PRACTICAL EXERCISES

Practical No.	Name of the Exercise
1	**Study of physical properties of minerals:** a) Colour b) Streak c) Lustre
2	**Study of physical properties of minerals:** d) Forms
3	**Study of physical properties of minerals:** e) Fracture f) Cleavage g) Hardness
4	**Determination of specific gravity of minerals.**
5	**Study of silica group of minerals.**
6	**Study of feldspar, amphibole and pyroxene groups of minerals.**
7	**Study of mica, olivine and zeolite groups of minerals.**
8	**Study of apophyllite, talc, gypsum, calcite and fluorite minerals.**
9	**Identify and describe the minerals in the given igneous rocks and classify them :** Granite and its varieties, pegmatite, syenite, syenite porphyry, diorite porphyry, gabbro, dolerite, basalt and its varieties, dunite, rhyolite.
10	**Identify and describe the minerals in the given sedimentary rocks and classify them :** Conglomerate, breccia, sandstone and its varieties, limestone and its varieties.
11	**Identify and describe the minerals in the given metamorphic rocks and classify them :** Marble, quartzite, muscovite schist, biotite schist, hornblende schist, mica garnet schist, tremolite schist, actinolite schist, granite gneiss, hornblende gneiss, augen gneiss.
12	**Study of topomaps.**
13	**Study of contour maps -** To draw profile of the maps and describe map nos. 1 to 10.
14	**Study of District Resource Map / (DRM).**
15	**Study of mineral resources of Maharashtra state.**
16	**Study of some important geological heritage sites of Maharashtra state:** i) Lonar meteor crater ii) Nighoj potholes iii) Honeycomb structure (Harihareshwar) iv) Natural bridge (Gulunchwadi) v) Columnar joints (Kolhapur, Naldurg and Gilbert hill) vi) Panchgani tableland vii) Sandan valley viii) Hot springs.
17	**Sketch and neatly label the landforms depicted in the given photographs:** a) River : erosional and depositional features b) Sea : erosional and depositional features c) Wind : erosional and depositional features d) Glacier: erosional and depositional features**.**
18	**Field work - Visit to nearby sites of geological interest and prepare report:** i) River meanders ii) Potholes iii) Columnar joints iv) Waterfalls v) Road cuttings vi) Spheroidal weathering vii) Red boles viii) Tableland/ Mesa/ Butte ix) Coastal erosional features

- **General Instructions for teachers :**

1 Mineral specimens which show the required physical properties clearly should be used.

2 Rock specimens should clearly show mineral characteristics.

3 Topomaps of your area of interest (area around your district where the college is located) should be downloaded from the Survey of India map portal : www.soinakshe.gov.in. The sample questions have been provided at the end of practical. Teachers can frame more questions based on available topomaps.

4 For section drawing use map nos. 1 to 10 from this textbook.

5 DRM of Nagpur district has been provided as a sample in textbook. Use DRM of your district for your practical which is available with Geological Survey of India, publication division, Central region, Nagpur : www.gsi.gov.in. Sample questions are provided at the end of practical. Teachers can frame more questions based on available DRM.

6 Use the given outline map of Maharashtra for marking mineral resources and geological heritage sites.

7 For drawing and labelling of landforms, alter the figures from textbook as per your requirement.

8 Teachers should strictly follow the rules for 'educational visit' given by concerned authority and institution.

- **General Instructions for students :**

1 Make the best use of time available for performing experiments.

2 Come prepared with subject knowledge.

3 Bring geometrical instruments, a notebook and a journal.

4 Handle the specimens carefully. Do not write on or mark the specimens.

5 Draw accurate, labelled diagrams, wherever necessary in the journal.

6 For practical nos. 1 to 8, observe each specimen carefully and write down the description referring to chapter 5 and for practical nos. 9 to 11 refer to chapters 4 and 5. Observe the properties in clear day light.

7 Observe the topomaps, write the description and get it checked by the teacher.

8 Complete the journal on the same day of the practical.

- **Following procedures are to be followed by a student while writing the journal :**

1 Write date and year in which the experiment is performed, name and roll number, title and exercise no. clearly.

2 Write the description of the specimen/map, area and avoid overwriting.

- **Practical No. 1**

Study of physical properties of minerals :

a) Colour b) Streak c) Lustre

- **Practical No. 2**

Study of physical properties of minerals :

d) Forms

- **Practical No. 3**

Study of physical properties of minerals :

e) Fracture f) Cleavage g) Hardness

- **Practical No. 4**

Determination of Specific Gravity of minerals :

Specific Gravity of a mineral is the ratio of the weight of the mineral in air to that of an equal volume of water displaced by it at Normal Temperature and Pressure (NTP).

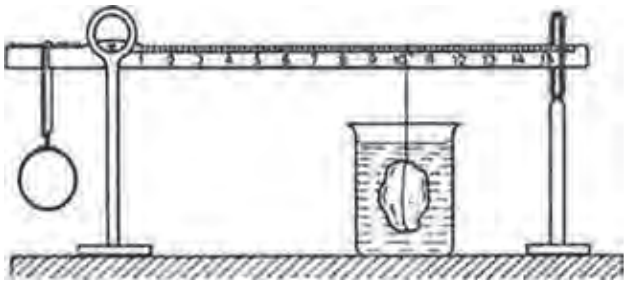
The specific gravity of a mineral can

be determined with the help of Jolly's spring balance and Walker's steel yard balance.

Walker's steel yard balance :

This instrument has a long graduated beam, which is pivoted on a pillar near one end. The beam is counterbalanced by heavy weight suspended to short arm near pivot.

The specimen tied to a thread is suspended on the long graduated steel beam and moved along the beam until it counterbalances the constant weight. The levelling of a beam is facilitated by a pointer on a vertical stand and a mark on the beam.



The reading 'Wa' is recorded by the position of sample in air, on the beam. The specimen is then immersed in water in beaker and is moved along the beam, until the constant weight is again counterbalanced and second reading 'Ww' is obtained. The reading 'Wa' and 'Ww' are inversely proportional to the actual weight of the body in air and water respectively.

If, Wa = Weight of mineral in air

Ww = Weight of mineral in water

Wa-Ww = Loss in weight

$$\therefore \text{Sp.gr} = \frac{Wa}{Wa - Ww}$$

Readings and Calculations :

Mineral	Readings	1st	2nd	3rd	Average	(Wa-Ww)
Quartz	Wa					
	Ww					
Calcite	Wa					
	Ww					
Barite	Wa					
	Ww					

- **Practical No. 5**

Study of silica group of minerals

- **Practical No. 6**

Study of feldspar, amphibole and pyroxene groups of minerals

- **Practical No. 7**

Study of mica, olivine and zeolite groups of minerals.

- **Practical No. 8**

Study of apophyllite, talc, gypsum, calcite and fluorite minerals.

- **Practical No. 9**

Identify and describe the minerals in the given igneous rocks and classify them : Granite and its varities, pegmatite, syenite, syenite porphyry, diorite porphyry, gabbro, dolerite, basalt and its varieties, dunite, rhyolite.

- **Practical No. 10**

Identify and describe the minerals in the given sedimentary rocks and classify them : Conglomerate, breccia, sandstone and its varieties, limestone and its varieties..

- **Practical No. 11**

Identify and describe the minerals in the given metamorphic rocks and classify them : Marble, quartzite, muscovite schist, biotite schist, hornblende schist, mica garnet schist, tremolite schist, actinolite schist, granite gneiss, hornblende gneiss, augen gneiss.

- **Practical No. 12**

Study of Topomaps

A topomap is characterised by large scale detailed and quantitative representation of relief, usually using contour lines, physical structures

and symbols. These maps are classified on the basis of scale. They show important natural and man-made features, such as relief, vegetation, water bodies, cultivated land, settlements, transportation networks, etc. The Survey of India with Head Quarters at Dehradun, prepares and publishes the topomaps in India for the entire country. The topomaps are drawn in the form of series of maps at different scales. Hence, in the given series, all maps employ the same reference point, scale, projection, conventional signs, symbols and colours.

The Survey of India prepares topomaps of India on 1:10,00,000, 1:250,000, 1:1,25,000, 1:50,000 and 1:25,000 scales providing a latitudinal and longitudinal coverage of 4° × 4°, 1° × 1°, 30' × 30' and 15' × 15' respectively. Each topomap has a numbering system.

Reading of topomaps : The study of topographical maps is simple. It requires the reader to get acquainted with the legend, conventional signs, symbols and the colour shown on the maps.

The first thing one can notice on a topomap is the name of the state, which is found at the top centre of the map. On the top left corner map number is printed. The map is divided into grids. These grids represent longitudes and latitudes. These can be read in the form of degree (°), minutes (') and seconds ("). This will help to pinpoint any location on the map with accuracy.

Latitude is angular distance measured North and South of the Equator. The Equator is 0°. As one goes North of the Equator, latitude increases upto 90° at the North pole. If one goes South of the Equator, the latitude increases upto 90° at the South pole.

Longitude is angular distance measured East and West of the Prime Meridian. The Prime Meridian is 0° longitude. As one goes East from the Prime Meridian, the longitude increases to 180°. This Meridian is known as the International Date Line. In the Eastern hemisphere, the longitude is given in degrees East and in the Western hemisphere, it is given in degrees West.

Horizontal lines on the map are latitudes and vertical lines are longitudes. On 1:50,000 scale map, latitudes and longitudes have 05' difference. Our nation India is North of the Equator and to the East of the Prime Meridian. The latitude is written as 19° 30' 15" North, while longitude is written as 75° 45' 10" East.

Map scale represents the relationship between distance on the map and the corresponding distance on the ground. The scale on the topomap is found at the bottom centre of the map.

Scale is represented in two different ways on a topomap. The first one is a ratio scale and second one is called linear / bar / graphic scale. 1 : 50,000 indicates 1cm on the topomap equals 50,000 cm (i.e.1/2 km) on ground. Below the ratio scale is a graphic scale representing distance in kilometres. The graphic or bar scale is a means of visually showing scale of the map and is used to make fast estimates of distances on the topomap. For. e.g. a map of 1 : 50,000 ratio scale will show a bar indicating that 2 cm on the map equals to 1 km. on the ground.

At the bottom left and bottom right corner of the map, conventional signs and symbols are shown. With the use of these symbols one can 'read' the topomap easily.

Contour lines are represented by brown lines in the map. With the help of contour lines, one can visualise three dimensional layout of the map. A contour line is an imaginary line that connects points of equal elevation above Mean Sea Level (MSL).

Branched dark brown lines on the map indicate drainage. Various patterns of drainage

can be studied. One can identify important rivers and their tributaries on the map.

Interpretation of topomaps :

Understanding of map language and sense of direction are essential in reading and interpreting topomaps. A thorough knowledge of the legend/ key given in the map showing various natural and manmade features is essential. Every Survey of India topomap contains a table showing conventional signs and symbols at the base of the map. Conventional signs and symbols are internationally accepted. A topomap is usually interpreted under the following heads :

a) Marginal information
b) Relief and drainage
c) Land use
d) Means of transport and communication
e) Human settlements

a) Marginal information : It includes the topomap no., its location, grid references, its extent in degrees and minutes of latitude and longitude, scale, districts covered etc.

b) Relief and drainage : Relief is the difference between the highest and lowest elevation in an area. A relief map shows the topography of the area, which includes the identification of the plains, plateaus, hill or mountains along with peaks, ridges, and the general direction of the slope. These features can be studied as follows :

- Hill : Map with circular contours, increasing in contour value towards centre represents a hill. It may exhibit steep or gentle slopes.
- Plateau : Contours at centre are absent indicating elevated flat land with respect to surrounding lowland.
- Plain : Absence of contours indicates plains.
- Ridge : A chain of hills with elongated or oval shaped contours.
- Depression : Circular contours with decreasing contour value towards the centre.
- Valleys : Sharp drop in contour values between two adjoining hillocks.
- Drainage of the area : Important rivers, their tributaries, type and extent of valleys formed by them and types of drainage pattern, e.g. dendritic, radial, trellis, etc. are studied.

c) Land use : It includes the use of land under different categories like :

- Natural vegetation and forest - dense or thin, reserved, protected, classified / unclassified.
- Agricultural, orchard, wasteland, industrial, etc.
- Facilities and services such as schools, colleges, hospitals, parks, airports, electric substations, post offices, police stations etc.

d) Means of transport and communication : Means of transportation include national or state highways, district roads, cart tracks, camel tracks, footpaths, railways, waterways, major communication lines, post offices, etc.

e) Human settlements : Settlements can be specified as follows:

- Rural settlements : Types and patterns of rural settlements e.g. compact, semi-compact, dispersed, linear etc.
- Urban settlements : Types of urban settlements and their functions e.g. capital cities, administrative towns, religious towns, port towns, hill stations etc.

