Lithological and Structural characterization of rocks around Sagar, District Sagar, Madhya Pradesh, India

Navneet Franklin James, Sunil Kumar Panday
Research Scholar
Department of Applied Geology
Dr.Harisingh Gour Vishwavidyalaya, Sagar M.P

Abstract: The present paper covers the lithological and structural setup **around** Sagar, District Sagar, M.P., the author(s) have found that the study area consist of rocks belonging to Mesoproterozoic (Vindhyan Supergroup) and the Upper Cretaceous (Deccan **Volcanic Province**) lava flows with Inter-trappean beds above which the laterite and alluvium of Pleistocene and recent period is covered. The Vindhyans rocks are older than the Deccans rocks forming the inliers. The study area falls under the SOI toposheet No's. 55 I/9 and 55 I/13. The Deccan trap lava blanket these are older units and gave rise to the major topographical features of the area, namely flat-topped hills and step-like terrances, this topography is the result of the variation in the hardness of different flows and of parts of the same flow. The Vindhyan sandstone is very well stratified. The major structural features include primary sedimentary structures like bedding plane, laminations, current bedding, graded bedding, ripple marks, etc. and secondary structures Joints, Tracks and trails, Amygdaloidal structure, etc. The author(s) have prepared the geological map of the area with help of Satellite images, LISS III, SRTM, toposheet on ArcGIS 9.3 software and verified with the field investigations.

Keywords: **Lithological, Structural, Sagar, Vindhyans, Deccans, topographical features, Satellite, LISS III, SRTM, toposheet**

Introduction

In context of regional geology, the local geology of the area predominantly consist of Deccan Traps with intertrappeans (**Table 1)**. Laterite occurs sparely and alluvium is present on all the flows (figure 1). There are 12 flows of the traps with intertrappeans around Sagar (P.O. Alexander, 1977). There are both AA and Pahoehoe flows, though at times it is difficult to judge different flows. Columnar joints are common but not prominent. Vesicles are abundant and show difference in size and shape with different flows. The flows are horizontal and vary in thickness laterally and vertically. Veneer of soil especially 'Regur' is present on all the flows. Obviously it is relatively thick forming the base for the agricultural activities.

These different flows can be identified/distinguished as:

- The break in topography: The topographic break in the slope is surest criteria to decide the contact between the two flows. This break is due to change in the physical properties of these flows and gives rise to step like appearances to trap hills.
- The presence of intertrappean/laterite: The presence of thin intertrappeans sediments or ash beds separates one flow from the other. They are formed during the time interval between the two successive eruptions.

Table 1. GEOLOGICAL FORMATION IN THE ORDER OF SUPERPOSITION

Pleistocene & Recent	**Alluvium** **-----------------unconformity--------------** **Laterite**
Upper Cretaceous	Deccan trap lava flow with intertrappeans beds of limestone and clay
--------------------------------------Unconformity-------------------------------------	
Precambrian	Vindhyan sandstone

Methodology

The author(s) have prepared the geological map of the area with help of Satellite images, LISS III, SRTM, toposheet no's 55 I/9 and 55 I/13 on ArcGIS 9.3 software and verified with the field investigations (figure 1.).

Result & Discussion

Lithology

- **Vindhyan Sandstone**

  In the study area, sandstone & quartzite of upper Rewa formation are well exposed. Near Bhapel village, Railway cutting of Sagar, Sanichary hills, and Pili Kothi hill Upper Rewa Quartzite are seen. The grains are almost rounded and invariably cemented by ferruginous materials. They are tough, massive & pinkish white to reddish & Break with sharp edges. They occasionally show cross bedding and ripple mark.

