LECTURE 3

PLOTTING GEOLOGICAL FEATURES ON A BASE MAP

LECTURE OUTLINE		Page

3.0 INTRODUCTION

Welcome to Lecture three of this study unit. In the previous lecture you were introduced to basic field equipments needed in a geological mapping exercise. You learned about basic lithologic and structural features that you should note while in the field. You also learned about the procedure to be followed while collecting, numbering and marking of specimens in the field.

In the present lecture, you are going to learn how to plot basic geological features such as faults, rock contacts, folds, mineral foliations etc on a base map. You are going to learn about methods that are used in locating points and oneself while in the field. This is another exciting lecture that I believe will stimulate your interest in carrying out a successful field mapping project.

3.1 OBJECTIVES

Objectives

At the end of this lecture you should be able to:

(a). Distinguish topographic and planimetric maps
(b). Describe various methods used in locating field data on a base map
(c). Describe and illustrate with specific symbols many of the geological features that can be plotted on a base map.
(d). Explain how contacts are mapped between rock units

3.2 THE SELECTION AND PREPARATION OF A BASE MAP

What exactly is a base map? A base map is a map that is used to plot geologic features and note numbers in the field. Ideally there are two types of base maps – planimetric and topographic maps. Planimetric maps only show drainage, culture (man-made features) and perhaps scattered elevations. On the other hand, topographic maps show all the features displayed in planimetric maps plus contours as well.

Topographic maps are the ideal maps used as base maps firstly because they allow cross sections to be made from them in any direction and secondly from the fact that their contours provide several means of plotting outcrops and topography accurately. Many quadrangle topographic maps with a scale of 1:50,000 or 1:25,000 are the most useful base maps. Small features must be plotted carefully on them.

Planimetric maps on the other hand are only useful when mapping very small areas. In particular, planimetric maps are valuable documents in areas where roads, buildings and water ways are spaced closely enough to permit accurate locations of geologic features. In many suburban areas, detailed, modern planimetric maps may be more preferable to generalized or outdated topographic maps, particularly where there is relatively little relief. Most planimetric maps are held by city or county surveyors and land assessors, by irrigation districts, local harbour and river authorities.

At least two copies of a base map are needed – one for plotting features in the field and the other for making geologic compilations as field work progresses. Extra copies may be used for plotting locations of rocks and fossil specimens.

Distinguish planimetric maps from topographic maps and briefly outline their specific uses.

3.3 LOCATING FIELD DATA ON A BASE MAP

A geological map is made by locating many points, lines and other data on a base map. Its value will depend on a good deal on the accuracy of determination of these locations. Points on the ground can be located on a map by a number of methods. The most suitable method depends on a given ground situation. Generally the methods outlined here below are used where the terrain and vegetation allows on average good visibility.

3.3.1 Location by Inspection

In such cases the points are recognized by configuration of features. Examples of such points include distinctive turns or intersections in streams, roads or ridges (see Fig. 3.1)

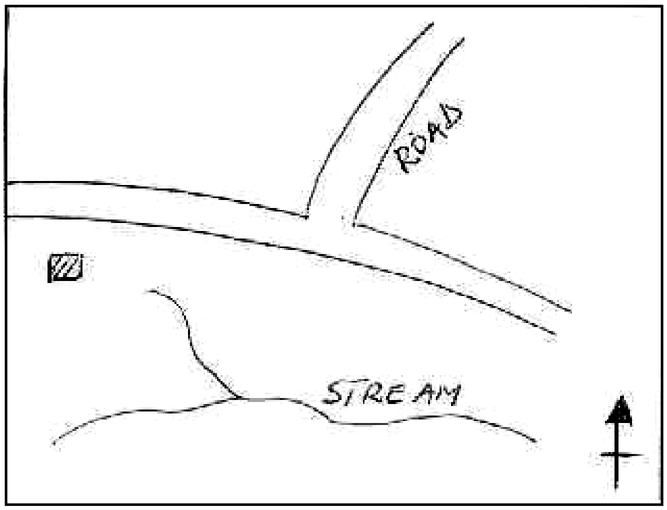


Fig. 3.1 Distinctive intersections in stream and roads.

