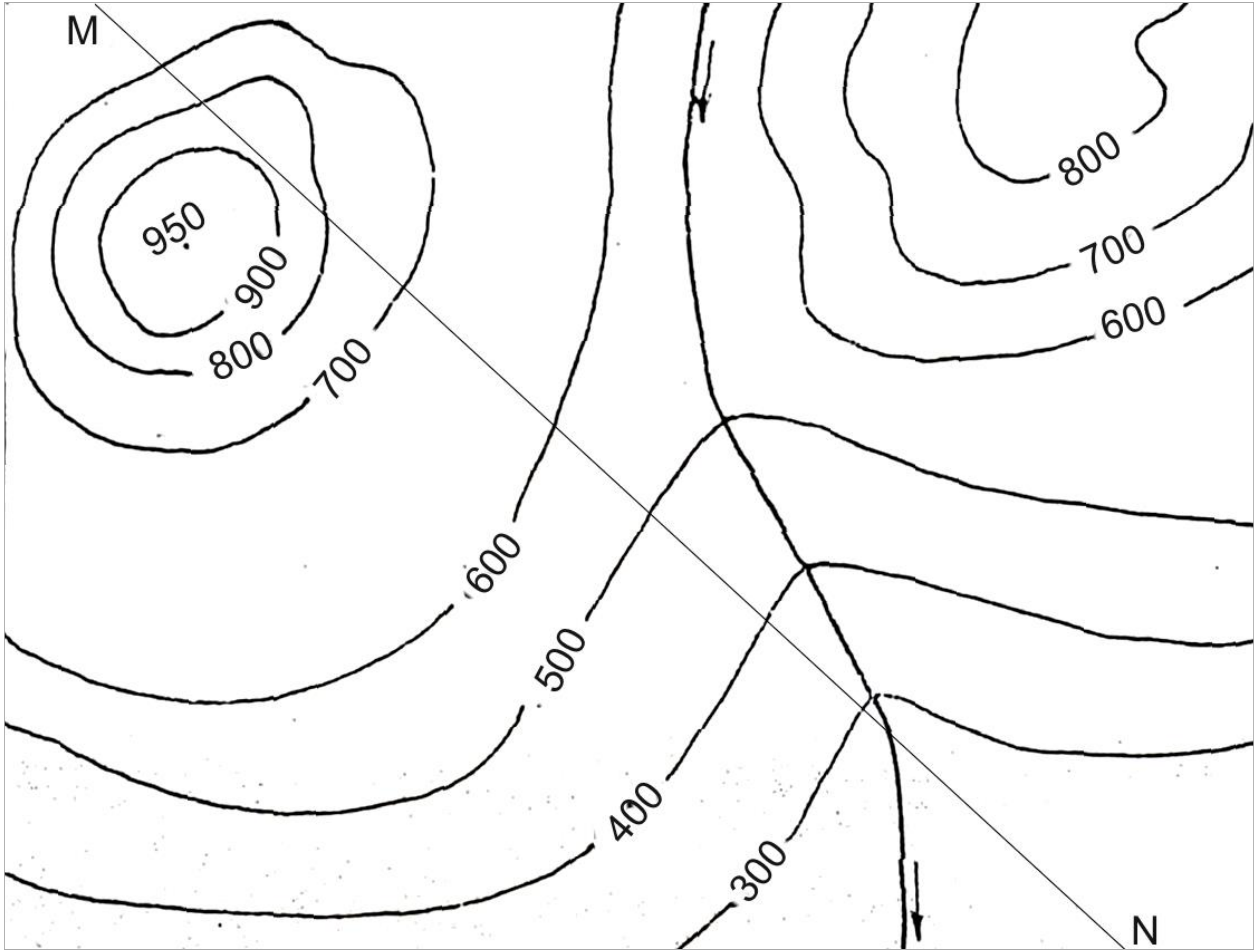
CONSTRUCTION OF A TOPOGRAPHIC PROFILE…..(11)

