Hemvati Nandan Bahuguna Garhwal University

2018-19

Geological Field Report

2018 - 19

Conducted In Neem ka Thana & Udaipur

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Acknowledgement

It is a matter of great pleasure for me to present this report on the field work conducted in Udaipur and Neem Ka Thana, Rajasthan, India. I have my deep expression of gratitude towards my all the faculty members for their worthy guidance and cordial support.

I am very thankful to Prof. Y. P. Sundriyal (Head of Department of Geology, HNBGU) for his enthusiastic encouragement, support, and guidance throughout the tour.

I also want to thank Dr. Sanjeev Kumar (Guest Faculty) and Prof. N. K. Chauhan (Sukhadia University, Udaipur) for their guidance and to enlighten me with their deep knowledge throughout the training to accomplish the field work successfully.

It was a tour, full of knowledge. It expanded my spectrum of understanding the subject matter of Geology. I also want to thank my peers who boosted me to perform well. At last but not the least I also want to thank the whole team including Non-Teaching and teaching staffs of our department who directly or indirectly helped us and the transporting agencies too. The role of each of them was inevitable for making this training successful.

Preface

Field work is one of the important integral part of geology. I must say that it broadens the mind and helps to understand geology comfortably. Generally, in field work a geologist collects geological samples and field data which is then analyzed in the laboratory of the geological departments and then represented in form of maps, slides, etc. After all the geological steps the ultimate goal is to understand the earth's history and understand the processes that occur on and beneath the Earth's surface. Whereas field training conducted for Master-students of geology, helps them to understand the geology of the real world which has been taught in the classrooms. Hence, In the academic session of final year of M.Sc. (hons) Geology in Hemvati Nandan Bahuguna Garhwal University, the students are facilitated with this well-organized field training event.

Our visit for field work training was in Udaipur and Neem Ka Thana. It was a program of 10 days, from 1^{st} April to 10^{th} April. First, we visited to Neem Ka Thana where we camped near the railway station. Here we visited two coal mines, Kolihan and Khetri copper mine. Our second visit was in Udaipur and we camped at Gujarati Samaj Bhavan in the city of Udaipur. Here we visited at different spots of Udaipur to study outcrops of rock and understand the geology. Here we saw different geological structures and also did the stereographic mapping of the region. The data and samples of rock were collected from these spots. Our program also included a one-day visit to GSI, Vedanta and Zawarwala mine. My all learnings and observations from this field work is presented in this report. Overall it was a successful field training, where I acquired lots of knowledge and had fun too.

Aims and objectives

The purpose of the Geological Field Training is to provide an opportunity to M.Sc. final year students for an alternative learning experience, which enhance the information that is being taught inside the classroom. It also has the aim to provide a point of relevance and understand the theoretical knowledge of geology in the real world. This field training program was primarily to learn various aspects of geological field studies not only just by the classical methods but also with the use of modern techniques such as Global Positioning System (GPS) which helps in digital mapping with location and altitude.

Data and Instruments used:

- Toposheet of Gujarat
- Brunton Compass
- Hammer
- GPS
- Safety Kit for underground mines
- Haversack

The tour timeline:

1st April 2019	We left for Haridwar
2nd April 2019	We reached Neem Ka Thana at evening at 08:00 pm travelled via Delhi
3rd April 2019	We visited to Kolihan Copper Mine
4th April 2019	We visited to Khetri Copper Mine
5th April 2019	We had lecture at Sukhadia university, Udaipur
6th April 2019	We had field work (outcrop mapping)
7th April 2019	We identification of geological structures (Udaipur) and Field work (outcrop mapping)
8th April 2019	We had field work (Study of geological structures) and visit to Vedanata
9th April 2019	We visit to Zawarmala mine and GSI
10th April 2019	We had lecture on stereographic projection and mapping with the help of field data

Contents

Study area of field tour (Day 1 & Day 2)

Jhunjhunu District, Rajasthan

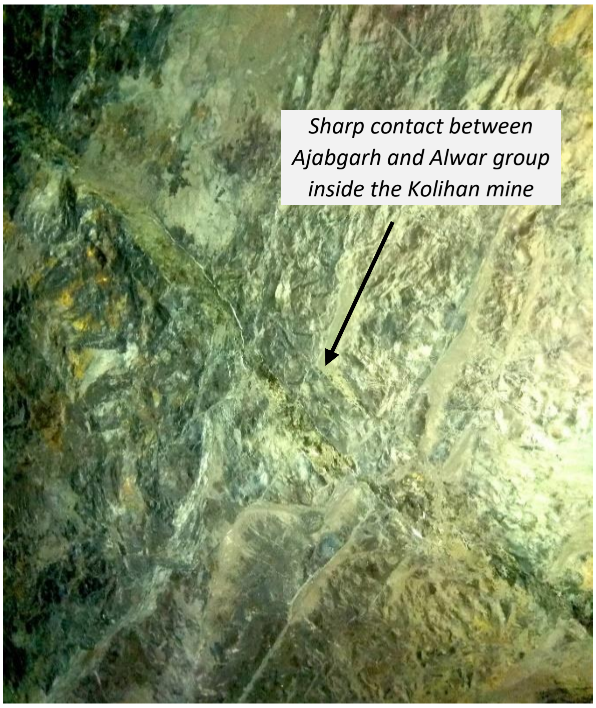
The district falls within Shekhawati region, and is bounded on the northeast and east by Haryana state, on the southeast, south, and southwest by Sikar District, and on the northwest and north by Churu District. It is located a 180 km away from Jaipur, the town is famous for the frescos on its grand Havelis special artistic feature of this region.

It is one of the prosperous Districts of Rajasthan. Its area is 5926 Sq. Km. Most of the part of the district is semi-desert. The Aravali ranges are embracing the south-eastern part of the district.

The Kolihan and Khetri copper mines of Jhunjhunu district lies on the Delhi supergroup.

Political boundaries of Delhi supergroup

The whole region lies under Delhi Super group. The extension of Delhi supergroup on surface is from the North through Ajmer and Mewar in Rajasthan to Idar and Palanpur (Gujarat) in the South.



Stratigraphy

Sant and others in 1980 studied these rocks in alwar district and proposed the stratigraphic distribution and classification, 6000 metres thick, these rocks are; the Delhi sequence start with basal conglomerate and show facies changes in the lower part, it is mainly arenaceous to calcareous in the middle part and the upper part is predominantly calcareous in nature.

Local volcanism is reported in Ajabgarh group and represented by mafic lava flows, tuffs and tuffaceous rocks with amygdoloidal lavas. Source rocks have mixed lithology with orthoquartzite, lower to middle grade metamorphic acid plutons.

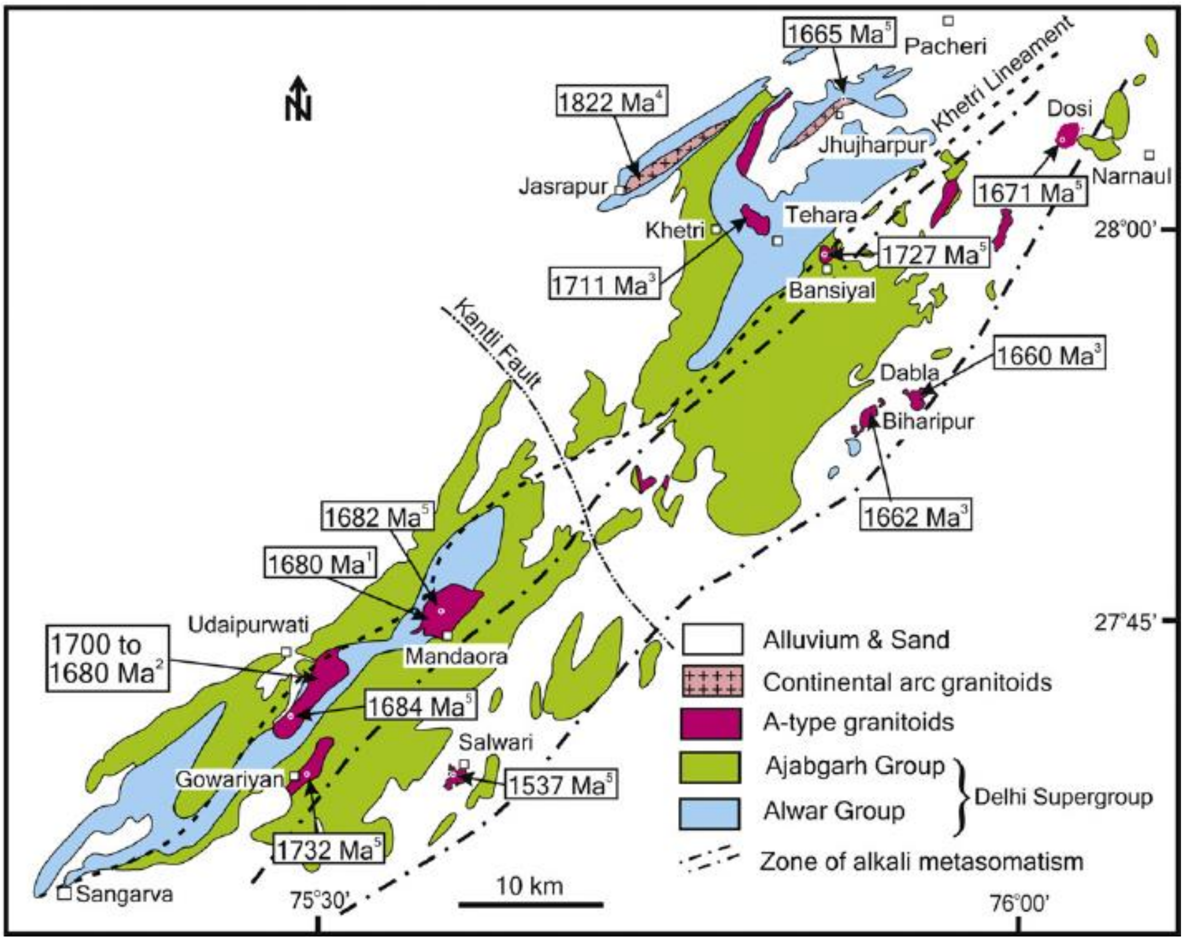
Supergroup	Group	Formation
Delhi Supergroup	Ajabgarh	Arravali
		Bharkol
		Thanaghazi
		Sariska
		Kushalgarh
		Partabgarh
	/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\Unconformity/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\	
	Alwar	Kankwarhi
		Rajgarh
	/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\Unconformity/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\	
	Railo	Tehla
		Dogeta

Metamorphism and Structure

Two distinct metamorphism facies have been noticed in these rocks in north-east Andolusite, Stranlite association where as in south-west it is medium grade. In the north central part of Aravalli mountains these rocks have been subjected to 2 phases of deformation whereas in Alwar region there are 3 generations of folding. The total strike length is about 700km.