  The Upper Rewa sandstone covers most of the part of the study area. It is fine to medium, red & brown in color. They generally represent the 8° to 12° dip towards SSW. They are well exposed in N & NW area of study area mainly in Jarara, Patora, Bhapel and few exposures are also observed in Bamhori Village. In thin section Medium to fine grained, sub angular to sub rounded (10×10 magnification) showing ferruginous cementing material with siliceous matrix, moderately sorted, mainly consist of quartz grains (identified by wavy extinction). In hand specimen Pinkish color, compact rock gives blocky appearance. Quartz Arenite in thin section Reddish brown color, medium to coarse grained, inequigranular grains of the quartz (identified by wavy extinction), no feldspar seen, angular to sub-angular grains (10×10 magnification) with ferruginous cementing material, poorly sorted. In hand specimen light pink color, very compact broken with sharp edges. The vindhyan sandstones are generally undisturbed and almost horizontal, with local dips up to 20 – 50 being not uncommon. Presence of abundant ripple marks and current bedding suggest their deposition in shallow agitated water.

- **The Deccan Traps (Malwa Trap)**

  12 flows covers the entire area. The Deccan trap immediately overlies the denuded surface of Vindhyan sandstones. **At few places Vindhyan are overlain by sedimentary beds of upper cretaceous age which are predominantly, friable sandstone and limestone**. ? The Deccan lava blanket these older units and give rise to the major topographical features of the different flows and of parts of the same flow. Laterite and alluvial constitute the youngest unit of the area under study.

  The Trap is well exposed in S & SE area of the study area. The prominent joint direction in the trap is NE-SW &NW-SE, which coincide with the joint direction in upper Rewa Sandstone. In the study area, three basaltic flows and two inter-trappeans are seen .On the basis of break in slope, size & shape of vesicles amygdaloidal structure, size and shape boulder, weathering pattern of inter-trappean bed etc. The basaltic flows are marked. Green and red bole are also noticeable in the study area. 12 flows occurs in and around Sagar district.

Lower flow of Basalt is melanocratic in color and compact and shows spheroidal weathering and small size vesicles, which are filled by, green color material cholorophiate. In thin section Medium grained, hemicrystalline shows sub-ophitic texture, consists of mainly plagioclase laths, clinopyroxene, little amount of iron oxide and chlorophyllite (10×10 magnification) is present as a secondary filling in the vesicles. In hand specimen melanocratic, aphanetic, vesicles are filled with green color mineral chlorophyllite.

Middle flow of Basalt is compact, melanocratic in color, vesicles showing reddish brown cholorophiate. In thin section Fine grained, hemicrystalline rock shows sub-ophitic texture, consists of mainly plagioclase laths, clinopyroxene and little amount of iron oxide (identified by metallic lusture), chlorophyllite (10×10magnification) is present as a secondary filling in the vesicles. In hand specimen Melanocratic, aphanetic, vesicles are filled with reddish brown color chlorophyllite.

Upper Flow is compact showing big boulder appearance. Here vesicles are filled with colourless, transparent, shining crystal of calcite. Few speaks of glauconitic are also seen. Abundance of chalcedony and opaline silica are also seen in the Southern margin of the study area.

- **Intertrappean sediments:** These sedimentary beds sandwiched between the lava flows, indicate that a considerable time gap between successive eruption. A number of these beds are fossiliferous indicating that the time gap was large enough for the development of an environment capable of supporting plants (mostly palms) and animal's life. Physa principia is one of the most characteristic species in the lower intertrappean at Sagar. Plant fossils at Sagar and other parts of central India have distinct Eocene affinities.
- **Laterite and Alluvium:** Not all flows have a laterite cover. A uniform thick cover is not usual, huge rounded boulders are more common. In composition these are invariable ferruginous, red to brown in colour and pesolitic. Alluvial cover in the area is extensive, ranging up to 10m in thickness but usually of limited extent. The hill tops and plateaus are normally covered with lateritic soil. As a result of weathering, the traps at lower elevations have given rise to 'Regur' or black cotton soil rich in plant nutrient such as lime, magnesia, iron and alkalies.

