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).

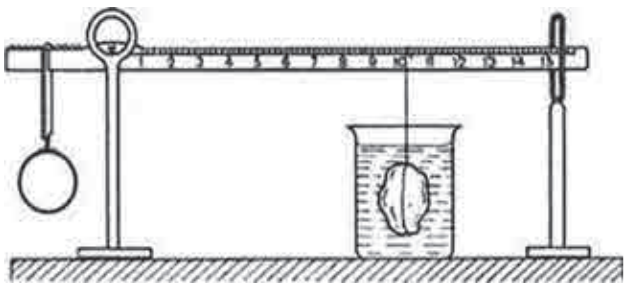
The specific gravity of a mineral can

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.).

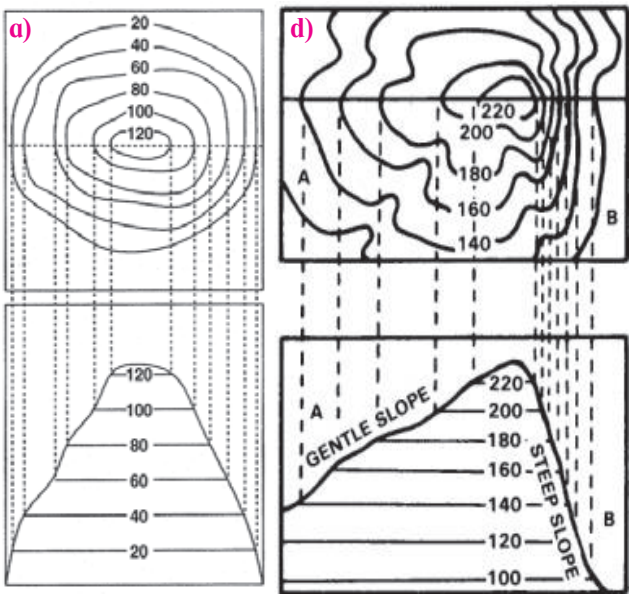


Fig. 1 : a) Symmetrical hill, b) Asymmetrical hill

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.

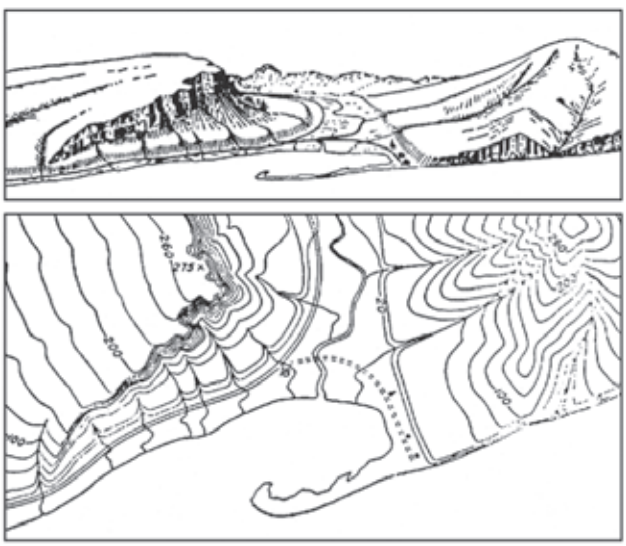


Fig. 2 : a) Landscape, b) A contour map derived from above landscape perspective. Contour lines are far apart for level land and closely spaced for steep slopes.

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).

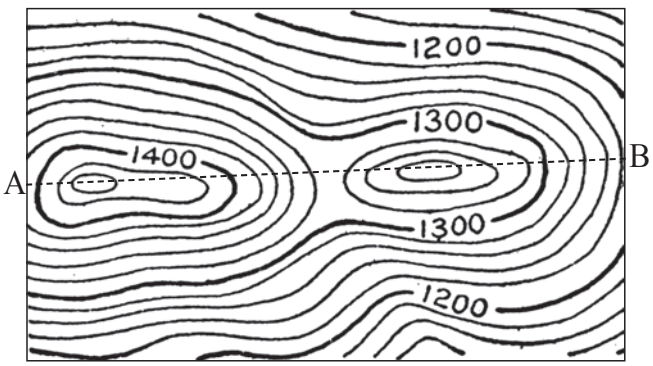


Fig. 3 : Ridge and saddle (AB is the ridge line)

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

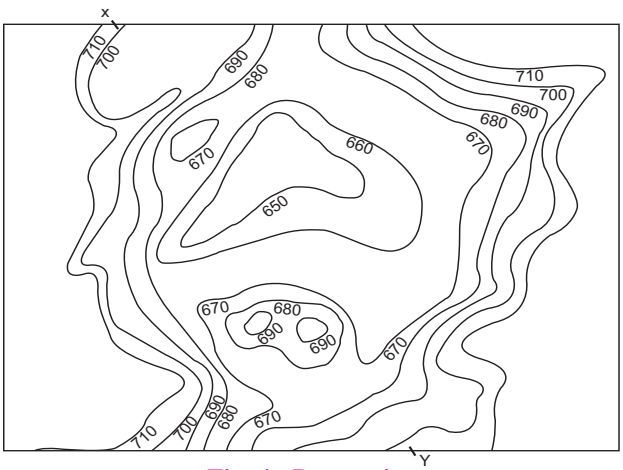


Fig. 4 : Depression

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.

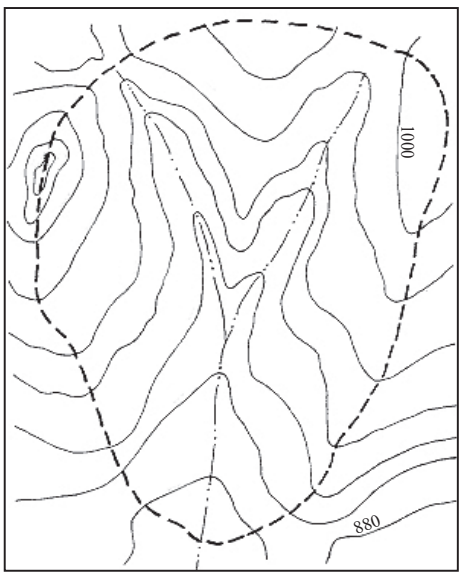


Fig. 5 : "V" Shaped Valley

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).

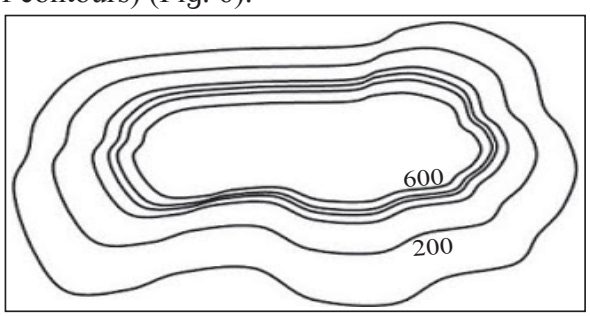


Fig. 6 : Plateau

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

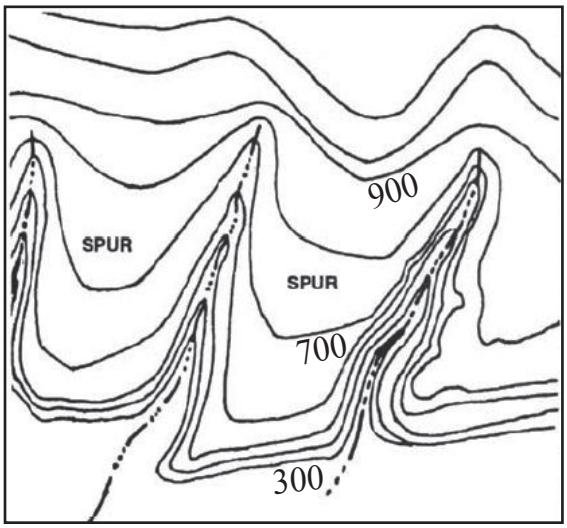


Fig. 7 : Spur

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.