Life & Age

In the form of small disc like fossils and fungal spores in Alwar Quartz granulite, the stromatolites are almost abundantly present. The age of the Delhi supergroup is Middle Proterozoic age ranging from 1800ma to 1500ma.

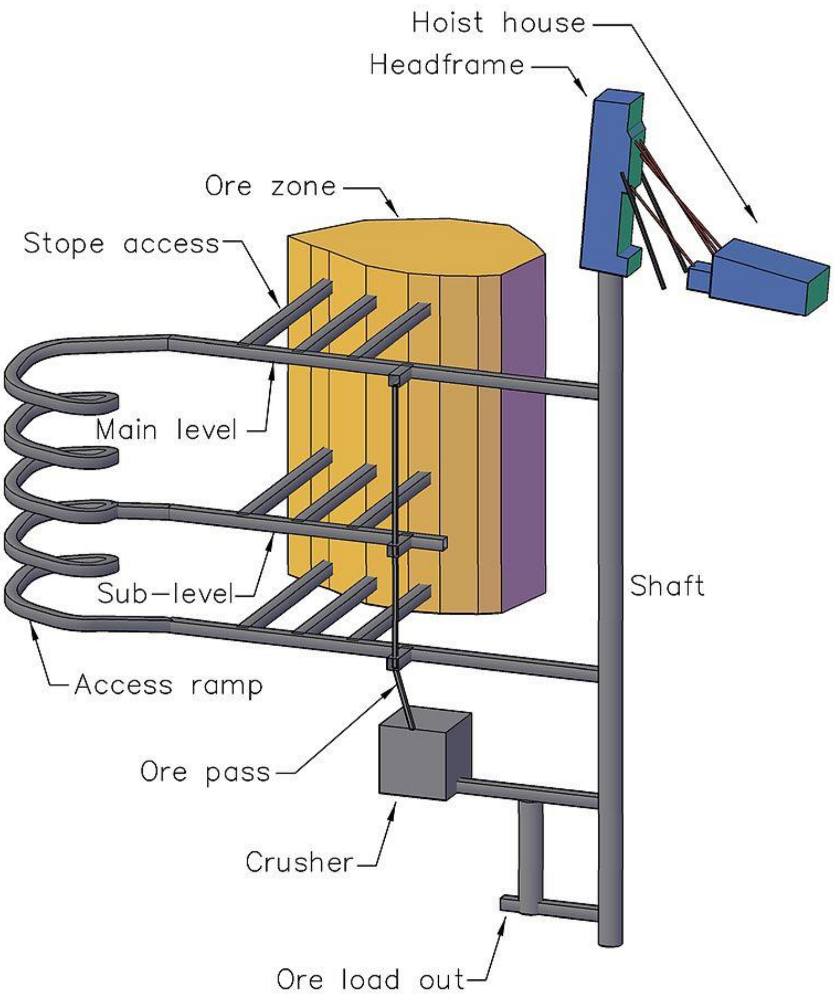


Deformation Environment

A shallow marine depositional environment has been proposed on the basis of cross-bedding, asymmetrical ripple marks. Although entire Delhi basin was shallow marine but apparently Ajabgarh group was deposited in comparatively deeper environment than Alwar group.

Deposition of this place occured without any major break in sediments, although local pauses in sedimentation are represented by discontinuous lenses of conglomerate at level in Alwar group. There is presence of syngnetic sulfide deposits in Khetri, Dehri, Ambaji, etc which show deposition reducing conditions.

Underground mining structure



Shaft

It is excavating a vertical or near-vertical tunnel from the top down, where there is initially no access to the bottom. It is mainly used for mobility of man power and materials.

Headframe

It is the structural frame above an underground mine shaft. Functions as a surface station.

Stope

An excavation in the form of steps made by the mining of ore from steeply inclined or vertical veins. **Stoping** is the process of extracting the desired ore or other mineral from an underground mine, leaving behind an open space known as a **stope**. Stoping is used when the country rock is sufficiently strong not to collapse into the stope, although in most cases artificial support is also provided.

Main level

Horizontal tunnel connecting the shaft to the sub levels, ramps, and other pathways.

Ore removal

In mines which use rubber tired equipment for coarse ore removal, the ore (or "muck") is removed from the stope (referred to as "mucked out" or "bogged") using center articulated vehicles (referred to as boggers or LHD (Load, Haul, Dump machine)). These pieces of equipment may operate using diesel engines or electric motors, and resemble a low-profile front end loader. LHD operated through electricity utilize trailing cables which are flexible and can be extended or retracted on a reel.

The ore is then dumped into a truck to be hauled to the surface (in shallower mines). In deeper mines, the ore is dumped down an ore pass (a vertical or near vertical excavation) where it falls to a collection level. On the collection level, it may receive primary crushing via jaw or cone crusher, or via a rock breaker. The ore is then moved by conveyor belts, trucks or occasionally trains to the shaft to be hoisted to the surface in buckets or **skips** and emptied into bins beneath the surface headframe for transport to the mill.

Day 1

Entrance Gate of Kolihan Copper Mine

Visit to Kolihan Copper Mine

Date: 3rd April 2019
Time: 07: 50am

Location:

Latitude: 28°0’49” N
Longitude: 75°46’44” E

Nearby;

Khetri town 3.0 KM
Jaipur 170 KM
Delhi 190 KM

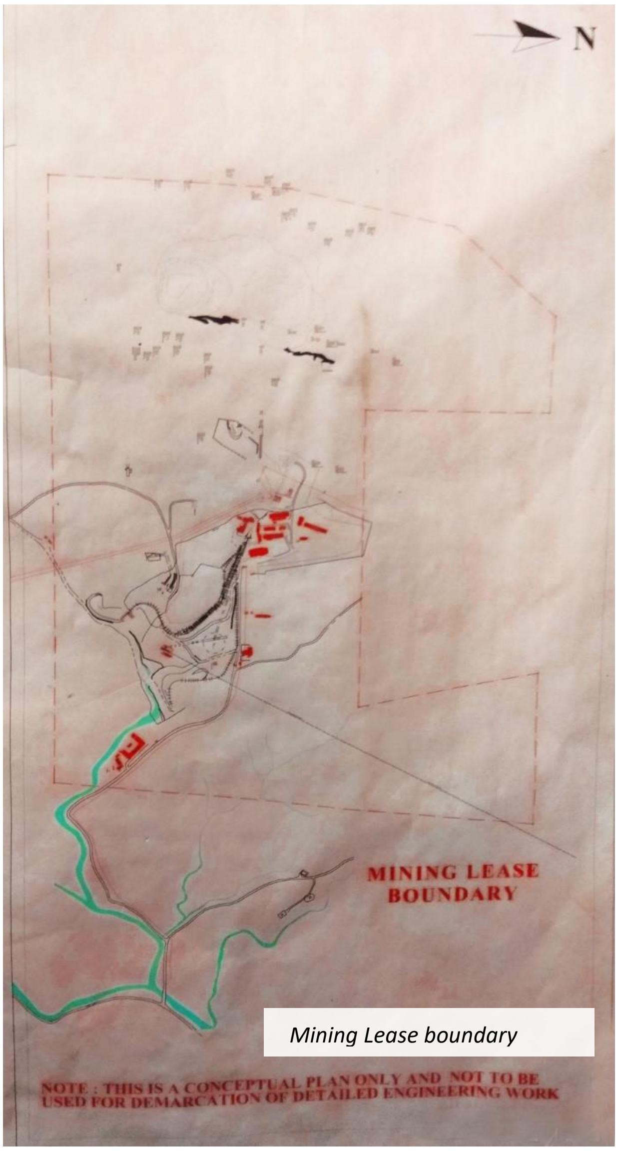
We camped at 'Neem Ka Thana,' 35km away from Kolihan mines (site). The mine is situated in Kolihan Nagar, Jhunjhunu district, Rajasthan.

About the mine

Under the Khetri Copper Complex, two underground mines are takes place, one is Khetri Copper Mine and another is Kolihan Copper Mine located at the foothills of Aravalli. All the mining methods are similar to the Khetri Copper Mine. The mining method installed is, blast hole stopping. The mine has different segments controlling different parameters of the mine (plan, finance, safety, infrastructure, etc.). The commencement of production was established in January, 1971. The total lease area is 163.23 ha., the protected forest area is 161.83 ha., and the non-forest area is 1.40 ha. The ore reserve as on 2018 is 14.5 million tons.