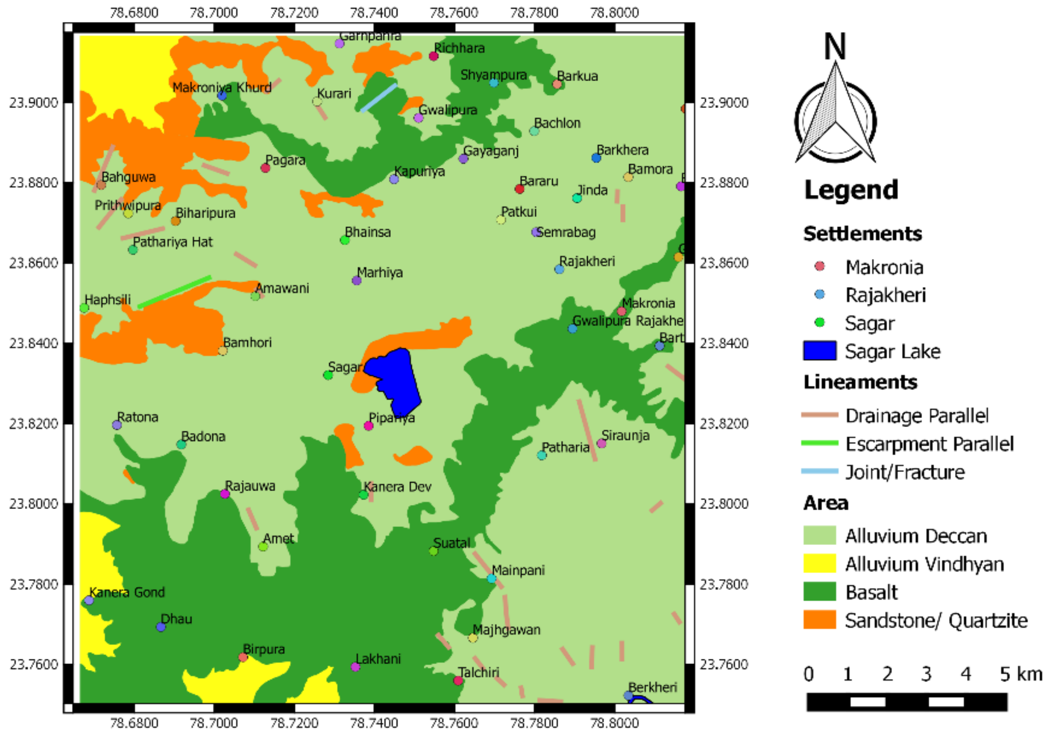

Fig 1 Showing the geological map of the study area, after P.O. Alexander, 1977

In figure 1 we can clearly see the area is composed of sandstones of Vindhyan formation which is the oldest formation which is been overlain by basalt rocks of Deccan trap formation the alluvium covers the rest of the areas. These alluvium is generally black cotton soil formed by the weathering of basalts and laterite soil which is formed by the weathering of sandstones. This map is been prepared on ArcGIS 9.3 and modified after P.O. Alexander, 1977.

Structural Set-Up of the area

The Vindhyan sandstone is very well stratified. The joint planes are observed generally to separate the rock into big blocks. Another internal feature shown by the Vindhyan sandstone is graded bedding, which is to be seen only at very few places. Ripple marks are to be seen here and there on the tops of these beds-symmetrical wave or oscillation ripple forms are the varieties observed in the area. Dips are ranging from 5^0 to 12^0 in a NNS direction.

The joint system of the area comprises two major sets and two minor sets of joints; the major sets trend NE-SW and NW-SE while the minor ones strike roughly N-S and E-W. The spacing of the joint varies from a few centimetres to a few meters. The typical joint directions are: - 140^0-320^0 – Strongest, 55^0-235^0 – Strongest.

In the study area, no major fold and fault are seen. PCD Layer is observed at the height of 560m - 570m in the NW Margin of the study area. Here some recumbent fold, Eye fold and Open fold are also observed. The general plunge direction of the fold is 20°N.

Vindhyans inliers consist of rocks surrounded by geologically younger rocks. Inliers results from the partial removal of overlying rocks and may be seen in valleys formed by denuded anticlines or domes and higher faulted crustal elevations. We found the inliers nature of Vindhyan near Bhapel.

The flows are of unequal thickness and each flow varies in its thickness from place to place. The vesicles and the amygdules appear to be usually concentrated at the top of the flows and generally help to separate one flow from other. The joints are very prominent and mostly of the column type. Sometimes the joint planes are so many in numbers and closely spaced that it becomes difficult to ascertain their trend.