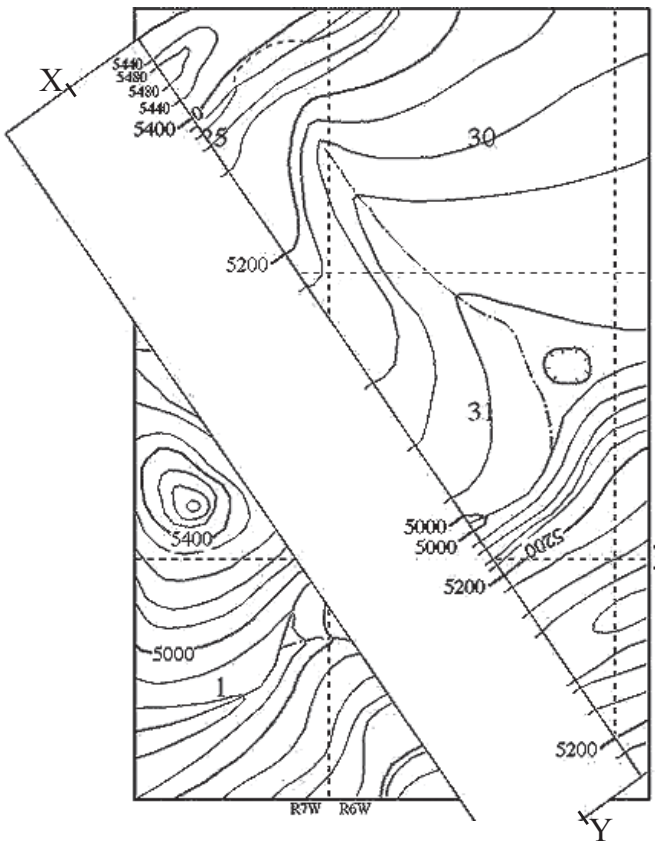


Fig. 8 : Marking the ticks wherever the contours cross the X-Y line

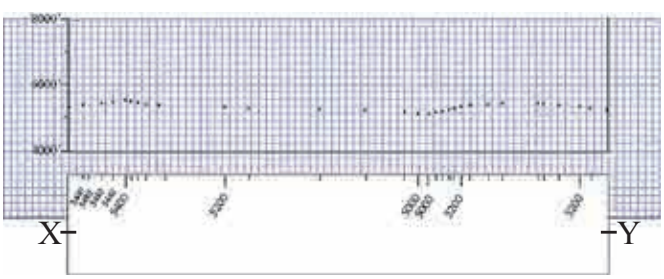
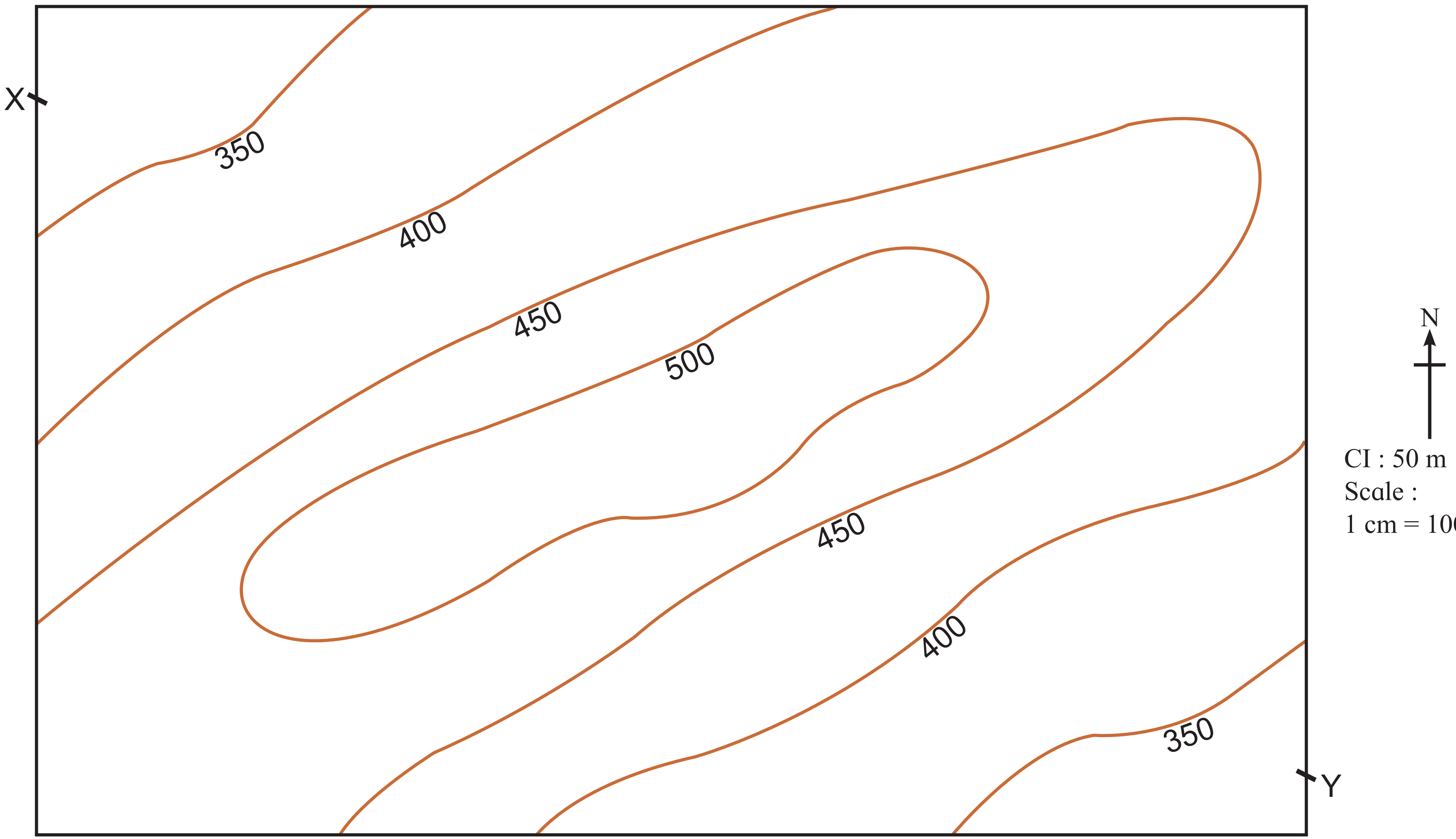


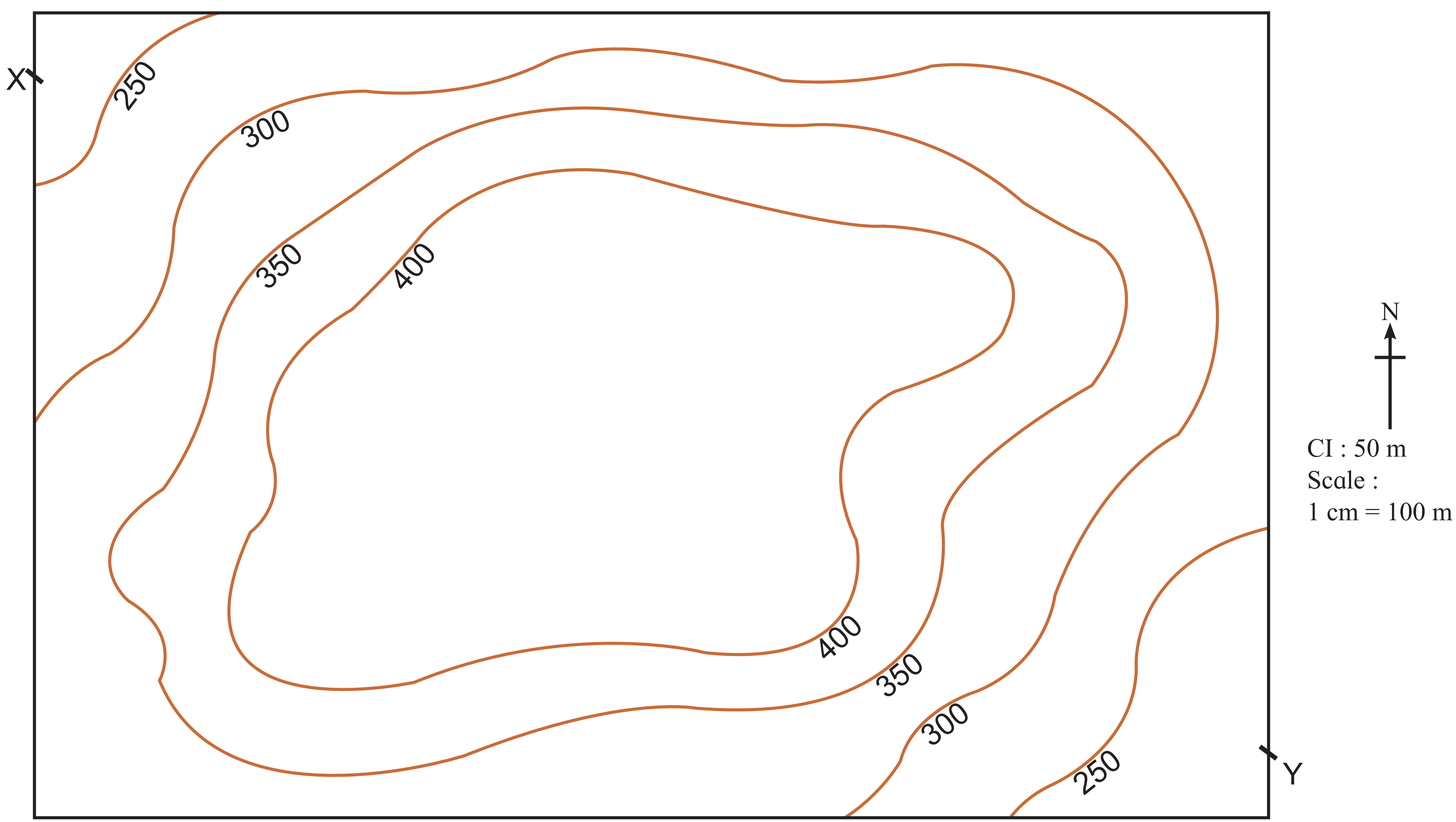
Fig. 9 : Marking elevations with the help of paper strip

Map no. 1



CI : 50 m
Scale :
1 cm = 100 m

Map no. 2



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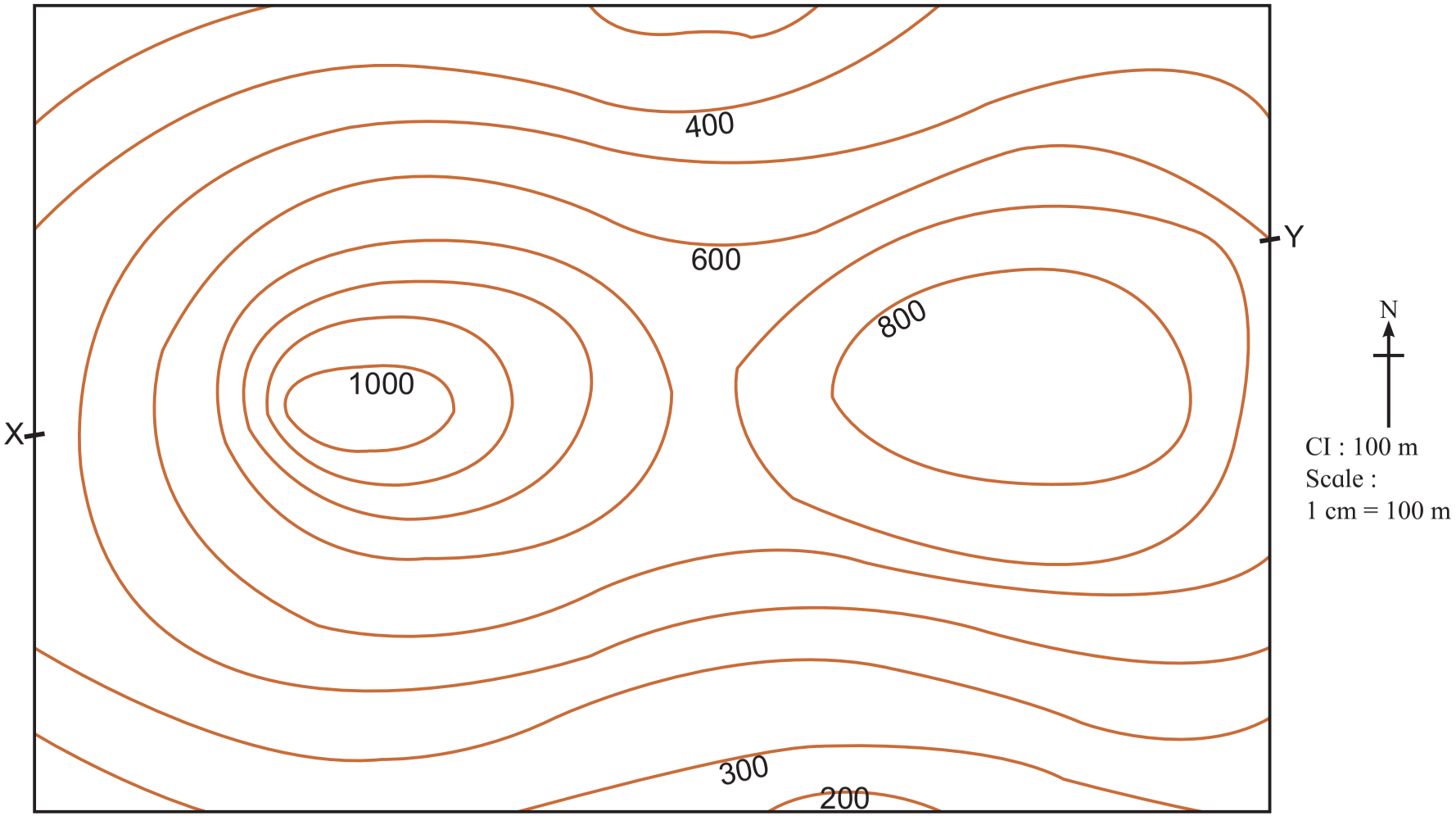
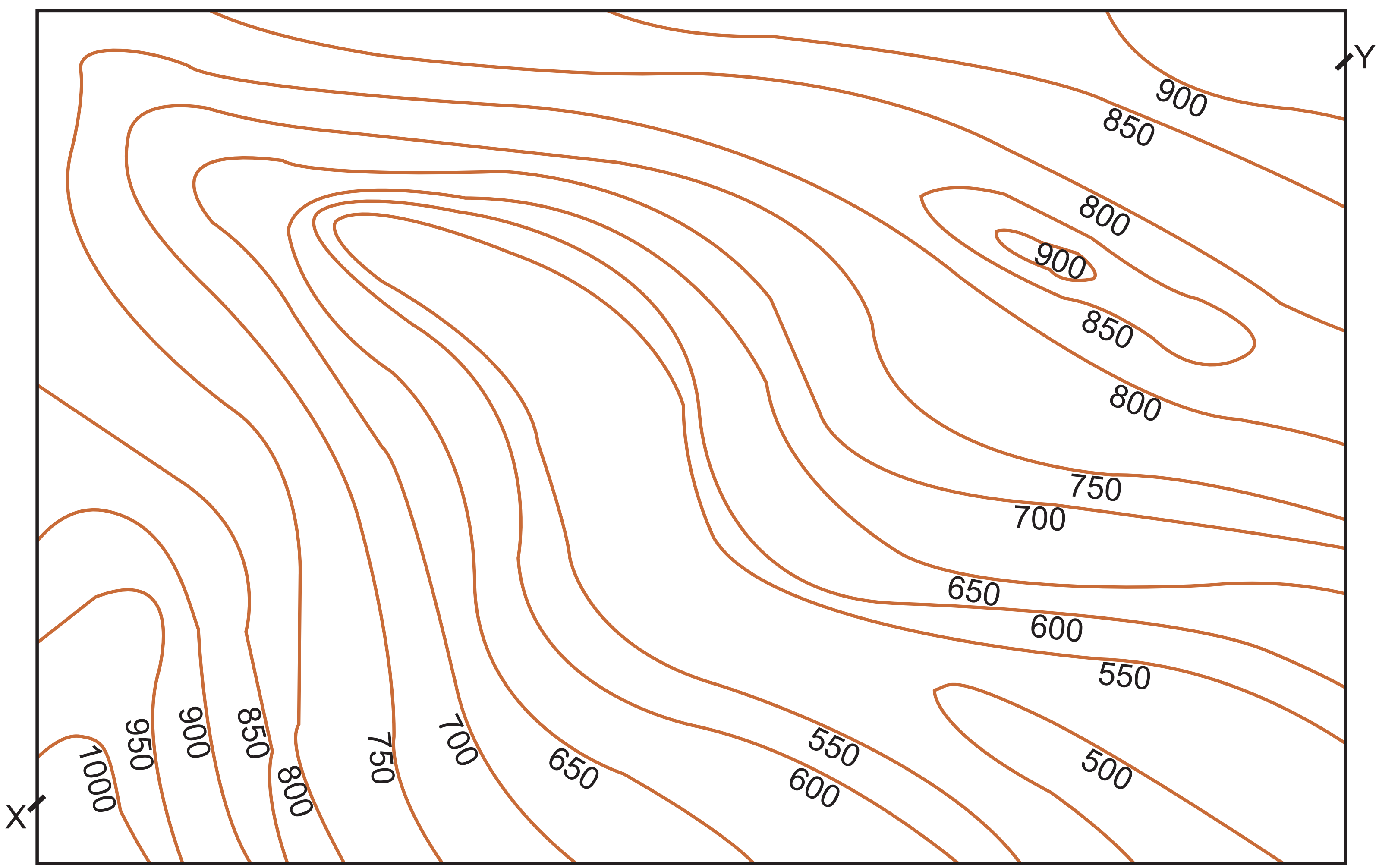