Horizontal scale	**=**	**1:50,000**
Vertical scale	**=**	**5 * horizontal scale**
	=	**5 * 1/50,000**
So, V. Scale	**=**	**1:10,000**



Practical Exercise 1: Construct a topographic profile along M-N & AB





INTRODUCTION TO GEOLOGICAL MAPS & SECTIONS

Geological Maps

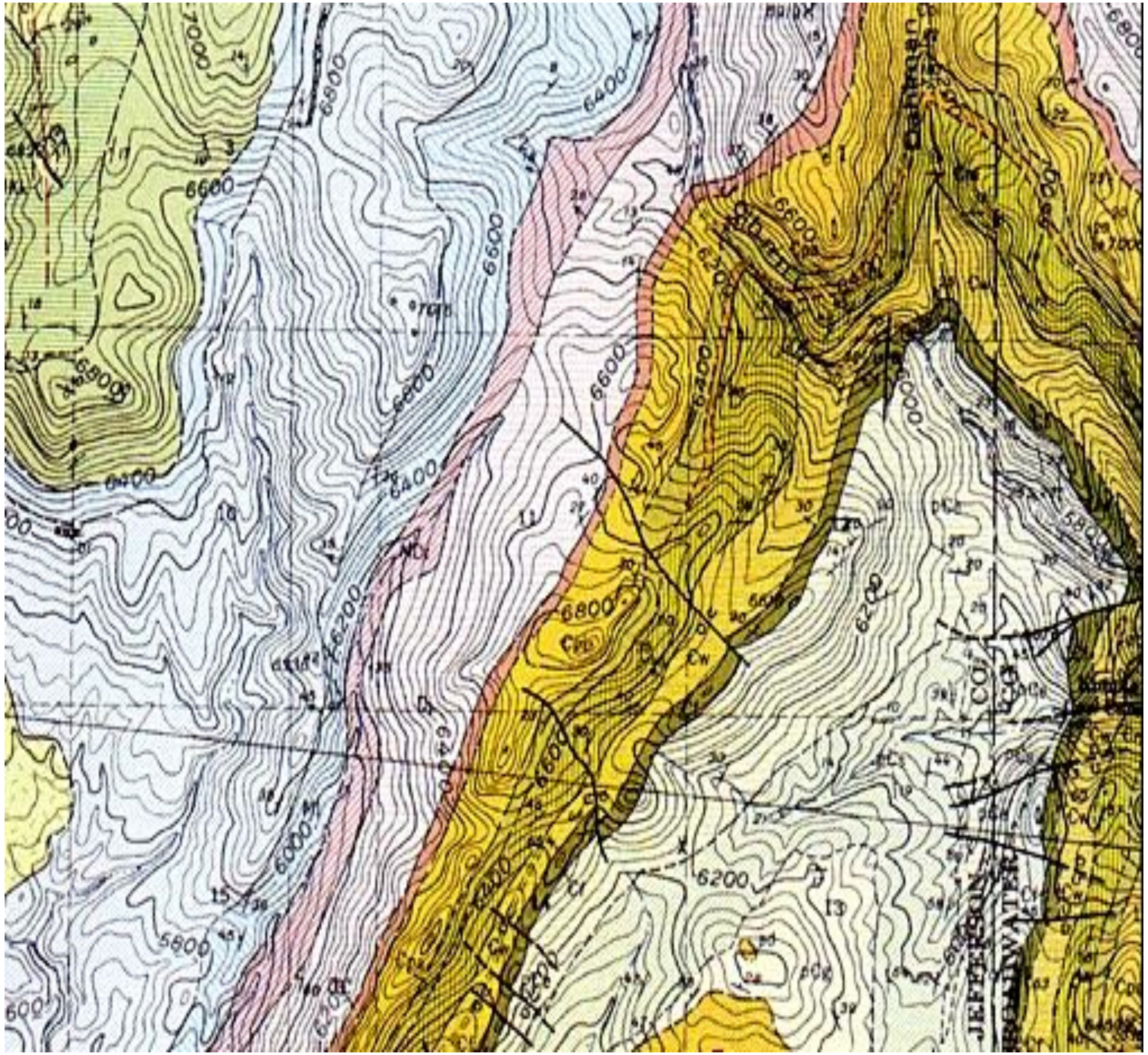
- The most useful information obtainable from a topographic map pertains to:
  - **Shape,** and
  - **form of the ground surface** – **relief** – which determines:
    - The appearance of the map and
    - Outcrop pattern of rocks

Thus, **the underlying geology determines the relief**.

