DEPARTMENT OF CIVIL ENGINEERING

MANUAL
FOR

ENGINEERING GEOLOGY LABORATORY

ENGINEERING GEOLOGY LAB

List of Experiments

1. Study of Physical properties of minerals
2. Identification of rocks forming silicate and ore minerals
3. Recognition of rocks
4. Use of clinometers compass and Burton compass for measurement dip and strike of formations.
5. Geological cross sections and study of geological maps.
6. Study of models of geological structures and out crops patterns of different types of rocks and land forms

Objective Of Engineering Geology Lab

- To understand the role of geology in the design and construction process of underground openings in rock.
- To apply geologic concepts and approaches on rock engineering projects.
- To identify and classify rock using basic geologic classification systems.
- To use the geologic literature to establish the geotechnical framework needed to properly design and construct heavy civil works rock projects.
- To identify and characterize intact rock/rock mass properties.

Experiment :- 1

Objective:- Study of Physical properties of minerals

Theory :- Earth is made up of minerals that are the constituents of rocks. Mineral specimens are usually identified by determining their physical properties.
Colour : Although the colour of some minerals, such as azurite, is quite distinctive, other minerals, such as quartz, occur in a variety of colours. Also there are many white minerals. Hence colour is frequently NOT a useful diagnostic property.
Streak: Streak is the colour of the powdered mineral. It is a useful diagnostic property for many coloured minerals — especially those with a metallic lustre. It is found by rubbing the specimen on a piece of unglazed tile, or streak plate.
Lustre: The lustre of a mineral is the way its surface shines when held up to the light. Lustre is a property distinct from colour. There are many ways of classifying and describing lustre, but the following system is adequate:

Vitreous — the mineral shines like glass — e.g. quartz, diamond
Metallic — the mineral shines like the surface of a metal — e.g. pyrite, galena
Earthy (dull) – the mineral does not shine at all — e.g. kaolinite

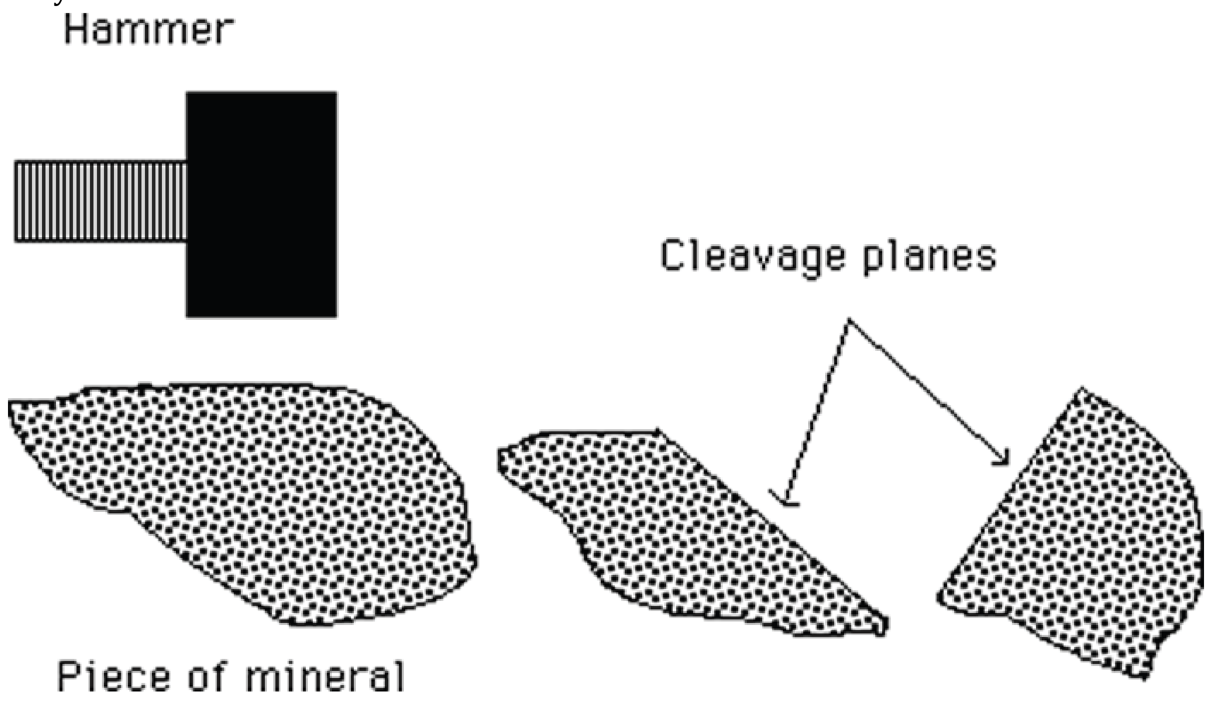
Hardness: The hardness of any mineral can be assigned a number between 1 and 10, on Moh's Scale of Hardness. The instruments used to determine the hardness of a mineral specimen are (in order of increasing hardness) a finger-nail, copper coin, knife blade and a quartz crystal.