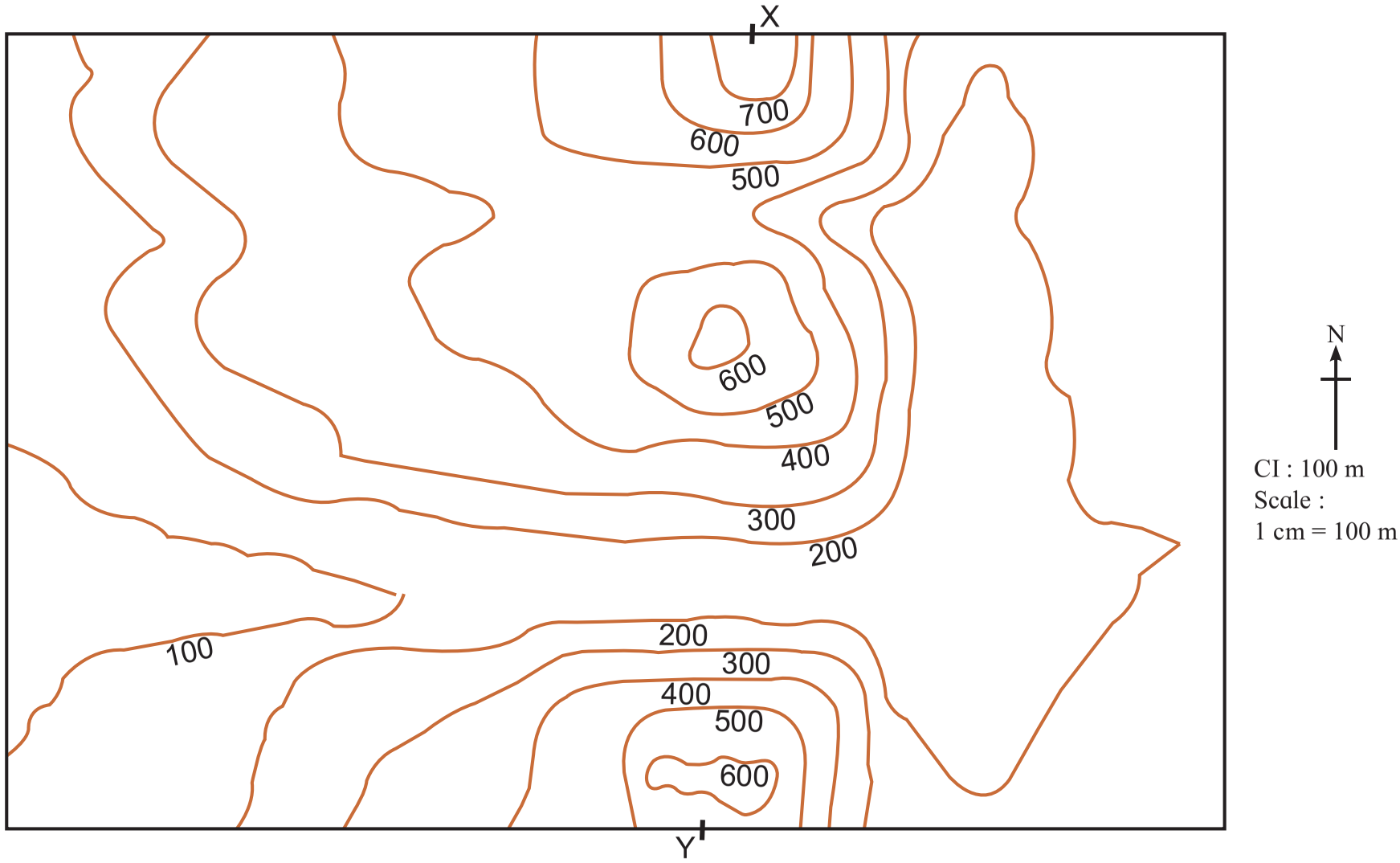
Map no. 4



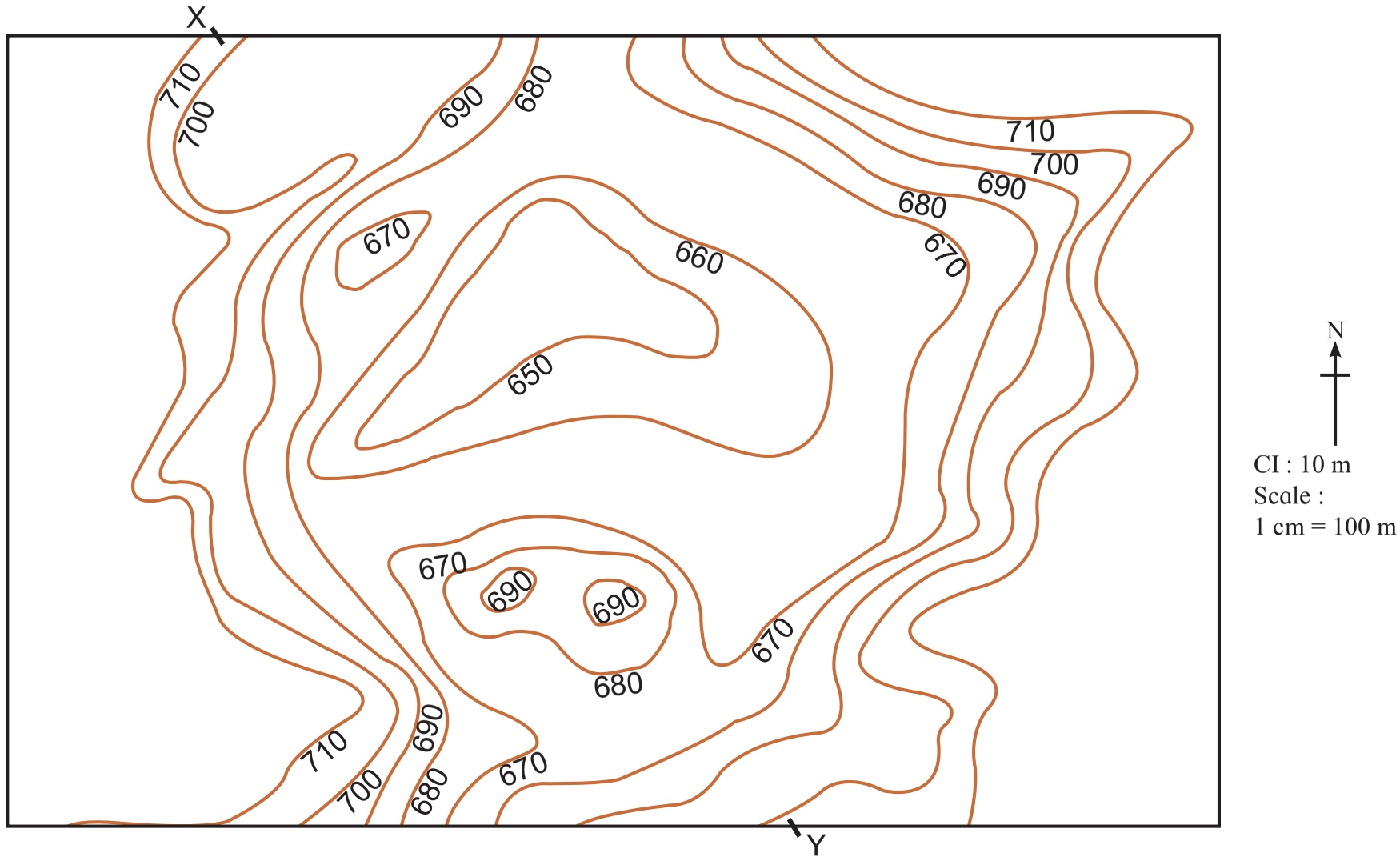
N

CI : 50 m
Scale :
1 cm = 100 m

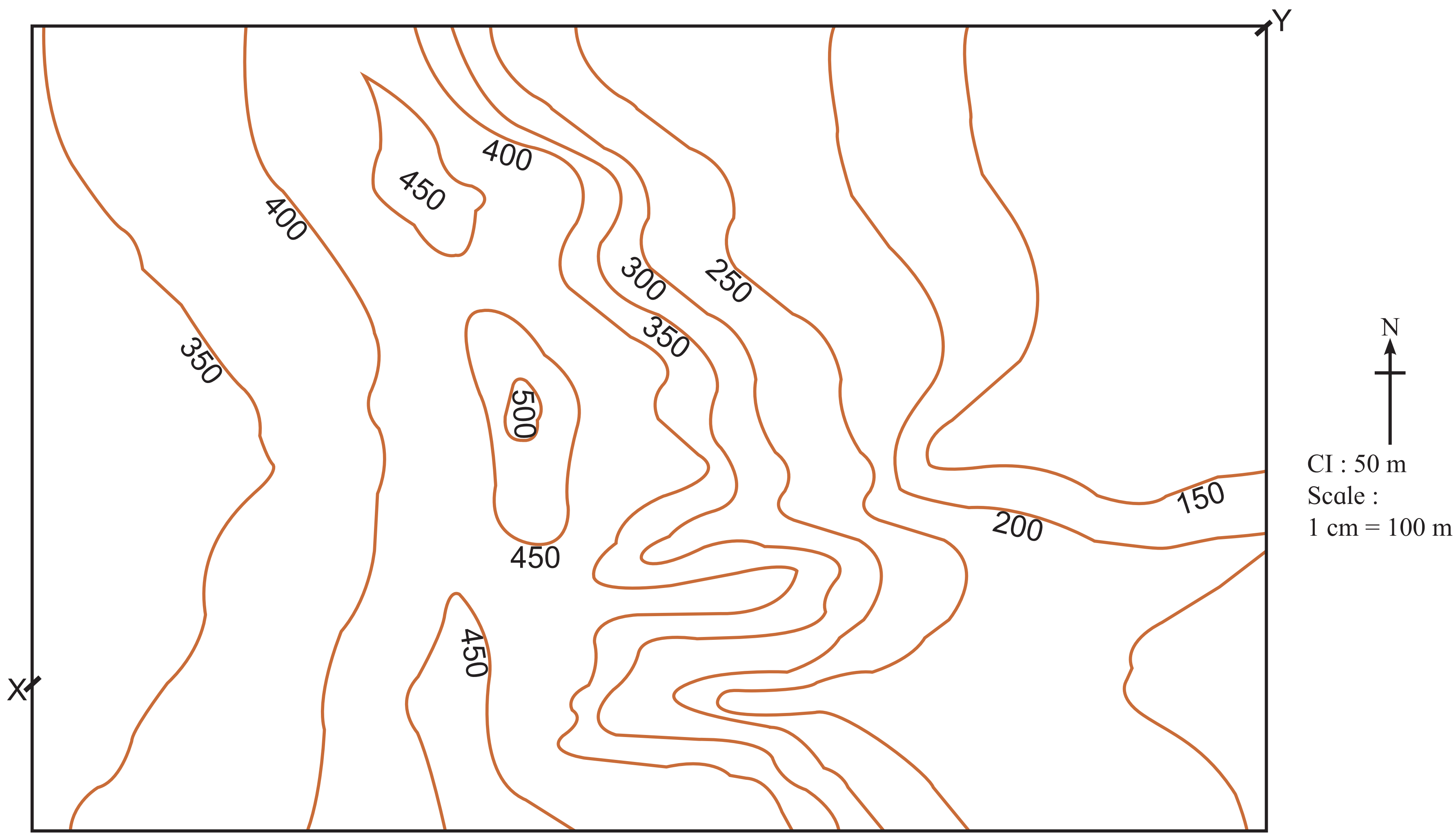
Map no. 5



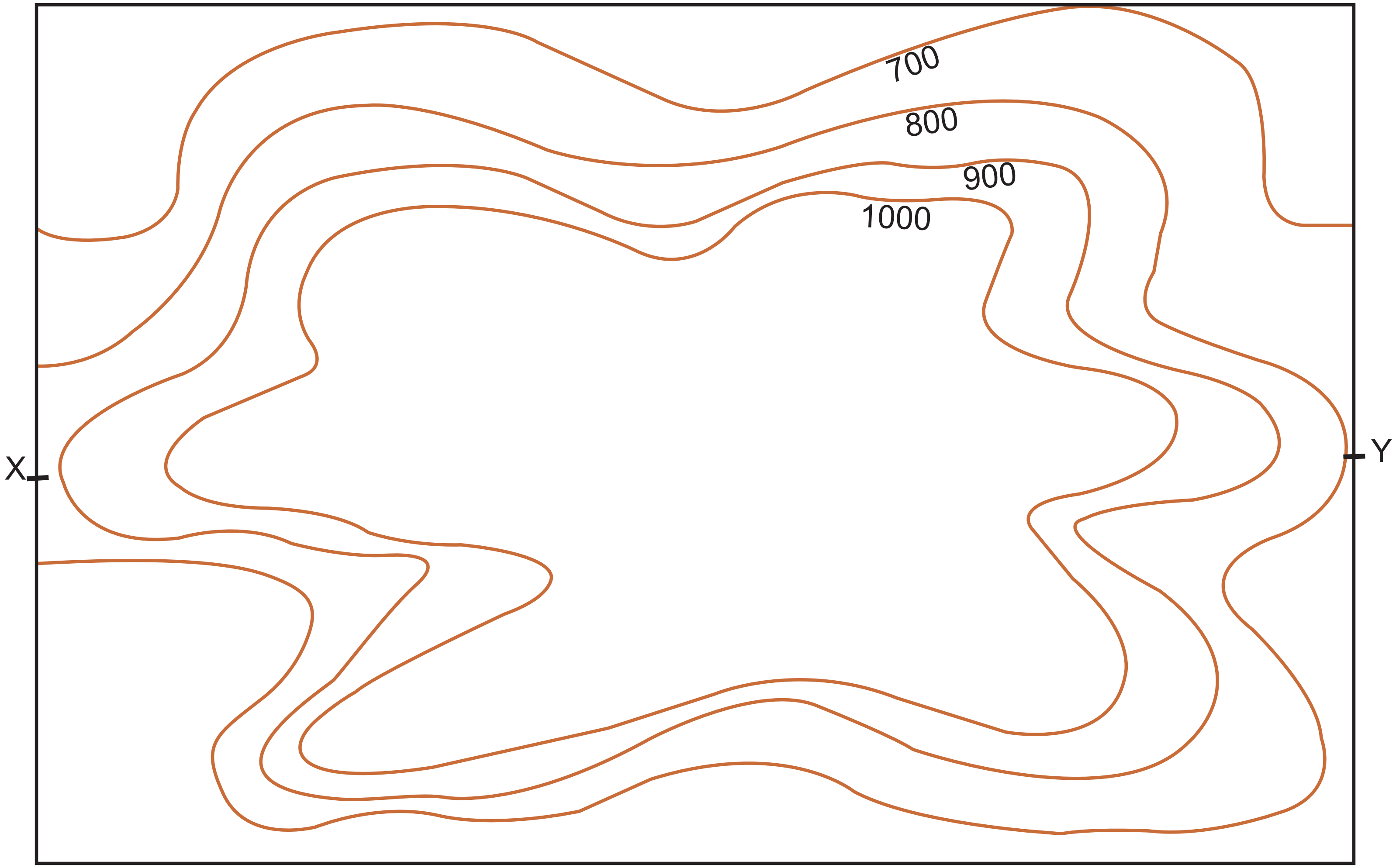