Activity :

Download topomap of your area from Survey of India map portal : www.soinakshe.gov.in

Sample questions

Q. 1. Answer the following :

1) What are topomaps?
2) Name the organisation which prepares the topomaps for India.

3) Which are the commonly used scales for mapping in our country (used by the Survey of India)?

4) What are contours?

5) What does the spacing of contours indicate?

6) What are conventional signs?

Q. 2. Draw the conventional signs and symbols of the following features :

1) International boundary 2) Villages

3) Footpath with bridges 4) Bench Mark

5) Places of worship 6) Railway lines

7) Metalled road

• Practical No. 13

Study of Contour Maps

Any real world location or objects on the Earth's surface which can be represented two dimensionally (on a paper, a computer monitor etc.) is called as a map. Many maps only show the two-dimensional location of an object without taking into consideration its elevation. Topomaps, on the other hand, deal with the third dimension by using contour lines to show elevational changes on the surface of the Earth (or below the surface of the ocean).

A topomap is a representation of three-dimensional surface on a flat piece of paper.

Relief of the land surface can be represented with the help of 'contour lines' or 'contours'. Contouring (drawing contours) is the standard method of representing relief on topomaps. Contour lines are defined as lines joining points of equal elevation. If we randomly measure elevations on the hill surface and join those elevation points having equal values, contours are generated. Following are the characteristics of contours :

1) Each contour has its value represented in the form of elevation in meters or feet.

2) All the elevations measured are with reference to the Mean Sea Level (MSL). The elevation of MSL is globally considered to be is 'Zero'.

3) Contours are continuous brown coloured lines on the topomaps published by Survey of India (SoI).

4) Every point on a contour line represents the same elevation.

5) Shifting from one contour line to another always indicates a change in elevation.

6) The difference in values between two adjacent contours is called Contour Interval (C.I.). It is uniform for all contours present in a particular map and it will not change. On Survey of India map, contour interval is usually 20 m and the scale is 1 : 50,000.

7) If the contour values go on increasing in a certain direction, it means you are moving uphill and if values are in decreasing order, you are moving downhill.

8) Contour lines never intersect one another.

9) Absence of contours indicate flat ground.

10) In any map, index contours are thicker than other contours. They carry a number which represents its elevation. Index contours help in finding values of adjoining contours.

Thus, with the help of contours one can see the broad features and relative heights of highlands and lowlands such as hills (symmetrical and asymmetrical), valleys, ridges, plateaus, spurs etc. Contours have different shapes and spacing. With the help of the shape of contours we can determine the feature and spacing suggests the type of slope.

1) Evenly spaced contours represent a uniform slope, e.g. symmetrical hill (Fig. 1a.).

2) Contours that are widely spaced indicate a gentle slope, contours that are closely spaced indicate a steep slope, e.g. asymmetrical hill (Fig. 1b.).

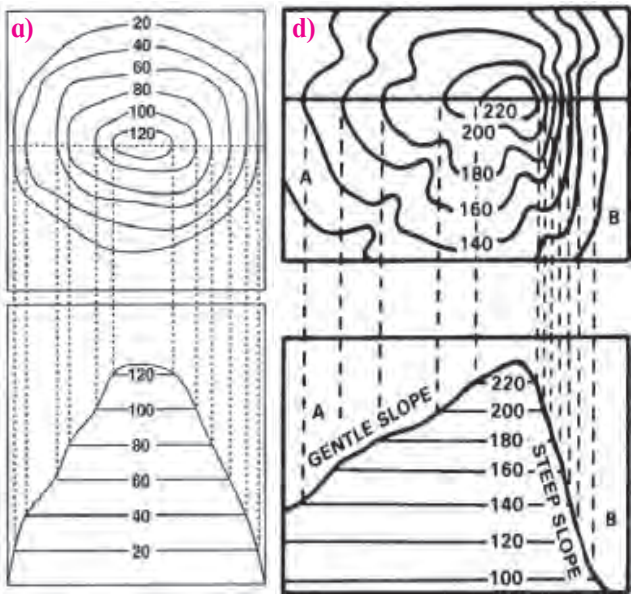


Fig. 1 : a) Symmetrical hill, b) Asymmetrical hill

Interpretation of contour patterns :

Shape of contours indicates the type of physical features present on the map. Compare the topomap with the landscape perspective from Fig. 2 a and b.

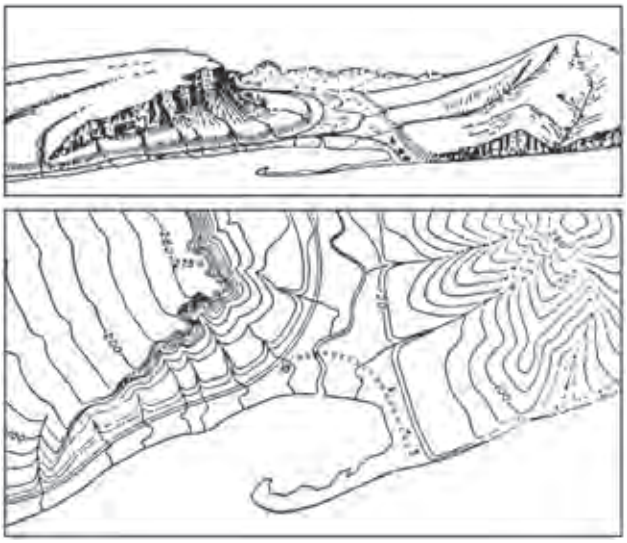


Fig. 2 : a) Landscape, b) A contour map derived from above landscape perspective. Contour lines are far apart for level land and closely spaced for steep slopes.

Different physical features represented by contours are as follows :

1) Hill : Hill appears as a set of closed and more or less circular shaped contour lines. Values of contours increase towards the centre. There are two types of hills : a) symmetrical hill and b) asymmetrical hill.

a) Symmetrical hill : A hill having uniform slope on all its sides. It is represented by evenly or regularly spaced circular contours with increasing elevations towards the centre (Fig. 1 a.).

b) Asymmetrical hill : A hill having steep slope on one side and gentle slope on the other. It is represented by closely spaced contours (steep slope) on one side and widely spaced contours (gentle slope) on the other side (Fig. 1 b.).

2) Ridges and saddles : A chain of hills is described as a ridge. A ridgeline can be drawn by joining tops of hills along a range. Water flows in opposite directions on either side of a ridgeline (Fig. 3).

Saddles are low points on the ridges. They are often important to map users, as they represent the lowest point for crossing the ridge. (Fig. 3).

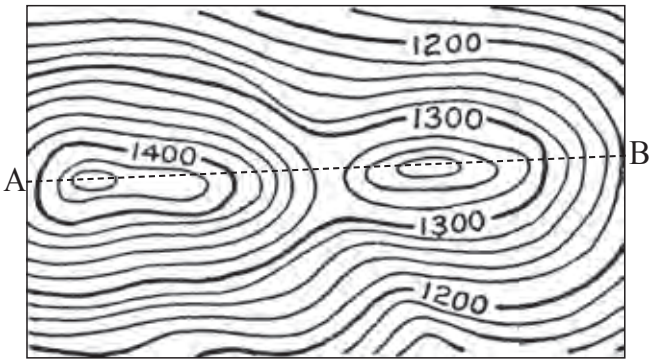


Fig. 3 : Ridge and saddle (AB is the ridge line)

3) Depression : Depression is represented by circular or semi-circular contours where the contour values decrease towards the centre (Fig. 4).

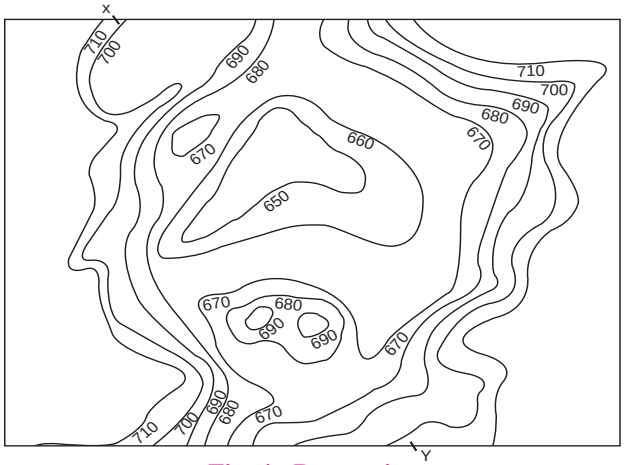


Fig. 4 : Depression

4) Valley : Valley is formed due to the channelling of running water in the form of streams over a long period of time. Water forms stream channels which have a lower elevation than the surrounding land. In contour maps the valley is depicted as a "V" shaped contour whose apex points upstream or towards higher elevation. As the stream flows downhill it will cross a number of contour lines, making a "V" on each. So valleys and stream channels appear on contour maps as a series of V's. If the stream has cut a narrow or deep channel, the V associated with it on the contour map will be narrow, if the stream channel is wider, the V will be wider (Fig. 5).

If the valley is formed due to a glacier, it is "U" shaped in cross section. The valley has a flat base, the sides of which are steeper than the valleys occupied by streams.

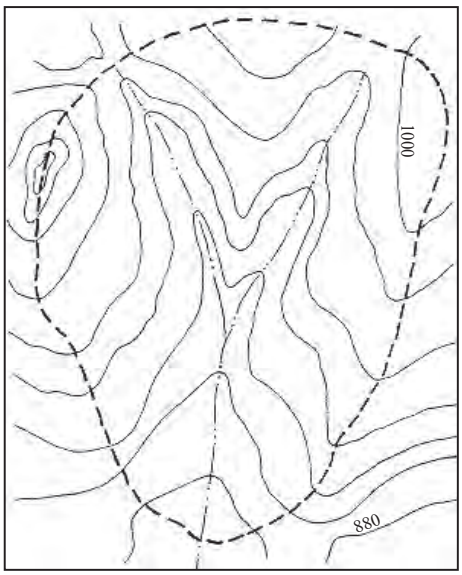


Fig. 5 : "V" Shaped Valley

5) Plateau : Plateau and tableland is a large elevated land. Plateau is fairly levelled. On a map it appears as a flat area. (with few contour lines) surrounded by sloping land (with a number of contours) (Fig. 6).

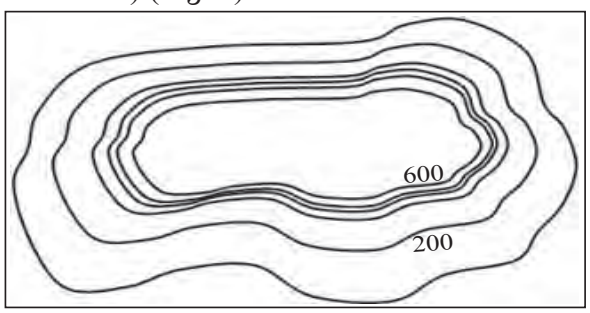


Fig. 6 : Plateau

6) Spur : Spur is represented by "V" shaped contours with its apex towards lowland which is reverse of "V" shaped valleys (Fig. 7).