The table below lists the minerals that define **Moh's Scale of Hardness**, and gives the relative hardnesses of the test items named above.

	Defining Mineral	**Test Item**
1	Talc	
2	Gypsum	
3	Calcite	Finger nail ~2.5
4	Fluorite	Copper coin ~3.5
5	Apatite	Knife blade ~5.5
6	Orthoclase	
7	Quartz	Quartz crystal 7
8	Topaz	
9	Corundum	
10	Diamond	

Density: It is not usual to measure the actual densities (relative to water = 1) of specimens; however, minerals should be classified according to whether they are light, medium or

heavy. This can be done by holding similar-sized specimens of two different minerals in your hands, and comparing their weights.
Cleavage: When a piece of a mineral is dropped or struck, it may tend to break so that flat, shiny surfaces are formed.



Minerals, or individual surfaces, that do not cleave to form flat faces are said to show fracture.
Cleavage is a diagnostic property for identification of minerals, but the cleavage of an actual specimen is not always easy to determine. Many specimens do not show the expected cleavage characteristics.
Magnetism: Some minerals that contain iron are magnetic. Magnetite is strongly magnetic, and will be attracted by a magnet. Other iron-bearing minerals such as ilmenite sand size particles.
Reaction to dilute Hydrochloric Acid: Some minerals especially carbonates, effervesce when a drop of dilute hydrochloric acid is placed on them. This is useful diagnostic test for calcite and a white mineral which is not easily distinguished.

Viva Questions

1. Differentiate between Rock and Mineral
2. What is streak ?
3. What instrument is used to find the streak?
4. Explain Clevage and Magetism.
5. Why study of minerals is important in Geology?

EXPERIMENT :-2

Objective :- Identification of rocks forming silicate and ore minerals

Theory:- Although about 4000 minerals are known to exist, only about 8 of them are common. These common rock forming minerals are the major constituents of igneous, sedimentary and metamorphic rocks. They constitute more that 99% of Earth's crust. You must be able to identify these 8 minerals, and you must know the mineral group to which each one belongs.

The following table lists the common rock-forming minerals…

Mineral	Group	SIGNIFICANT DIAGNOSTIC PROPERTIES				
		H	Colour	Lustre	Cleavage	Other properties
Quartz	Silicate	7	Clear when pure. Impurities cause many colour variations.	Vitreous	None	Hexagonal crystals
Feldspar group: Orthoclase Plagioclase	Silicate	6	Orthoclase: pink, cream Plagioclase: white, grey	Vitreous	2 at ~90°	
Biotite	Silicate	2.5	Black	Vitreous: sometimes appears metallic	1	Thin sheets are flexible and elastic
Muscovite	Silicate	2.5	White or clear		1	
Amphibole (*e.g.* Hornblende)	Silicate	5.5	Black	Vitreous	2 at 120°	Often confused with Pyroxene
Olivine	Silicate	6.5	Green	Vitreous	none	Small green crystals. Often enclosed in a basalt volcanic 'bomb'.
Pyroxene (*e.g.* Augite)	Silicate	5.5	Black	Vitreous	2 at 87° & 93°	Often confused with Amphibole
Calcite	Carbonate	3	White or clear	Vitreous	3 **not** at 90°	Effervesces with acid
Clays (*e.g.* Kaolinite)	Silicate	2.5	White	Dull	None	Very powdery

Properties:- Properties Such as Hardness, Density and cleavage are often impossible to determine in these specimens. However, colour, lustre and streak are usually sufficient for identification of common ore minerals

Mineral	Composition	SIGNIFICANT DIAGNOSTIC PROPERTIES				
		H	Colour	Lustre	Streak	Other properties
Galena	Lead sulphide (PbS)	2.5	Grey	Metallic	Lead-grey	Very high density, 3 cleavage planes at 90°
Chalcopyrite	Copper iron sulphide ($CuFeS_2$)	3.5	Greenish-gold or many colours (iridescent)	Metallic	Greenish black	Iridescent specimens are known as 'peacock ore'.
Malachite	Copper carbonate [$Cu_2CO_3(OH)_2$]	3.5	Green	Vitreous or dull	Green	Green colour is diagnostic.
Sphalerite	Zinc sulphide (ZnS)	3.5	Brown/black	Metallic	Brown	Dodecahedral cleavage (6 planes of cleavage)
Bauxite	Mixture of aluminium hydroxides	2	Brown	Dull	Brown	Consists of round nodules (*i.e.* pisolitic). Easily recognised.
Haematite	Iron oxide (Fe_2O_3)	6	Reddish brown to black	Usually dull	Reddish brown	Appearance of mineral varies. Streak is diagnostic.
Magnetite	Iron oxide (Fe_3O_4)	6	Black	Metallic	Black	Strongly magnetic.