Map no. 6



Map no. 7

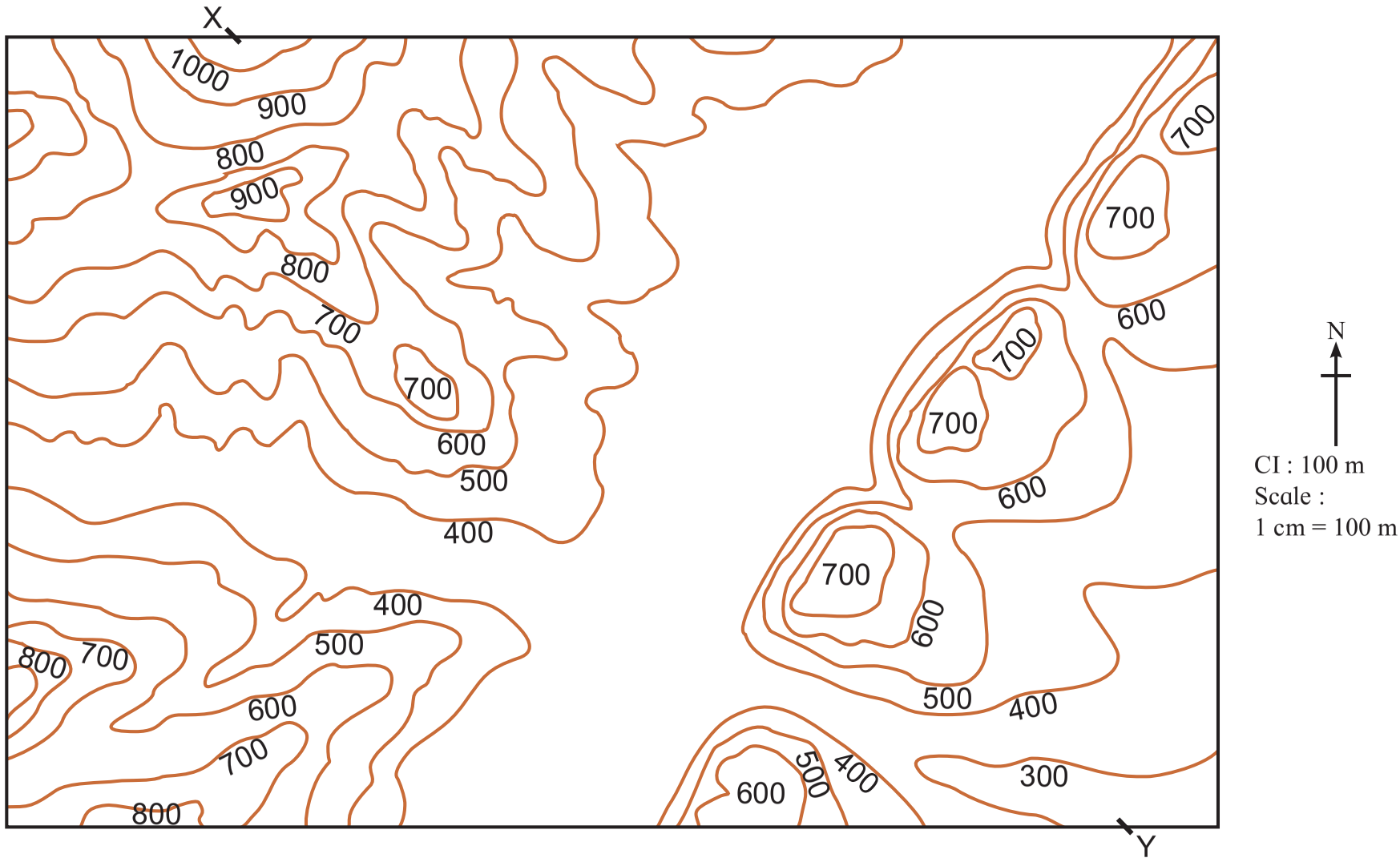


Map no. 8



CI : 100 m
Scale :
1 cm = 100 m

Map no. 9



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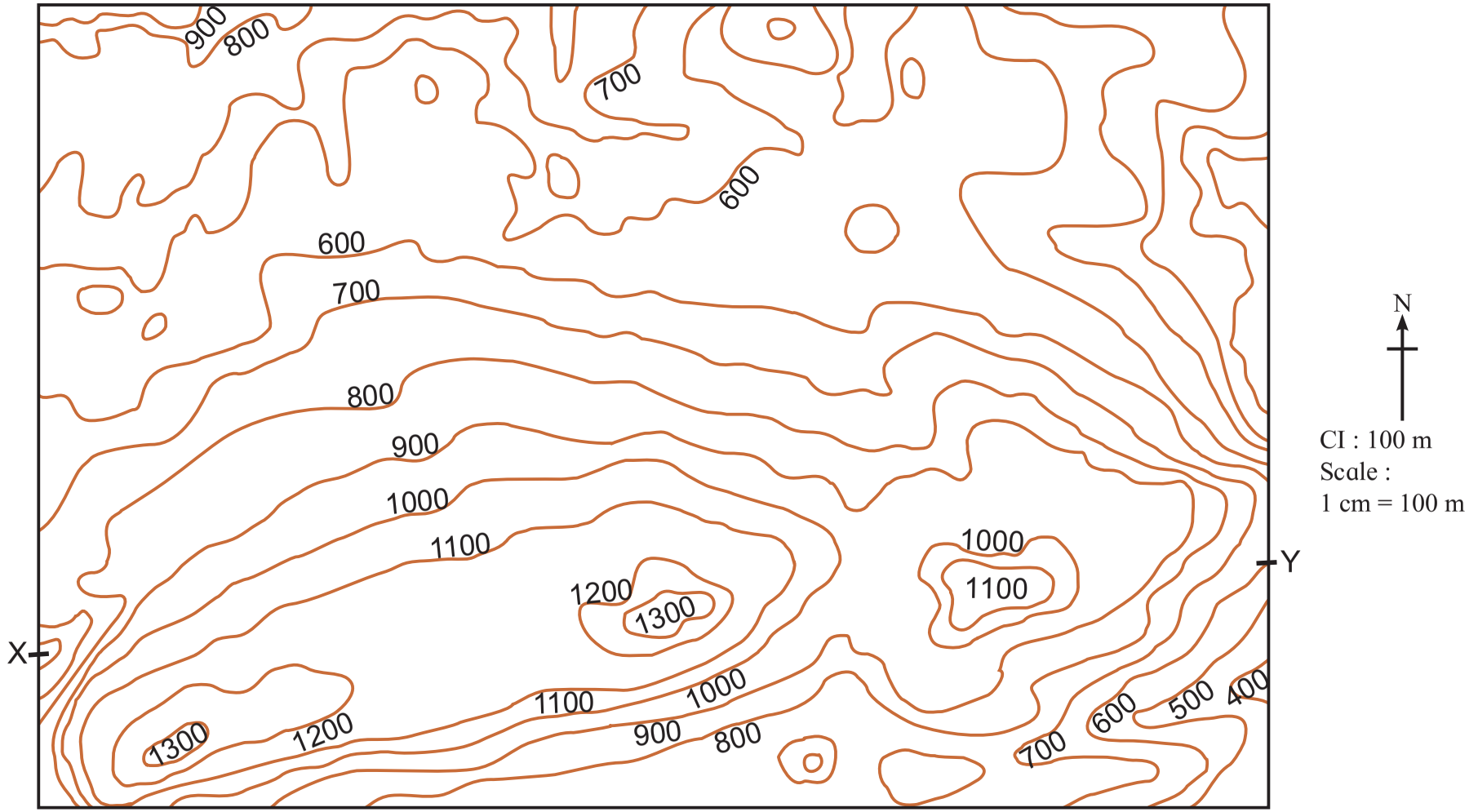