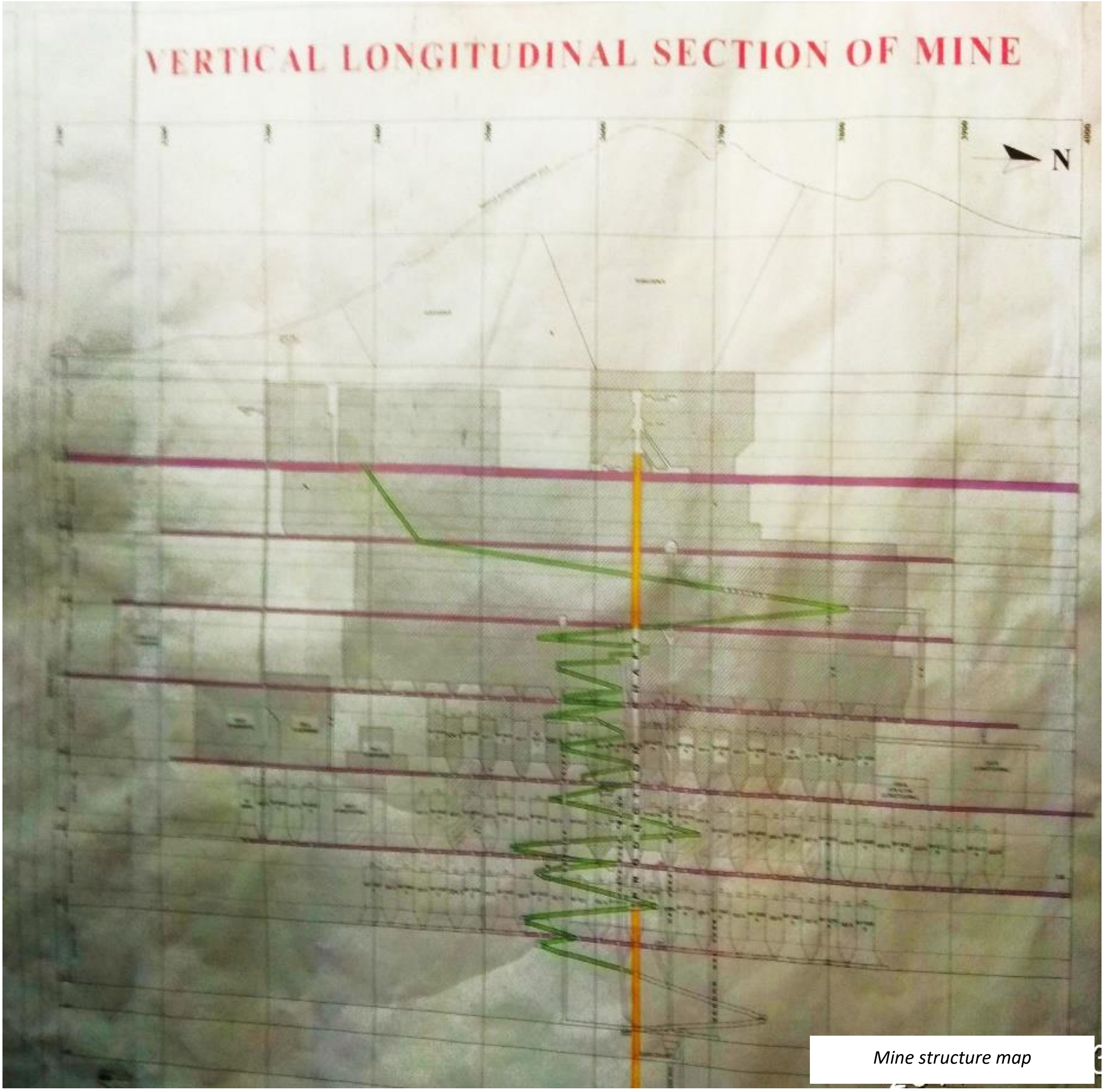
Further details are as follows:

- Stratigraphic position: Ajabgarh and Alwar suite of rocks of Delhi system of supra crustal belt.
- Strike length: 750m
- Average dip of the ore body: 70-75°
- Width of the ore body: 75-120m
- Peak level: 670 ML
- Valley level: 422ML
- Host rock: Garnetiferous Chloride Quartz Schist, Quartzite, Amphibole Quartzite
- Sulphide mineralization: Bands Stringers, Lenticles and dissemination of Chalcopyrite, Pyrrhotite



Mining Lease boundary

- <u>Control of mineralization:</u> Bedding, Fractures, Joints, Shears and Foliation planes
- <u>By products:</u> Gold, Silver, Tellurium, Selenium, etc.
- Annual production: 1 million tons of copper ore
- <u>Mode of entry:</u> Adit at 424 ML, underground shaft at 424 ML, Decline from 424 ML to 64 ML



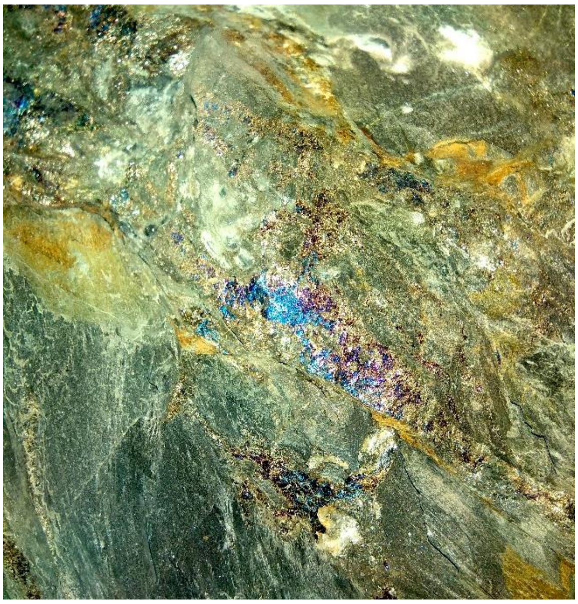
Mine structure map

Department of geology (Kolihan copper mine)

Digging of host rocks inside a sub-level tunnel

Rocks and Minerals in the mine:

Host rock (Amphibole Quartzite)

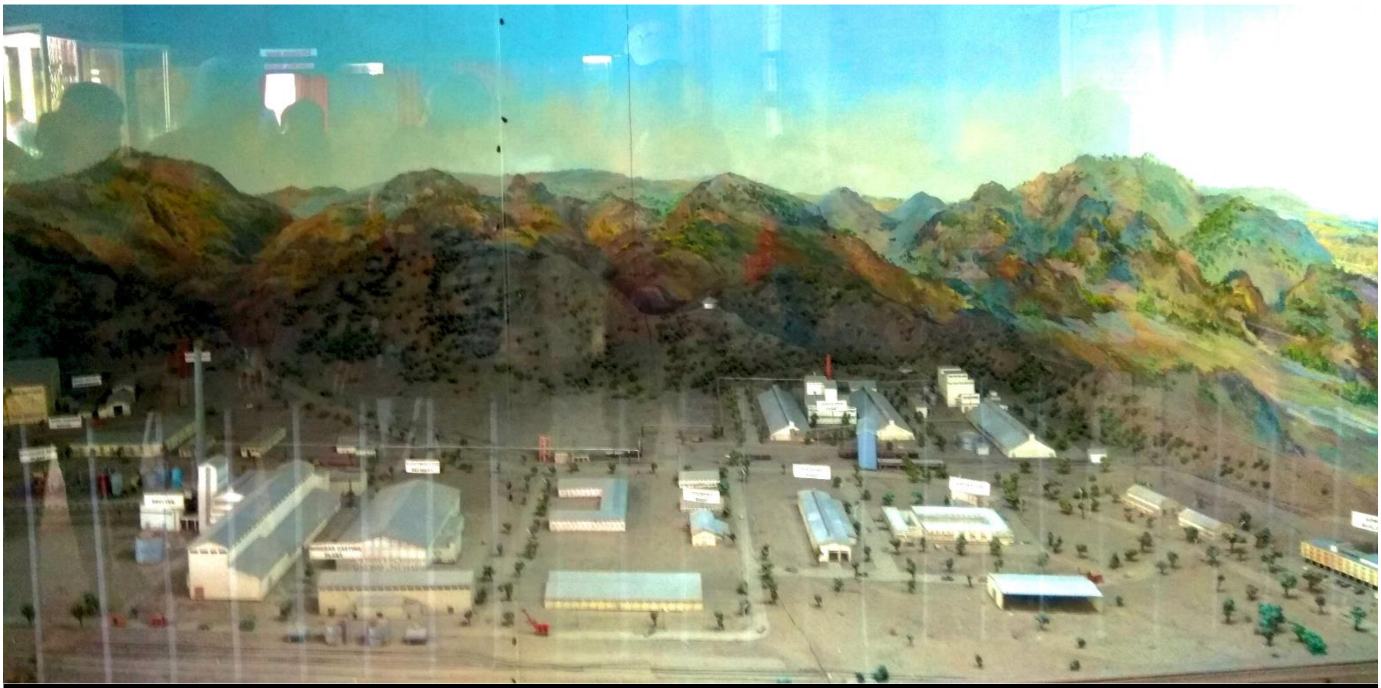


Bornite (a. k. a. peacock ore)

Group Photograph at Kolihan Copper Mine

Day 2

Visit to Khetri Copper Mine



Surface Infrastructural Model of Khetri Copper Mine

Date: 4th April 2019
Time: 07: 30am

Location:

Latitude: 28°04’35.194” N
Longitude: 75°48’47.115” E

We camped at ‘Neem Ka Thana,’ 35km away from Khetri copper mines (site). The mine is situated in Khetri Nagar, Jhunjhunu district, Rajasthan, about 190 km southwest of Delhi and 180 km north of Jaipur.

About the mine

Khetri Copper Complex (KCC) is a major constitute part of Hindustan Copper Limited. The Geological Survey of India began prospecting this area in 1954 and exploratory mining by the Indian Bureau of mines began in 1957. The project was handed over to the National Mineral

Development Corporation in 1961 for further investigation. The design to proceed with the development of Khetri Copper complex was taken in 1962. Shaft sinking and mine development began in 1964 and the first production of ore took place in 1970. The project was transferred to the Hindustan Copper Limited in 1967.

There are four mines in Khetri complex; two major Khetri and Kolihan Underground mines, the Chandmari open pit and Dariba Underground mine. Two underground mines are in operation at Khetri Copper Complex. Khetri mine was designed to produce 5000 tons per day considering four level under production. Maximum production done from the mine was over 1 million tons in the year 1990 to 1993 (1.00 million tons in 1990-1991, 1.06 million tons in 1991-1992 & 1.05 million tons in 1992-1993) when four levels were active. Until 01/04/2006 cumulative extraction from Khetri mine is over 20.9 million tons of ore containing more than 1,69,022 tons copper.