Rock-forming minerals:-

Minerals are the building blocks of rocks. Geologists define a mineral as:

A naturally occurring, inorganic, solid, crystalline substance which has a fixed structure and a chemical composition which is either fixed or which may vary within certain defined limits.

Some minerals have a definite fixed composition, e.g. quartz is always SiO_2, and calcite is always $CaCO_3$. However, other minerals exhibit a range of compositions between two or more compounds called end-members. For example, plagioclase feldspar has a composition that ranges between end-members anorthite ($CaAl_2Si_2O_8$) and albite ($NaAlSi_3O_8$), so its chemical formula is written as (Ca, Na)(Al, Si)$AlSi_2O_8$.

There are also minerals which form both by inorganic and organic processes. For example, calcite ($CaCO_3$) is a common vein mineral in rocks, and also a shell-forming material in many life forms. Calcite of organic origin conforms to the above definition except for the requirement that it be inorganic. This is an inconsistency in the definition of a mineral that is generally overlooked.

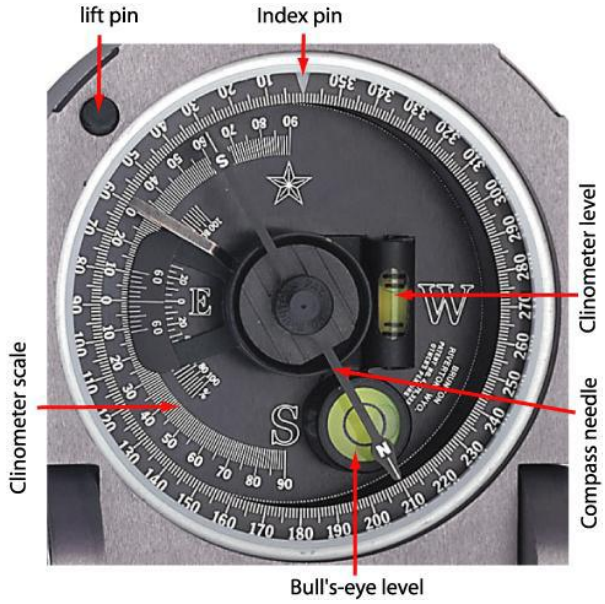
How can a mineral be identified?

A particular mineral can be identified by its unique crystal structure and chemistry. Geologists working in the field, however, don't usually have access to the sophisticated laboratory techniques needed to determine these properties. More commonly, they use Properties which can be observed with the naked eye (or with a hand lens) or determined with simple tools (e.g. a pocket knife).

Useful physical properties for identifying a mineral include its cleavage / fracture, colour, crystal habit / mode of occurrence, hardness, lustre, specific gravity, streak and transparency**.**

EXPERIMENT No. :- 3

Objective:- Use of Brunton Compass for measurement dip and strike of formations.

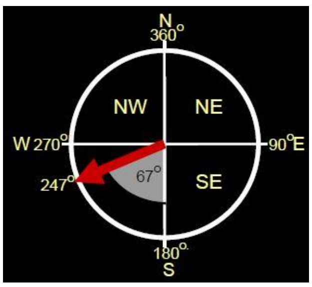


Theory :- The brunton compass are used for measurement of dip and strike of formations.

Compass Mastery:-

•Locate North, Set local declination
•Measure Bearings*=
•Measure Strike and Dip of planes
•Measure Trend and Plunge of lines
•Measure Vertical Angles
  omeasuring height / thickness of a feature

Recording a Bearing:-
Bearing: direction from one point to another
Recording notation:
•Azimuth: “247°”



Strike: *Direction of the line of intersection between a tilted plane and a horizontal plane*

•Compass must be horizontal (bull's eye bubble centered), with compass edge flush to the tilted plane

Dip: *The maximum slope of a plane, measured from horizontal. The dip direction is always perpendicular to strike.*

The dip direction is:

•The "fall line" in skiing

•The direction water runs down a sloping surface

•The direction a pebble rolls down a sloping surface

Viva Quations :-

1. What is brunton compass?
2. What is the use of brunton compass?
3. What is deep and strike?
4. What is the working procedure of brunton compass?

<u>EXPERIMENT No.:-</u> 4

OBJECTIVES:-

- Recognizing rock characteristics.
- Classifying different rock types.