3.3.2 Location by Inspection and Bearing line

Data along linear features such as ridges, roads or streams can often be located by taking a bearing to a point that can be identified exactly on the map, then plotting the reverse bearing from that point to intersect the linear feature on which the observer stands (see Fig. 3.2)

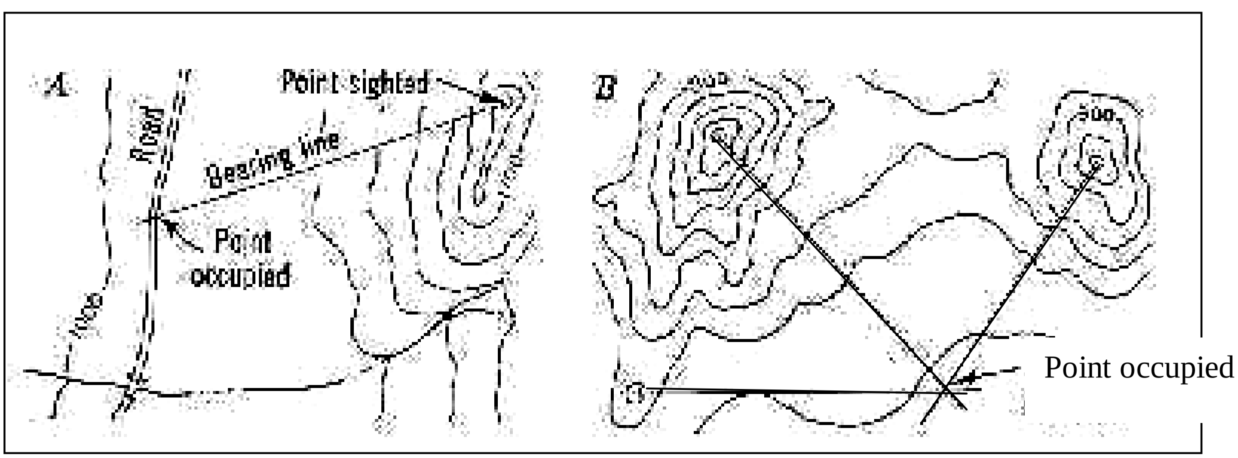


Fig. 3.2 (A). Locating a point along a road by taking a bearing to a nearby hilltop.

(B). Locating a point by drawing three lines from nearby features

3.3.3 Locating by Intersection of a Bearing line

In some cases, points that can be identified on the map are often too distant for pacing, and intersection methods must be used. Three points are found that can be identified exactly on the map, and the bearings to these points are measured with a compass. When the reverse bearing lines are plotted on the map with a protractor, they should intersect at the point occupied (see Fig. 3.2 B).

3.3.4 Location by Bearing and Pacing

Where geologic data do not lie along an identifiable map feature, they may be located by reading a bearing to a nearby point that can be identified on the map. The distance to that point can then be paced, and after a backsight is taken to recheck the bearing, the distance should be checked by pacing back to the outcrop. The average bearing and distance are then used to plot the outcrop on the map. If it is not possible to pace in both directions, a tally counter should be used to eliminate any errors in counting.

3.3.5 Location by Intersection of a Bearing and Contour lines

The elevation of the point occupied can be found and then finding a bearing of a distant point. The intersection of the bearing line and the appropriate contour lines on the map will locate the point. The elevation can be determined with an accurate altimeter or barometer.

3.3.6 Using control signals for locations

When mapping featureless plains and marshlands it may be necessary to set up control signals before geologic features can be plotted accurately. Control signals include:

(i) Heaps of rocks

(ii) Flags on poles

(iii) Distinctive trees

(iv) Distinctive rocks

The control signals should be visible over as large an area as possible. The signals must first be located accurately on base maps by triangulation methods.

In an ideal geological setting environment in the field, attempt by using your compass, (and barometer where applicable) and topographic maps to:

1. Locate yourself by using intersection of bearing lines
2. Locate specific outcrops or points of interest in your base maps using different location methods.