Mine layout

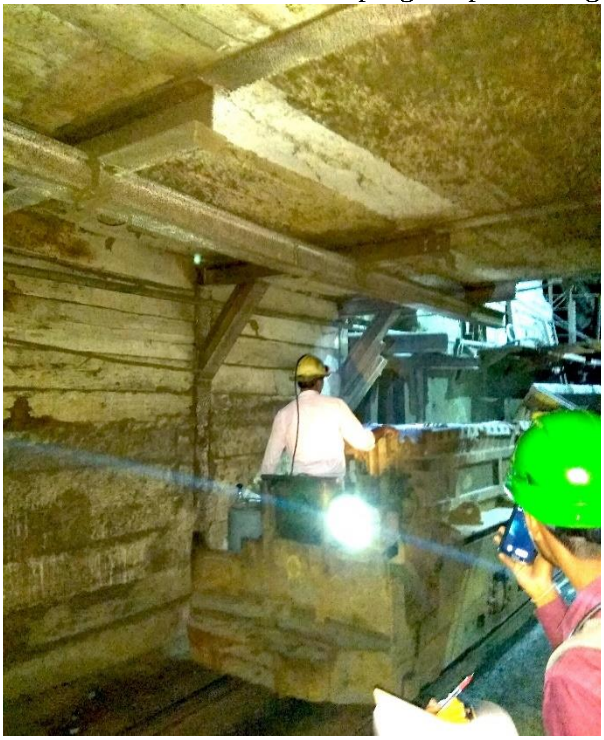
Mine working extends over a strike length of about 3.6 kms. It is the largest underground metal mine in the country. The mine is divided into main levels at ~60-meter level interval. The top level is 421meter level (ML) and the lowest level is 0ML coinciding with mean sea level (MSL).

Ore from upper four levels viz. 421ML, 350ML, 300ML and 240 ML is completely mined out and present production is contributed by 180ML and 120 ML. The mine is developed on track system of transportation except 421ML and 300ML, which were developed on trackless system.

Mining procedure from extraction onwards

<u>Extraction of ore</u>

The method of exploration, development and stopping are similar in both the mines. A footwall drive is developed based on surface drill hole intersections and definition drilling is carried out from these drives to delineate the geometry of ore body, with the help of underground diamond drill machine. The removal of blasted rock in sublevels is done by auto-loaders. At main levels, trackless load haul dump (LHD) and low-profile dump trucks (LPDT) are used. Principal stoping method is sub level stoping for narrower ore bodies (preferably less than 15mts) and large diameter blast hole stoping used for wider ore bodies. In sub level stoping, stope drilling is done in ring fashion by pneumatic drifter either BBC 120 or M-110 C. The hole diameter is 57 mm and maximum hole length is 25 meter. In blast hole stoping method, large diameter holes are mostly parallel to the general dip of the ore body. The hole diameter is 165mm and length is about 50 meters. The machines in use are Down The Hole (DTH) drilling machine like Mission Megametic. The mine is highly mechanized. For transportation of ore bodies from underground to the surface, Granby Cars of 10 tons capacity in combination with trolley wire locomotive are used.



Locomotive used inside the mine

Dedusting Unit of Ore

The ore from the mine is transferred to the dedusting unit. Here the ore is cleaned to remove the unwanted components. The process of cleaning may involve washing, boiling, drying, etc. Further after dedusting the ore is prepared for the crusher.

Crushing Unit

In this unit large masses, boulder, cobbles, pebbles, etc., are crushed or milled under the large rollers with very heavy capacity. The rollers installed at several levels crushes the rocks into fine particles or powdered material.

Concentration / Floatation Plant:

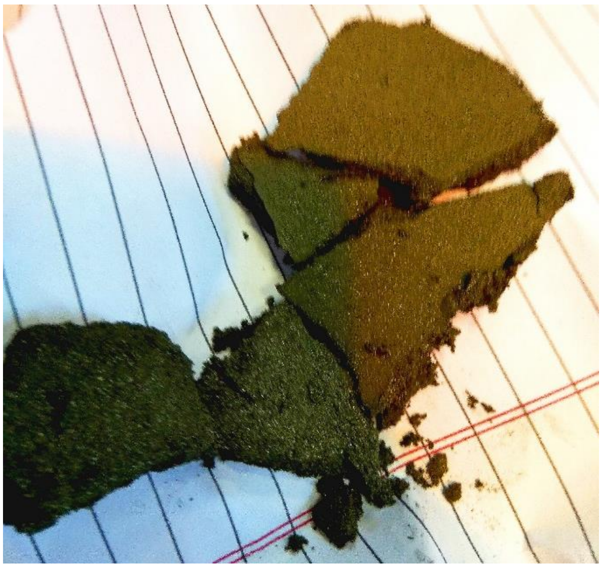
The powdered material from the crushing unit is poured in a solvent along with pynol and other chemical substances. This mixture is processed by stirring it with high speed, resulting in formation of foams floating on the surface of the solvent. These foams are concentrated with copper which is removed for further process.

Solution mixing and separating unit

Bubbles floating with copper concentration

Filtration Plant:

The concentrated copper foam is filtered in this unit by drying, forming cakes of copper mineral, etc.



The above image shows a large roller over which cakes of copper concentration are prepared. The bottom image is of copper-cake.

Study area of field tour (Day 3 to Day 8)

Udaipur, Rajasthan

Udaipur is located in the southernmost part of Rajasthan, near the Gujarat border. It is surrounded by Aravalli Range, which separates it from Thar Desert. It is around 660 km from Delhi and approximately 800 km from Mumbai, placed almost in the middle of two major Indian metro cities. Besides, connectivity with Gujarat ports provide Udaipur a strategic geographical advantage.[6] Udaipur is well connected with nearby cities and states by means of road, rail and air transportation facilities.

Geology of Udaipur

Udaipur is located on metasedimentary rocks of Aravalli Supergroup (~1800 Ma) represented by phyllite, graywacke, quartzite, dolomite, intra-formational conglomerate that were deposited in Precambrian sea nearly 2300 million years before present (BP). The suite of granitic and gneissic rocks, formed between 3300 and 2500 million years BP, constituted the floor of the Aravalli Sea. The deposited sediments were intensely folded, mildly metamorphosed, and uplifted. Long period of erosion produced the present-day physiography. Sedimentary structures can be seen in these rocks in road cutting and exposures at Fateh Sagar, Doodhtali, DM's residence Bhupalpura and several other locations in and around Udaipur city.

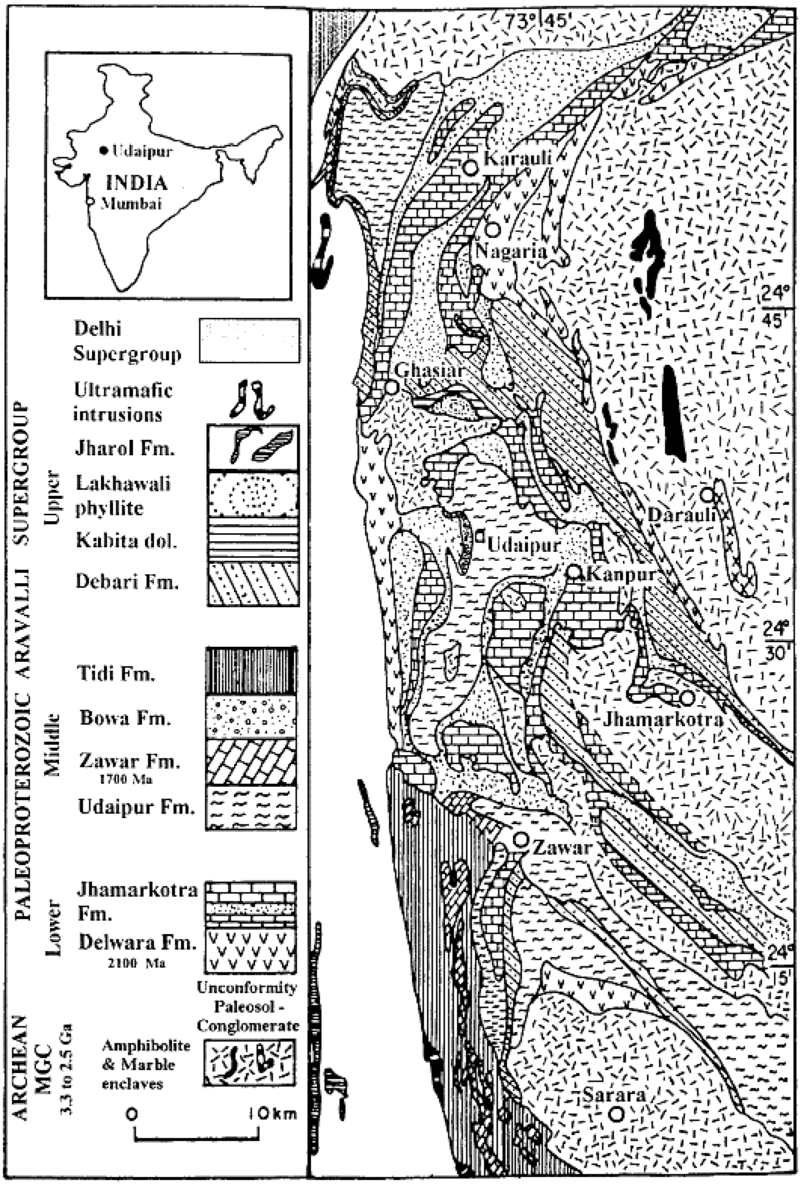
This area is rich in mineral and decorative stones. Important and unique ones are: serpentinite (green marble), white & pink marbles, rock phosphate, lead-zinc (World's oldest known mining & smelting center), wallastonite, talc, amphibole asbestos, calcite, barite, etc.

The oldest rocks, perhaps, the remnants of the primordial crust, the Mewar Gneiss popularly known as the Banded Gneissic Complex with pockets of paleosols (that altered to fine'-grained, talcose white mica) form a flat terrain at the eastern entrance of the city: Basement rocks also crop out between Neemach Mata and Bari Lake and around Titari and Udai Sagar areas. At the foot hill side of Neemach Mata, the basement granite shows metasomatized remobilization making its contact with the cover rocks.