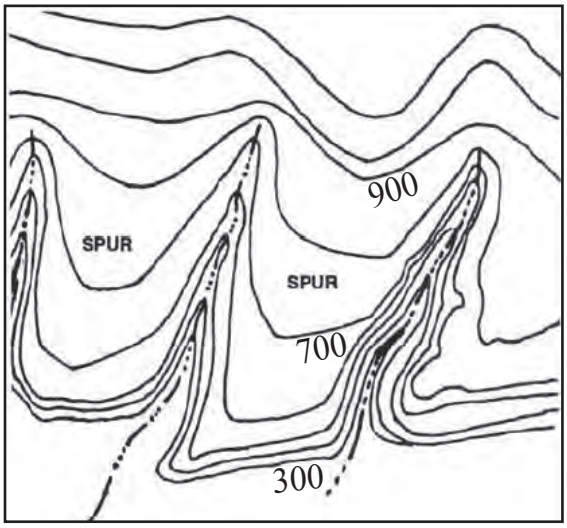


Fig. 7 : Spur

Creating topographic profile :

Topographic profile is a cross-sectional view along a line drawn through a portion of a topomap. Topographic profile is useful in understanding topomaps as well as it is very useful for geologists in analysing numerous problems. There are two types of topographic maps – 1) Contour maps (as described above) and 2) Geological maps. In the geological map, bedding planes are introduced between or on the contours.

Procedure for drawing topographic section along X-Y line :

1) Join X-Y point by straight line. Keep a blank paper strip along X-Y line on the map. Mark both X and Y points, by keeping point X on left side of the paper strip and point Y at right side of the paper strip (Fig. 8).
2) Mark the point of intersection between the X-Y line and contour line as tick marks on the paper strip. Write the elevation of the index contours below their respective marks on your paper strip.
3) Once all the markings are done, remove your paper strip from the map. On the blank paper draw a line (base line) at least as long

as X-Y section line. Place your paper strip with the tick marks along the base line and mark the start (X) and end (Y) points of your section line.

4) Transfer all tick marks on the base line with their appropriate elevations. Remove the paper strip. Draw vertical lines above your start (X) and end (Y) points. These will be the boundaries of your profile.

5) Look at the scale give on the map
e.g. 1 cm = 100m.

6) Plot all the points with respect to their elevations and scale, perpendicular to the tick marks on the base line. For example, if a tick mark shows elevation 1200m, the point should be plotted at a height of 12cm perpendicular from the tick mark on the base line (Fig. 9).

7) Join all the points with freehand and smooth line (Fig.10). This is the topographic profile of the map along X-Y line.

Description of Map :

Topographic map is described on the basis of following points :

Topography of the area : Interpret the contour patterns with the help of their shape and spacing and identify the types of physical features present in the given map. Each map is provided with geographical North mark. Write the location of each feature with respect to its direction. For example an asymmetrical hill is located at north east side of the map having height 600m with its steep slope directed towards northeast and gentle slope towards southwest. The description of physical features can be written along following points :

a) Hill : It may be either symmetrical or asymmetrical. If symmetrical hill is present, write its location on the map and its height. For asymmetrical hill add a direction of its steep and gentle slopes.

b) Depression : Write its location and depth.

c) Valley : Describe the direction of flow, e.g. A "V" shaped valley is flowing towards the western side of the map.

d) Plateau : Write its location and height.

e) Ridge : Draw a ridge line and mark the saddle on the map and write its orientation in the description, e.g. Ridge line is oriented in Northwest – southeast direction. Describe the number of hills it contains with their locations and heights.

f) Spur : Write its location and slope direction.

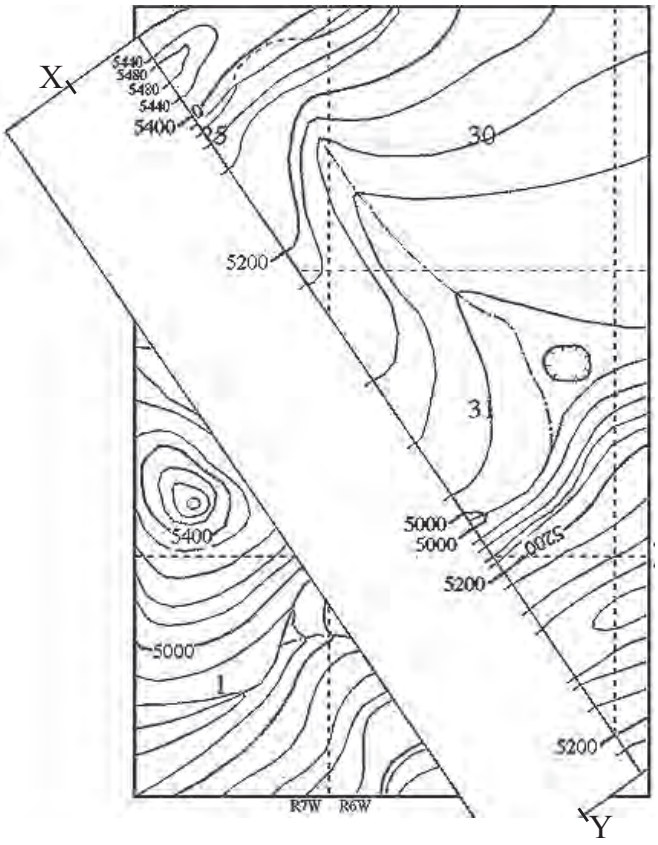


Fig. 8 : Marking the ticks wherever the contours cross the X-Y line

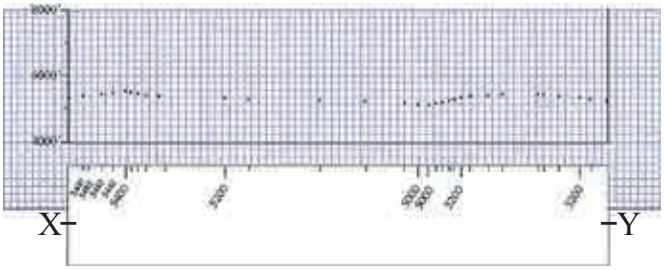
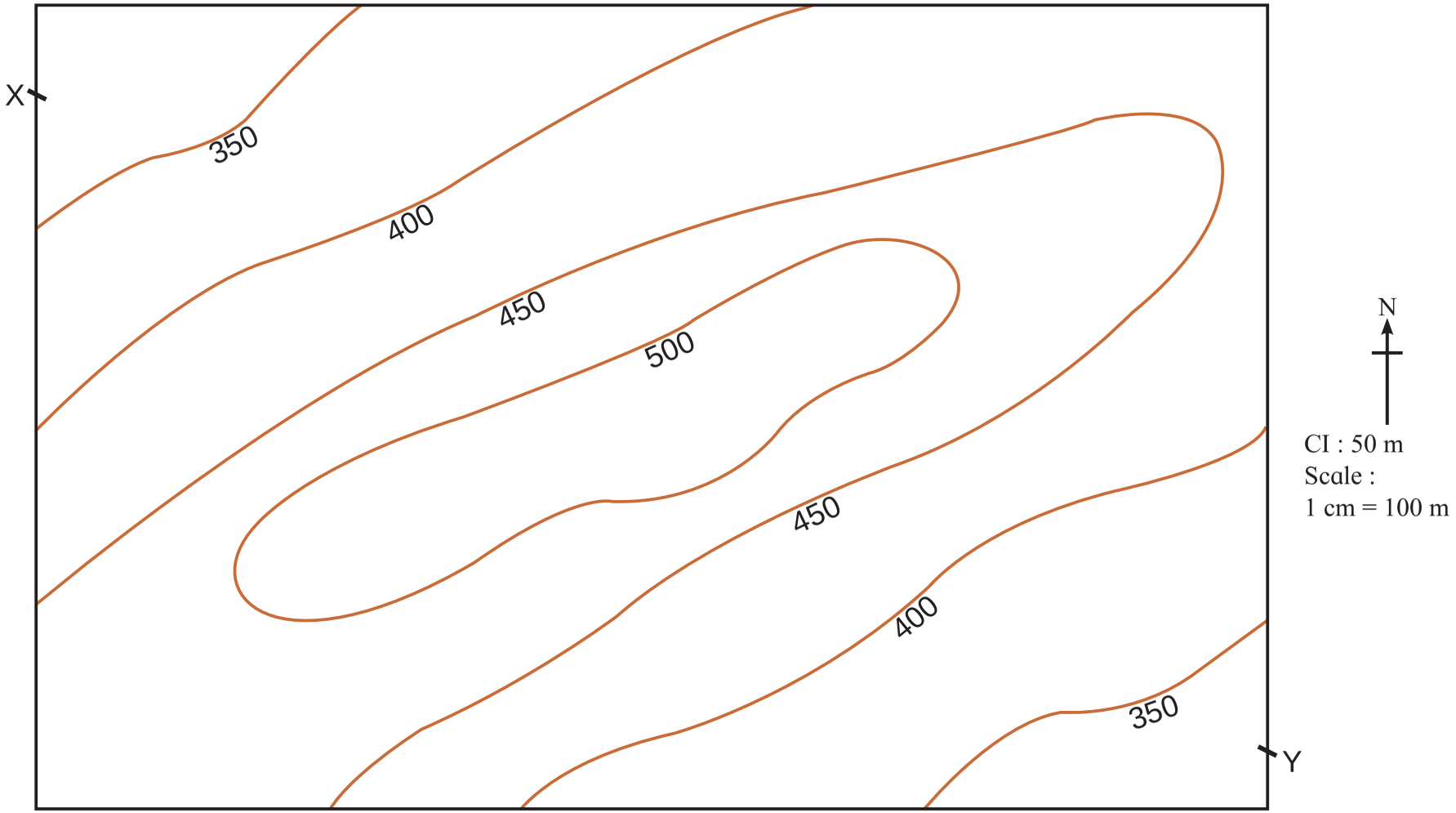
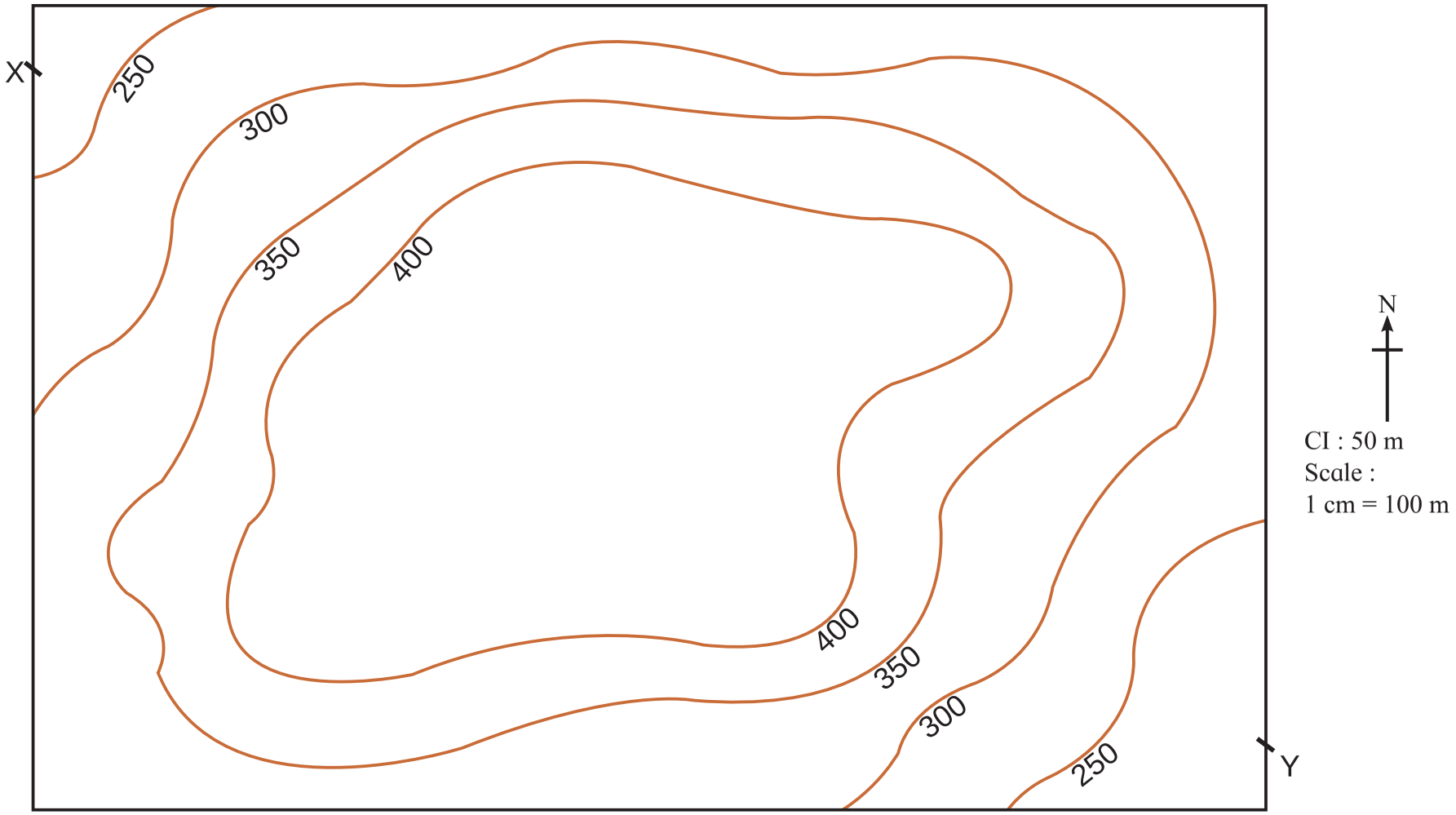