• Practical No. 14

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
Laterite			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 micaceous 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			MESO PROTEROZOIC	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	Junewani Fm.			Light grey, buff to brown, very fine grained, massive rock
Quartzite and quartz-muscovite schist	Chorbauli 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.			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
Quartzite (± 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

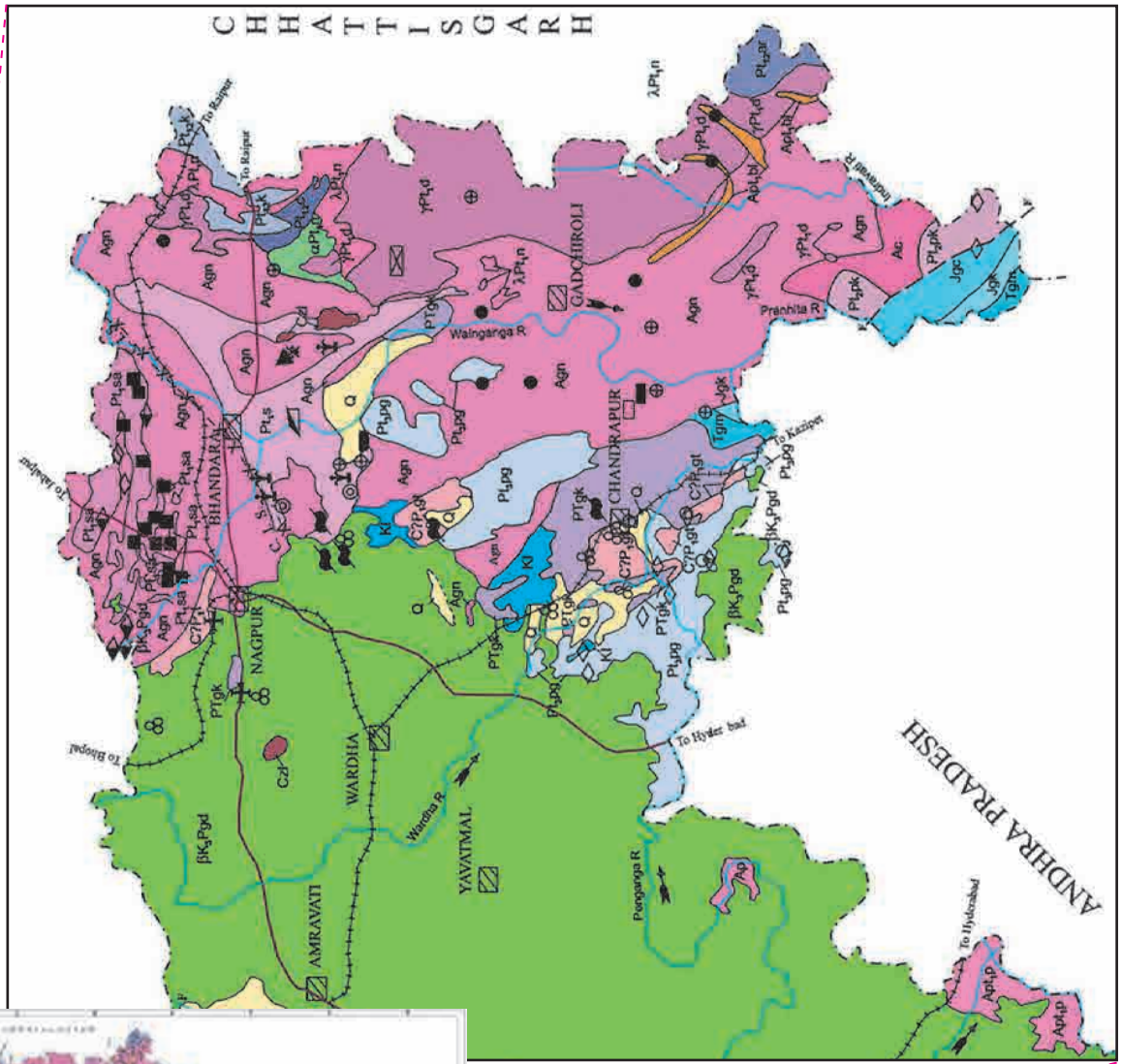
GENERAL INDEX

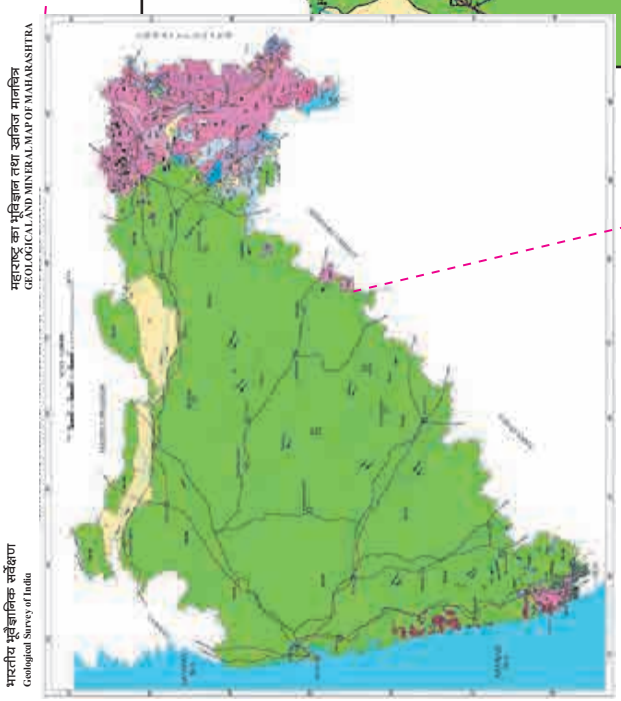
- District boundary
- State boundary
- Height of triangulation station in m
- Railway line
- Road
- Settlement
- Drainage with direction of flow
- Reservoir

• 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

Q	Alluvium			Quaternary
Czl	Laterite			Cainozoic
Kl			Deccan Trap	Upper Cretaceous to Palaeogene
Jgc	Lameta Group Chikiala Formation	Sandstone, chert limestone and clay Ferrugenous sandstone and conglomerate		Upper Carboniferous to Lower Cretaceous
Jgk	Kota Formation	Sandstone, grit, red clay and limestone		
Tgm	Maleri Formation	Ferrugenous calcareous sandstone and shale		
PTgk	Kamthi Formation	Ferrugenous sandstone		
C?P$_1$t	Talchir Formation	Shale, siltstone, sandstone, conglomerate and tillite		
Pt$_3$pg Pt$_3$bm	Penganga Group/ Badami Group (Kaladgi Basin)	Limestone, shale, chert, sandstone/ Shale, sandstone, quartzite		Neo Proterozoic
Pt$_3$pk	Pakhal Supergroup	Dolomite, limestone, shale, sandstone, quartzite		Meso Proterpzoic
Pt$_3$ab Pt$_3$k	Abujhmar Group/ Khairagarh Group	Basalt, shale, sandstone and conglomerate/ Alternating sequence of Sandstone, siltstone,grit and metabasalt		Palaeo-Meso- Proterozoic
Pt$_3$sa	Sausar Group	Calc.-gneiss, marble, biotite granulite schist, quartzite and schistose grit	λPt$_3$d Dongargarh Granite (Granite)	
Pt$_3$s	Sakoli Group	Metabasalt, metapellites (phylite, mica schist), quartzite, BIF, banded chert and tuff	λPt$_3$n αPt$_3$n Bijli Rhyolite /Pitepani volcanics Rhyolite, acid tuff and rhyolitic conglomerate/ Green tuff, metabasalt and gabbro	Nandgaon Group Palaeo Proterozoic
APt$_3$p	Peninsular Gneissic Complex (Younger phase)	Granite gneiss and granite	Apt$_3$bl Bailadila Group (Meta-ultramafite/gabbro, meta-basalts, quartzite, mica-schist, phylite,BHQ) Apt$_3$dc Chitradurga Group (BIF, phyllite, schist, amphibolite,quartzite	βApt$_3$dc Chitradurga Group (Metabasalt) Dharwar Supergroup Archaean-Palaeo Proterozoic
Ac	Bhopalpatnam granulite	Pyroxene granulite, charnockitic gneiss, charnockite		Archaean
Ap	Peninsular Gneissic Complex (Older Phase)	Granite gneiss and migmatite with enclaves of amphibolite, quartz mica schist, BMQ, quartzite and meta ultramafics	Agn 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

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.