The sediments of the Aravalli Supergroup are divisible into; Lower, Middle and Upper Groups, which were deposited about two and a half billion years ago. The two high ridges, Iniamagara-

Sajjangarh in the west and Debari in the east, that include two linear "outliers of Delhi Formations" (now considered part of the Aravalli Supergroup) and define the limits of the Udaipur valley; have emerged at the same place where the two deep seated liastric faults, that had develop during the beginning of the Aravalli basin formation, out poured basic lava. All along these ridges basic volcanic with vesicles and pillow structures are spread in the form of green schist that is noticeable east of Debari Zinc Smelter, Bari Lake and at the northern termination of Iniamagara.

Sedimentation of Aravalli rocks began with dumping of large assorted blocks in the basic lava along the margins of the graben so formed. Diamictites of the Lower Aravalli Group so formed are exposed along the hills to the east of Debari Zinc Smelter, to the south of Nandeshwer and in a river section at Koriyat. Tuffaceous material associated with the lava can easily be seen displaying paper-thin laminations and micro grading along the Koriyat-Nai section. Around Koriyat the basal volcanics have been observed to be interlayer with carbonates.



The basal sequence of coarse and fine clastics, represented by conglomerate, quartzite; phyllite is exposed on the either sides of Udaipur valley: Most of the high ridges around Koriyat, Bari, Nai and Undri on western side and Udai Sagar, Debari, and Girwa on the eastern and northern sides represent these lithounits.

These linear outcrops of conglomerate-arkose-quartzite sequence, exposed on either side of the Udaipur valley, were thought to be the "outliners" of Delhi "System" (now Supergroup) by earlier workers (Heron, 1953). This interesting coarse clastic sequence to the east of Udaipur City, popularly known as Debari Formation, has seen several ups and downs during the history of geological research in the area. Banerjee (1971) dividing the Aravalli rocks in to Debari, Maton, and Udaipur Formations, assigned it the lower most position in the sequence. On the other hand, Roy and Paliwal (1981) equated this sequence with the greywacke-phyllite sequence of Udaipur Valley Formation-C. This sequence suffered a lot of oscillation in its stratigraphic position in subsequent publications. Similar sequence, popularly known as lniamagra sequence is exposed around Koriat, Bujara, Undari etc. to the west of Udaipur city has retained its basal status.

System	**Series**	**Litho-unit**	**Igneous-meta derivatives**
Delhi system	Ajabgarh	Mainly impure calcareous & argillaceous metasediments	-------------
	Alwar series	Mainly argillaceous smetasediments	----------------
	Raialo Series	Schist, marble with local/basal grit	Aplogranite, epidiorites, hornblende schist & ultra-basics
Aravalli system	--------------	Impure limestone, phyllites, quartzite, schist's with based conglomerate &tuffs	Soda syenites
Pre Aravalli-system	--------------	Schists, gneisses & quartzites	Pegmatites, granites, aplite & basic rocks
Banded gneisses complex & Bundelkhand granite			

Day 3

Lecture at Sukhadia university, Udaipur

Lecturer: Prof. N. K. Chauhan

Topic: Mapping techniques and structural features within Udaipur

Date: 5th April 2019
Time: 03: 00 PM

Venue:

Department of Geology,

Sukhadia University, Udaipur

Notes on the lecture

Scale of mapping

The scale of a map is the ratio of a distance on the map to the corresponding distance on the ground. This simple concept is complicated by the curvature of the Earth's surface, which forces scale to vary across a map. Because of this variation, the concept of scale becomes meaningful in two distinct ways. The first way is the ratio of the size of the generating globe to the size of the Earth. The generating globe is a conceptual model to which the Earth is shrunk and from which the map is projected.

The numerical scale of a map indicates the relationship of distance measured on a map and the corresponding distance on the ground. This scale is usually written as a fraction and is called the representative fraction. The RF is always written with the map distance as 1 and is independent of any unit of measure. (It could be yards, meters, inches, and so forth.) An RF of 1/50,000 or 1:50,000 means that one unit of measure on the map is equal to 50,000 units of the same measure on the ground.

If the ratio of scale is more (1:50,000) the scale shows less details of the map or is small scale map and if the ratio is less (1:10,000) the scale shows more details of the map or is large scale map.

Types of geological mapping

- Contact tracing
  The contact between two strata or bed layers of different age is mapped
- Outcrop mapping
  Outcrops of different rocks are measured in terms of dip and strike, and other geological parameters which are then used for mapping.
- Traverse mapping
  Traverse is a method in the field of surveying to establish control networks.[1] It is also used in geodesy. Traverse networks involve placing survey stations along a line or path of travel, and then using the previously surveyed points as a base for observing the next point.

Types fold crenulations

- S type
- Z type

Day 4

Field work (outcrop mapping)

Date: 6^{th} April 2019

Time: 08: 00 AM

Location

We were in a village called Majaam. There were several peaks close to each other, which was good for mapping, in the learning stage.

Latitude- 24° 41’ 55.945” N

Longitude- 73° 32’ 27.08” E

Concept of toposheet numbering:

To identify a map of a particular area, a map numbering system has been adopted by Survey of India.

The system of identification is as follows:

An International Series (within 4° N to 40° N Latitude and 44° E to 124° E Longitude) at the scale of 1: 1,000,000 is being considered as base map. The base map is divided into sections of 4° latitude x 4° longitude and designated from 1 (at the extreme north-west) to 136, covering only land areas and leaving any 4° square if it falls completely in the sea.

<u>By Comparison</u>

For Indian Topographic maps, each section is further divided into 16 sections (4 rows by 4 columns), each of 1° latitude x 1° longitude (1:250,000), staring from a letter A (North-West corner) and ending on P, column-wise. These degree sheets are designated by a number and an alphabet such as 53 C.

These degree sheets are further sub-divided in the following ways

Each sheet is divided into four parts (2 rows by 2 columns), each of 30' latitude x 30' longitude (1:100,000) designating them by cardinal directions NW, NE, SW, and SE. Such sheets are identified as 53 M/SE.

Degree sheets have also been divided into 16 sheets (4 rows by 4 columns), each 15' latitude x 15' longitude (1:50,000) and numbered from 1 (at the north-west corner of the particular degree sheet) to 16, column wise and are identified as 53 B/3.

Each 1:50,000 scale sheet contains four (2 rows by 2 columns) 1:25,000 sheet (7' 1/2 latitude x 7' 1/2 longitude) which are numbered NW, NE, SW, and SE. Such sheets are identified as 53 O/14/NE.

In this way, the topographic map of most of the area of India may be acquired at the scale available and subsequently can be updated and upgraded as required for a particular project. For large scale maps, further surveying needs to carried out.

Toposheet used:

Region: Gujarat
Toposheet no.: 45H/10
Scale: 1: 25,000
Contour interval: 20m
Scale on toposheet we used to locate our position during mapping was 1: 10,000

Readings of strike direction, dip amount and dip direction we collected from field

Spot 1

Latitude- 24°41’55.945” N

Longitude- 73°32’22.081” E

Village - Majaam

Spot 2

UTM

35 13 04

27 31 488

Three-way path in Majaam connecting other villages.