Fig. 9 : Marking elevations with the help of paper strip

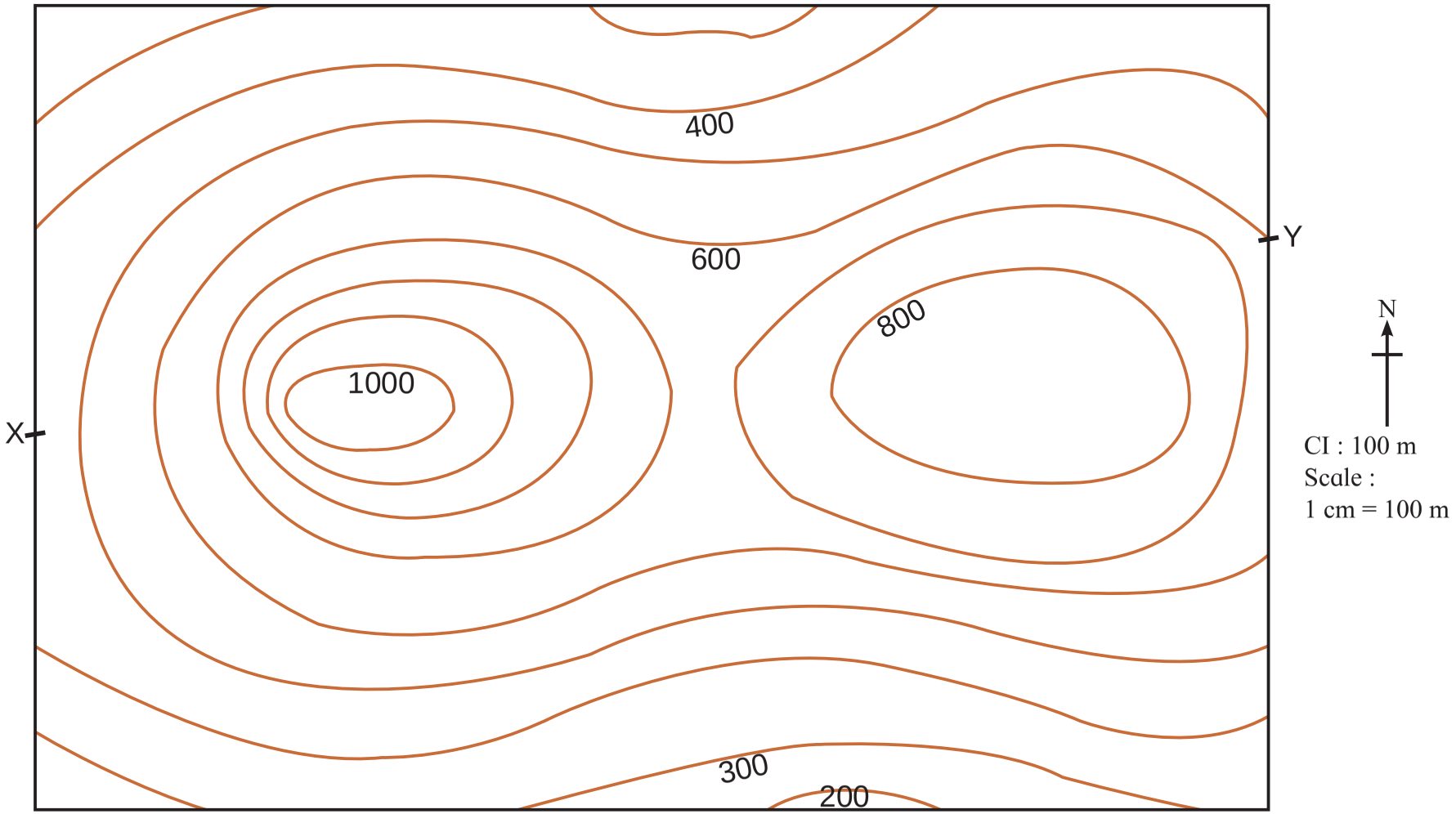
Map no. 1



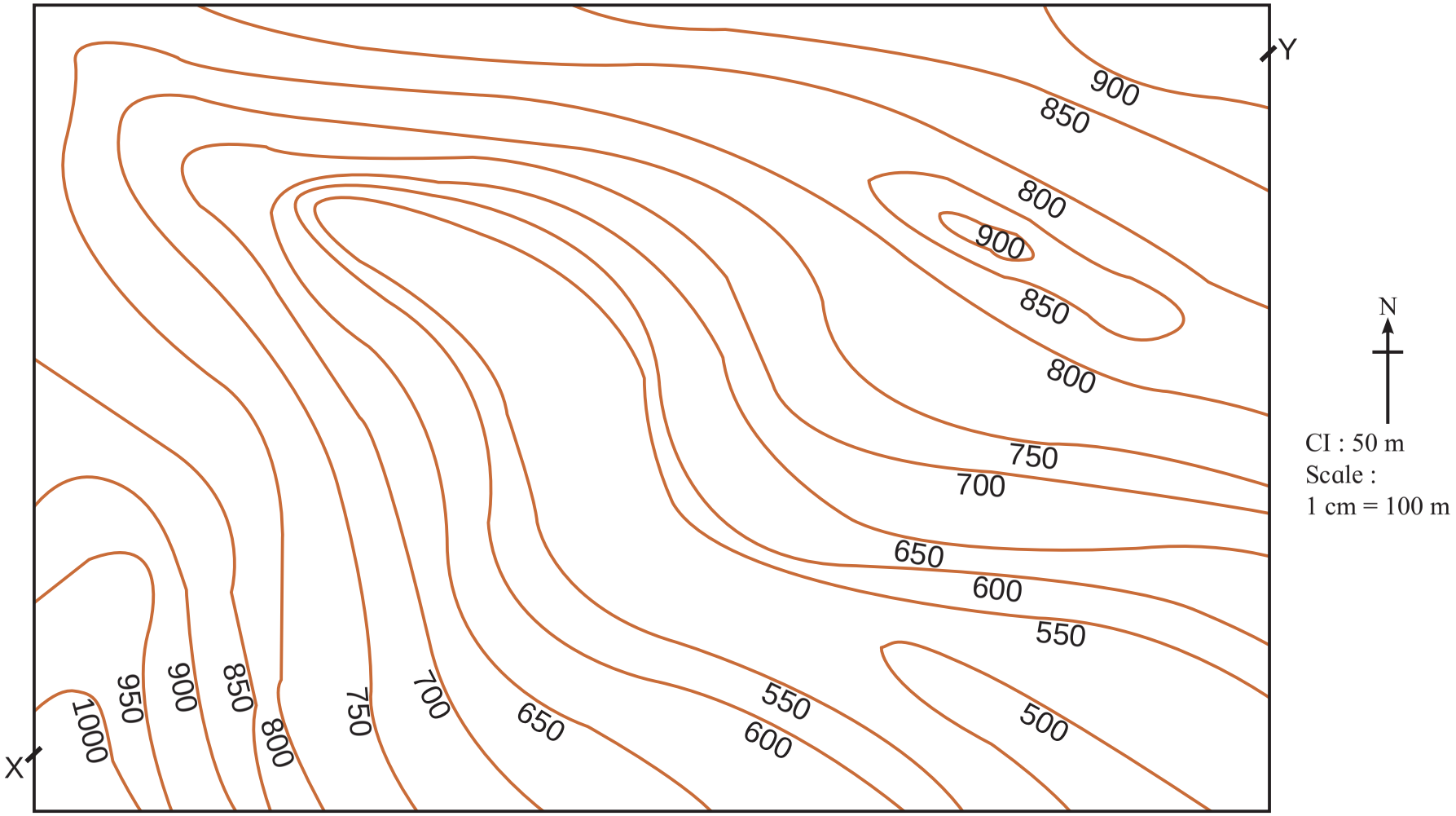
Map no. 2



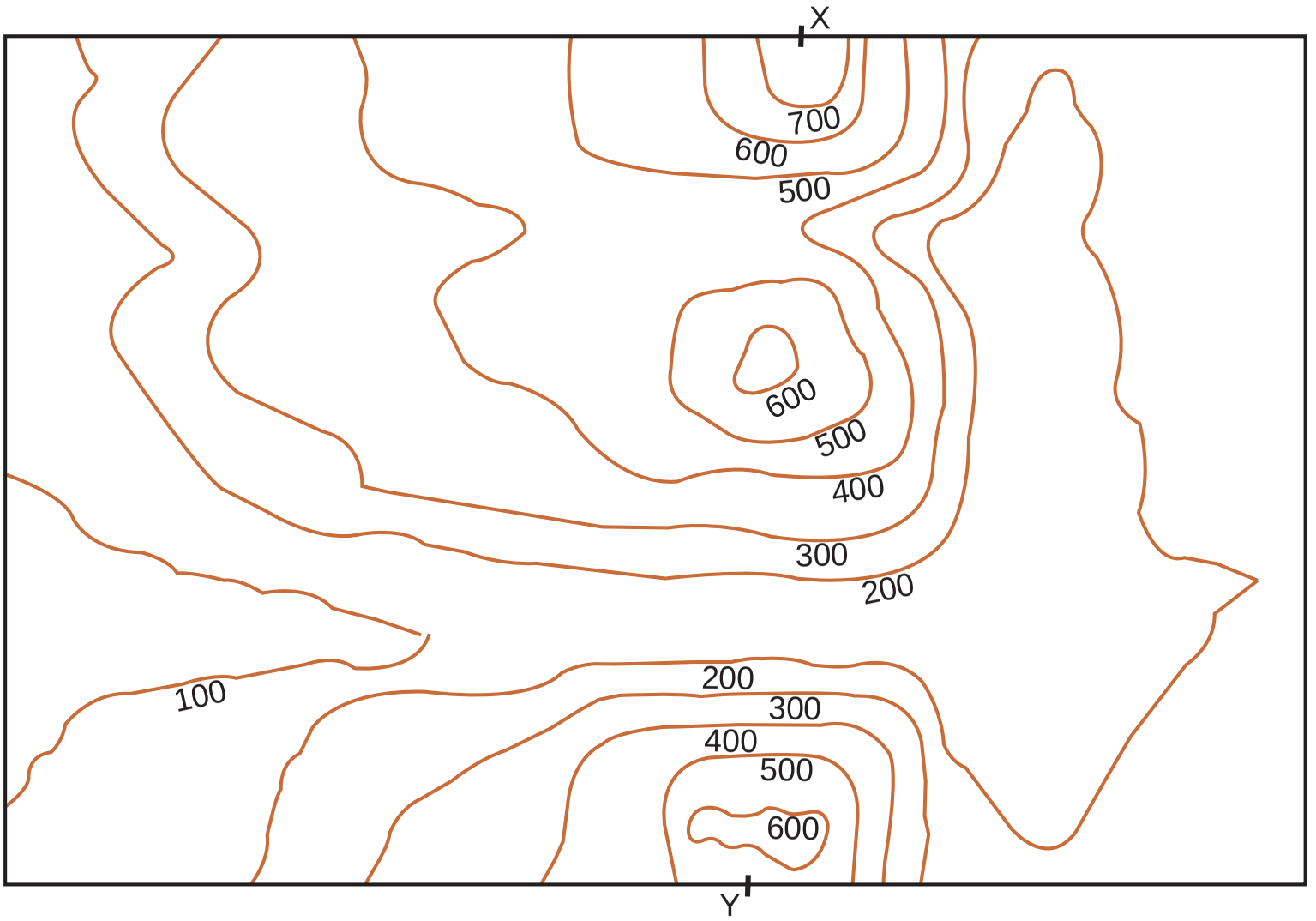
Map no. 3



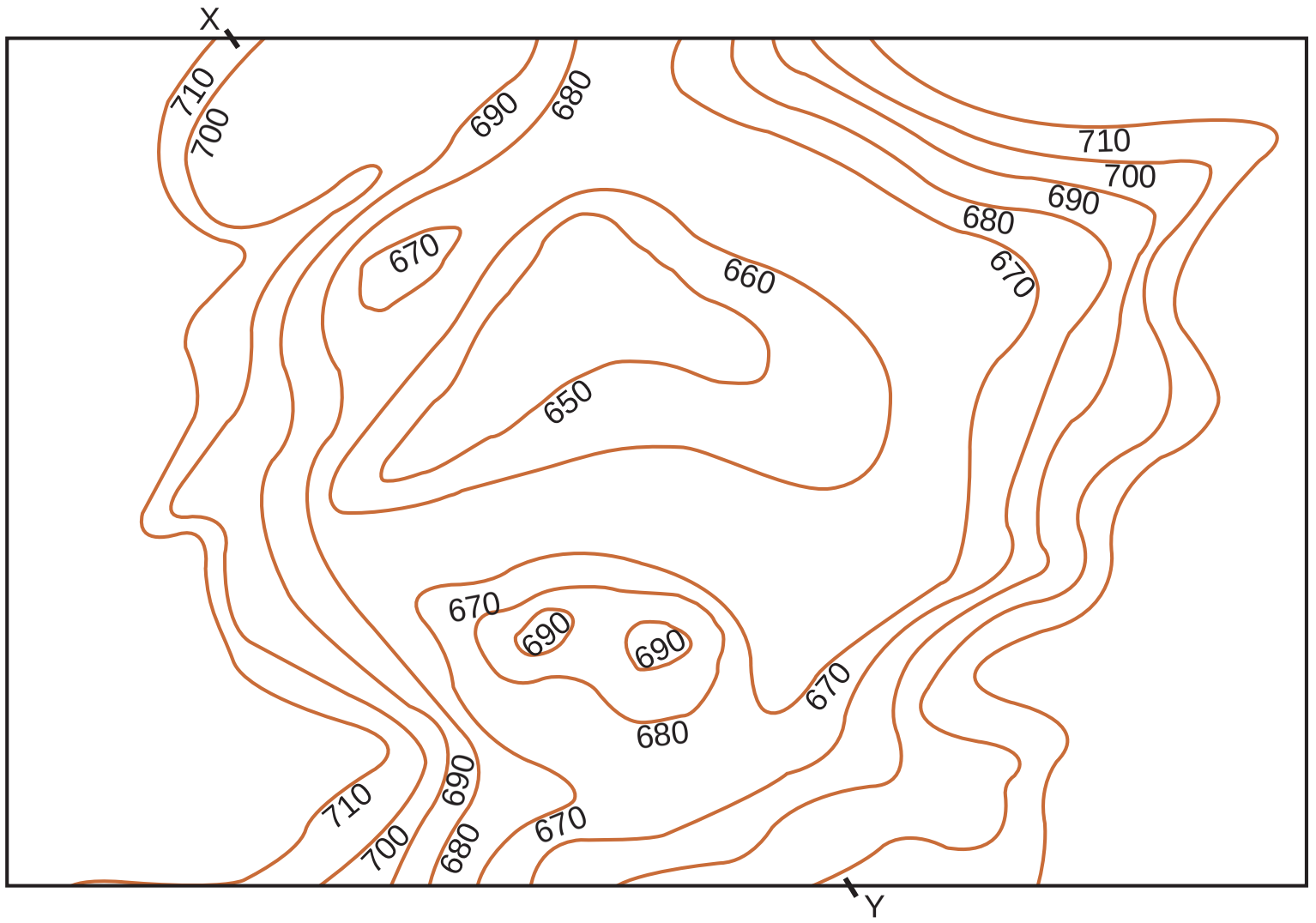
Map no. 4


X
Y
1000
950
900
850
800
750
700
650
600
550
500
900
850
800
900
850
800
750
700
650
600
