LECTURE 4

USE OF GEOLOGICAL FIELD EQUIPMENTS: COMPASS, CLINOMETER AND HANDLEVEL

4.0 INTRODUCTION

Welcome to lecture 4 of this unit. In the previous lecture you learned how to plot basic geological features such as faults, rock contacts, and folds etc on a base map and the methods used in locating points and oneself while in the field. In this lecture we shall learn the usage of the compass, clinometer and hand-level as some of the important equipments used in a geologic field study.

Compass, clinometer and hand levels are tools that can be used to make a great variety of surveys and to measure the attitudes of various geologic structures in the field. These three basic equipments are usually combined in the Brunton Pocket Transit, which is commonly called the **Brunton compass**. For most routine procedures, the compass is usually held by hand though it may be mounted on a tripod for more precise measurements. Please note that, although the detailed instructions for use given in this lecture pertain especially to the Brunton compass, the same general procedures can readily apply to other kinds of compasses, clinometers and hand levels.

4.1 OBJECTIVES

Objectives

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

(a). Describe and illustrate the various parts of the Brunton compass.

(b). Outline the procedure of taking bearings with the compass

(c). Distinguish Dip and Strike attitude measurements.

(d) Determine suitable parameters for measurement of dip and strike attitudes in the field.

(d) Measure the trend and plunge of linear features

(e) Describe the safety procedures and maintenance of the compass and clinometer.

4.2 THE BRUNTON COMPASS

The major parts of the Brunton compass are shown in Figure 4.1. The compass itself is made up of brass and aluminium – these being materials that will not affect the magnetized compass needle.

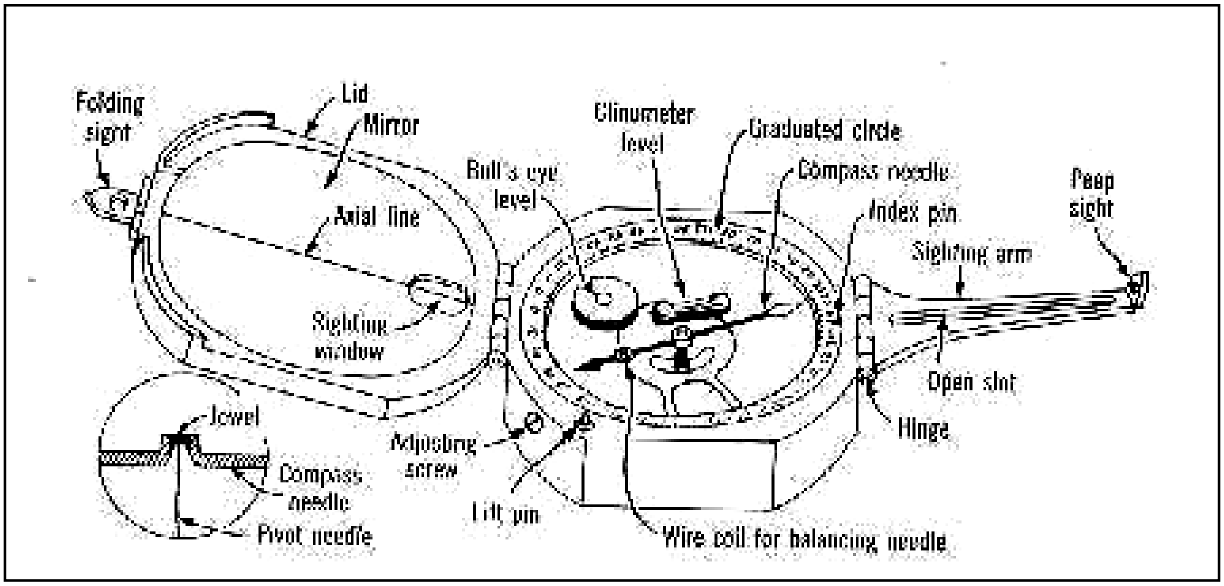

Fig. 4.1. The Brunton Compass. Inset at lower left shows enlarged section through needle bearing.

When the compass is open, the compass needle rests on the **pivot needle** (see Fig. 4.1). The compass needle can be braked to a stop by pushing the **lift pin**, which is located near the rim of the box. When the compass box is closed, the lift pin protects the pivot needle from wear by lifting up the compass needle. The round **bull's eye bubble** is used to level the compass when a bearing is read, and the tube bubble is used to take readings with the **clinometer**. The clinometer is moved by a small lever on the under-side of the compass box (not shown in the Figure).