Spot 3

UTM

35 12 61

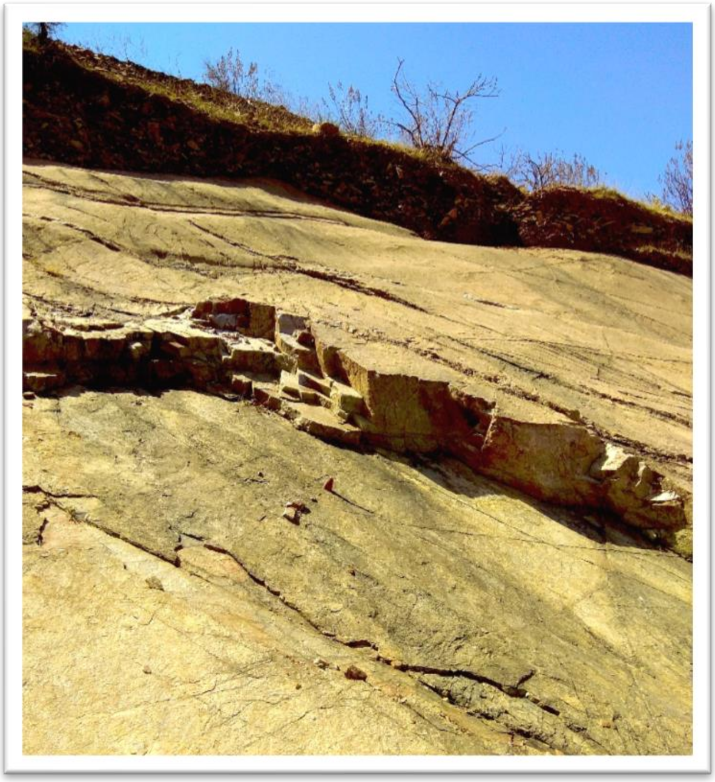
27 31 443

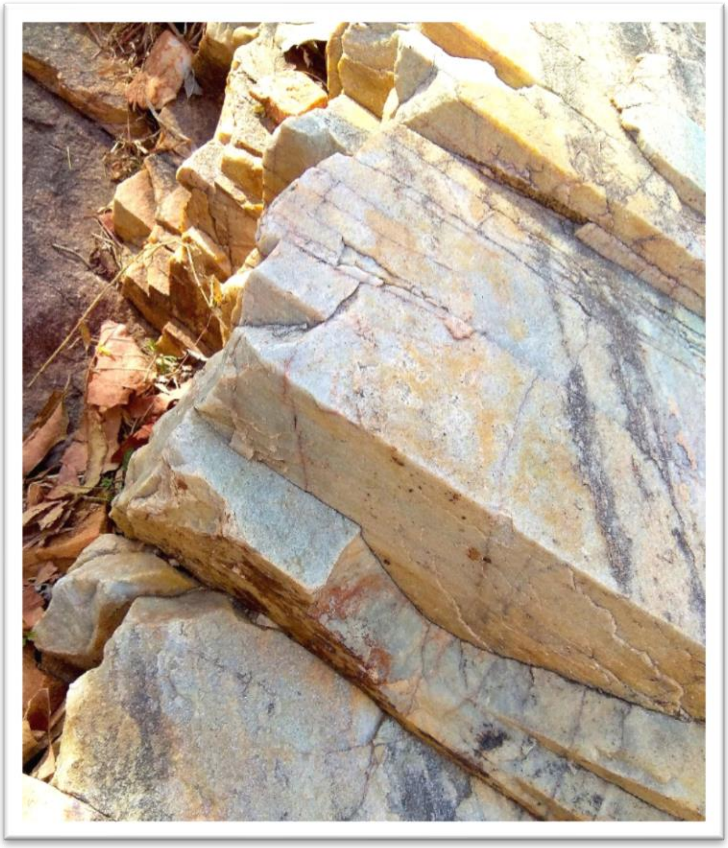
Strike Direction- 316°N

Dip Direction- 45°N

Dip Amount- 38°

Rock type- Quartzite





Spot 4

UTM

35 13 04

27 31 462

Strike Direction- 260°N

Dip Direction- 350°N

Dip Amount- 42°

Rock type- Quartzite

Spot 5

UTM

35 10 63

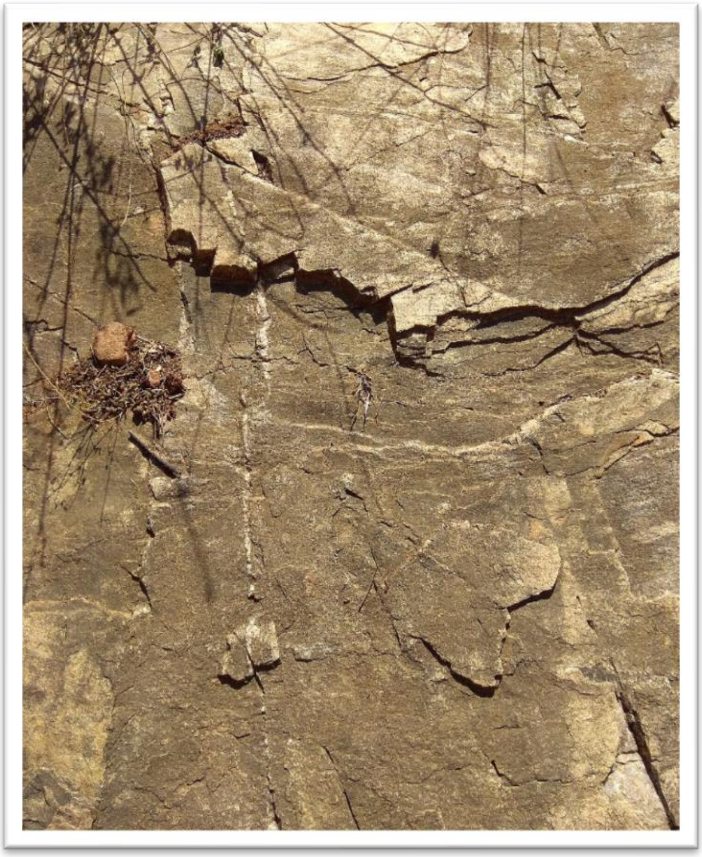
27 31 307

Strike Direction- 220°N

Dip Direction- 320°N

Dip Amount- 42°

Rock type- Quartzite



Spot 6

UTM

35 09 20

27 31 162

Strike Direction- 235°N

Dip Direction- 32°N

Dip Amount- 40°

Fold structures- S0 // S1

Spot 7

UTM

35 08 23

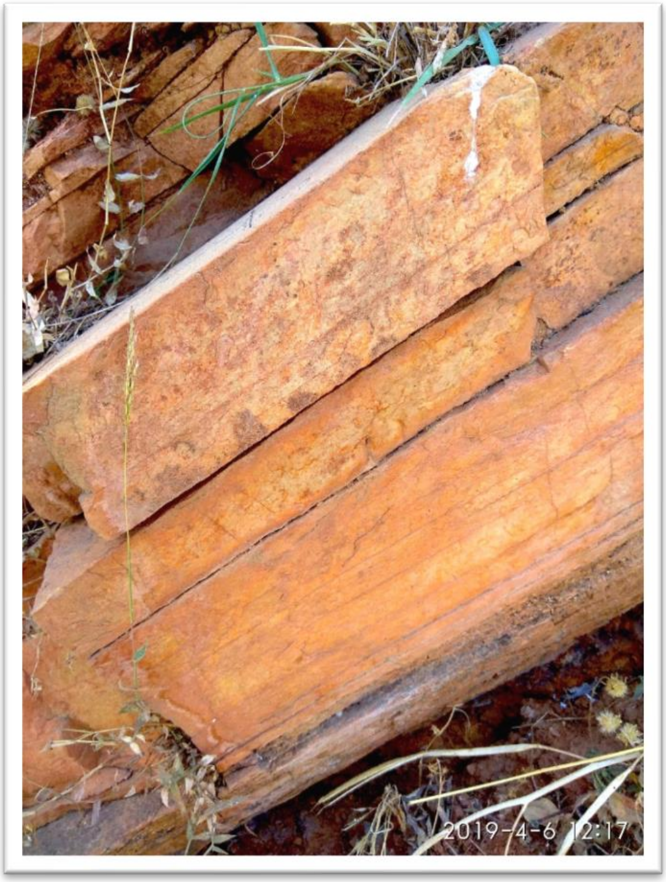
27 31 076

Strike Direction- 270°N

Dip Direction- 0°N

Dip Amount- 26°

Fold-limb of quartzite rock.



Spot 8

UTM

35 07 30

27 30 480

Strike Direction- 183°N

Dip Direction- 263°N

Dip Amount- 10°

Spot 9

UTM

35 06 69

27 30 838

Located our position on the toposheet with help of Brunton compass;

Forward bearing for highest peak (876m): 60°N

Forward bearing for brown peak: 97° N

Forward bearing for another peak with a wall boundary: 43° N

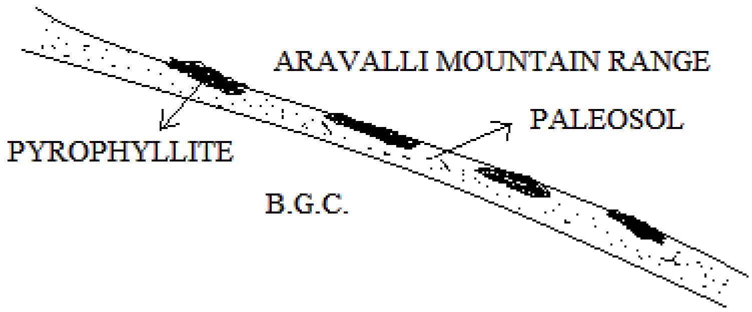
Day 5

Identification of geological structures (Udaipur) and Field work (outcrop mapping)

Date: 7th April 2019
Time: 07: 30 AM

Location: Jamuniya Ki Naal

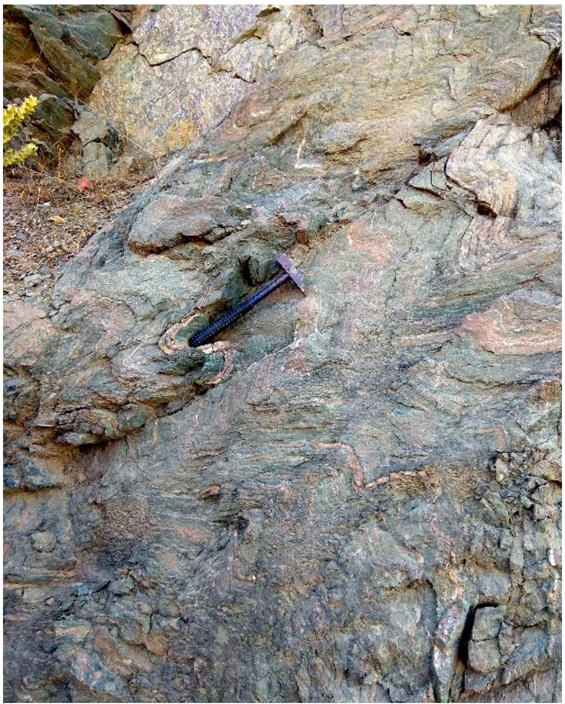
Jamuniya Ki Naal is situated at north of Udaipur alongside the NH 76. Regional structures of the Aravalli Mountain in Udaipur are considered to have N to NNE trending synclinorium with the core occupied of Delhi Super Group. Jamuniya ki Naal formation is in Lower Aravallis which have lithology as metavolcanics and chlorite schist. In Jamuniya ki Naal, the rock type is Banded Gneissic Complex (BGC). The age of BGC is almost 3.8 billion years. The area



shows the prominent folding structures and bending. Here we found the tectonic melange which is basically gneiss. Here deposits of FeS_2 along bedding planes are present.

Identification of different structures

Crenulations cleavage: In metamorphic terrain like Aravalli Mountain, the schistosity may be crinkled into small folds with a wavelength of a fraction of an inch. One limb of these small folds becomes a zone of weakness. Eventually the mica flakes are rotated into discrete zones parallel to the axial planes of the crinkles and displacement may take place along these zones. The rock tends to break parallel to these zones.



Interference structure

Interference pattern and superimposed folds: Many complex fold systems are the result of interference between two or more than two fold sets of simpler geometry. If a layer which already possesses a set of folds is refolded by a second set of folds, a complicated three-dimensional shape is produced. The second set of folds is set to be superimposed on the first and the resulting geometry is termed an interference structure.

Lineation: Lineation is a set of linear structures produced in rock as a result of deformation and is therefore the linear counterpart of a foliation.

Mullion structures: Mullions consists of a series of parallel columns. Each column may be several inches a diameter and several feet long. Each column is composed of folded sedimentary or metamorphic rocks.