550
N
CI : 50 m
Scale :
1 cm = 100 m

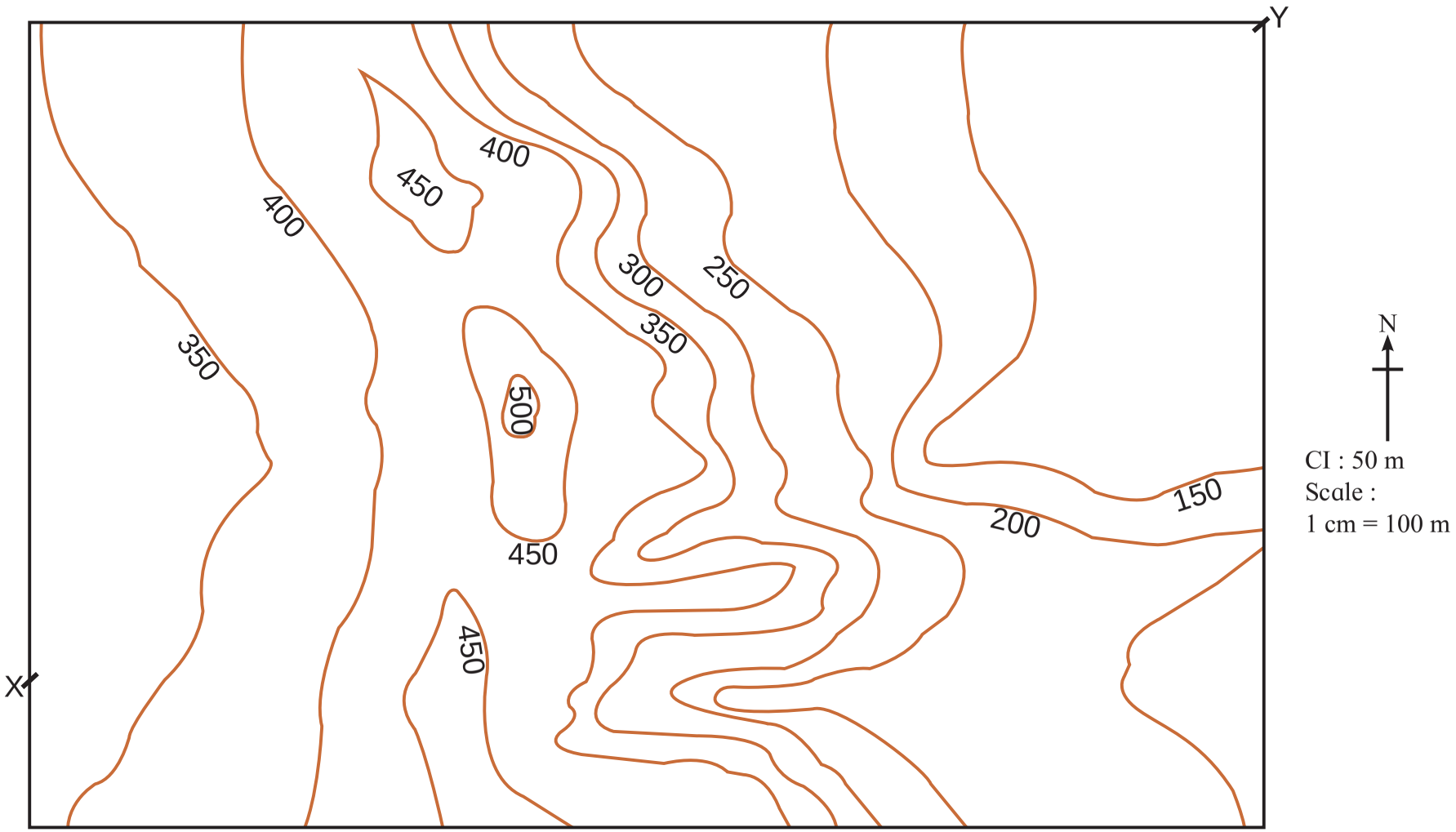
Map no. 5


X
700
600
500
600
500
400
300
200
100
200
300
400
500
600
Y
N
CI : 100 m
Scale :
1 cm = 100 m

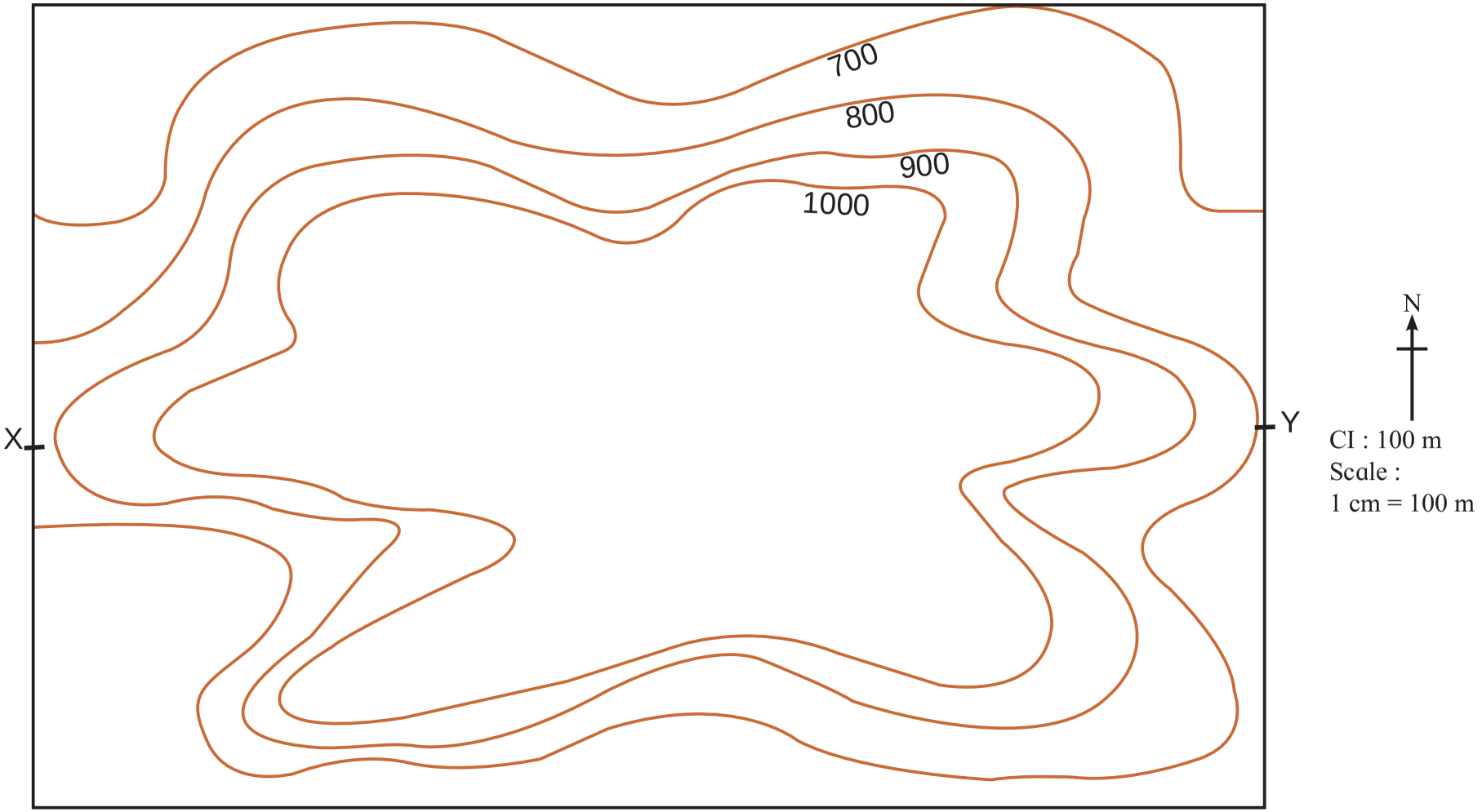
Map no. 6


X
Y
710
700
690
680
670
660
650
710
700
690
680
670
670
690
690
680
670
710
700
690
680
670
N
CI : 10 m
Scale :
1 cm = 100 m