VOCABULARY:

i. Conglomerate
ii. Gneiss
iii. Granite
iv. Marble
v. Obsidian
vi. Sandstone
vii. Schist
viii. Scoria
ix. Shale

MATERIALS:

i. Identification sheets made in pre lab
ii. Rocks
iii. 10% HCL Solution (Optional)

<u>Theory</u>:-

Rocks record the earth's history when those rocks where formed. When students get a piece of rock in lab they need to associate different environments of sedimentary, igneous, and metamorphic. Although sedimentary is the most common rock found on the surface of earth, students can most of the groups very easily. It is very common for building and see the different types of rocks, even if they did not form in that city.

Discuss with the students that rocks have key characteristics, just like minerals, but that identifying rocks is much more difficult, in this lab they will become familiar with the key characteristics of small group of sedimentary, igneous and metamorphic,

PROCEDURE:-

1. Review the rocks on the pre lab identification sheets. You may want to go over some of the characteristics described below.

BLACK, GLASSY - black-the color; glassy - have students imagine broken glass
RED, HOLES - red-the color; holes, - like Swiss cheese
LARGE MINERALS - visible, obvious minerals
WHITE, FLAT, LIGHT - white-the color; flat - as a pancake; _ like a balloon
PEBBLES, GLUED - sand size; sand grains look like they are pasted together
FLAT, LAYERS - pancakes stacked on top of each other
SHINY - like a new car
WHITE AND GRAY MINERALS - the minerals are large enough to see and are white and gray; fizz - if you have dilute HCl(can be bought in a hardware store as Muriatic Acid -

Cement Cleaner) pour just a drop on a specimen so students can see it fizz (DO NOT LET CHILDREN PLAY WITH HCl).

2. See if the students can match the rocks in their packets with the characteristics on the identification sheet. Frequently check on their process. as they decide which rock belongs where.

3. Discuss with students which rocks belong to which group as grouped below:
   IGNEOUS - granite, scoria, obsidian

   SEDIMENTARY - sandstone, conglomerate, shale

   METAMORPHIC - marble, schist, gneiss

Physical Properties of rocks:-

i) **Hardness** :- A scratch test developed by a German mineralogist Fredriech Mohs in 1822 is used to determine mineral hardness. He developed a hardness scale that helps to identify mineral properties.

ii) **Color** :- Color can sometimes be helpful when identifying minerals. However, some minerals have more than one color, like quartz. Quartz can be blue, brown, pink, red, purple, and almost any other color, or it can be totally colorless. Therefore, geologists have developed a better way of using color as an identifying property. This property is called a streak.

iii) **Streak** :- Streak is the name given to the colored residue left by scratching a mineral across an abrasive surface, such as a tile of unglazed porcelain. The streak may not always be the same color you see in the hand specimen. A mineral with more than one color will always leave a certain color of streak. Hematite is a mineral that can be red, brown, or black, but it will always leave a characteristic reddish brown streak.

iv) **Luster** :- Another mineral property that geologists use to identify minerals is luster. Luster is the way in which the surface of a mineral reflects light. There are two main types of luster: metallic and nonmetallic. A metallic luster is shiny and similar to the reflection from a metal object, such as a faucet. A mineral that does not shine like metal has a nonmetallic luster. For example, the wall has a nonmetallic luster.

v) **Cleavage** :- Cleavage is another property used to distinguish minerals. Cleavage is the tendency for minerals to break along flat planar surfaces. Cleavage is rated as good, fair and poor depending on the quality of the flat surface produced. Mica, for example, is a mineral that has good cleavage.

vi) **Chemical Reaction** :- A weak acid is used to tell if rocks or minerals contain calcium carbonate ($CaCO_3$). If the specimen fizzes (giving off CO_2) when it comes in contact with acid, it is considered carbonate rich. If it does not contain calcium carbonate, it will not fizz. Calcite and aragonite are two minerals that will always fizz.