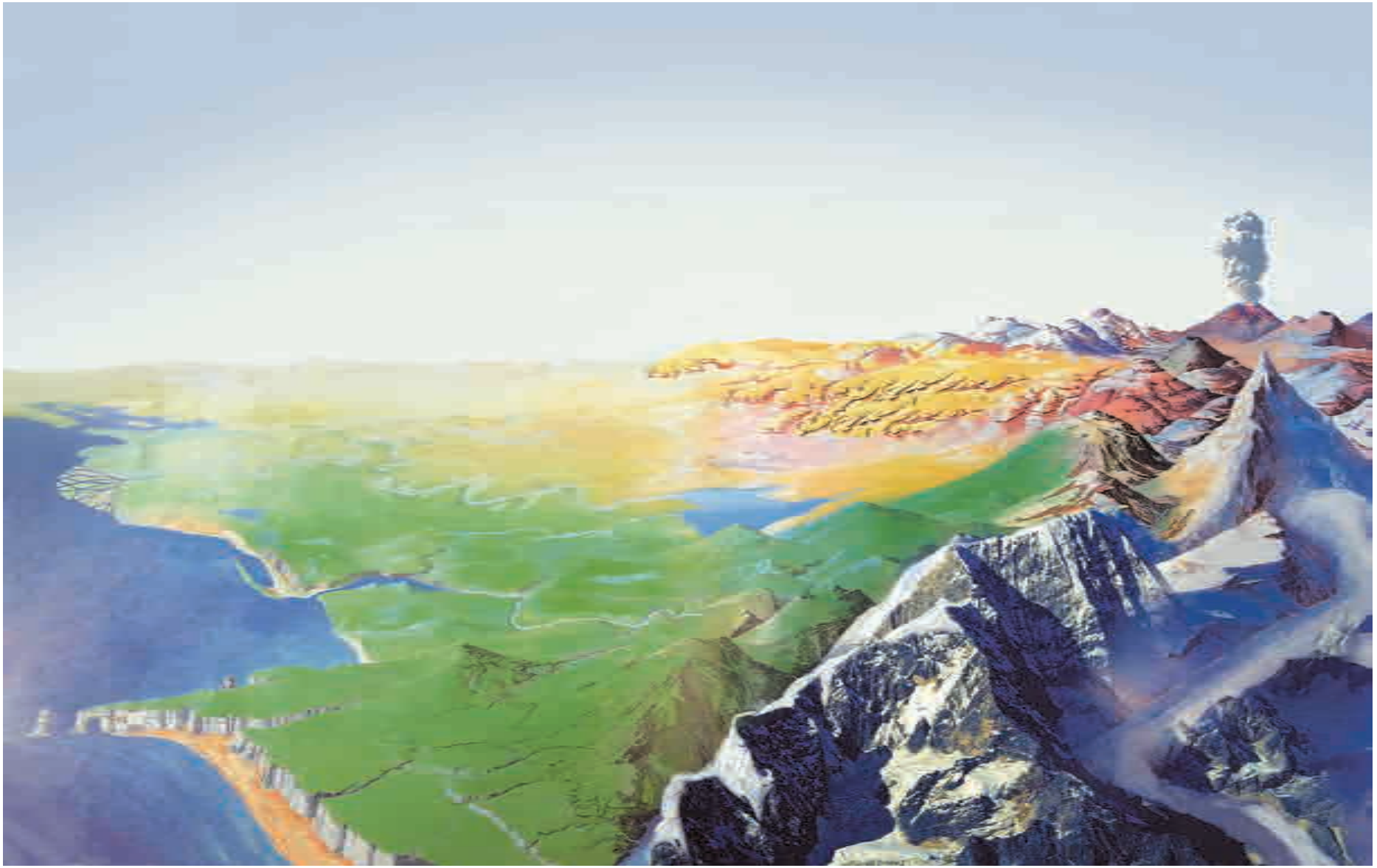
During fieldwork :

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

Observe the following picture carefully. Identify the landforms formed by different agents of erosion. Number them with pencil here and write their names in the sequence in your notebook.



GLOSSARY

- **Aa lava flow :** (A Hawaiin term) A lava flow with a surface covered by angular, jagged blocks. also called blocky lava.
- **Abrasion :** The mechanical wearing away of a rock by friction, rubbing, scraping or grinding.
- **Accretion disc :** A disc of interstellar material gathered into orbit by gravitational field of a star or black hole and gradually spiralling into the object.
- **Aeolian :** Pertaining to wind.
- **Aeolian environment :** The sedimentary environment of deserts, where sediment is transported and deposited primarily by wind.
- **Amphibole :** An important rock-forming mineral group of ferromagnesian silicates. Amphibole crystals are constructed from double chains of silicon-oxygen tetrahedra Example: Hornblende.
- **Amphibolites :** A granular metamorphic rock consisting of mainly hornblende (Amphibole mineral) and plagioclase with little or no quartz and mud, washed out from the glacier.
- **Angle of repose :** It is a stable or critical angle at which a sloping surface composed of loose material is stable.
- **Aphanitic texture :** A rock texture in which individual crystals are too small to be identified without the help of a microscope. In hand specimens, aphanite rocks appear dense and structure less.
- **Asthenosphere :** The zone of Earth directly below the lithosphere, from 70 km to 200 km below the surface. Seismic velocities are distinctly lower in the asthenosphere than in adjacent parts of Earth's interior. The material in the asthenosphere is therefore believed to be soft and plastic in nature.
- **Avalanche :** A large amount of ice snow, dirt or rock or mixture of these material falling or sliding or flowing suddenly or quickly down the side of a mountain.
- **Backwash :** The return sheet flow down a beach after a wave is spent.
- **Bar :** An offshore, submerged, elongated ridge of sand or gravel built on the seafloor by waves and currents.
- **Basalt :** A dark-coloured, aphanitic (fine-grained) igneous rock composed of Plagioclase (over 50 percent) and Pyroxene. Olivine may or may not be present. Basalt and Andesite represent 98 percent of all volcanic rocks.
- **Batholith :** A large discordant plutonic rock with more than 100 square kilometre surface exposure, a large intrusive mostly of granite.
- **Bay :** It is a body of water partially surrounded by land along the shore line.
- **Baymouth bar :** A narrow, usually submerged ridge of sand or gravel deposited across the mouth of a bay by longshore drift. Baymouth bars commonly are formed by extension of spits along embayed coasts.
- **Beach :** A deposit of wave-washed sediments along a coast between the landward limit of wave action and the outermost breakers.
- **Bed :** A layer of sediment 1 cm or more in thickness.
- **Bedding plane :** A surface separating consecutive layers of sedimentary rock.
- **Bedload :** Material transported by currents along the bottom of a stream or river by

rolling or sliding, in contrast to material carried in suspension or in solution.

- **Bedrock :** The continuous solid rock that underlies the regolith everywhere and is exposed locally at the surface. An exposure of bedrock is called an outcrop.
- **Big Bang Theory :** This theory explains how the Universe began with a small singularity then inflated over the period of 13.8 billion years to the cosmos.
- **Biosphere :** The totality of life on or near Earth's surface.
- **Biotite :** "Black mica." An important rock-forming ferromagnesian silicate with silicon-oxygen tetrahedral arranged in sheets.
- **Bog :** An area of wet muddy ground that is formed due to accumulation of dead plant material.
- **Bole beds/ Red bole :** It is reddened clay rich horizon between basalt flows.
- **Boulder :** A rock fragment with a diameter of more than 256 mm (about the size of a volleyball). A boulder is one size larger than a cobble.
- **Braided stream :** A stream with a complex system of converging and diverging channels separated by bars or islands.
- **Carbonaceous :** Containing carbon.
- **Carbonate mineral :** A mineral formed by the bonding of carbonate ions $(CO_3)_2$ with positive ions. For example: Calcite ($CaCO_3$), Dolomite ($CaMg(CO_3)_2$).
- **Carbonate rock :** A rock composed mostly of carbonate minerals. Examples: Limestone, Dolomite.
- **Cave :** A naturally formed subterranean open area, chamber, or series of chambers, commonly produced in Limestone by solution activity.
- **Cement :** Minerals precipitated from groundwater in the pore spaces of a sedimentary rock and binding the rock particles together.
- **Chert :** A Sedimentary rock composed of granular cryptocrystalline silica.
- **Clastic texture :** The texture of sedimentary rocks consisting of fragmentary particles of minerals, rocks or organic skeletal bound by some cementing material.
- **Clastic :** 1. pertaining to fragments (such as mud, sand, and gravel) produced by the mechanical breakdown of rocks. 2. A sedimentary rock composed chiefly of consolidated clastic material.
- **Clay minerals :** A group of fine-grained crystalline hydrous silicates formed by weathering of minerals, such as, Feldspar, Pyroxene or Amphibole.
- **Clay :** Sedimentary material composed of fragments with a diameter of less than 1/256 mm. Clay particles are smaller than silt particles.
- **Conglomerate :** A coarse-grained sedimentary rock composed of rounded fragments of pebbles, cobbles or boulders.
- **Continent :** A large landmass, from 20 km to 60 km thick, composed mostly of granitic rock. Continents rise abruptly above the deep-ocean floor and include the marginal area submerged beneath sea level. Examples: the African continent, the South American continent.
- **Core :** The central part of Earth below a depth of 2900 Km.
- **Country rock :** A general term for rock surrounding an igneous intrusion.
- **Crater :** An abrupt circular depression formed by extrusion of volcanic material, by collapse or by the impact of a meteorite.
- **Creep :** The imperceptibly slow downslope movement of material.

- **Crevasse :** 1. (glacial geology) a deep crack in the upper surface of a glacier. 2. (Natural levee) A break in a natural levee.
- **Cross-bedding :** Stratification inclined to the original horizontal surface upon which the sediment accumulated. It is produced by deposition on the slope of a dune or sand wave.
- **Crust :** (Planetary structure) the outermost layer or shell of Earth (or any other differentiated planet). Earth's crust is generally defined as the part of Earth above the Mohorovicic discontinuity. It represents less than 1 percent of Earth's total volume. See also continental crust, oceanic crust.
- **Cryosphere :** It is a permanent frozen water part of the Earth system.
- **Crystal form :** The geometric, symmetrical network of atoms within a crystal.
- **Crystal lattice :** A symmetrical three dimensional arrangement of atoms inside the crystal.
- **Crystal :** A solid, polyhedral form bound by naturally formed plane surfaces resulting from growth of a crystal lattice.
- **Crystalline texture :** The orderly arrangement of atoms in a crystal.
- **Cuesta :** An elongate ridge formed on the tilted and eroded edges of gently dipping strata.
- **Debris flow :** The rapid downslope movement of debris (rock, soil and mud).
- **Decomposition :** Weathering by chemical process. Synonymous with chemical weathering.
- **Denudation :** The combined action of all of the various processes that cause the wearing away and lowering of the land, including weathering, mass wasting, stream action, and groundwater activity.
- **Depression :** 1. (structural geology) A circular or elliptical downward. After erosion, the youngest beds are exposed in the central part of the structure. 2. (Topography) a depression into which the surrounding area drains.
- **Detrital :** 1. pertaining to detritus. 2. A rock formed from detritus.
- **Detritus :** A general term for loose rock fragments, produced by mechanical weathering.
- **Diastrophism :** It is large scale deformation at Earth's crust by natural process leading to formation of continuous and oceans through tectonic stresses. It is also called as tectonism.
- **Differential erosion :** Variation in the rate of erosion on different rock masses. As a result of differential erosion, resistant rocks form steep cliffs, whereas non-resistant rocks form gentle slopes.
- **Diorite :** Aphanitic intrusive igneous rock consisting mostly of Plagioclase, Feldspar and Pyroxene, with some Amphibole and Biotite.
- **Discharge :** Rate of flow; the volume of water moving through a given cross section of a stream in a given unit of time.
- **Disintegration :** Weathering by mechanical process. Synonymous with mechanical weathering.
- **Dissolved load :** The part of a stream's load that is carried in solution.
- **Divide :** A ridge or other topographic feature which separates adjacent drainage basins dividing water to flow in opposite directions.
- **Dolomite:** 1. A mineral composed of Ca Mg $(CO_3)^2$. 2. A sedimentary rock composed primarily of the mineral Dolomite.
- **Dolostone :** A sedimentary rock composed mostly of the mineral Dolomite. Sometimes referred to simply as Dolomite.