A compass should be checked to ascertain that:

1. Both levels have bubbles
2. The hinges are tight enough so that the lid, sighting arm, and the peep sights do not fold down under their own weight, and
3. The point of the sighting arm meets the black axial line of the mirror when the mirror and sighting are turned together until they touch.

Describe and illustrate the various parts of the Brunton compass.

4.3. TAKING BEARINGS WITH THE COMPASS

4.3.1 What is a bearing?

A bearing is the compass direction from one point to another. A bearing always has a unidirectional sense; for example, if the bearing from A to B is N 30 W, the bearing from B to A can only be S 30 E. Using the Brunton compass, the correct bearing sense is from the compass to the point sighted when the sighting arm is aimed at the point. The white end of the needle gives the bearing directly because the E and W markings are transposed.

To read accurate bearings, three things must be done simultaneously:

- The compass must be levelled
- The point sighted must be centered exactly in the sights, and
- The needle must be brought nearly to rest.

4.3.2 Procedure of Taking a Bearing

a**). When the Point sighted is from the Level of the waist or chest**

When the point sighted is visible from **the level of the waist or chest**, the following procedure should be used as illustrated in Fig. 4.2 A.

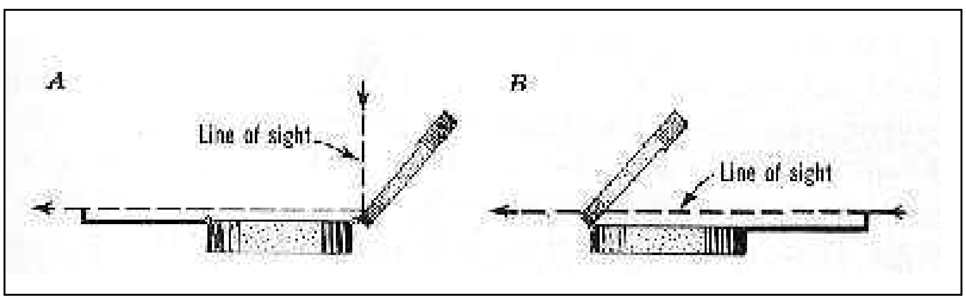

Diagram Fig.4.2A Compass set for taking a bearing at waist height (A) and at height of eye (B).

1. Open the lid about 135^o; turn the sighting arm out and turn up its hinged point (Fig.4.2A).
2. Standing with the feet somewhat apart, hold the compass at waist height with the box cupped in the left hand.
3. Center the bull's eye bubble, and, keeping it approximately centered, adjust the mirror with the right hand until the point sighted and the end of the sighting arm appear in it.
4. Holding the compass exactly level, rotate the whole compass (on an imaginary vertical axis) until the mirror images of the point sighted and the tip of the sighting arm are superimposed on the black axial line of the mirror.
5. Read the bearing indicated by the white end of the needle, which should be nearly at rest.
6. After reading the bearing, check to make sure the line of sight is correct and the compass is level.
7. Record or plot the bearing at once.

Take a walk to an open field and attempt to take the bearing of two objects that can be sighted at the waist or chest level.

b). When the Point sighted is from the eye level or on a steep downhill sight.

When the point sighted is visible only at eye level (see Fig. 4.2 B) or by a steep downhill sight, the following instructions should apply.

1. Fold out the sighting arm as above, but open the lid only about 45^o (Fig. 4.2B).

2. Hold the compass in the left hand at eye level, with the sighting arm pointing toward, and about 1ft from, the right eye.
3. Level the compass approximately by observing the mirror image of the bull's eye bubble, and, holding the compass approximately level, rotate it until the point sighted appears in the small sighting window of the lid.
4. Holding the compass exactly level, rotate it until the point sighted and the point of the sighting arm coincide with the axial line of the window.
5. Read the bearing mirror, double checking for alignment and level.
6. Transpose the direction of the bearing before recording or plotting it (the compass was pointed in reverse of its bearing direction).

Take a walk to a hilly terrain and attempt to take the bearing of two objects that can be sighted at the eye level or on a steep downhill.

4.4. USING THE BRUNTON COMPASS AS A HAND LEVEL

The Brunton compass is converted to a hand level by setting the clinometer exactly at 0, opening the lid 45^o, and extending the sighting arm with the sighting point turned up. The compass is held in the same way as when measuring vertical angles. It is tilted slowly until the mirror image of the tube bubble is centered. Any point lined up with the tip of the sighting arm and the axial line of the sighting window is now at the same elevation as the eye of the observer. By carefully rotating the entire instrument with a horizontal motion, a series of points that are at the same elevation can be noted.

