tively. In each quadrant, the readings are marked from zero to 90 degrees. The N and the S markings on the dial, stand for zero degrees, while the E and the W markings stand for 90 degrees (Fig. 2a).

In the circular bearings, the marking of N on the dial, stands for zero or 360 degrees. The reading of 90 stands for the east direction, 180 for the south direction, while 270 stands for the west direction. The values of the angle, increase in an anti-clockwise manner (Fig. 2b). At this juncture, it is felt necessary to explain asto why the compass is called as a "clinometer compass". Unlike "the land surveyors', the geologists have to record the inclination of the "bedding planes of rocks, the joint planes, the fault planes, the plunge of lineation, and so on". This aspect can not be achieved by the magnetic needle of the "Surveyors compass". The word "clino" means angle (inclination), and "meter" means a measurer. Therefore a "clinometer compass" is an instrument that measures the inclination of the planar surfaces from zero (horizontal) to 90 degrees (vertical), besides being useful in measuring the directions.

In order to measure the inclination of the planar surfaces, a "non-magnetic strip" is fixed below the needle of the compass (in the case of a clinometer compass), and it is called as a "pendulum", because it swings like the pendulum of a clock. In the case of a Brunton compass, the strip is fixed between the pivot of the needle, and the "E" marking on the dial. These features have been shown in Figs. 4a, b,c and those can be seen in Photos 1a, c.

In the case of a clinometer compass, the "pendulum" rests on the dial, when the instrument is monitored to take the bearings, trends of shears, and so on. In such a position of the compass, the pendulum is ineffective, as far as the measurement of the inclination of a planar surface is concerned. When the dial is made vertical (Figs. 4a and 5), the pendulum becomes operative, and it can then register the inclination of a planar surface.

If the planar surface be reasonably smooth, then the bridge of the clinometer compass should be placed on the surface, whose inclination is to be measured (Fig. 4a). If the surface be not smooth, or be inclined one, then the bridge should be monitored parallel to such a surface (Fig. 4b and 6, see frontispiece photo, wherein the geologist is holding bridge of the clinometer compass parallel to the dipping beds).

The mechanism of measuring the inclination of a planar surface with a Brunton compass is a bit complicated operation. The "index" which replaces the "Pendulum" of the clinometer compass (Fig. 4c.), is required to be manipulated by the "lever" which is fixed at the backside of the Brunton compass (Photo 1b). The lever is manipulated till the "air bubble" of the spirit level attached to the index, comes to the centre. The position of the index on the dial, registers the inclination of the planar surface. All this manipulation is required to be picked up and mastered, through a rigorous practice and patience.

PROCEDURE OF MEASURING THE TREND OF LINEAR ELEMENTS

Whenever the direction of any linear element is required to be measured (it may be the trend of a shear, the trend of a fault), *the north end of the dial should be oriented towards the object to be cited.* This is achieved by placing the clinometer compass on the palm of the hand, and then bending the bridge on the left hand side. In fact, the bridge bends only on the left hand side of the clinometer compass. By so doing, the

CHAPTER 4

Methods of Geological Mapping

INTRODUCTION

The preparation of a geological map from the data collected during the field work, comprises of marking the outcrops of the several rocks, as well as the several structural features possessed by them, on the base map (i.e., the topographical map). The igneous, the sedimentary, and the metamorphic rocks, possess different petrographical and structural features. Their mode of occurrence in the crust of the earth, is also different. Therefore, the methods to be adopted in mapping these three rock units, are found to be different. The methods are described in the following paragraphs.

SOME COMMON PROCEDURES

The first step is to get familiar with the topography of the area as presented in the base map (the topographical sheet). As already mentioned, certain inferences could be drawn, in respect of the petrographical and the structural features of the rocks, from the shapes of the hills, the shapes of the streams and the rivers, the shapes of the valleys, and so on. The presence of the ridge-morphology, suggests the existence of vertical beds (rocks), or a basic dyke (dolerite, basalt). A hill with a steep slope on one side (the contours will be found to be very closely spaced to one another), and a gentle one in the diametrically opposite direction (on this side, the contours will be found to be spaced farther apart from one another), is indicative of the hill being composed of gently dipping sedimentary rocks. Such a topography is described as the "Dip slope and Escarpment scenery". A very straight course of a stream or a river, acutely meandering stream or a river, indicate presence of a fault, or closely spaced shears. A gorge is invariably observed to be the site of a fault.

Therefore, the topographical map, the aerial photographs, the satelite imageries, should be critically studied, before setting out for the mapping exercise, specifically in respect of the shapes of the hills, the valleys, the streams, the rivers, and even the sea coasts. The topographical maps also have the bench marks, sites of temples, idgah, fort, and other prominent "land marks", on them. These are very useful during the process of locating the position of oneself (the geologist) on the map, corresponding to his position in the field, while carrying out the field work.