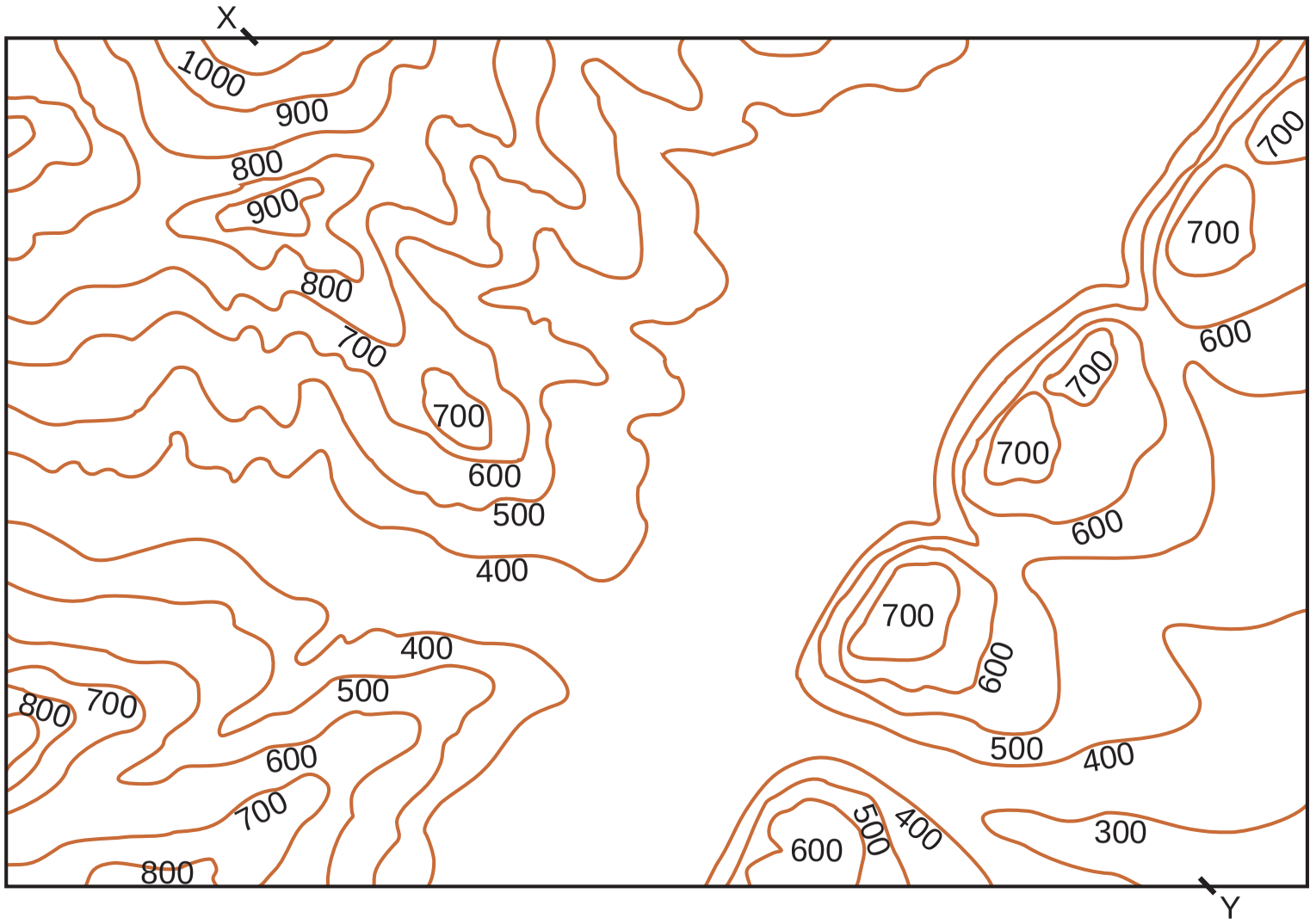
Map no. 7


Y
X
400
450
400
300
250
350
350
500
450
450
150
200
N
CI : 50 m
Scale :
1 cm = 100 m

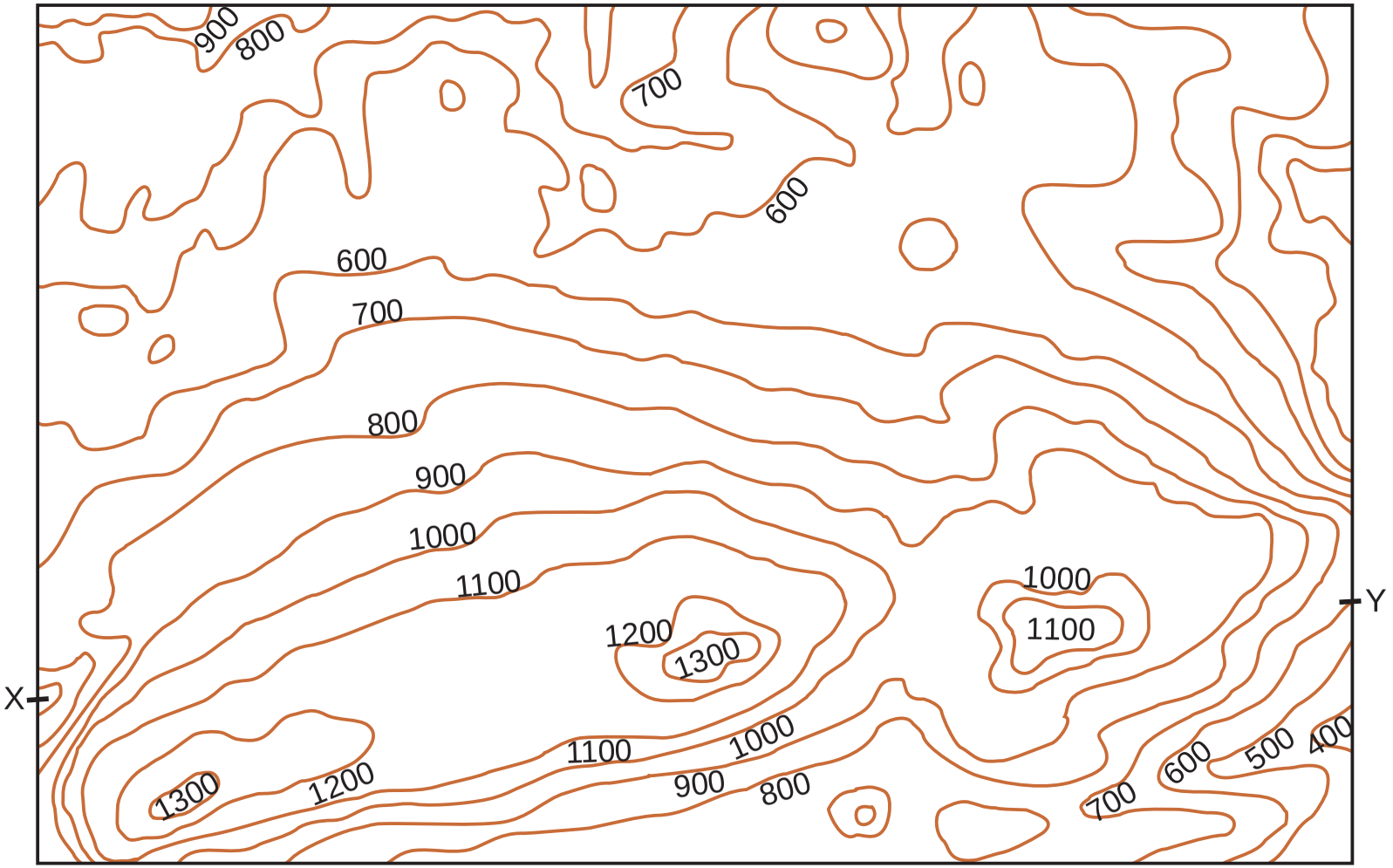
Map no. 8



Map no. 9


X
Y
1000
900
800
900
800
700
700
600
500
400
400
500
800
700
600
700
800
700
700
600
700
600
500
400
600
500
400
300
N
CI : 100 m
Scale :
1 cm = 100 m

Map no. 10


900
800
700
600
600
700
800
900
1000
1100
1200
1300
1000
1100
1300
1200
1100
1000
900
800
700
600
500
400
X
Y
N
CI : 100 m
Scale :
1 cm = 100 m

• Practical No. 14

Study of District Resource Map (DRM) for Nagpur District. (Note : Use your own DRM)

Nagpur district is situated in the eastern part of Maharashtra and renowned for its citrus orchards and manganese deposits. It falls in Survey of India degree sheet nos. 55K, L, O, P between latitudes 20°35':21°44'N and longitudes 78°15':79°40'E. It covers an area of 9892 sq. km and is bounded by Chhindwara, Seoni and Balaghat districts of Madhya Pradesh in the north; Bhandara, Chandrapur, Wardha and Amravati districts of Maharashtra in the east, southeast, south and southwest and northwest respectively. Nagpur is the district headquarters and Katol, Narkher, Kondhali, Jalalkheda, Savner, Mohpa, Kalmeshwar, Ramtek, Kantni, Mauda, Kuhi and Umrer are some of the major towns. Nagpur is well connected with other metropolitan cities by Southeastern Railway, Central Railway and National Highways Nos. 6 and 7. Nagbhir-Nagpur and Nagpur-Chhindwara extension lines (0.76m guage) of Southeastern Railway pass through the southeastern and northwestern part of the district. All important places within the district and adjacent districts are well connected by a network of state highways and all weather roads.

Nagpur district lies along the southern fringes of the Satpura range. It is hilly in the northeast and west where the elevation varies from 350m to 583m msl. The southern and eastern parts have a vast pediplain with gentle slopes towards east. The average elevation of the pediplain surface is about 300m msl. Pench and Kanhan are the main tributaries of Wainganga river flowing from northwest to southeast in the northern part.

Rock formations ranging in age from Archaean to Recent are exposed in the district. Tirodi Gneissic Complex of Archaean to Palaeo Proterozoic age (>2500-2200 m.y.) comprising migmatite, orthogneiss and granulite occupies the eastern and northeastern part. An outcrop of granulite is marked at 14 km northeast of Mauda. Amgaon Gneissic Complex of Archaean-Palaeo Proterozoic age occupies the southeastern part and comprises granitic gneisses and migmatitic gneisses with calc-silicate, quartzite, ultramafic and amphibolite. Sakoli Group of Meso Proterozoic age (2000-1600 m.y.) occupies the southern part and comprises mica schist, phyllite, carbonaceous phyllite, metabasalt with associated tuff, metarhyolite and felsic volcanics with associated tuff. Sausar Group of Meso Proterozoic age occupies the northern part and comprises quartz-muscovite schist, feldspar-muscovite schist and intercalated quartzite (Sitasawangi Formation); calc-gneiss and manganiferous marble with pockets of manganese ore (Lohangi Formation); muscovite-biotite shcist with manganese ore (Mansar Formation); quartzite and quartz-muscovite schist (Chorbaoli Formation); muscovite-biotite schist and quartz-biotite granite (Junewani Formation) and crystalline limestone and dolomite (Bichua Formation) which are repeatedly tight folded. The Sausar Group is a ***store house of manganese ore*** deposits. Talchir Formation of Carboniferous to Permian age (345-230 m.y.) and Kamthi Formation of Permian to Triassic age (280-195 m.y.) of Gondwana Supergroup are exposed around Umrer, Savner and Kamthi. Former comprises of boulder bed, sandstone and shale and latter comprises of sandstone and ferruginous sandstone. Coal seams occur in Barakar Formation underlying the Kamthi Formation. Lameta Group of Cretaceous age (136-65 m.y.) is exposed between northwest of Nagpur and south of Umrer as disconnected patches. Almost half of the district in its western and southern parts is occupied by the Deccan Trap comprising 60m thick pile of basaltic flows of Cretaceous to Palaeogene age (60-62 m.y.). At places, Intertrappean (sedimentary) beds separate the individual flows. Isolated laterite cappings are found around Kondhali. Alluvial deposits of Pleistocene to Recent age are found along Kanhan, Jam, Wunna and Sur rivers.