While in a normal classroom environment, attempt to convert your Brunton compass into a hand level. By rotating the entire instrument with an horizontal motion, attempt to line up a series of point objects at the same elevation level.

4.5 DIP AND STRIKE

In this section, we shall try to understand the significance of Dip and Strike. Dip and strike are two important attitude parameters to be deduced in the field for any inclined or layered strata.

4.5.1 Dip

What is Dip and why is it a vector quantity?

Dip is essentially an angle of inclination of the bed. It is defined as the amount of inclination of a bed with respect to an horizontal plane. This is measured on a vertical plane lying at right angles to the strike of the bedding (see Fig. 4.3)

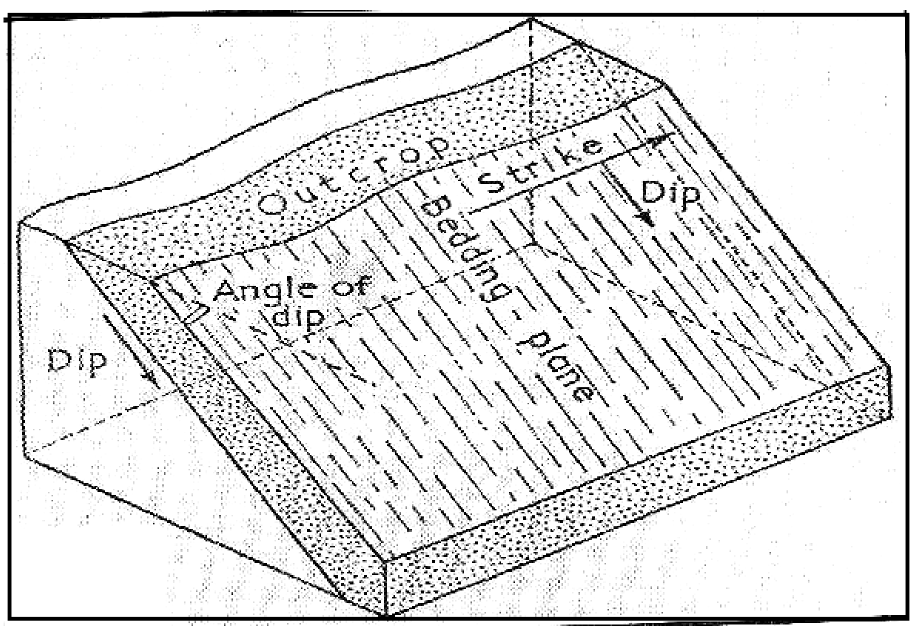

Fig. 4.3 The bedding plane, strike and dip of an inclined rock outcrop

The dip of a bed has got two components, namely direction as well as magnitude. Hence the dip of a bed is a **vector quantity**. The amount of dip is the angle which varies from “0” to “90” according to the disposition of the bed. The direction of dip is the geographic direction, along which a bed has maximum slope.

In case of horizontal beds, the Dip is “zero” degree and for a vertical bed the Dip is “90” degrees. Accordingly the symbolic representation of a horizontal and vertical bed in a map is also different, which may be seen from the following figures A, B, and C.

Types of Dip

There are two types of Dips, namely: (i). ***True Dip*** and (ii). ***Apparent Dip***

(i). **True Dip** – It is the maximum amount of slope along a line perpendicular to the strike, in other words, it is the maximum slope with respect to the horizontal. It may also be stated as the geographical direction along which the line of quickest descent slopes down.

(ii). **Apparent Dip** – Along any direction other than that of the true dip, the gradient is scheduled to be much less and therefore it is defined as the apparent dip. The apparent dip of any bed towards any direction must always be less than its true dip.

4.5.2 Strike

What is strike and why is it a scalar quantity?

The direction of the line along which an inclined bed intersects a horizontal plane is known as the strike of the bed. It is a scalar quantity, as it has only one component, i.e., **direction** but not magnitude. The strike of the bed is independent of its amount of dip.

4.5.3 Importance of Dip and Strike

In structural geology, Strike and Dip are quite important for the following purposes:

(a). To determine the younger bed of formation. It is well known that younger beds will always be found in the direction of Dip. If we go in the direction of dip, relatively beds of younger age will be found to out-crop and older rocks in the opposite direction.

(b). In the classification, and nomenclature of folds, faults, joints and unconformities, the nature of dip and strike is of paramount significance. Thus the attitude, which refers to the three dimensional orientation of some geological structures, is defined by their dip and strike.

Why is Strike and Dip important parameters in structural geology?