Study in thin section:

- Vesicular Basalt from well near Lal Pahari is showing sub-ophitic texture in which laths of Plagioclase are surrounded by small crystals of Pyroxenes. The amount of both the minerals is approximately same.

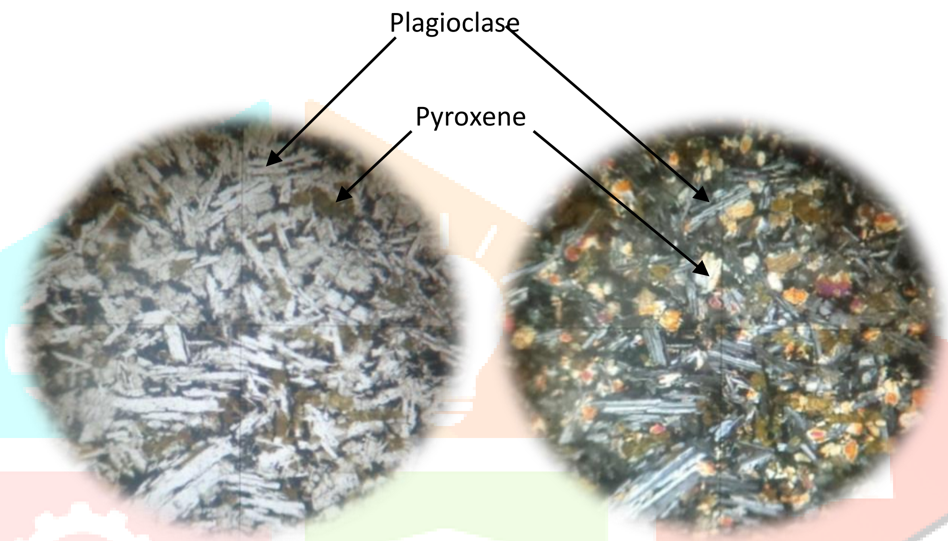

Figure 2. a. Deccan basalt under PPL b. Deccan basalt under UCN

- The Basalt from hill near Bhapel is also showing sub-ophitic texture but it is Plagioclase dominated.