3.3.7 Location by use of a Global Positioning System (GPS)

The Global Positioning System (GPS) is a satellite-based navigation system that was developed by the US Department of Defense (DoD) in the early 1970's as the next generation replacement to the transit system (El-Rabany 2006). Initially GPS was developed as a military system to fulfill US military needs. However, it was later made available to civilians, and is now a dual-use system that can be assessed by both military and civilian users.

The GPS comprises of 24 orbiting satellites, in 6 orbital planes, that transmit navigational signals for Earth-bound use. Using this technology, latitude, longitude, and elevation are accurately calibrated using a hand-held instrument that reads radio signals from satellites. GPS provides continuous positioning and timing information anywhere in the world under any weather conditions.

GPS has numerous application in land surveying, marine or ocean and air navigation, managing the movement of fleets of trucks, mining and resource mapping, and environmental planning. Vehicle and personal tracking and navigation are rapidly growing applications. It is expected that the majority of GPS users will be in vehicle navigation. Future users of GPS will include automatic machine guidance and control, where hazardous areas can be mapped efficiently and safely using remotely controlled vehicles.

GPS is also useful to the backpacker and sportsperson. Some commercial airlines are using GPS to improve accuracy of routes flown and thus increases fuel efficiency.

Scientists are currently using GPS to accurately determine the height of Mount Everest in the Himalayan Mountains.

Farmers use GPS to determine crop yields on specific parts of their farms. A detailed plot map is made to guide the farmer as to where more fertilizer, proper seed distribution, irrigation applications, or other work is needed. A computer and a GPS unit on board the farm equipment guides the work.

The importance of GPS to geologists and geographers is obvious because this precise technology reduces the need to maintain ground control points for location, mapping, and spatial analysis. Instead, geologists or geographers working in the field can determine their position accurately as they work. Boundaries and data points in a study area can be easily determined and entered into a data base, and the need for traditional surveys is reduced. For this and myriad other applications, GPS sales are expected to exponentially grow in the years to come.

1. Briefly describe the Global Positioning System (GPS).
2. Outline four applications of the GPS technology.

3.4 LOCATING GEOLOGIC FEATURES BY TRAVERSING

To map geologic features in wooded areas, traverses must be made from whatever features that can be identified accurately on the maps. Compass-pace methods are generally suitable for these traverses. Preliminary reconnaissance of a traverse course in every wooded country may take nearly as much time as the traverse itself, but in fairly open country, a reconnaissance may profitably indicate where outcrops occur, what they look like from a distance, and the spacing of traverse lines needed to locate enough of them.

In wooded or bushy areas, the traverse should follow the course of least resistance by making use of open ridges, stream courses, paths and clearing that permit relatively long and clear courses for bearings and pacing.

3.5 USING A BAROMETER (OR ALTIMETER) TO LOCATE GEOLOGIC FEATURES ON A MAP

In wooded or bushy-grown areas where pacing is difficult and where there are only occasional open views of the surrounding country, a barometer or altimeter may be used effectively to locate points on a topographic map. This method is also used to locate geologic boundaries on hillsides. There are three prerequisites required here, namely:

(i) The contours of the map must be accurate
(ii) The contour interval must be such that the contours are spaced fairly close
(iii) The instrument must permit reading to within about 2m.

3.6 GEOLOGIC FEATURES TO BE PLOTTED ON THE BASE MAP

Contacts and faults are the most important geologic features plotted on the map. Folds are generally depicted on the map as a line showing the trace on the ground of the axial plane. Although these trace lines can be located and plotted directly in some places, symbols for most large folds can be drawn only after rock units and bedding attitudes (strike and dips) have been plotted over large areas. Where the folds are well exposed, it's important to observe and record the following: -