4.6 MEASURING STRIKE AND DIP

The strike and dip of planar geologic structures, such as bedding, faults, joints and foliations, can be determined by several methods with the Brunton compass. Strike is generally defined as the line of intersection between a horizontal plane and the planar surface being measured. It is found by measuring the compass direction of a horizontal line on the surface. Dip is the slope of the surface at right angles to the line (see Fig. 4.3).

The best method for measuring a given strike and dip depends on the nature of the outcrop and the degree of accuracy desired. The amount of the dip, too, may affect the choice because steeply dipping planar structures can be measured far more accurately and easily than gently dipping ones. Special methods are needed to measure dips of less than 5^o accurately.

In the section on taking bearings (Section 4.2.1), it was noted that a bearing has a unidirectional sense and that the white ended of the compass needle must be read in all cases. It is recommended that for measuring strike only **the north half of the compass** be used, regardless of which end of the needle points there. Strikes would thereby be read as **northeast or northwest**, never southeast or southwest. This helps eliminate the occasional serious error of transposing a strike to the opposite quadrant when reading, plotting, or recording it. These errors can occur easily where two men are working together and calling out structural data from one to the other.

In a geological field setting, attempt the measurement of Dip and Strike attitudes for inclined strata.

4.6.1 Where to Take Strike and Dip

Before measuring strike and dip, it must be determined whether the attitude will reliably represent bedding. Some “outcrops” are not in place at all, being large boulders, blocks of float, or segments of landslides. A general survey of the slopes around outcrops will generally resolve such problems. If there is still some question as to the reliability of a measurement, a question mark may be entered next to the plotted symbol or the strike line may be broken.

Outcrops should also be examined to make certain that what is taken for bedding or foliation is not jointing, bands of limonite staining, or some other kind of discoloration. Changes in texture (especially grain-size) or changes in mineral composition are the best indicators of bedding.

In massive sandstones, bedding may be shown only by the approximate planar orientation of mica flakes, platy carbonaceous or fossil fragments, shale chips, or platy and elongate pebbles. The possibility that bedding features in sandstones are only local cross-bedding must be considered. The identification of bedding in metamorphic rocks may be still more difficult, and there are a number of planar structures of igneous and metamorphic rocks that should be identified carefully wherever they are measured and plotted.

4.7 MEASURING TREND AND PLUNGE OF LINEAR FEATURES

Trend and **plunge** are used to define the attitudes of linear features. The **trend** of a linear feature is the compass direction of the vertical plane that includes the feature. If the feature is horizontal, only the compass direction is needed to define its attitude. If it is not horizontal, the trend is taken as the direction in which the feature points (plunges) downward. The **plunge** is the vertical angle between the feature and a horizontal line.

To measure the trend of a linear feature, the observer stands, if possible, directly over a surface that is parallel to the linear feature (Fig. 4.4). This surface is sometimes described as "containing" the feature or as the surface on which its maximum length is seen.

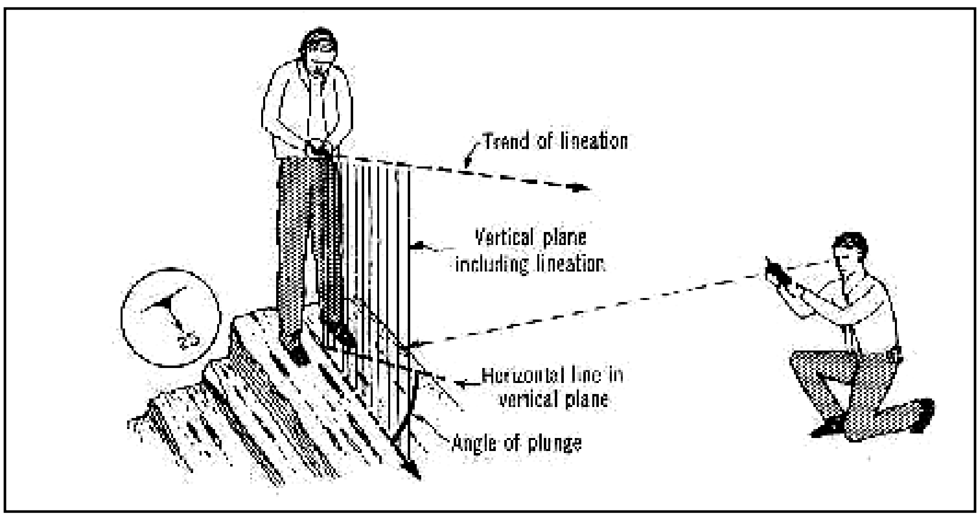

Fig. 4.4 – Measuring the trend of linear structures.