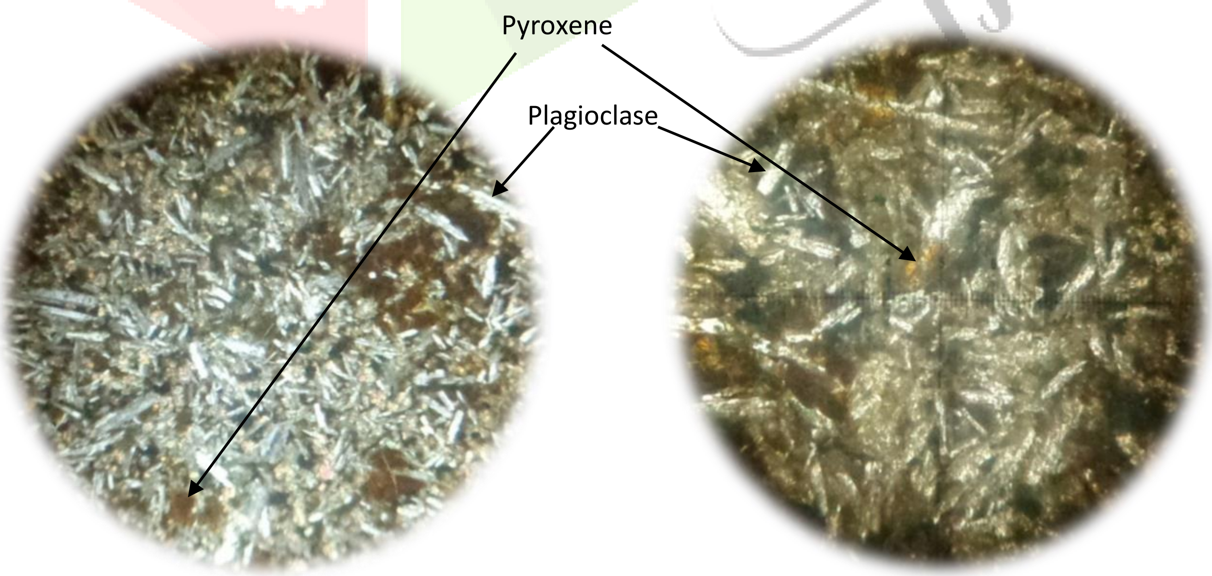

Figure 3. a. Deccan basalt under PPL b. Deccan basalt under UCN

Structural Characteristics

The major structural features include primary sedimentary structures like bedding plane, laminations, current bedding, cross bedding, graded bedding, ripple marks, mud cracks, rain drop imprints and syn-sedimentary slumping (pene contemporaneous Deformational structures), secondary structures such as joints, tracks and trails, etc. are those features that, are seen or studied best in the outcrop rather than in hand specimen or in thin section. Texture deals with grain-to-grain relations, best seen under microscope; structure deals with larger organizational units and is most clearly seen in the field. Study of structures, therefore, is as old as geology itself.

Primary sedimentary structures like bedding plane, cross bedding, current crescent structures, graded bedding etc. have been used as guides to the agent or environment of deposition. Structures such as graded bedding, mud cracks, current crescent structures and current-bedding have been used to ascertain stratigraphic sequence and top & bottom of beds.

i. **Bedding or stratification-**Bedding is a sedimentary structure composed of layers, each of which is distinguished by mineralogical composition, colour, and characteristics of rock particles etc. Bedding is typical of sedimentary rocks, constituting one of the most important features. The layers are usually separated from each other by more or less distinct bedding planes. (figure. 4)

Insoluble mechanically transported material is deposited in layers on the surface of accumulation which may be horizontal or inclined. These layers are called as "Bedding or stratum". Stratification may be the result of variations in composition, color of different layers, textures of layers and porosity of the different layers.

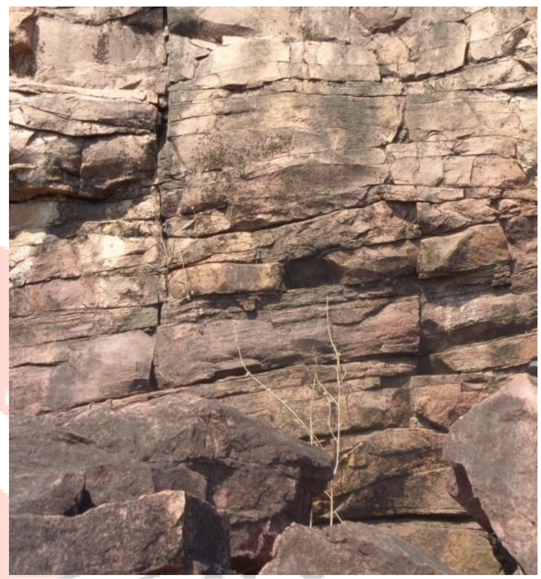

Fig 4. beddind in Vindhyan near bhapel

ii. **Laminations-**

If the individual layers are extremely thin, having the thickness less than 1 cm. the structures are known as "Lamination" (fig 5) and the layer is known as "Lamina" (plural-laminae). There are two types of laminations:

Dimictic lamination- When the contact between two laminae is sharp.

Symictic lamination- in such type of lamination, the contact between two laminae is rough.

The plane of contact between the laminas is known as laminating plane.

Fig 5 Laminations in Vindhyan near Tili

iii. **Current bedding-**

Any bedding structure produced by the current action under shallow water condition, is termed as Current bedding. The structure is original, and not due to tilting or folding. It generally develops when sandbanks are built up in shallow water. (Fig 6)

The oblique lines of cross- bedded layer always meet the upper concordant bedding at a higher angle and lower portion tangentially.