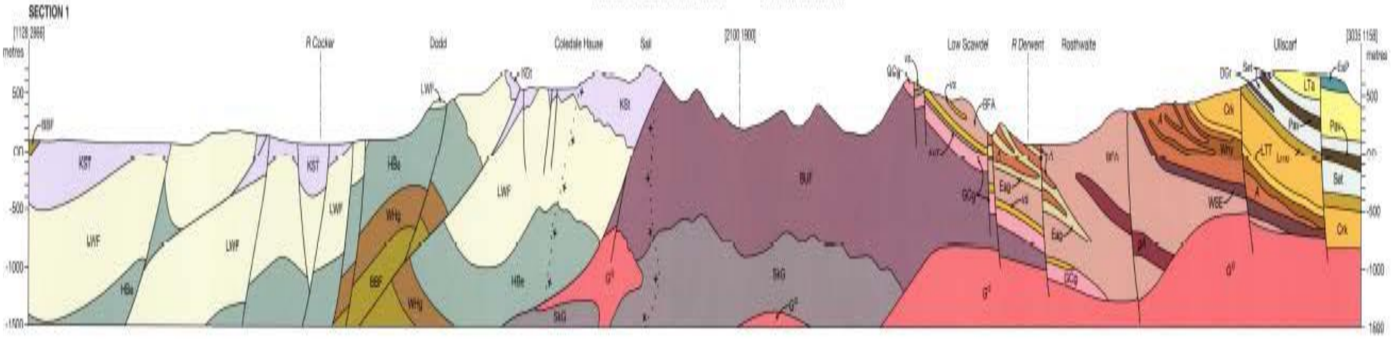
Viva Quations :-

1. What is Rock.?
2. Properties of Rocks.
3. What is the Classification of Rocks?.

EXPERIMENT No.:-5

Objective :- Geological cross section and study of Geological map

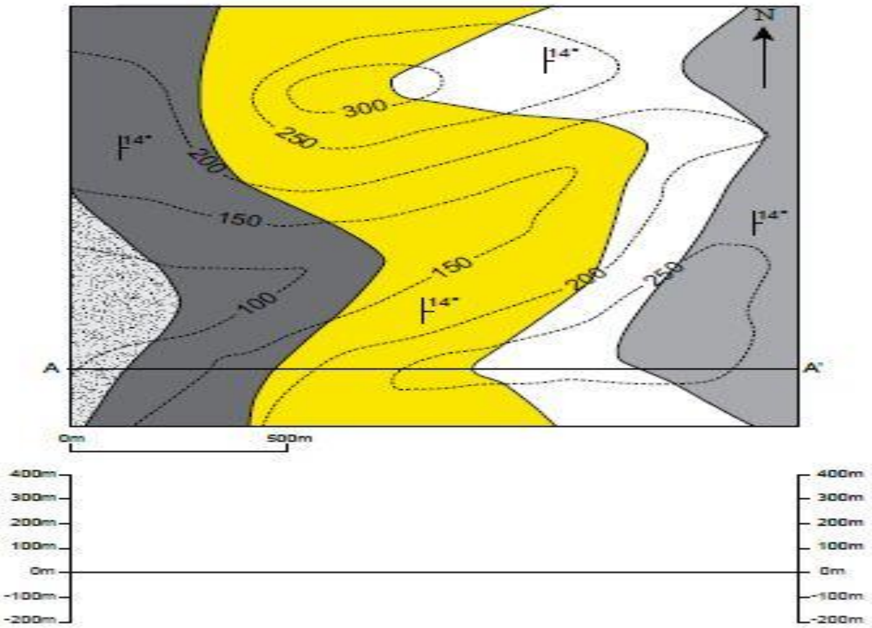
Theory:-A cross section should be consistent with all the available data, although there are often several viable interpretations of the same data. Most cross sections are drawn to true scale, that is, where the horizontal scale is the same as the vertical scale. This means the true dip of the rock units are shown. Vertical exaggeration, where the vertical scale is increased relative to the horizontal, is sometimes used to make a cross section clearer. However, it also increases the dips of the rock units exaggerating the geological structures.



Procedure:-

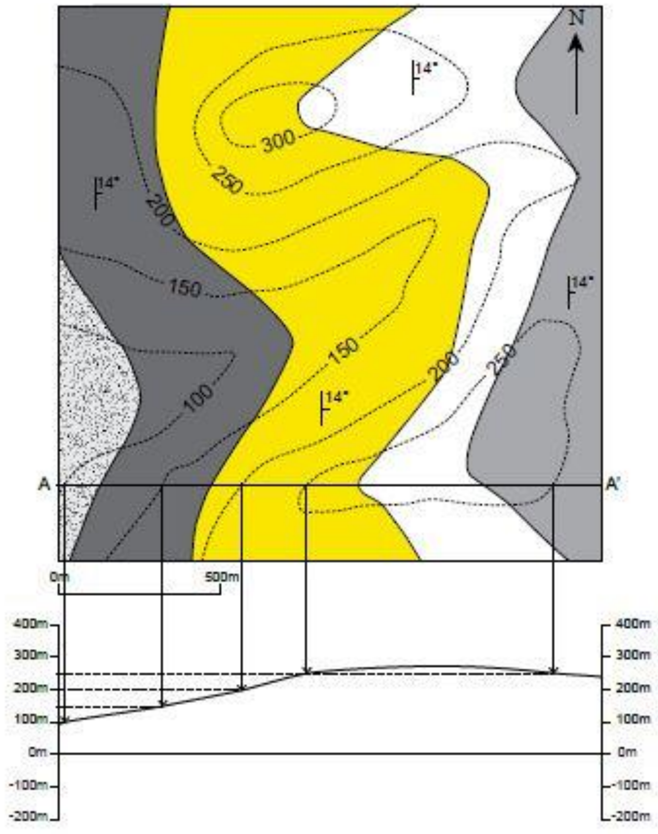
Step 1:

Determine the line along which to draw the section.The line of section should berepresentative ofthe study area, be perpendicular to the majorstructural feature of the area (e.g. large scalefolds or faults), cross as many structural featuresas possible and run through areas with the mostdata readings.