- **Double refraction :** Optical phenomena exhibited by same minerals especially calcite where light ray enters the crystal and splits up into separate rays.
- **Drainage basin :** The total area that contributes water to a single drainage system.
- **Drainage system :** An integrated system of tributaries and a trunk stream, which collect and funnel surface water to the sea, a lake, or some other body of water.
- **Dyke :** A tabular or sheet like discordant igneous body that cuts vertically or steeply inclined across host rock.
- **Earthquake :** A series of elastic waves propagated in Earth, initiated where stress along a fault exceeds the elastic limit of the rock so that sudden movement occurs along the fault.
- **Ecliptic plane :** An imaginary plane containing the Earth's orbit around the sun.
- **Ecology :** The study of relationships between organisms and their environments.
- **Entrenched meander :** A meander cut into the underlying rock as a result of regional uplift or lowering of the regional base level.
- **Epicentre :** The area on Earth's surface that lies directly above the focus of an Earthquake.
- **Equigranular :** It is a rock characterised by crystal/ mineral at nearly same size.
- **Erosion :** It is the action of surface processes (such as water, wind or ice flow) that removes and transports soil, rock or dissolved material from one location to another on the Earth's surface.
- **Escarpment :** A narrow cliff, with a very steep slope.
- **Esker :** A long, narrow, sinuous ridge of stratified glacial drift deposited by a stream flowing beneath a glacier in a tunnel or in a subglacial streambed.
- **Estuary :** A bay at the mouth of a river, formed by subsidence of the sand or by a rise in sea level. Fresh water from the river mixes with and dilutes seawater in an estuary.
- **Evaporite :** A rock composed of minerals derived from evaporation of minerals, derived from evaporation of mineralized water. Examples: Rock salt, Gypsum.
- **Exposure :** Bedrock not covered with soil or regolith; outcrop.
- **Extrusion :** It is the movement of relatively viscous lava onto the Earth's surface through volcanic activity.
- **Extrusive rock :** A rock formed from a mass of lava that flows out on the surface of Earth. Example: Basalt.
- **Fan :** A fan-shaped deposit of sediment. See also alluvial fan, deep sea fan.
- **Fault block :** A rock mass bounded by faults on at least two sides.
- **Fault scarp :** A cliff produced by faulting.
- **Fault :** A surface along which a rock body has broken and been displaced.
- **Felsic :** Of rocks consisting chiefly of feldspars, felspathoids and quartz having light colour.
- **Ferromagnesian minerals :** A variety of silicate minerals, containing abundant iron and magnesium. Examples: Olivine, Pyroxene, Amphibole.
- **Fissure eruption :** Extrusion of lava along a fissure.
- **Fissures :** It is long narrow opening, cracks, fissures in surrounding rock.
- **Flood Basalt Province :** Flood basalt province is largest eruption of lava on Earth exceeding 2000 cubic volume. It is one type

of large igneous province that characterise the Earth surface formed in geological past.

- **Flood basalt :** An extensive flow of basalt erupted chiefly along fissure. Synonymous with plateau basalt.
- **Floodplain :** The flat, occasionally flooded area bordering a stream.
- **Fluvial Environment :**The sedimentary environment of river systems.
- **Fluvial :** Pertaining to a river or rivers.
- **Focus :** The area within Earth where an Earthquake originates.
- **Foliation :** A planar feature in metamorphic rocks, produced by the secondary growth of minerals. Three major types are recognized: slaty cleavage, schistosity and gneissic layering.
- **Formation :** A distinctive body of rock that serves as a convenient unit for study and mapping.
- **Fossil Fuel :** Fossil fuels (oil, natural gas and coal) are sources of energy that have developed within the Earth over millions of years from plant or animal remains.
- **Fossil :** Naturally preserved remains or evidence of past life, such as; bones, shells, casts, impressions and trails.
- **Gabbro :** A dark-coloured, coarse grained rock composed of Ca-plagioclase, Pyroxene and possibly Olivine, but no Quartz.
- **Gangue :** It is commercially worthless material that surrounds or mixed with a wanted mineral in an ore deposit.
- **Geology :** The Scientific study of origin of Earth rocks, minerals, landforms and life forms and the processes that have affected them over the course of Earth's history.
- **Geomorphic Processes :** A process of physical and chemical changes which affect modification of Earth's landform and natural forces acting upon it to produce landform.
- **Geothermal energy :** It is the thermal energy or heat generated and stored in the Earth.
- **Geothermal Gradient :** It is increase in temperature with increase in depth due to outward heat flow from hot interior.
- **Glass :** 1. a state of matter in which a substance displays many properties of solid but lacks crystal structure. 2. An amorphous igneous rock formed from a rapidly cooling magma.
- **Glassy rock :** It is a rock formed by rapid cooling of lava or magma in which crystallisation does not take place.
- **Glassy texture :** The texture of igneous rocks in which the material is in the form of natural glass rather than crystal.
- **Gneiss :** A coarse-grained metamorphic rock with a characteristic type of foliation (gneissic layering), resulting from alternating layers of light-coloured and dark-coloured minerals. Its composition is generally similar to that of granite.
- **Gneissic Complex :** It is the primordial sialic basement crust along cratonic zones as undergone repeated period of folding and deformation, episode of metamorphism and emplacement of granite.
- **Gondwana land :** An ancient supercontinent of southern hemisphere comprising of landmass like South America, Antarctica, Africa, India and Australia, formed 200Ma
- **Graded bedding :** A type of bedding in which each layer is characterized by a progressive decrease in grain size from the bottom of the bed to the top.
- **Gradient :** (stream) the slope of a stream channel, measured along the course of the stream.

- **Grain :** A particle of a mineral or rock, generally lacking well-developed crystal faces.
- **Granite :** A coarse-grained igneous rock, composed of K-Feldspar and Quartz, with small amounts of ferromagnesian minerals and Plagioclase.
- **Granulation :** It is crushing of mineral and rock by low stress at low temperature along a plane of movement.
- **Groundwater :** Water below Earth's surface. It generally occurs in pore spaces of rocks and soils.
- **Headland :** An extension of land seaward from the general trend of the coast; a promontory, cape or peninsula.
- **Headward erosion :** Extension of a stream headward, up the regional slope of erosion.
- **Horizon :** 1. (geologic) a plane of stratification assumed to have been originally horizontal. 2. (Soil) a layer of soil distinguished by characteristic physical properties, soil horizons generally are designated by letters (for example, a horizon, B. horizon, C. horizon)
- **Hydrosphere :** The waters of Earth, as distinguished from the rocks (lithosphere), the air (atmosphere), and living things, (biosphere).
- **Hydrothermal Deposits :** Concentration of metallic minerals formed by precipitation of soil from hot mineral- laden water by magma (Hydrothermal solutions)
- **Hydrothermal solutions :** a hot water solution originating within the Earth carrying dissolved mineral substances.
- **Ice sheet :** A thick, extensive body of glacial ice that is not confined to valleys. Localized ice sheets are sometimes called ice caps.
- **Ice wedging :** A type of mechanical weathering in which rocks are broken by the expansion of water as it freezes in joints, pores or bedding planes. Synonymous with frost wedging.
- **Igneous rock :** Rock formed by cooling and solidification of molten silicate minerals (magma). Igneous rocks include volcanic hypabyssal and plutonic rocks.
- **Index contour :** A contour line shown on a map in a distinctive manner for ease of identification, being printed more prominently than other contour lines, generally labelled with value along its course.
- **Intermittent stream :** A stream through which water flows only part of the year.
- **Internal drainage :** A drainage system that does not extend to the ocean.
- **Intrusion :** 1. Injection of a magma into a pre-existing rock. 2. A body of rock resulting from the process of intrusion.
- **Intrusive rock :** Igneous rock which, while it was fluid, penetrated into or between other rocks and solidified. It can later be exposed at Earth's surface after erosion of the overlying rock.
- **Isomorph :** Existence of two or more substance in the same crystal form, structure and composition.
- **Island arc :** Long, curved chain of oceanic islands associated with intense volcanic and seismic activity and orogenic processes.
- **Isostasy :** It is the equilibrium (balance) that exists between parts of the Earth's crust like lithosphere floating above Asthenosphere on underlying mantle.
- **Lacustrine :** A sedimentary deposit formed in the base of ancient lakes.
- **Lagoon :** A shallow body of seawater separated from the open ocean by a barrier island or reef.
- **Lava :** Magma that reaches Earth's surface.

- **Levee (natural) :** A broad, low embankment of a river channel during floods.
- **Lithification :** The processes by which sediment is converted into sedimentary rock. These processes include cementation and compaction.
- **Lithosphere :** The relatively rigid outer zone of Earth, which includes the continental crust, the oceanic crust and the part of the mantle lying above the softer asthenosphere.
- **Load :** The total amount of sediment carried at a given time by a stream, glacier or wind.
- **Loess :** Unconsolidated, wind-deposited silt and dust.
- **Longitudinal profile :** The profile of a stream or valley drawn along its length, from source to mouth.
- **Longshore current :** A current in the surf zone moving parallel to the shore. Longshore currents occur where waves strike the shore at an angle. The waves push water and sediment obliquely up the beach, and the backwash returns straight down the beach face, so the water and sediment follow a zigzag pattern, with net movement parallel to the shore.
- **Mafic :** Relating or containing group of dark coloured silicate minerals
- **Magma :** A mobile silicate melt, which can contain suspended crystals and dissolved gases as well as liquid.
- **Magmatic differentiation :** A general term for the various processes by which early-formed crystals or early-formed liquids are separated and removed from a magma to produce a rock with composition different from that of the original magma. Early crystallized ferromagnesian minerals commonly are separated by gravitational settling, so that the parent magma is left enriched in silica, sodium and potassium.
- **Mantle :** The zone of Earth's interior between the base of the crust (the Moho discontinuity) and the core.
- **Marble :** A metamorphic rock consisting mostly of metamorphosed Limestone or Dolomite.
- **Mass movement :** The transfer of rock and soil downslope by direct action of gravity without a flowing medium (such as a river or glacial ice). Synonymous with mass wasting.
- **Matrix :** The relatively fine-grained rock material occupying the space between larger particles in a rock. See also groundmass.
- **Metamorphism :** Alteration of the minerals and textures of a rock by changes in temperature and pressure and by a gain or loss of chemical components.
- **Mineral :** A naturally occurring inorganic solid having a definite internal structure and a definite chemical composition that varies only within strict limits. Chemical composition and internal structure determine its physical properties, including the tendency to assume a particular geometric form (Crystal form).
- **Mohorovicic discontinuity :** The first global seismic discontinuity below the surface of Earth. It lies at a depth varying from about 5 Km to 10 Km beneath the ocean floor to about 35 Km beneath the continents. Commonly referred to as the Moho.
- **Mudflow :** A flowing mixture of mud and water.
- **Natural arch :** An arch-shaped landform produced by weathering and differential erosion.
- **Nebula :** It is a giant interstellar cloud of faintly luminous diffused cloud of dust and gas in space.
- **Neutrons :** It is neutral subatomic particle, which is a constituent of atomic nucleus except hydrogen. It has no electric charge.

- **Nucleons :** It is a collective name for two important subatomic particles, neutrons and protons which are located in the nucleus of atoms.
- **Obsidian :** A glassy igneous rock with a composition equivalent to that of granite.
- **Ocean basin :** A low part of the lithosphere lying between continental masses. The rocks of an ocean basin are mostly basalt with a veneer of oceanic sediment.
- **Orogen :** A belt of the Earth's crust involved in the formation of mountains.
- **Orogenic :** It is a process of mountain formation especially by folding and faulting of the Earth crust.
- **Outcrop :** An exposure of bedrock.
- **Outwash plain :** The area beyond the margins of a glacier where melt water deposits sand, gravel,
- **Outwash :** Stratified sediment washed out from a glacier by melt water streams and deposited in front of the end moraine.
- **Oxidation :** Chemical combination of oxygen with another substance.
- **Pa hoe hoe lava flow :** A type of lava flow whose surface is glassy, smooth, undulating and ropy. (A Hawaiian term), also called ropy lava.
- **Pebble :** A rock fragment with a diameter between 2 mm (about the size of a match head) and 64 mm (about the size of a tennis ball).
- **Pediment :** A gently sloping erosion surface formed at the base of a receding mountain front or cliff. It cuts across bedrock and can be covered with a veneer of sediment. Pediments characteristically form in arid and semiarid climates.
- **Peninsula :** An elongate body of land extending into a body of water.
- **Peridotite :** A dark-coloured igneous rock of coarse-grained texture, composed of olivine, pyroxene and some other ferromagnesian minerals, but with essentially no feldspar and no quartz.
- **Permafrost :** Permanently frozen ground.
- **Physiographic map :** A map showing surface features of Earth.
- **Physiographic :** The study of the surface features and landforms of Earth
- **Plate tectonics :** It deals with the dynamic of Earth's lithosphere to understand mountain building process, volcanoes, Earthquakes, evolution of Earth surface and reconstruction of past continents and oceans.
- **Pleistocene :** An epoch of Quaternary period representing the time between 2.6myto 11700 years ago.
- **Plucking (glacial geology) :** The process of glacial erosion by which large rock fragments are loosened by ice wedging, become frozen to the bottom surface of the glacier, and are torn out of the bedrock and transported by the glacier as it moves. The process involves the freezing of subglacial meltwater that seeps into fractures and bedding planes in the rock.
- **Point bar :** A crescent-shaped accumulation of sand and gravel deposited on the inside of a meander bend.
- **Pore space :** The spaces within a rock body that are unoccupied by any matter.
- **Porosity :** The percentage of the total volume of a rock or sediment that consists of pore space.
- **Pothole :** A hole formed in a stream bed by sand and gravel swirled around in one spot by eddies.
- **Protons :** It is a subatomic particle found in the nucleolus of an atom. It has positive electrical charge equal and opposite to that of electron. Number of protons is called atomic number.