The second step is how to locate oneself on the map, during the mapping exercise. In order to achieve this goal, bearings are taken to at least to two known objects/spots, that are marked on the topographical map. Such objects could be, a temple built on a hill top, or an idgah, or any other prominent monument that has been marked on the map. These objects should also be distinctly visible to the person (geologist), from the spot (his position in the field), from where he is desiring

Photo 4. The photograph depicts "xenolithic structure". Note that the xenoliths are dark, varying in sizes, but are elongated ones. Also note that the xenoliths, in this case, are displaying parallelism between their longer dimension. Note that the handle of the hammer is placed parallel to the longer axes of the xenoliths. The xenoliths are occurring in gray granites exposed in the southeastern vicinity of Gangavati town, Raichur-Bellary districts, Karnataka state. (Courtesy- Dr. V. N. Hegde).

The disposition, the distribution, the shapes and the sizes of the xenoliths are of paramount importance in deciphering the mode of origin of the granitic rocks. Therefore, whenever the xenoliths are met with, separate and detailed sketches should be drawn, depicting the position of each and every xenolith. If these be found to possess one of their dimension greater than the others, the trend of the longer axes of the xenoliths should be invariably recorded, and accurately shown in the form sketches. The magmatic or the non-magmatic origin of the granitic rocks, is many times proved from the shape and the attitude (trend) of the longer axes of the xenoliths. Effort must also be made to identify the minerals composing the xenoliths, during the field work, because, this knowledge later helps to trace the source rock of the xenoliths. Whatever is observed in the outcrop of the xenolith, it should be faithfully and accurately documented in the form sketches. It is also advisable to take field photos, especially of the shapes and the sizes, and disposition of the xenoliths. Such photos are to be later scrutinised carefully in the laboratory. Such a study helps to classify the xenoliths into i) Cognate and ii) Accidental varieties. But this is possible, provided acute observations are made during the field studies. The xenoliths are also called as the inclusions, the schlirens, the rafts, and so on.

In conclusion it may be noted that with the igneous rocks, the mapping should be conducted on the following lines;

(a) The contact with the country rocks to be traced and studied very carefully,
(b) The disposition, the shapes and the sizes of the xenoliths to be mapped carefully,
(c) The trend of the dykes to be recorded, and these intrusions to be followed along their extent till these disappear,
(d) The samples to be collected along the width of the dykes and the sills,
(e) Separate sketches on bigger scale to be drawn for the dykes and the sills,
(f) Field photos to be especially taken, wherever xenoliths are encountered,

Locate the side on which the off-set beds" truncate abruptly" (in the case of the current bedding), or the direction in which the grain size becomes fine (in the case of the graded bedding), or the side on which the ripple is concave (in the case of the oscillation ripples). Then the side on which the off-set beds truncate abruptly, or the grain size becomes fine, or the ripples are concave, that side marks the top of the bed. These features are shown in Figs. 18 a,b,c and 19a,b,c,d.

Therefore, while mapping the sedimentary rocks, it is also necessary to devote attention to the current bedding, the graded bedding, and to draw separate sketches, besides taking field photographs of these structures.

The boundary of the sedimentary rocks with the igneous, or the metamorphic rocks, is required to be traced and mapped. Such a procedure alone will enable to describe the limit and the shape of the basin into which the sediments were laid. It is generally observed that the sedimentary basins are more long than wide, and possess an elongated form. Thus the famous "Tethys" which gave rise to the Alpine-Himalayan mountain ranges, is several hundred kilometers long, but the width is considerably small. The Kaladgi sedimentary basin is about 230 km. long, but the width is considerably less. The features to be emphasized is that the shapes of the sedimentary basins have been established, only after a careful, faithful, and accurate mapping of the sedimentary rocks.

The indicators of depth of a basin (and therefore the thickness of the sedimentary rocks comprising the basin) are primary structures namely, the ripple marks, the mudcrakes, and rain prints. These structures reflect a shallow depth of water, and in turn that of the basin. Therefore, while conducting mapping exercise, the presence of the said structures, and their disposition in the area, are required to be recorded.

The sedimentary rocks help to establish the climate under which the sediments were derived. The "Millette seed sands" in a sandstone, indicate an arid climate. "Facetted pebbles, unassorted pebbles, extremely large sized boulders, undecomposed laths of felspars, varved clays"' all of these e features, indicate a cold climate to be prevalent, at the time of disintegration and the decomposition of the parental rocks, and transportation and deposition of the products of weathering. Therefore while mapping, one should look out for the aforesaid features, in order to get an idea about the palaeoclimate of the region.

METHODOLOGY FOR METAMORPHIC ROCKS

These rocks share the characters of the sedimentary and the igneous rocks, because, these are derived from them. Therefore, to some extent, the features of the field techniques adopted for mapping the igneous and the sedimentary rocks, are also adopted to the metamorphic rocks too. However, there are certain petrographical, and the structural elements that are the monopoly of the metamorphic rocks. Those elements must be taken into consideration, while carrying out mapping, in a metamorphic terraine. The details have been elaborated in the following paragraphs.

The uniqueness of the metamorphic corks is their distinctive mineralogy and the textures. These rocks are recrystallised and reconstituted from the pre-existing sedimentary and/or the igneous rocks. The source of heat is required to be located, which had brought about the recrystallisation (metamorphism) of the pre-existing rocks. While dealing with the igneous rocks, it was said that the magma intrudes into the crustal rocks. As the magma starts crystallising, heat is given out, which in