Nagpur district is well known for its economic mineral deposits, particularly manganese ore. About 55 manganese ore deposits have been explored. Some of the important deposits are located at Gumgaon, Ramdongri, Kodegaon, Kandri, Satak, Mansar, Lohdongri, Kachurwahi, Waregaon, Bhandarbodi, Manegaon, Mandekasa and Hiwra. The other mineral deposits found are copper at Pular and Parsori in Umrer tehsil and tungsten at Agargaon in Umrer tahsil. Important coalfields are located in Kamthi and Umrer areas. Clay deposits associated with rocks of Kamthi Formation are located at 25 km east of Nagpur and 21 km northeast of Savner. Limestone, calcitic marble and dolomitic marble deposits are found at Katta, Hiwara, Kadbikhera, Sarkaritola, Pauni, Chorbaoli, Deolapar, Mansar, Chargaon, Kachurwahi, Junewani, Kardi and Dahoda.

Other economic minerals reported are antimony (Kolari), chromite (Taka), gold (Pular-Parsori, Mokhabardi and Kolari in Bhiwapur tehsil), lead-zinc (Anjani, Tambekhani, Kolari, Bhaori), kyanite (10 km southeast of Kuhi) and mica (Koradi).

EXPLANATION

LITHOLOGY	STRATIGRAPHIC STATUS		AGE	NATURE AND CHARACTERISTICS
Alluvium			QUATERNARY	Loamy consisting of sand, silt and clay with pebbles and gravels at places, soft, unconsolidated
Lateritic			CAINOZOIC	Yellow to reddish brown, porous, exhibits pisolitic structure
18 sample flows of basalt	Karanja Fm.	SAHYADRI GROUP (DECCAN TRAP)	CRETACEOUS-PALAEOGENE	Dark grey, sparsely to moderately porphyritic, massive rock
6 flows of basalt (3 sample & 3 compound)	Chikhli Fm.			Dark grey, sparsely to moderately porphyritic, massive rock
Intertrappean beds				Red and grey clay, limestone and sandstone
Undifferentiated basalt				Dark grey, fine grained with compact and massive clinkery surface
Conglomerate, sandstone, shale, limestone		LAMETA GROUP	CRETACEOUS	Green and red, medium grained, calcareous, friable, arkosic and unfossilifers rock
Sandstone and ferruginous Sandstone	Kamthi Fm.	GONDWANA SUPERGROUP	PERMIAN-TRIASSIC	Reddish yellow, buff, dark brown, medium to coarse grained, hard and compact rock
Boulder bed, sandstone, shale	Talchir Fm.		CARBONIFEROUS-PERMIAN	Greenish, fine grained, compact sandstone with interbedded greenish shale
Granite, pegmatite				Medium to coarse grained and composed of feldspar, biotite and muscovite
Crystalline limestone, dolomite	Bichua Fm.	SAUSAR GROUP		Pale, buff to creamy white, medium grained rock
Muscovite-biotite schist, quartz-biotite and granulite	Jonewani Fm.			Light grey, buff to brown, very fine grained, massive rock
Quartzite and quartz-muscovite schist	Chorbaoli Fm.			Light buff, grey to reddish, massive rock
Muscovite-biotite schist with manganese ore	Mansar Fm.			Light grey to pale brown, silvery white, coarse grained, laminated and fissile rock
Calc-gneiss and manganiferous marble with manganese ore pockets	Lohangi Fm.			Greenish to brown, black, fine to coarse grained rock
Quartz-muscovite schist, feldspar-muscovite schist and intercalated quartzite	Sitasongi Fm.		MESO PROTEROZOIC	White, grey to pink, fine to medium grained rock
Silicified zone, quartz reef				White, angular to subangular fragments in quartzose matrix
Metarhyolite, tuff, felsic volcanics and associated tuff		SAKOLI GROUP		Light grey to black, very fine grained, porphyritic, tuffaceous and massive rock
Mica schist				Silvery sheen, greyish to greenish grey, medium to coarse grained and well foliated
Phyllite, carbonaceous phyllite				Grey, light greenish, brown, soft, well foliated and crenulated
Tourmalinite, orticule				Black, closely associated with felsic rock
Metabasalt with associated tuff				Earthy green, fine grained, porphyritic, vesicular and amygdular, hard rock
Amphibolite	AMGAON GNEISSIC COMPLEX		ARCHAEAN PALAEO PROTEROZOIC	Dark green, medium to coarse grained, massive, hard and at places shows spheroidal weathering
Ultramafic rock				Greyish white to light green, foliated and crenulated at places
Quarzite (± Kyanite, Sillimanite)				Pink, white, grey and at places black due to presence of magnetite
Calc-silicate rock				Greenish to brown, medium to coarse grained rock
Granite gneiss with migmatitic gneiss	Granitic gneisses with migmatite/ granite	TIRODI GNEISSIC COMPLEX		**Migmatite :** course to medium grained, mesocratic, distinctly gneissose and often porphyroblastic **Gneiss :** light to dark grey, medium to coarse grained and distinctly banded **Granite :** light grey, medium to coarse grained and massive
	Granulite			Pale brownish, medium to coarse grained having greasy appearance

STRUCTURAL INDEX

- Confirmed litho-contact
- Inferred litho-contact
- Central Indian Shear zone (CIS)
- Attitude of bedding : inclined/vertical
- Attitude of foliation : inclined/vertical
- Attitude of joint : inclined/vertical
- Overturned anticline
- Anticline showing plunge
- Thrust
- Fault
- Lineament
- Boundary for data base gap

MINERAL INDEX

- Antimony
- Chromite
- Clay
- Copper
- Coal
- Gold
- Lead
- Zinc
- Kyanite
- Limestone
- Dolomite
- Manganese
- Mica
- Tungsten

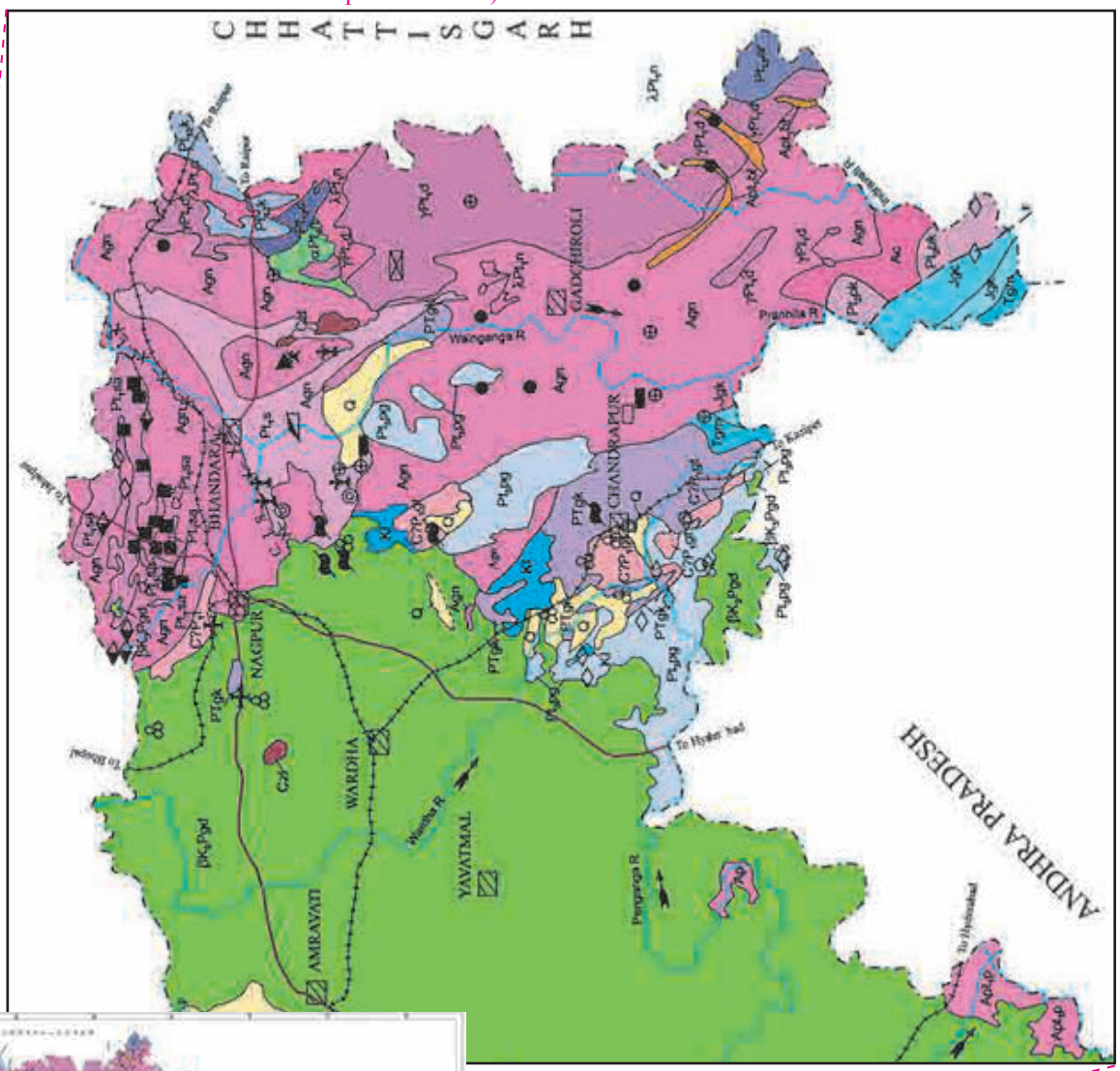
GENERAL INDEX

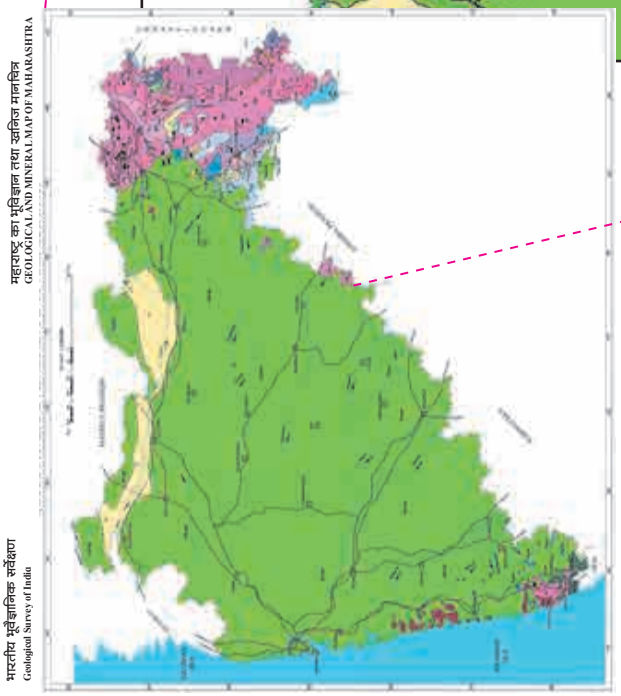
- District boundary
- State boundary
- Height of triangulation station in m
- Railway line
- Road
- Settlement
- Drainage with direction of flow
- Reservoir

• Practical No. 15

Study of Mineral Resources of Maharashtra state.