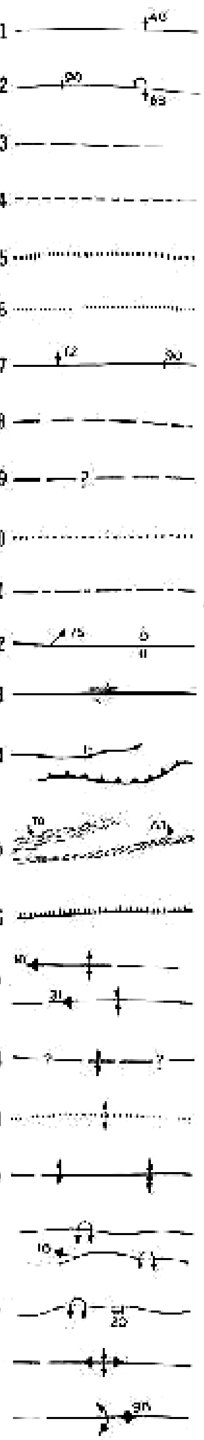
(i) The trend and plunge of the axis
(ii) The strike and dip of the axial plane
(iii) The plunge of small-scale folds associated with axial region and limbs
(iv) The strike and dip of secondary cleavages
(v) The intersection between these cleavages and the bedding

A large number of planar structures can be plotted. Structural features that show their strike and dip includes: -

(i) Bedding
(ii) Compositional layering (banding) in igneous and metamorphic rocks
(iii) Various cleavages
(iv) Mineral foliations
(v) Veins
(vi) Joints

These features must be classified as accurate as possible and plotted with distinctive symbols that show clearly what kind of features has been mapped as presented in Table 3.1

Table 3.1 Distinctive symbols for geological features (After Compton, 1968).



Symbols	Explanation
1	Contact, showing dip
2	Contact, vertical (left) and overturned
3	Contact, located approximately (give limits)
4	Contact, located very approximately
5	Gradational contact (a new symbol)
6	Contact, projected beneath mapped units
7	Fault, showing dips
8	Fault, located approximately (give limits)
9	Fault, existence uncertain
10	Fault, projected beneath mapped units
11	Possible fault (as located from aerial photographs)
12	Fault, showing trend and plunge of linear features (*D*, down-thrown side; *U*, upthrown side)
13	Fault, showing relative horizontal movement
14	Thrust faults; *T* or sawteeth in upper plate
15	Fault zones, showing average dips
16	Normal fault; hachures on downthrown side
17	Anticline (top) and syncline, showing trace of axial plane and plunge of axis; dashed where located approximately
18	Anticline, existence uncertain
19	Anticline, projected beneath mapped units
20	Asymmetric anticline; steeper limb to south
21	Overturned anticline (top) and syncline, showing trend and plunge of axis
22	Overturned anticline, showing dip of axial plane
23	Doubly plunging anticline, showing culmination
24	Vertically plunging anticline

Table 3.1 cont………

Symbols	Explanation
25	Inverted (synformal) anticline
26	Monocline or flexure in homocline
27	Axial trend of small anticline (left) and syncline
28	Axial trend of folds that are too small to plot individually; patterns show general shapes of folds in profile
29	Strike and dip of bedding
30	Strike and dip of overturned bedding
31	Strike and dip of bedding where tops of beds are shown by primary features
32	Strike of vertical bedding; stratigraphic tops to north
33	Horizontal bedding
34	Undulatory or crumpled beds
35	Strike and dip of bedding, uncertain
36	Strike of bedding certain but dips uncertain
37	Strike and dip of foliations
38	Strike of vertical foliations
39	Horizontal foliations
40	Strike and dip where bedding parallels foliation
41	Strike and dip of joints (left) and veins or dikes
42	Strike of vertical joints (left) and veins or dikes
43	Horizontal joints (left) and veins or dikes
44	Trace (left) and mapped shape of ore vein
45	Body of high-grade ore, with stipples showing wall-rock alteration
46	Body of low-grade ore