The observer faces in the direction in which the linear feature points downward. He determines the bearing of this direction (the trend) by holding the compass at waist length and looking down vertically on the feature through the slot of sighting arm. When the slot is parallel to the trend of the feature, the bearing at the white end of the needle is read. The trend is then plotted on the map as a line originating at the point occupied by the observer.

To measure the plunge of the feature, the observer moves so that he is looking at right angles to its trend (Fig. 4.4, right). The reading is taken on the trace of the linear feature seen from this position, exactly as in taking the dip of the trace of the bed. An arrow point is then drawn on the map at the downward plunging end of the trend line, and the amount of plunge is lettered at the end of this arrow. For horizontal linear features, an arrow point is drawn at both ends of the line (see Table 3.1 symbols no. 53 & 54 in the previous lecture).

1. In a geological field setting, attempt the measurement of trend and plunge for a linear feature.
2. Use the correct symbols for the measured trend and plunge parameters.

4.8 CARE AND ADJUSTMENT OF THE BRUNTON COMPASS

4.8.1 Care of the Brunton compass

Remember that as a competent geologist, it is important to take a good care of your Brunton compass or any other equipment if you are to obtain reliable data in the field. The compass, for example, should never be carried open in the hand while walking over rough or rocky ground. If extra mirror or glass covers are included in the field gear, these can be replaced in the field, but if the hinges are bent or the level vials broken, the instrument must be sent to the manufacturer for repair.

If the compass is used in the rain, or if it is accidentally dropped in water, it should be opened and dried because the needle will not function properly when the bearing is wet. The glass cover can be removed by forcing the point of a knife blade under the spring washer that holds it in place. With the washer off, the glass cover can be lifted from the box, and the needle taken off its bearing. The cone-shaped pit of the jewel bearing should be cleaned and dried with a sharpened toothpick and a bit of soft cloth or soft paper. The needle lift is then removed and the inside of the compass dried and cleaned. It is safe to suggest that this opening and cleaning of the compass should be done by a competent technician. More details of the serving procedure is presented by Compton (1968).

4.8.2 Adjustment of the Brunton Compass

Before a new or a borrowed compass is used in the field, it should be checked to make certain the clinometer level is correctly set. To do this, the clinometer is set at 0, and the compass is placed on a smooth board that has been leveled exactly with an alidade or a good carpenter's level (a bull's eye is not sufficiently accurate for this). If the tube bubble does not come to centre, the compass is opened as described above and the clinometer level vial moved appropriately. Ordinarily, this can be done without loosening the clinometer set screw. The new setting is checked by placing the compass on the board again, and the procedure repeated until the bubble is centered exactly.

In starting work in a new field area, one may find that the dip of the earth's magnetic field is so great as to cause the compass needle to rub against the glass lid when the compass is held level. To correct this, the glass cover is removed and the copper wire coil on the needle moved one way or the other until the needle lies level.

1. Explain why it is important to take care of your compass while in the field.

2. Describe the procedure of adjusting a compass whose clinometer level is not correctly set.

4.9 USE OF THE HAND LENS

Geologists often look at rocks with a small magnifier called a **hand lens** in order to pick out fine details – the twinning on a plagioclase crystal in gabbro or the shape of quartz grains in sandstone, for example.

Most hand lenses consist of one or several optical elements protected by a metal or plastic swing-out case. There are 7X, 10X, 14X, and 20X magnifiers. Geologists usually carry a hand lens on a cord around their necks to have it handy.

When looking at a specimen through a hand lens, first bring the lens close to your eye with one hand. Then with the other hand move the sample towered the lens until it comes into focus. You should tilt your head back a bit so that as much light as possible falls on the sample. Natural sunlight is preferable to incandescent or fluorescent lighting.

Give examples of the usage of the hand lens in a geological mapping exercise.

4.10 Summary

In this lecture we have learned the various parts of the Brunton compass. We have discussed and learned various methods and techniques of taking bearings in the field. We have learned about strike and dip measurements and their primary importance in structural geology. Further to these we have defined the trend and plunge parameters of linear features and showed how their measurements are determined in the field. We illustrated the symbols to be used in describing these parameters. Finally we learned some basic procedures of taking care of the compass and how to make some physical adjustments incase of minor faults that may be detected in a compass.

4.11 References

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

Gokhale, N.W. 2003. Theory of Structural Geology. CBS Publishers and Distributers, New Delhi, India.