Mullion Structures

Drag folds: Drag folds form when a competent bed slides like quartzite past on incompetent bed like phyllite, schist etc. Such minor folds may form on the limbs of larger folds because of the slipping of beds past each other or they may develop beneath over thrust blocks. The axial planes of the drag folds are not

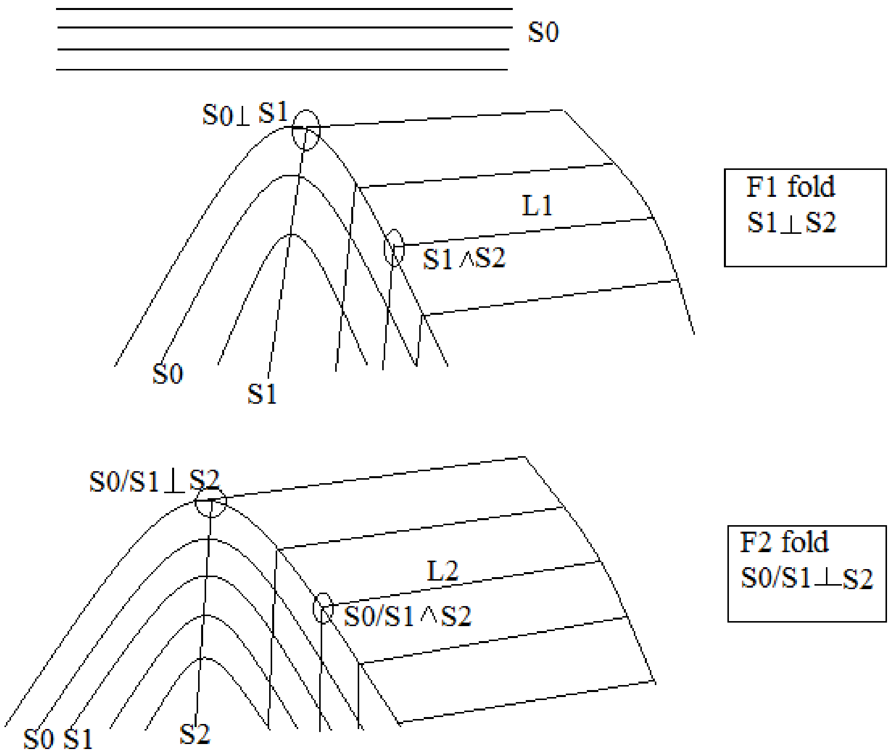
Drag folds

perpendicular to the bedding of the competent strata, but are inclined at an angle. The traces of the axial planes of the folds are parallel to the long axis. Such structural features may form during sedimentation, when a sheet of sediment slides over a weaker bed.

Description of folds on the basis of their alignments

F1 fold: - F1 fold is develop after the first stage of deformation. In F1 fold, the first cleavage plane (S0) is perpendicular to deformed cleavage plane (S1) in hinge zone. L1 lineation is present in F1 fold.

F2 fold: - F2 fold is develop after the second stage of deformation. In F2 fold, the first cleavage plane (S0) is parallel to deformed cleavage plane (S1) and S0 & S1 is perpendicular to S2 in hinge zone.



S1 cleavage is also called early cleavage. S1 cleavage always very closely spaced.

Intersection of bedding with cleavage on cleavage plane, there are traces of bedding on cleavage plane.

Intersection of bedding with cleavage on bedding plane, there are traces of cleavage on bedding plane.

Ultramafic trend of Kaliguman to Kherwada. East of Kaliguman lineament, shallow water facies are present and west of Kaliguman lineament, deep water facies are present.

On joint there is no mineral aligned. Joint formed by release of strain & cleavage formed by stress.

Field work

Location: Majaam

Latitude- 24° 41’ 55.945” N
Longitude- 73° 32’ 27.08” E
Time: 08: 00am

Readings of strike direction, dip amount and dip direction we collected from field

Spot 1

UTM

35 19 18

27 31 867

Strike Direction- 354°N

Dip Direction- 84°N

Dip Amount- 65°

Spot 2

UTM

35 19 75

27 31 842

Strike Direction- 355°N

Dip Direction- 92°N

Dip Amount- 32°

Spot 3

UTM

35 20 16

27 31 793

Strike Direction- 90°N

Dip Direction- 357°N

Dip Amount- 23°

Spot 4

UTM

35 20 55

27 31 704

Strike Direction- 134°N

Dip Direction- 42°N

Dip Amount- 30°

Day 6

Field work (Study of geological structures)

Date: 8th April 2019
Time: 09: 00 am

Location 1: Near Dewari grid station

10-12 km east of Udaipur station

We studied the alignment of elongated clasts within the matrix of structures. The rock type was metamorphosed conglomerate (Arkosic). The clast was composed of tourmaline, quartz, feldspar.

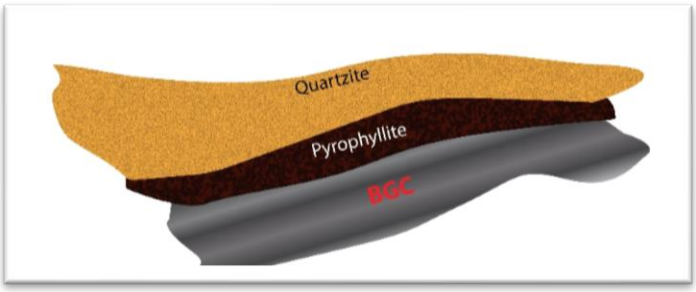
Polylithic metamorphosed conglomerate

Location 2: Near Sagar lake

Spot 1-

Latitude: 24° 36’ 47.888”
Longitude: 73° 50’ 63.11”

The region was also inclusive of Mica schist bearing garnets.



Lithological succession

Configuration of bed

Strike direction- N 167°

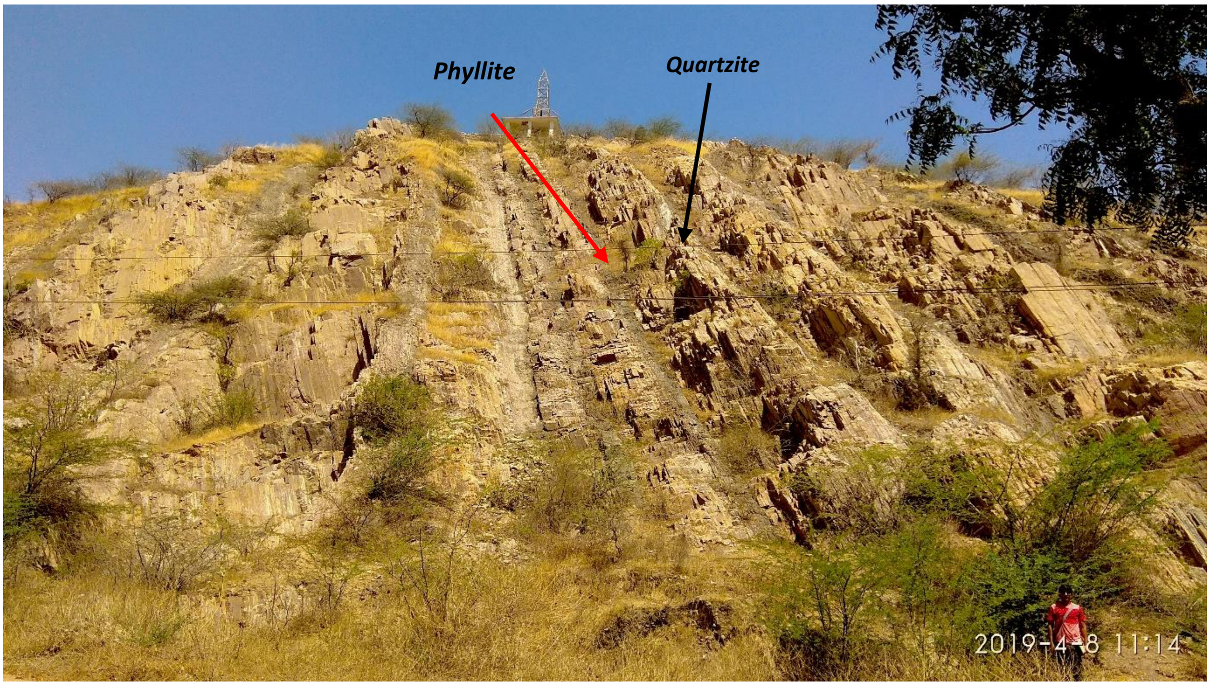
Dip direction- N 70°, Dip amount- 50°

Spot 2-

Latitude- 24° 36’ 47.579” N

Longitude- 73° 50’ 00.888” E

This region consisted of local faults and beds of quartzite and phyllite are alternately present.



Alternate bands of quartzite and phyllite. On the bottom right a boy is standing for scaling, with height of 6 ft.

Local Faults

Visit to Vedanta

Group Photograph at Vedanta

Time: 3:00 pm

Speaker: Pradeep Jain and Dr. Kashif

Topic: Geophysical exploration techniques

About Vedanta

Vedanta Resources Limited is a globally diversified Natural Resources Company with interests in zinc-lead-silver, Iron ore, Steel, Copper, Aluminum, Power, Oil and Gas.

Our dynamic portfolio follows a history of consistent geological discovery, technological advancement and sustainable development. With a business model focused on growth, expansion and value creation for our shareholders, positive impact on the community, we operate in and leave a legacy of pride.

Operating responsibly and ethically is an integral part of Vedanta's core values. We deliver on our commitments to all internal and external stakeholders by demonstrating these values through our actions, processes, systems and interactions. We constantly learn and develop; and endeavor to improve our operations. We are fully committed to working with integrity and have upheld 'uncompromising business ethics.' While our business has expanded over the last 3 decades into many locations around the world, our operations have positively impacted the communities we operate in.