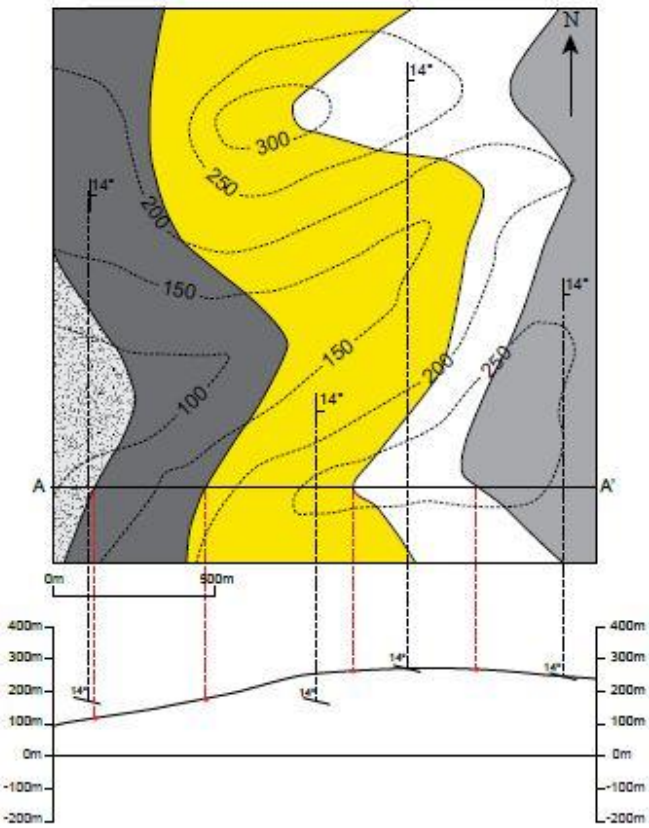
Step 2:
Draw axes of an appropriate scale with theopographic values. Unless there is a reason todo otherwise, draw a true-scale section.

Step 3:
Transfer the topographic information from themap to the section. Project the height of eachtopographic contour, where it crosses the lineof section, on to the section and draw in thetopography.



Step 4:
Transfer the lithological boundaries, faults etc onto the cross section in the same way.

Step 5:
Transfer bedding readings on to the section,correcting for apparent dip if necessary (see figure). Plot the readings at the height at which theyoccur, so where a reading is extrapolated froma greater or lesser height than the topographyof the cross section plot it above or below thetopography as appropriate.



Step 6:

Using the bedding readings as a guide, drawin the lithological boundaries both above andbelow the surface. Geology extended abovethe topography is shown by dashed lines. Whendrawing the section always consider what isgeologically reasonable behavior for the layerse.g. sudden changes in a unit's thickness or dipshould be justifiable.

Step 7:- Stand back and admire your work.

Viva Questions :-

Q1. What do you mean by Geological Map?

Q2. What are lithological boundaries?

Q3. What do you mean by Scale?

EXPERIMENT No.:- 6

Objective:-**Outcrop patterns on geological maps**

Theory:-If the Earth's surface was flat, if there was notopography, then geological maps would besimple. They would be a direct reflection ofthe underlying geology. However, topographyinteracts with the geology to produce morecomplex but predictable patterns.

Horizontal and vertical strata:
Horizontal and vertical strata are the moststraightforward to interpret on a map. Horizontaloutcrops will always follow the topographiccontours (figure 2a), whilst vertical layers willalways form straight lines (figure 2b).

Dipping strata
Dipping layers interact with the topography inpredictable ways. In valleys, beds will appear to'vee' either up or down the valley in the directionof dip (figure 2c and 2d). This is because thevalley side acts as an approximate cross section–not always helpful on small scale maps but onlarge scale maps and in the field this is a usefulaid in interpretation.