Geological Maps.....contd.

A Geological Map:

- Is the **most basic & essential** document for a geologist.
- It gives the overall picture of:
  - ✓ **Occurrence**, and
  - ✓ **Distribution** of various **rock types** at ground surface.



Geological Maps.....contd.

From the geological symbols (dips & strikes) on the map, an impression can be made of the **3-D arrangement** of rocks beneath the ground surface.

Geological Maps.....contd.

From careful study of a good geological map, one can:

- ✓ **Deduce the geological history of an area** – i.e., **determine relative ages of rocks** and successive geologic events like deposition, erosion, intrusion, metamorphism, deformation, etc.
- ✓ Tell where possible zones of weakness are located, which is important to know for construction of dams, towns, roads, etc.

Geological Maps…..contd.

Before construction of a geological map, a **base map** is needed on which to plot the geological data – **a topographic Map**.

Horizontal Beds

We will now turn our attention to the question of **how** rock layers/strata **intersect Earth’s surface.**

This **intersection determines outcrop patterns &** **tells where strata will occur on Earth's surface.**

Horizontal Beds.....contd.

- Firstly, let’s look at **horizontal beds**.
- Take a simple example of a flat horizontal Earth’s surface – A **horizontal** rock layer may be imagined ***parallel*** to the surface.

Horizontal Beds.....contd.

If the layer is **at the Earths's surface;**

- The whole surface will consist of this rock
- The rock forms one continuous outcrop
- The geological map of such an area swould show only **one colour and no geological contacts.**

Horizontal Beds…..contd.

Of course, the Earth's surface is **NOT** flat. It has **topographic relief**, **produced by carving** action **of** erosion.

⇒ **Therefore, realistically, the outcrop pattern of horizontal** layers will be different and **dependent on the nature of topography.**

Horizontal Beds…..contd.

Now, recall:

- That topography is defined by **topographic contour lines**
  - ✓ Which essentially, are intersections of **imaginary horizontal planes** with the **Earth's surface.**

Horizontal Beds.....contd.