Fig 6 showing current bedding with paleo-current direction towards northwest

iv. Trough cross bedding-

The ripples on the sandy bottom usually migrate down the current action. This causes the development of miniature cross laminations. While the ripple marks appears as a surface feature, the cross laminations usually appears as an internal feature i.e. seen in section. Such cross laminations are called trough cross beddings. (Fig 7)

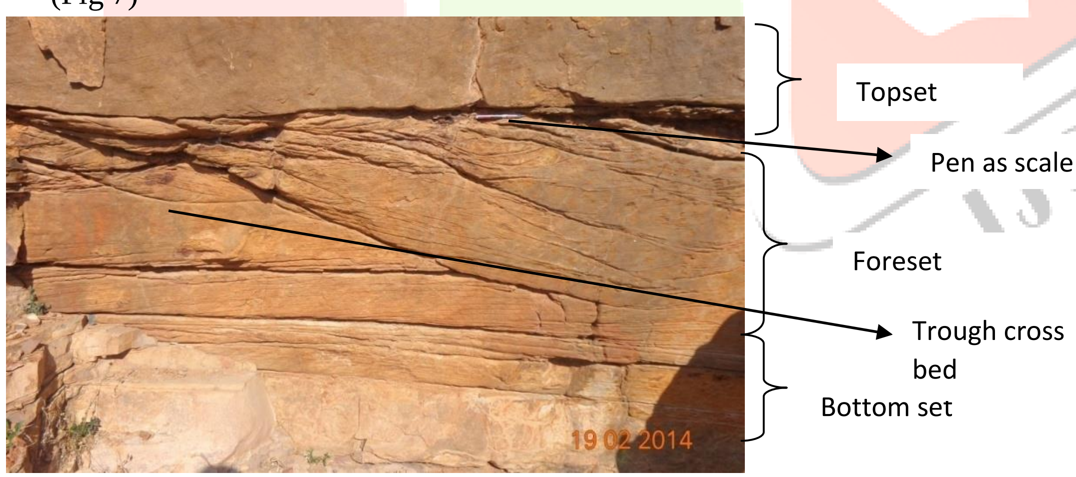

Fig 7 Trough cross beddings seen in Tilli section of Vindhyan sandstone

v. **Graded bedding** The bedding in which, there is a gradation of grain size from coarser at the base to finer at the top is termed as Graded bedding. It is having a sharp contact with underlying strata. In such type of bedding each layer displays a gradual change in particle size. The occurrence of graded beds indicates the stratigraphic order. They often occur in succession one above the other. Although graded bedding has been reported from different types of rocks, it is most seen in deep sea sandstones known to have been emplaced by turbidity currents. (fig 8)

Fig 8 Graded bedding encountered in Lal Pahari

vi. **Ripple marks**

Ripple marks are the minute wavy undulations formed on the surface of the beds by current in shallow water or by wind action; hence they may be aqueous or Aeolian in nature. Ripple marks are of two types: symmetrical and asymmetrical.

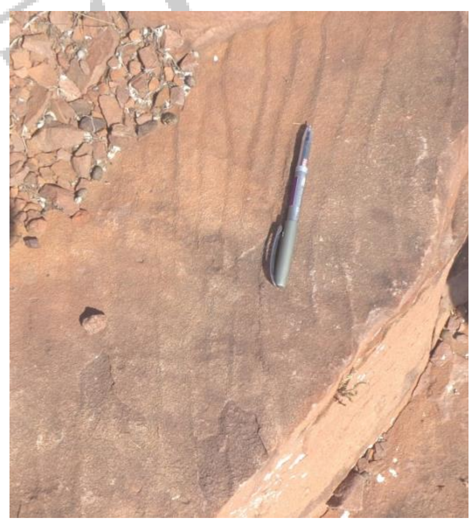

Fig 9 asymmetrical ripple marks

- **Symmetrical or oscillation ripple mark-** These are symmetrical in shape also called wave ripple marks. Wave ripple marks are produced on the shallow sandy bottom of standing water agitated by oscillatory motion at the water surface. They have sharp crests and rounded troughs. The shapes of symmetrical ripples are therefore good indicators of younging direction.

- **Asymmetrical or Current ripples mark-** These are asymmetrical in shape, having both the crests and troughs rounded. When a current of water flowing over a sandy bottom exceeds a certain velocity, the surface of sand is thrown into a series of asymmtric waves of more or less uniform wavelength. The waves have gentle slopes against the current direction known as stoss side and have steeper slope on lee side.Current ripple marks therefore indicates the paleocurrent direction.(fig. 9)

vii. **Mud cracks-** They are irregular polygonal fractures of "V" shaped with broader top and tapering at the bottom. Therefore they help in determining top and bottom beds of the area encountered locally in the alluvium. (fig. 10) The crack system develops as a result of shrinkage. Shrinkage in most cases is caused by loss of water by drying, which implies exposure. The cracks have therefore been termed as desiccation cracks or sun cracks.