Table 3.1 cont………

Symbols	Explanation
47 	Trend and plunge of lineation
48 	Vertical lineation
49	Trend of horizontal lineation
50 	Trend of intersection of cleavage and bedding
51 	Trends of intersections of two cleavages
52 	Trends of pebble, mineral, etc., lineations
53 	Trends of lineations lying in planes of foliations
54 	Trends of horizontal lineations lying in planes of foliations
55 	Vertical lineation and foliation
	ACCESSORY SYMBOLS FOR SMALL-SCALE MAPS
56 	Shafts, vertical (left) and inclined
57 	Adits, open (left) and inaccessible
58 	Trench (left) and prospect
59 	Mine, quarry, or glory hole
60 	Sand, gravel, or clay pit
61 	Oil well (left) and gas well
62 	Well drilled for oil or gas, dry
63 	Wells with shows of oil (left) and gas
64 	Oil or gas well, abandoned (left) and shut in
65 	Water wells: flowing (left), nonflowing, and dry (right)
	ACCESSORY SYMBOLS FOR LARGE-SCALE MAPS (plotted to scale)
66 	Glory hole, open pit, or quarry
67 	Trench (left), open cut, and pit (right)
68 	Portal of tunnel or adit, that on right with open cut

3.7 MAPPING CONTACTS BETWEEN ROCK UNITS

Tracing and plotting contacts between rock units are the basic procedures of geologic mapping. This is the most efficient way of mapping units at small and intermediate scales (e.g., 1:25,000 or 1:50,000).

Mapping is best started along a sharp contact between two distinctive rock units. The contact should be mapped by walking along its trace and plotting points on the map where the contact can be seen or where its position can be inferred closely. The number of points that must be recorded accurately will vary with the degree of irregularity of the contact. A sharp, well-exposed contact is drawn as a solid thin line. Many contacts are exposed at only few places; some are not exposed at all in natural outcrops. Such contacts can be mapped by walking a zigzag course between outcrops of the two rock units that lie on either side and by plotting a line that passes between the limits thereby established.

Contacts between quartz rich and quartz poor rocks can be located by the distribution of quartz grains abundance in the soil. Such examples of contacts include:

(i) a contact between sandstone and shale

(ii) a contact between sandstone and limestone

(iii) a contact between granite and gabbro

When no large residual fragments can be found, the composition, color and texture of the soil itself may be used to trace contacts between many rock units. In areas where down slope creep has displaced and mixed the float, the up-slope limit of fragments from a unit can be used to locate upslope contact of that unit. In such a case, contact can be established between a conglomerate rock and shale (see Fig. 3.3).

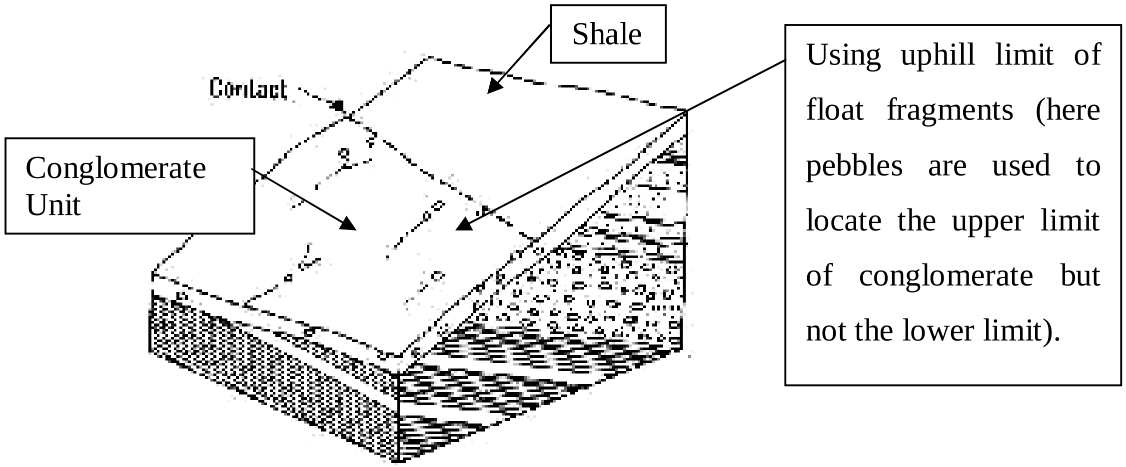


Fig. 3.3. Using the uphill limit of float fragments to locate the upper contact of a unit.

Vegetation commonly varies from one bedrock to another particularly in areas of moderate rainfall and high summer temperatures. Soils weather from rocks and their degree of fertility is governed by the mineralogy and nature of the rock outcrops.