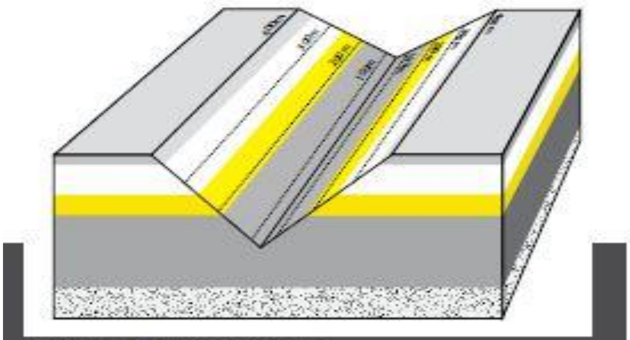


Figure 2a: Horizontal beds

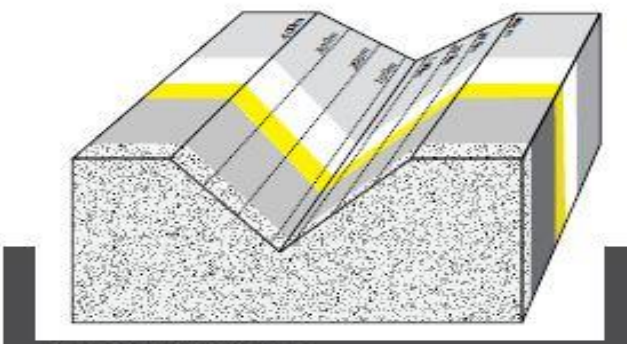


Figure 2b: Vertical beds

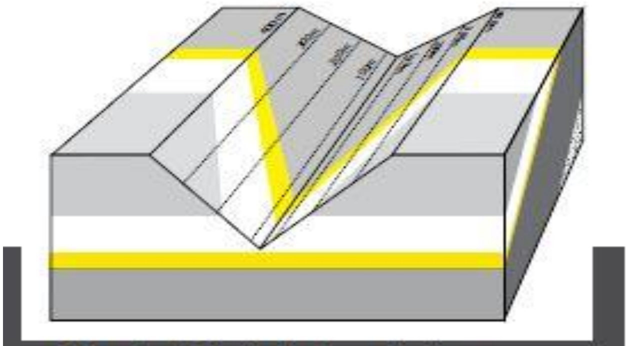


Figure 2c: Beds dipping towards viewer

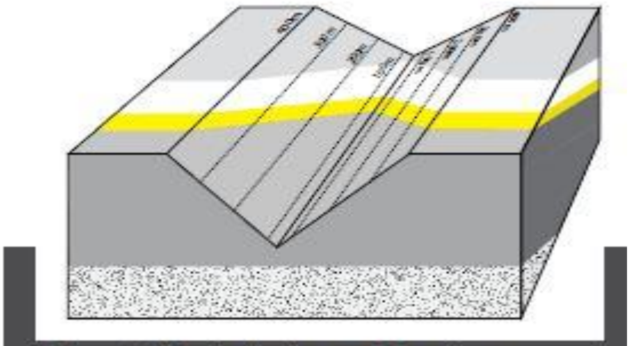


Figure 2d: Beds dipping away from viewer

- Outcrop, structure and age relationships

A. Folding of rocks

a. Layer cake relations

(1) oldest on bottom, youngest on top

b. Fold Types

(1) Anticlines-upfolded forms, results in older rocks becoming enclosed within younger strata

(2) synclines-downfolded forms, results in younger rocks becoming enclosed within older strata.

(3) symmetrical folds- both limbs of the fold dipping at same angle away from fold axis

(4) asymmetrical folds- both limbs of the fold not dipping at same angle away from fold axis

(5) overturned folds- condition in which one limb of fold has been tilted beyond vertical

(6) plunging folds- axis of fold is tilted

(7) Domes- more or less circular equivalent of anticline, oldest rocks exposed in center of dome

(8) Structural Basin- more or less circular equivalent of syncline, youngest rocks exposed in center of dome (not to be confused with depositional basin)

c. Outcrops Patterns Associated with Folded Rocks

(1) As rocks are folded, and subsequently subjected to erosion, regular patterns become evident in relation to type of rock that outcrops and age of the rock that outcrops in an area of folded strata. In essence, erosion exposes the interiors of the folds

(2) Non-plunging Folds- axis of fold is horizontal, results in parallel bands of dipping strata about the fold axis

(a) anticlines- oldest strata exposed along fold axis

(b) synclines- youngest strata exposed along fold axis

(3)Plunging Folds-axis of fold is tilted, results in alternating V-shaped bands of dipping strata oriented about the fold axis.