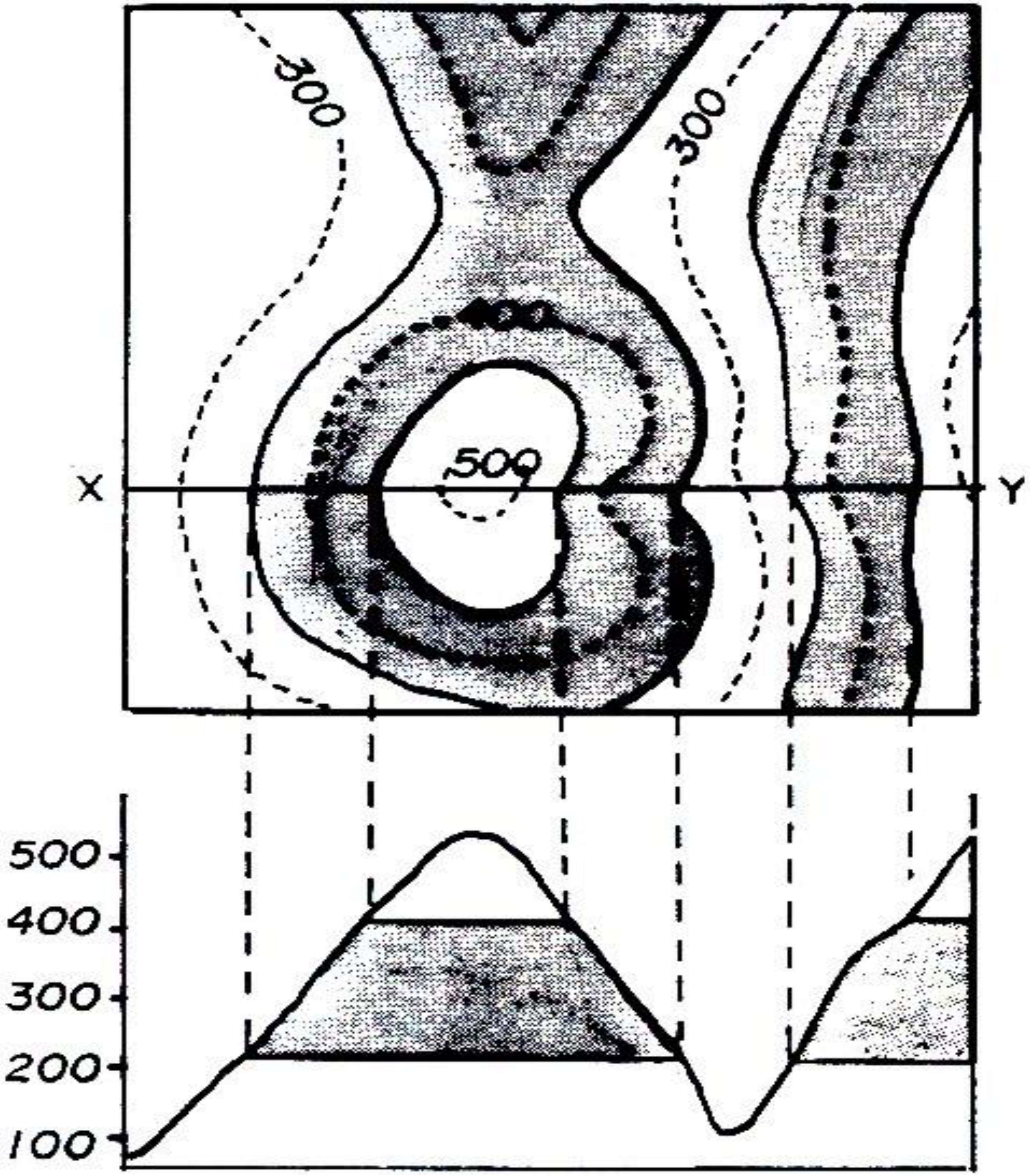
It follows that:

- A horizontal layer intersects the topography along lines parallel to the topographic contour lines. In other words:
- The outcrop of a horizontal layer is parallel to the contour lines or imaginary horizontal planes of contour lines.

Horizontal Beds.....contd.