Figure 10. Mud cracks

viii. **Raindrop prints-**

These are sedimentary structures formed at the top of sediments by raindrops. They have concave top and convex bottom and hence are also used as criteria for recognizing top and bottom. (Fig. 11)

Fig. 11 Raindrop prints

ix. **Syn-sedimentary Slumping structure or Penecontemporaneous Deformation (PCD)-** The structure which is formed during deposition but before consolidation due to earthquake or any other disturbances is termed as Penecontemporaneous deformational structure (PCD) or syn-sedimentary slumping. These slumping structures have been recognized in Hapsilli hill, Bhapel hill, Ratauna hill. (fig. 12)

Fig.12 slumping in hill near dairy farm at the top of the hill

x. Herringbone structure

The herringbone structures are formed due to tidal action near shore line. The dip direction of the cross beds above and below the reactivation surface is different. (fig. 13)

Fig. 13 Herringbone structure seen in Hapsilli

xi. Vesicles

Vesicles are found generally at the upper part of lava flows. They are formed when different gases of the magma escape as it comes in contact with the surface temperature and pressure. (Fig. 14) They increase towards the top of the flow.

Fig. 14 vesicles arranged in channel

xii. Colour banding

The colour banding has been seen in the Vindhyan sandstone in the well section at the foothills of Hapsilli hill. (fig. 15) It has also seen in the quartz in Deccan Trap volcanic hills.

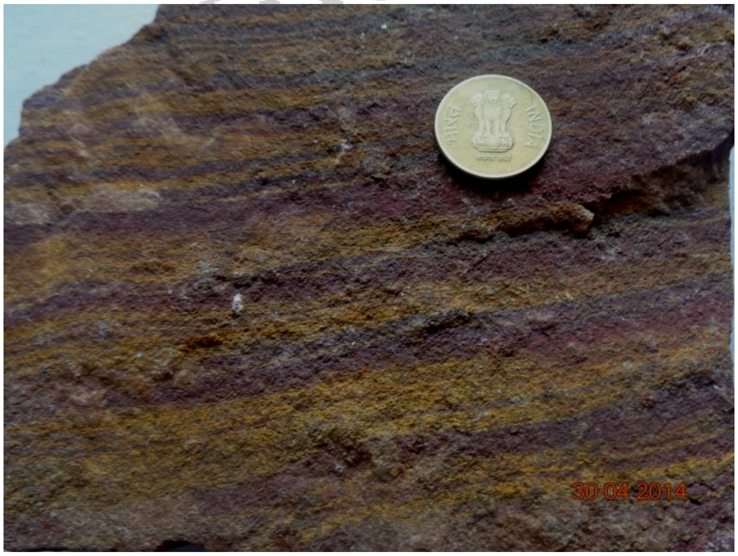

Fig. 15 colour banding I Lal pahari Sandstone

A. Secondary structures

i. Columnar joints-

Columnar joints are formed in tabular igneous masses. These joints divide the rock masses into generally hexagonal columns may also in rhombic or triangular columns. Columnar joints are the characteristic feature of basalts. [Fig 16]

Fig 16 Planar view of three set of joints in Jarara hill, Trend shown by pen, hammer and brunton compass

ii. Amygdaloidal structure-

When the vesicles are filled by Zeolites or any other mineral is called as amygdaloidal structure. (Fig 17)

Fig 17 Amygdaloidal structure

iii. **Geode structure-**

A geode is actually a hollow shell of rock, the interior of which is lined with an inwardly projecting crystal. The rock shell is generally made up of Chalcedony and inner incrustation of Quartz. (fig 18)