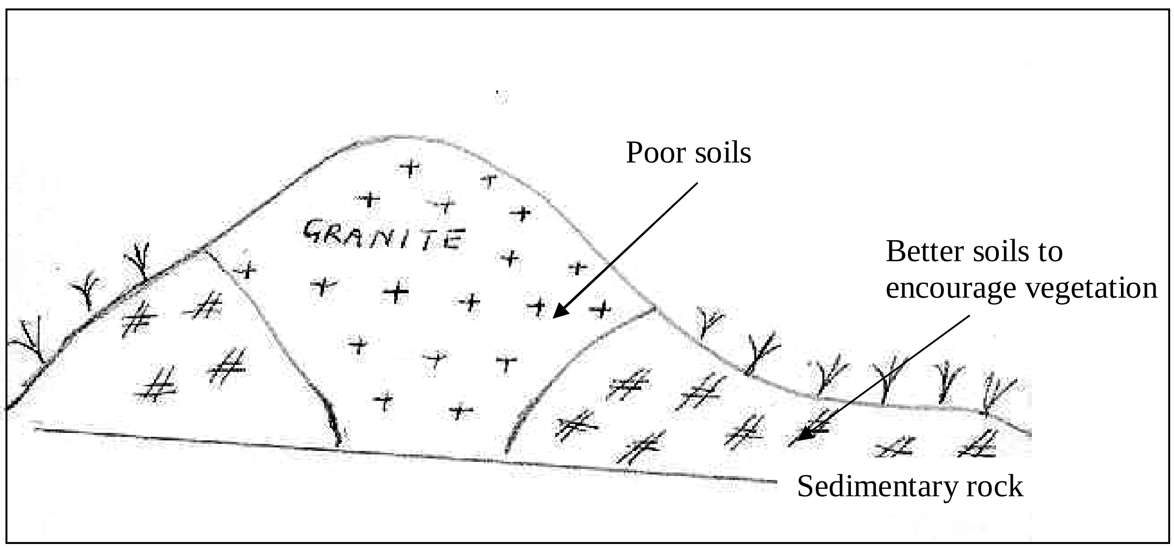


Fig. 3.4 Nature of soils is governed by the underlying geological rock units.

When there is no indication of the trace of a contact, it can be projected on the basis of strike and dip symbols measured nearby. This can be done by standing where the contact is exposed, setting the clinometer of the compass for the dip of the beds, and sighting in the direction of the strike as if measuring the dip. Several points are located accurately on the map where the imaginary projected surface intersects the ground surface. The trace of contact is then dashed in between these points to conform naturally to the topography.

3.8 MAPPING BY THE OUTCROP OR EXPOSURE METHOD

The method is used where the scale of the map is large (i.e. 1:12,000 or more). In this method, each exposure is plotted to scale by drawing its contacts with surrounding surficial materials. Letter symbols or colors are used to designate the units within the outcrop areas. Thin solid lines are drawn at the contacts of the units where observed on the outcrop areas. Dotted lines are used where the outcrops are covered (see Fig. 3.5).

One advantage of the outcrop method is that observed facts are separated from inferences. In addition to this, other geologists can find isolated or hidden outcrops easily and can evaluate the evidence on which concealed contacts can be drawn.