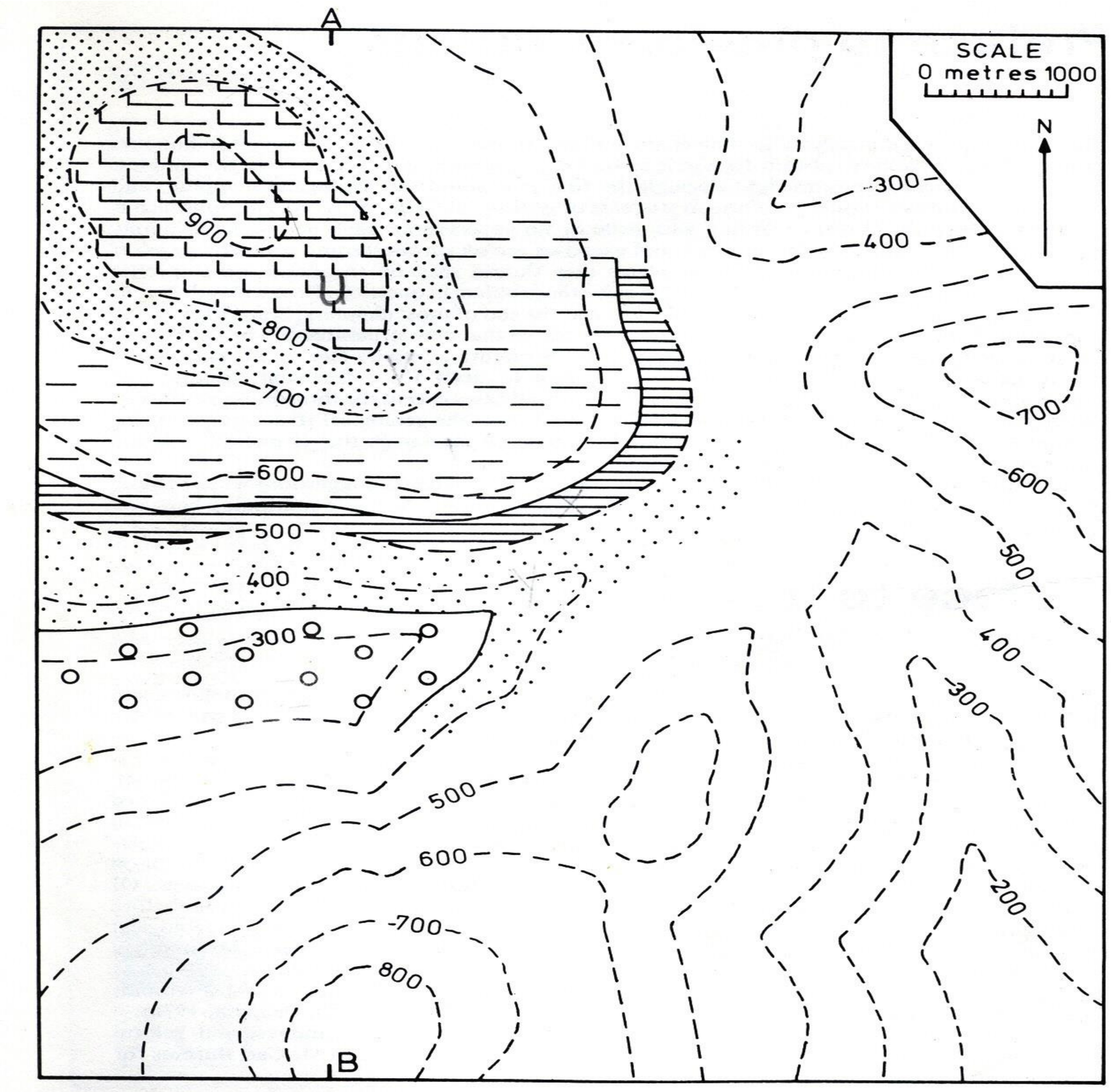
Section (Profile) Drawing:

- ✓ Draw a base line the exact length of line **X-Y** on Map
- ✓ Mark off, on baseline, points at which topographic contour lines and geological contacts cross the line of section
- ✓ From the baseline, erect perpendiculars corresponding in length to the height of ground.
- ✓ Complete the profile and connect the underlying geology to complete the geological section.



Practical Exercise 2

The geological outcrops are shown in the north-west corner of the map. <u>It can be seen that the beds are horizontal as the geological boundaries coincide with, or are parallel to, the ground contour lines.</u> Complete the geological outcrops over the whole map. How thick is each bed? Draw a vertical column showing each bed to scale, 1 cm = 10 m. Draw a geological section along the line A-B. (Contours in metres)



Map 1

Practical Exercise 3

Information

A vertical borehole drilled on a site at point C (**170 m** above sea level) passed through the following rock Formations:

0 – 20 m   Sandstone;

20 – 50 m Marble

50 – 80 m Schist

80 – 170 m Gneiss

All the bedding and foliation planes encountered in the borehole display a horizontal attitude.

Answer the following:

Complete the geological map of the area.

Draw a vertical section (i.e. a geological cross-section) along the line **A – B** and mark on it the rock Formations intersected by the borehole.

Note: The solid geology is obscured by alluvium below the **60 m** contour.