Quartz crystal projecting towards the centre

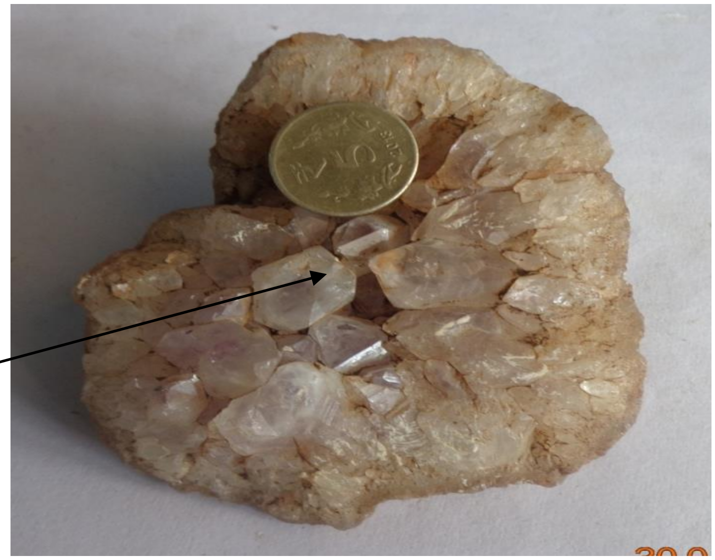

Fig 18. Geode in Deccan Trap

Summary

The local geology of the area comprises of Vindhyan sandstone as the older formation which is been overlain by the Deccan trap lava flow during the upper cretaceous period containing with intertrappean beds of limestone and clay, above which the laterite and alluvium of Pleistocene and recent period is covered.

The Deccan trap of Sagar immediately overlies the denuded surface of Vindhyan sediments. At a few places Vindhyan are overlain by the sedimentary beds of upper cretaceous and Limestones. The Deccan trap lava blanket these are older units and gave rise to the major topographical features of the area, namely flat-topped hills and step-like terrances, this topography is the result of the variation in the hardness of different flows and of parts of the same flow.

The Vindhyan formation exposed around Sagar belongs to the upper Rewa sandstone group which is exclusively arenaceous, consisting of unfossiliferous medium grained sandstone. The grains are almost rounded and invariably cemented by ferruginous material. Presence of abundant ripple marks and current bedding suggest their deposition in shallow agitated water.

Acknowledgement

Authors are thankful to Prof. R.K. Rawat, Head & Guide, Department of Applied Geology, Dr. Harisingh Gour Vishwavidyalaya, Sagar (M.P.) for providing necessary laboratory facilities, field equipment, etc., for conducting the research work. We also wish to express our sincere thanks to all faculty members and Non-teaching staff of Department of Applied Geology, Dr. Harisingh Gour Vishwavidyalaya, Sagar (M.P.) for their help and encouragement to carried-out this work. It’s our pleasure to thanks those knowingly and unknowingly, who have helped make this work success.

References

1. Alexander, P.O. (1977), “Geochemistry & Geochronology of Deccan trap lava flows around Sagar, M.P.”, India.
2. Billing, M.P., (1982), “Structure Geology”, 3rd edition, Prentice Hall of India Pvt. Ltd., New Delhi, pp. 493-581.
3. Dixit, V.K., Geohydrology of Deccan traps and the Vindhyan rock formations around Sagar District M.P.

4. James, N.F. & Rawat, R.K. 2015. Current Status of Pollution in Sagar Lake Using Geoinformatics. IJETST. Vol.02Issue07Pages 2855-2859.
5. Rawat, R.K. & James, N.F. 2013. Identification of Sources of Pollution in Sagar Lake UsingRemote Sensing Techniques, Indian Cartographer, Vol. XXXIII, pp 373-375.
6. Subramanyam, V. 1973 Geomorphology and its applied aspects of the area around Sagar (M.P.) University of Sagar, Ph.D. Thesis (Unpublished).
7. Subramanyam, V., (1976), Evolution of landscape around Sagar, Madhya Pradesh, Proceed Indian National Science Academy, vol. 41, A, No.5, pp. 448-469.
8. Thornbury, W.D., (2005), Principles of Geomorphology, CBS Publishers & distributers.
9. West, W.D. &Choubey V.D. 1964. The Geomorphology of the Country around Sagar and Katangi (M.P.). Journal Geological Society of India. Vol. 5. pp. 41-55.