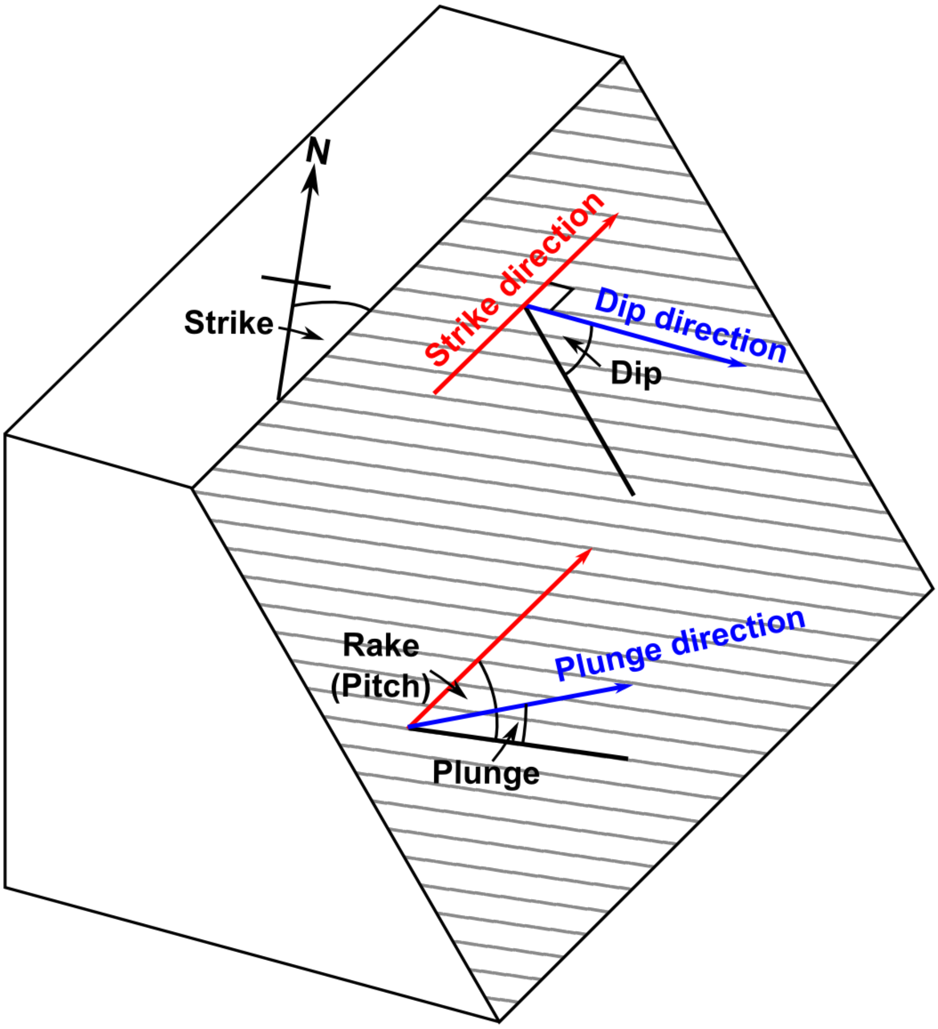
(a) anticlines- oldest strata exposed in the center of the V, V points in direction of plunge of fold axis

(b) syncline- youngest strata exposed in the center of the V, V points in opposite direction of plunge of fold axis.

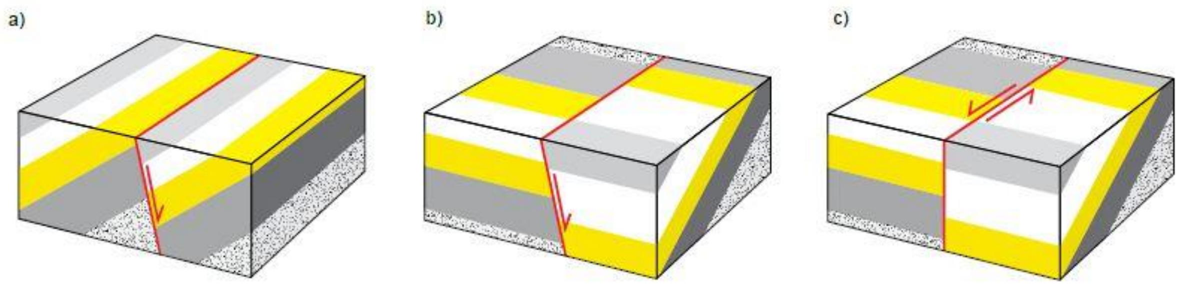
(4) Doubly Plunging Folds- fold axis is plunging in two opposite directions, results in a flattened oval pattern, or a double V-shaped pattern <<<>>>>.

(a) anticlines- oldest strata exposed in center of flattened oval

(b) synclines-youngest strata exposed in center of flattened oval.



Faults on maps:-Faults can occur at any angle with respect to bedding and so the outcrop patterns produced are not unique to any one fault type. Figure **a** and **b** show two potential outcrop patterns for anormal fault.



Fold on maps:- Figure shows the different outcrop patterns for folds. The limbs of the folds form a repeating pattern on either side of the axial plane. For anticlines, the oldest rocks are in core of the fold and the rocks get younger away from the axial trace (figure a). For synclines, the youngest rocks are in the core and the rocks get older
away from the axial trace (figure b).

Plunging folds form the same repeating pattern as non-plunging folds, except their limbs converge around the axial traces. The limbs of synclines open in the direction they plunge (figure c); whilst the limbs of anticlines close in the direction they plunge (figure d).

Viva Questions:-

1. What is Fault ?.
2. What is Fold ?.
3. What do you mean by Syncline and anticyline?
4. What are types of folds?