(For Practical Numbers : 15 refer to chapter number 6)





L E G E N D

Alluvium				Quaternary
Laterite				Cainozoic
		Deccan Trap		Upper Cretaceous to Palaeogene
Lameta Group / Chikiala Formation	Sandstone, chert limestone and clay / Ferrugenous sandstone and conglomerate		Gondwana	Upper Carboniferous to Lower Cretaceous
Kota Formation	Sandstone, grit, red clay and limestone			
Maleri Formation	Ferrugenous calcareous sandstone and shale			
Kamthi Formation	Ferrugenous sandstone			
Talchir Formation	Shale, siltstone, sandstone, conglomerate and tillite			
Penganga Group / Badami Group (Kaladgi Basin)	Limestone, shale, chert, sandstone/ Shale, sandstone, quartzite			Neo Proterozoic
Pakhal Supergroup	Dolomite, limestone, shale, sandstone, quartzite			Meso Proterpzoic
Abujhmar Group / Khairagarh Group	Basalt, shale, sandstone and conglomerate/ Alternating sequence of Sandstone, siltstone,grit and metabasalt			Palaeo-Meso- Proterozoic
Sausar Group	Calc.-gneiss, marble, biotite granulite schist, quartzite and schistose grit	Dongargarh Granite (Granite)	Bijli Rhyolite /Pitepani volcanics Rhyolite, acid tuff and rhyolitic conglomerate/ Green tuff, metabasalt and gabbro	Nandgaon Group / Palaeo Proterozoic
Sakoli Group	Metabasalt, metapellites (phylite, mica schist), quartzite, BIF, banded chert and tuff			
Peninsular Gneissic Complex (Younger phase)	Granite gneiss and granite	Bailadila Group (Meta-ultramafite/gabbro, meta-basalts, quartzite, mica-schist, phylite,BHQ)	Chitradurga Group (BIF, phyllite, schist, amphibolite,quartzite / Chitradurga Group (Metabasalt)	Dharwar Supergroup / Archaean-Palaeo Proterozoic
Bhopalpatnam granulite	Pyroxene granulite, charnockitic gneiss, charnockite			Archaean
Peninsular Gneissic Complex (Older Phase)	Granite gneiss and migmatite with enclaves of amphibolite, quartz mica schist, BMQ, quartzite and meta ultramafics	Gneissic Complex (Amgaon/Bastar?Tirodi Gneiss) (Granite gneiss and migmatite with enclaves of amphibolite, quartz mica schist, BMQ, quartzite and meta ultramafics)		

INDEX TO MINERALS

Clay	Ilmenite	Barytes	Tungsten Ore
Bauxite	Manganese	Gold	Ochre
Dolomite	Copper Ore	Pyrophyllite	Glass sand
Limestone	Chromite	Zinc Ore	Sillimanite
Iron Ore	Coal	Kyanite	Dimensional stone

INDEX TO GEOLOGICAL STRUCTURES

Fault

C.I.S. Central India Shear Zone

Lonar Crater

• Practical No. 16

Study of some important geological heritage sites of Maharashtra state.

1) **Geoheritage sites :** Geoheritage sites are geologically important sites found either locally or globally. These sites are a result of natural processes and not formed by human intervention.

- These are tourist destinations and provide local and regional economic benefits.
- Geoheritage sites can be small, but scientifically significant, such as a road cut etc. They can also be extensive areas with international recognition.
- These geoheritage sites are vulnerable to urbanization, infrastructure development, agriculture, over-use and erosion.
- Conservation strategies, appropriate to the type of site are important for protection of geoheritage sites from loss, in order to maintain them for long-term public interest.

2) **Geodiversity :** Geodiversity is the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landforms, processes) and soil features. It includes their assemblages, relationships, properties and interpretations.

3) **Geoconservation :** It includes actions and measures taken to preserve geodiversity and geoheritage for the future.

4) **Geotourism :** It is the tourism with a strong focus on natural wonders (including geological and geomorphic features).

Some important geological heritage sites of Maharashtra state :

1) **Lonar meteorite crater (Lonar, Buldhana district (19.9756°N, 76.5092°E, 610-msl) :** Lonar crater is a unique crater found in Deccan basalt and has been created due to an impact of a meteorite. The crater's age has been estimated to be around 52,000 years (Pleistocene). This remarkably circular crater is nearly 150 m. deep. The average diameter of the impact crater is ~1.8 km. The monsoon runoff flows into lake via multiple streams. As the water evaporates gradually during the dry season, the dissolved salts are left behind. The concentration of salts steadily increases and the lake water becomes brackish and then saline (Fig.1).

It was earlier thought of as a volcanic crater but the presence of high pressure/ high temperature mineral - Maskelynite has confirmed that the crater originated due to a hyper velocity meteorite impact.

Fig. 1 : Meteorite crater at Lonar

2) **Nighoj potholes (Nighoj, Ahmednagar district. (18.9319°N, 74.2627°E, 575-msl) :** This site shows magnificent potholes in basalt flows within the rocky channel of the Kukadi River. The narrow inner channel (~300m long and >15m. deep), exhibits intricately undulating walls with remnants of multiple potholes of various sizes (~1 - 5m) and shapes (Fig. 2).

Fig. 2 : Potholes at Nighoj

3) **Honeycomb structure (Harihareshwar, Raigad district. (17.9912°N, 73.0183°E, 5-msl) :** The sea cliff at Harihareshwar has a well developed honeycomb structure within basalts. It displays a great variety of micro-features and patterns such as circular solution depressions, potholes, honeycomb structure etc. They are formed due to chemical weathering caused by sea water (Fig. 3).

Fig. 3 : Honeycomb structure at Harihareshwar

4) **Natural Bridge (Gulunchwadi, Ane ghat, Pune district. (19.1512°N, 74.2169°E, 755-msl) :** Gulunchwadi village on Ahmednagar – Kalyan highway has a natural bridge in Aradara nala. The nala passes under this rock bridge, which is about 2 - 7 m. high and has a span of 10 - 13 m. The basaltic bedrock has been incised by Aaradara nala, along a winding course in this stretch. (Fig. 4).

Fig. 4 : Natural bridge at Gulunchwadi

5) **Columnar joints :** Columnar joints in basalt develop due to contraction induced by conductive cooling. Tension from the contraction gives rise to polygonal fracture system (pentagonal or hexagonal). Spectacular columnar joints in basalt have been reported from following sites in Maharashtra :

a) Panhala hill (Panhala fort area, Kolhapur district (16.4822°N, 74.0627°E, 907-msl)

b) Jyotiba hill (Jyotiba hill, Wadi Ratnagiri village, Kolhapur district (16.4730°N, 74.1038°E, 910-msl)

c) Tumzai hill (Tumzai, Jadavwadi village, Kolhapur district (16.4028°N, 74.0324°E, 889-msl)

d) Bandivade village (Bandivade village area, Kolhapur district (16.4913°N, 74.0020°E, 875-msl)

e) Naldurg (Naldurg fort area, Naldurg village, Osmanabad district (17.8171°N, 76.2896°E, 566-msl),)

f) Gilbert hill (Gilbert hill,, Andheri Mumbai (19.1206°N, 72.8402°E, 10-msl)(Fig. 5)

Fig. 5 : Columnar joints, Tumzai Hills, Panhala

6) **Tableland, Panchgani (Mahabaleshwar) (Panchgani, Satara district (17.9221°N, 73.6725°E, 1386-msl) :** Panchgani is a plateau in the Deccan flood basalt terrain and is capped by thick laterite. The basalt sequence here has many horizontally placed lava flows, sometime separated by red boles. Panchgani is known for its impressive laterite-capped tableland and string of mesas (Fig. 6).

Fig. 6 : Tableland at Panchgani

7) **Sandhan valley (Samrad, Ahmednagar district (19.5129°N, 73.6863°E, 740-msl) :** Sandhan is a classic example of a slot canyon in the Deccan traps. Canyons (valleys) which are significantly deeper than their widths are termed as slot canyons. The Sandhan canyon is upto 100 m deep and 2 - 30 m. wide. Canyons are primarily formed by the process of scouring by flood waters rushing through narrow openings in rocks along fractures and lineaments (Fig. 7).

Fig. 7 : Sandhan valley at Samrad

8) **Hot springs :** Chot spring is spring produced by the emergence of geothermally heated groundwater onto the surface. This hot water can have temperatures upto 100°C. Hot springs can result a) in a region which has suffered recent volcanic activity or in which magmatic activity still continues at greater depth or b) when the rock structure is favourable, the groundwater may travel to greater depths and get heated due to increase in temperature. When this hot water emerges on the surface, it gives rise to hot springs.

Hot springs from Maharashtra are formed due to favourable rock structure type. Some of the localities of hot springs in Maharashtra are given below.

Konkan region :

a) Vajreshwari (19.4870° N, 73.0280° E) : Thane district

b) Pali (18.5380°N, 73.2207° E) : Raigad district

c) Aravali (17.29725°N, 73.5°E) : Sangameshwar, Ratnagiri district

d) Unhale (16.3750° N, 73.2222° E) : Rajapur, Ratnagiri district

e) Tural (17.2554° N, 73.5300° E) : Ratnagiri district (Fig. 8)

Marathwada region :

f) Unkeshwar (19.34° N, 78.22° E) : Nanded district

North Maharashtra region :

g) Unapdev (20.16°N, 75.29°E) : Jalgaon district

Fig. 8 : Hot springs at Tural

• Practical No. 17

Draw sketch and label the various landforms seen in the photographs :

a) River : erosional and depositional features

b) Sea : erosional and depositional features

c) Wind : erosional and depositional features

d) Glacier : erosional and depositional features

(For Practical no. : 17 refer to chapter number 3)

• Practical No. 18

Fieldwork

Geology is a natural science. Nature is the best 'guide to study geology'. It mainly requires the study and understanding of basic phenomena in the classroom followed by fieldwork. The observations made in the field are useful in understanding basic concepts in geology and it is a good practice to be one with nature.

Preparation for fieldwork :

Before going for field studies, you should plan your programme. Know the topography of the area, rock types (lithology) of the area, accessibility, areas to be covered in given time and possible obstacles and problems likely to occur during fieldwork. Prepare a check list of all the geological instruments and accessories required during fieldwork.

Before you start fieldwork, study and read the topomap in detail. Mark the areas to visit. With the help of contours delineate hilly, undulating or plain lands in the area. Mark the villages and the cities falling in the area for immediate help, during problems in the field. Locate the roads to reach the proposed study area.

With the help of geological map of the area, plan your route in the area that will cover observation and study of maximum number of rock types and structures. Care should be taken while planning the route. If you are planning to take a traverse across the hill, the other side of the hill should have a road for easy accessibility. Estimate the time required for your planned route. Starting the fieldwork early in the morning and ending before sunset is the best. Generally, fieldwork is arranged in winter and bright sunny days of summer.

A topomap is a must during fieldwork to check whether everything is going on according to plan. Clinometer similar to Magnetic compass is useful to orient yourself with respect to north direction. During fieldwork, a geological hammer is required to collect rock and mineral samples. A notebook is essential to note down the points and draw figures of the structures found in the study area. Carry lunch box and water bottle for keeping your self energetic and fresh. Field shoes, helmet, safety jackets and sample bags are essential during fieldwork. These are essential accessories. Other items like medicines, first aid kit, ropes, measuring tape, camera etc. can be put in your haversack.

During fieldwork :

Discipline should be maintained during fieldwork. Your activities should not disturb local people and natural habitats. Taking observations and noting them in the notebook is essential. Click photographs of the features/ rocks etc. by placing a suitable scale (hammer, pencil, coin, etc.)

Fieldwork : Visit to nearby site of geological interest and report writing :

1) River meanders
2) Potholes
3) Columnar joints
4) Waterfalls
5) Road cuttings
6) Spheroidal weathering
7) Tableland / Mesa / Butte
8) Coastal erosional features etc.
9) Geologically important sites