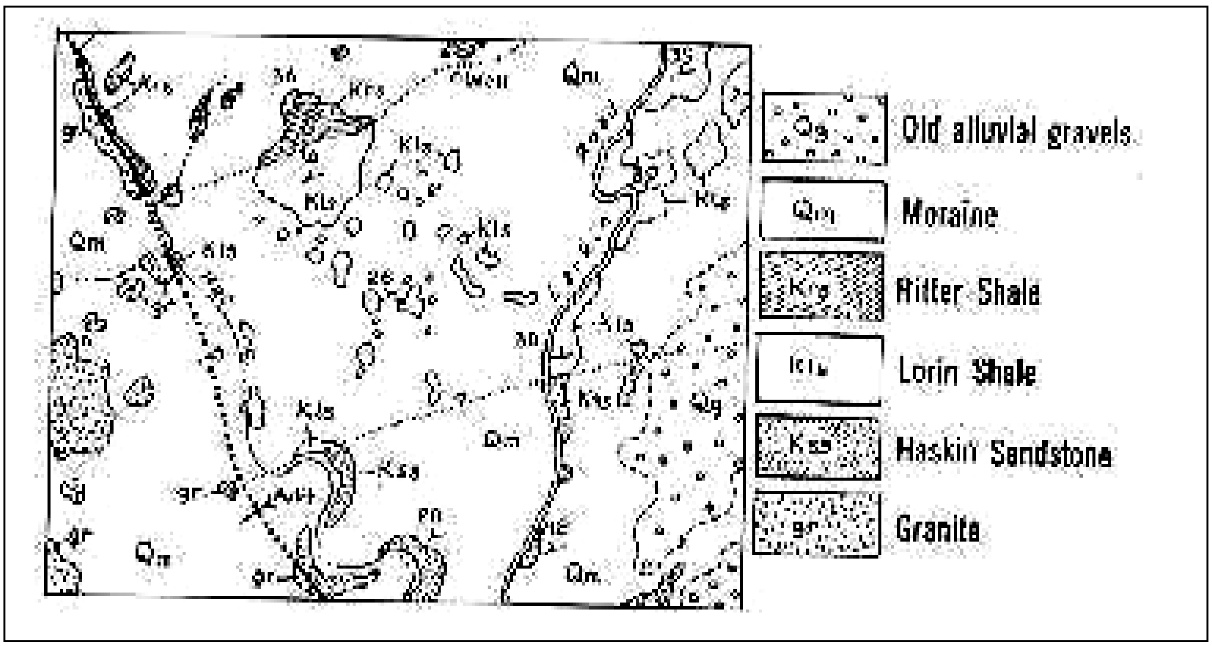


Fig. 3.5 Fragment of an outcrop map.(After Compton, 1968).

3.9 USIING COLORED PENCILS IN MAPPING

Waterproof colored pencils can be used effectively to map rock units where outcrops are scattered or gradations are broad. A distinctive color should be chosen for each unit and a mark made on the map at each outcrop of the unit. Most outcrops must be shown diagrammatically by small spots, but the larger ones should be drawn approximately to scale. The marks must be made so lightly that contours show through them and structure symbols can be plotted over them. As an area is mapped, the colored spots will show not only where contacts must pass but also the dimensional accuracy of their location.

Where colors are used to plot outcrops of certain rock types, gradational zones will appear as uncolored bands, and a gradational contact symbol (see section 3.5 of this lecture) may then be located within this band. This method of finding gradational rock boundaries is particularly useful for internal contacts of plutonic igneous rock bodies, zones of alteration, or contacts between metamorphic zones, as all of these boundaries may be irregular and unpredictable.

Pencil marks must be moderately erasable and waterproof. Since pencils are lost easily in the field, a piece of about 5cm long may be cut from each and carried in a pocket. A color can be selected quickly from these stubs, and if one is lost it can be replaced from the supply in camp.

3.10 Summary

SUMMARY

In this lecture you have learned what a base map is and how to distinguish topographic and planimetric maps. We learned how to locate field data on a base map. For example you learned how to plot geologic features such as contacts, faults, and folds on a base map. We learned how a large number of planar structures such as beddings, cleavages, mineral foliations, veins and joints with distinctive dip and/ or strike attitude data can be classified accurately and plotted with distinctive symbols on a base map. Where the scale of map is sufficiently large enough (e.g. 1: 12,000), we learned how mapping can be carried out using rock outcrops or exposure method. In this method, each exposure is plotted to scale by drawing its contacts with surrounding surficial materials. Finally we learned how waterproof colored pencils can be used to map out rock units whose outcrops are scattered or gradations are broad.

3.11 References

REFERENCES

Compton, R.R. 1968. Manual of Field Geology. John Wiley & Sons, Inc. New York. 378pp.

El-Rabany, A., 2006. Introduction to GPS. 2nd Edition, Artech House publishers, London. 246pp.