- **Protostar :** An early stage in the evolution of a star after the beginning of the collapse of gas cloud but before contraction.
- **Pumice :** A rock consisting of frothy natural glass.
- **Pyrogenetic Minerals :** Mineral which are crystallised from a completely or almost completely unhydrous magma.
- **Radiogenic heat :** Heat generated by radioactivity.
- **Radiometric dating :** Determination of the age in years of a rock or mineral by measuring the proportions of an original radioactive material and its decay product. Synonymous with radioactive dating.
- **Recessional moraine :** A ridge of till deposited at the margin of a glacier during a period of temporary / stability in its general recession.
- **Recrystallisation :** Reorganization of elements of the original minerals in a rock resulting from changes in temperature and pressure and from the activity of pore fluids.
- **Red bole beds :** Interbasaltic clay occuring in the volcanic terrain.
- **Regolith :** The blanket of soil and loose rock fragments overlying the bedrock.
- **Rejuvenated stream :** A stream that has had its erosive power renewed by uplift or lowering of the base level or by climatic changes.
- **Relief :** The difference in altitude between the high and the low parts of an area.
- **Rhyolite :** A fine-grained volcanic rock composed of Quartz, K-Feldspar, and small amount of Plagioclase. It is the extrusive equivalent of Granite.
- **Rift valley :** 1. a valley of regional extent formed by block faulting in which tensional stresses tend to pull the crust apart. Synonymous with graben. 2. The down dropped block along divergent plate margins.
- **Ripple marks :** Small waves produced on a surface of sand or mud by the drag of wind or water moving over it.
- **River system :** A river with all of its tributaries.
- **Roche moutonnée :** An abraded knob of bedrock formed by an overriding glacier. It typically is striated and has a gentle slope facing the upstream direction of ice movement.
- **Saltation :** The transportation of particles in a current of wind or water by a series of bouncing movements.
- **Sand :** Sedimentary material composed of fragments ranging in diameter from 0.0625 mm to 2 mm. Sand particle is larger than silt particle but smaller than gravel. Much sand is composed of quartz grains, because quartz is abundant and resists chemical and mechanical disintegration, but other materials, such as, shell fragments and rock fragments can also form sand.
- **Sandstone :** A sedimentary rock composed mostly of sand-size particles, usually cemented by calcite, silica, or iron oxide.
- **Scarp :** A cliff produced by faulting or erosion.
- **Shingle :** A mass of small rounded pebbles, specially on a sea shore.
- **Schist :** A medium-grained or coarse grained metamorphic rock with strong foliation
- **Schistosity :** The type of foliation that characterizes schist, resulting from the parallel arrangement of coarse-grained platy minerals, such as, Mica, Chlorite and Talc.
- **Shore :** The zone between the water line at high tide and the waterline at low tide. A narrow strip of land immediately bordering a body of water, especially a lake or an ocean.

- **Sill :** A tabular body of intrusive rock injected between layers of the enclosing rock.
- **Sinkhole :** A depression formed by the collapse of a cavern roof.
- **Snowline :** An altitude of a given area above which the land is permanently covered by snow.
- **Solumn :** Upper part of soil profile which is influenced by plant root, A- horizon, B-horizon.
- **Sorting :** The separation of particles according to size, shape, or weight. It occurs during transportation by running water or wind.
- **Spit :** A sandy bar projecting from the mainland into open water. Spits are formed by deposition of sediment moved by longshore drift.
- **Splay :** A small deltaic, deposit formed on a floodplain where water and sediment are diverted from the main stream through a crevasse in a levee.
- **Spring :** A place where groundwater flows or seeps naturally to the surface.
- **Stellar :** Relating to stars or star-like.
- **Stream load :** The total amount of sediment carried by a stream at a given time.
- **Striation :** A scratch or groove produced on the surface of a rock by a geologic agent, such as a glacier or stream.
- **Subaerial :** Occurring beneath the atmosphere or in the open air, with reference to conditions or processes (such as erosion) that occur on the land. Contrast with submarine and subterranean.
- **Subduction zone :** A geologic process in which one edge of one crustal plate is forced below the edge of another.
- **Suspended load :** The part of a stream's load that is carried in suspension for a considerable period of time without contact with the stream bed. It consists mainly of mud, silt and sand. Contrast with bedload and dissolved load.
- **Swash :** The rush of water up onto a beach after a wave breaks.
- **Talus :** Rock fragments that accumulate in a pile at the base of a ridge or cliff.
- **Terrace :** A nearly level surface bordering a steeper slope, such as, a stream terrace or wave-cut terrace.
- **Texture :** The size, shape, and arrangement of the particles that make up a rock.
- **Tidal flat :** A large, nearly horizontal area of land covered with water at high tide and exposed to the air at low tide. Tidal flats consist of fine-grained sediment (mostly mud, silt and sand).
- **Till :** Unsorted and unstratified glacial deposit.
- **Tillite :** A rock formed by lithification of glacial till (unsorted, unstratified glacial sediment).
- **Turbulent flow :** A type of flow in which the path of motion is very irregular, with eddies and swirls.
- **Unconformity :** A structure between successive rocks representing a missing interval in geologic record, produce by interruption in deposition or erosion.
- **Veins :** An epigenetic filling of minerals in fault, fracture, cracks, features in surrounding rocks.
- **Vesicle :** A small hole formed in a volcanic rock by a gas bubble that became trapped as the lava solidified.
- **Volatile :** 1. Capable of being readily vaporized. 2. A substance that can readily be vaporized, such as; water or carbon dioxide.

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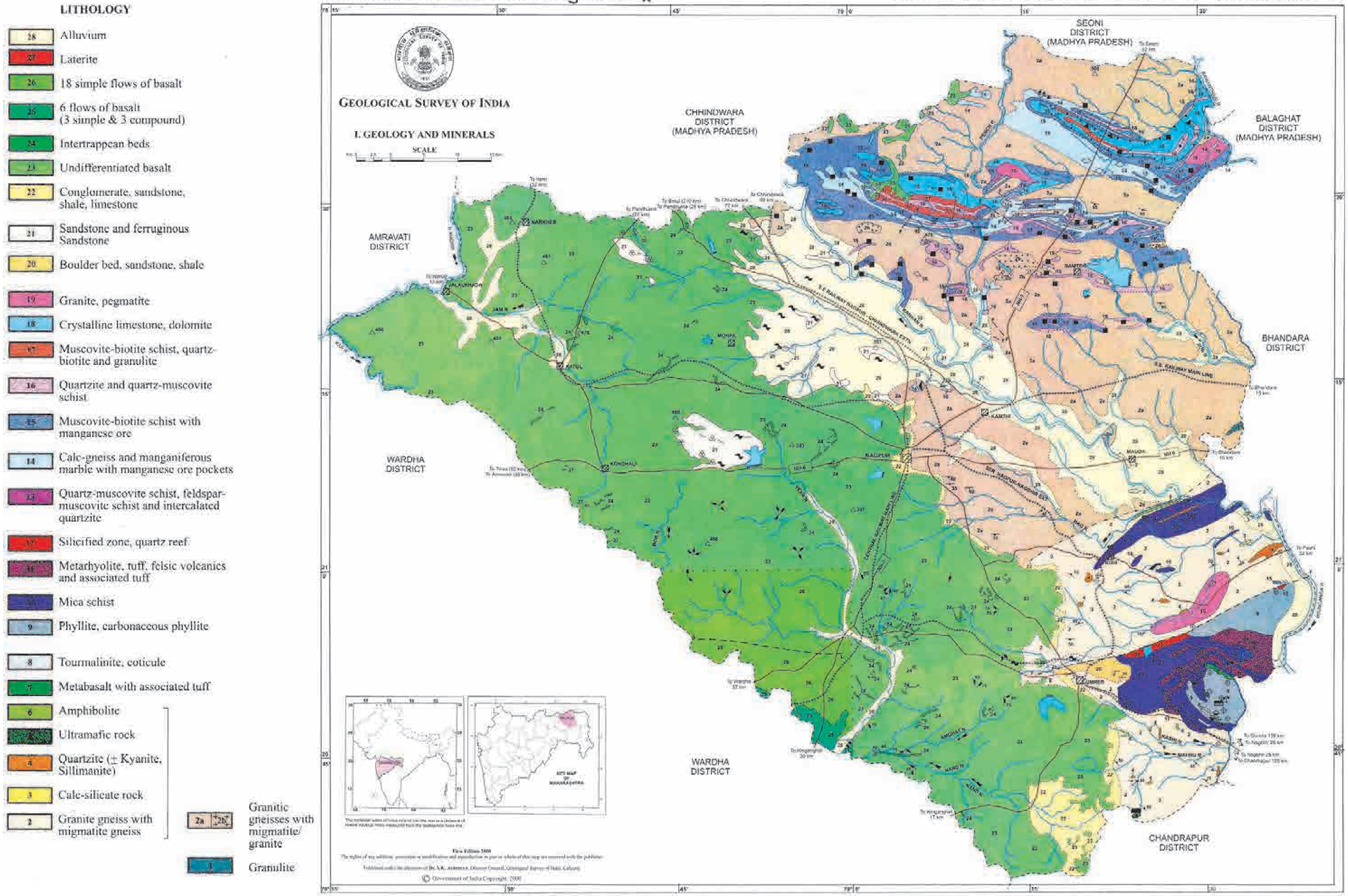
जिला संसाधन मानचित्र–जिला नागपुर महाराष्ट्र

DISTRICT RESOURCE MAP NAGPUR DISTRICT, MAHARASHTRA



DRM based practicals :

Answer the following questions :

Geomorphology (map II) :

1) Name two localities of valley filled deposits.
2) Name the locality situated in highly dissected area near a dam-site.
3) Name the main river along with it's tributaries.
4) Identify the flow directions of river.
5) Name two towns located near palaeo-channels.
6) Mention the number of dam sites. Name the nearest village/town near the dam sites.

Geohydrology (map III) :

1) Identify and mark the water-divides.
2) Name the town most favourable for groundwater development.
3) At what depths can groundwater be encountered in following towns:
   a) Nagpur b) Umrer c) Savner d) Ramtek
4) Identify the towns with shallower groundwater.
   a) Nagpur and Savner b) Katol and Nagpur
   c) Savner and Ramtek d) Kondhali and Umrer
5) Identify and describe whether the river flow is controlled structurally.

Geotechnical and natural hazards (map IV) :

1) What is the average trend of lineaments?
2) For which towns will you recommend anti-seismic civil engineering structures?
3) Identify the town located in a dangerous zone with reference to earthquakes from the following pairs :
   a) Ramtek and Nagpur b) Kamthi and Kondhali
   c) Ramtek and Kamthi d) Savner and Kamthi
4) In which direction and at what distance is an earthquake epicentre located from Savner and Ramtek

Land-use (map V) :

1) Name the towns which have mixed forest cover near Ramtek and Umrer
2) Identify the land use pattern around the following towns;
   Kamthi :
   Nagpur :
   Katol :
   Kondhali :
   Savner/Ramtek :
3) Give the location of sheet erosion and gullied land.