Geophysical Exploration

Exploration geophysics is an applied branch of geophysics and economic geology, which uses physical methods, such as seismic, gravitational, magnetic, electrical and electromagnetic at the surface of the Earth to measure the physical properties of the subsurface, along with the anomalies in those properties. It is most often used to detect or infer the presence and position of economically useful geological deposits, such as ore minerals; fossil fuels and other hydrocarbons; geothermal reservoirs; and groundwater reservoirs.

Exploration geophysics can be used to directly detect the target style of mineralization, via measuring its physical properties directly. For example, one may measure the density contrasts between the dense iron ore and the lighter silicate host rock, or one may measure the electrical conductivity contrast between conductive sulfide minerals and the resistive silicate host rock.

The main techniques used are:

1. Seismic tomography to locate earthquakes and assist in Seismology
2. Reflection seismology and seismic refraction to map the surface structure of a region.
3. Geodesy and gravity techniques, including gravity gradiometric.
4. Magnetic techniques, including aeromagnetic surveys to map magnetic anomalies.
5. Electrical techniques, including electrical resistivity tomography and induced polarization.
6. Electromagnetic methods, such as magnetotellurics, ground penetrating radar, transient/time-domain electromagnetics and SNMR.
7. Borehole geophysics, also called well logging.
8. Remote sensing techniques, including hyperspectral imaging.

Day 7

Visit to Zawarmala mine and GSI

Date: 9th April 2019

Time: 08: 00 AM

Group Photograph at Zawarwala Mine

Location: Zawarmala mine

Latitude: - 24˚22′ North

Longitude: - 73˚43′ East

Geological highlights

The lead and zinc ore mineralization are hosted by sheared metamorphosed dolomite. Ancient mining from 400 B.C.

Mineral list:

Dolomite
Galena
Hydrozincite
Pyrite
Silver
Sphalerite

In Zawar mines, the ore is mainly galena (lead & zinc) and sphalerite (zinc & cadmium).

Metals	Reducing Temperature (In presence of C)	Boiling Temperature
Iron	1000-1200˚C	2750˚C
Copper	425-650˚C	2567˚C
Tin	1300-1400˚C	2625˚C
Lead	700-800˚C	1750˚C
Zinc	1000˚C	913˚C

Zinc is volatile because its boiling temperature is less than its reducing temperature. Zn ores was calcined to zinc oxide by roasting in air to convert sulfides into oxides. Calcinations sites were kept away from the old settlements as fumes of SO_2 were unpleasant and injurious.

$$2ZnS+3O_2 \rightarrow 2ZnO+2SO_2$$

Reducing agent helps to increase CO.

Reducing Agent: Borax, ghee, treacle, salt/nausadar (ammonium chloride) etc.

$CaMg(Co_3) \rightarrow CaO+MgO+2Co_2$

$Co_2+C \rightarrow 2CO$

$ZnO+CO \rightarrow Zn+Co_2$

Use of lead: - Sanitary items like pipes.

Use of zinc: - Brass.

		Intrusive	Rakhabdev Ultramafic
Proterozoic	Jharol group		Schist Phyllite & slates
	Udaipur group	Tiri subgroup	Phyllite Quartzite Phyllitic dolomite Gritty dolomite Massive dolomite conglomerate Greywacke
			Purple phyllite carbon phyllite Stramatolitic dolomite
		Intrusive	Ahar river granite
	Debari group		Quartzite Conglomerate Metavolcanics
Archean			Pyrophyllite Banded gneiss

Second visit:

Geological Survey of India, Training and Capacity Building, Field Training Center, Zawar

Group Photograph at GSI

Date: 9th of April, 2019

Time: 03: 00 PM

Lecture on: "Ancient Mining and Metallurgy of Zawar".

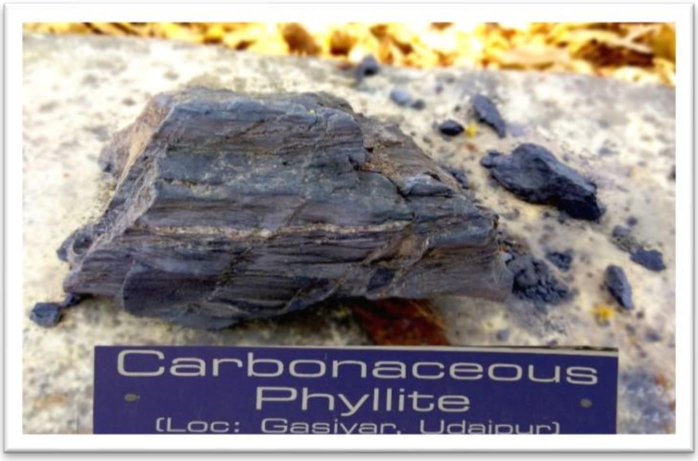
Speaker: Dr. Arvind Kumar.

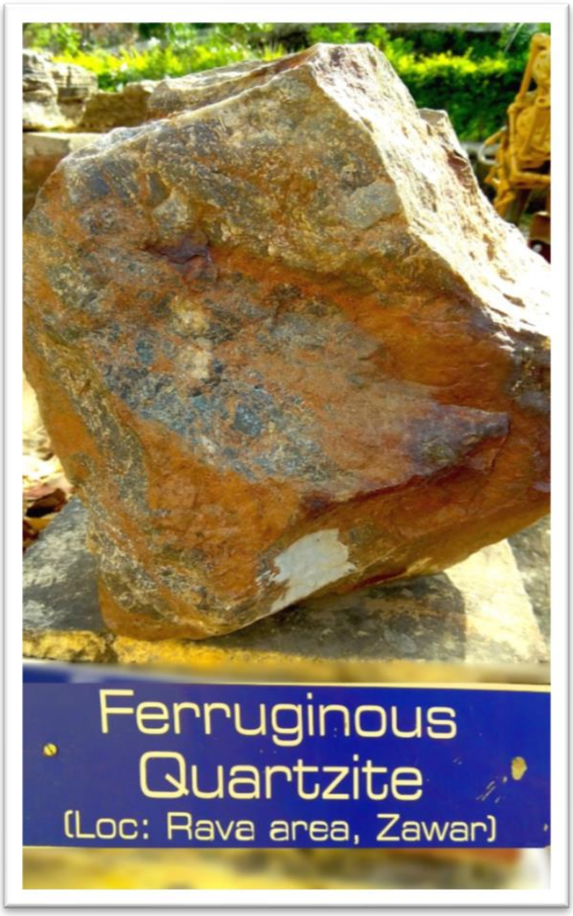
Notes:

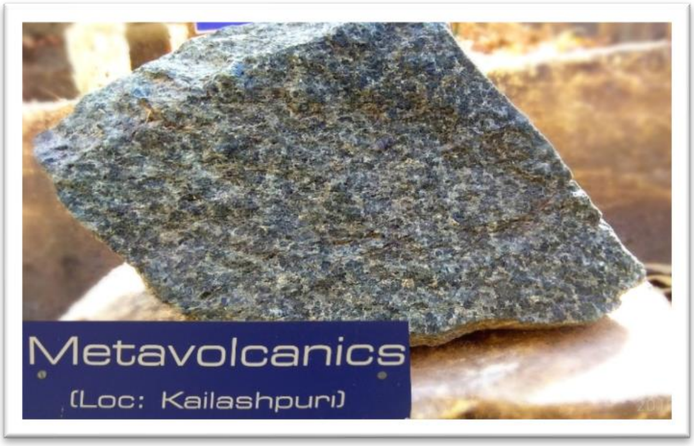
In this lecture we knew many things related to Zawar mine. Zawar mines are one of the oldest lead and zinc mines in India. These are mute testimony to the exploitative and extractive excellence achieved by the country during ancient time. The technology, with time, had modernized and refined but Zawar serves as one of the major Lead Zinc producing unit of

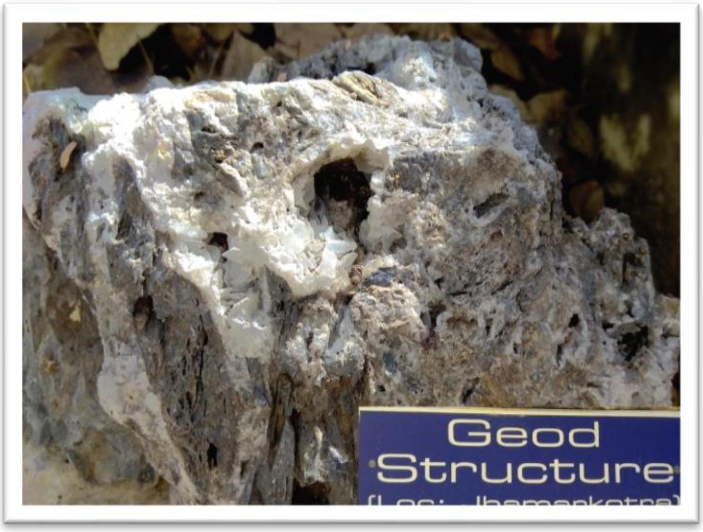
Hindustan Zinc Limited, the world's largest integrated Lead Zinc producer. A Vedanta Group listed on London Stock Exchange. The exact date of commencement of mining activity in the Indian subcontinent cannot be given a specific date but it was well developed in India during early period, notably at the time of Indus valley civilization (Circa 3200-2500 BC). There are evidences of presence of ancient mines & metallurgical slag heaps and furnace debris scattered in Rajasthan and adjoining areas of Gujarat. The occurrence is confined to different mineral belts which are broadly trending in NE-SW direction from Alwar (Rajasthan) in north to Khandia (Gujarat) in south along the strike of Aravalli Mountain Range. Total 145 localities have been identified from where evidences of ancient mining and metallurgy have been recorded.

Rock collections and other models at GSI


Carbonaceous
Phyllite
(Loc: Gasiyar, Udaipur)


Ferruginous
Quartzite
(Loc: Rava area, Zawar)


Metavolcanics
(Loc: Kailashpuri)


Geod
Structure


Pegmatite
(Loc: Bhilwara)


Baryte
(Loc: Dariba Gossan)


Baryte
(Loc: Jagat, Udaipur)


Slag
(Loc: Dariba, Rajsamand)


Gossan
(Loc: Rajpura-Dariba)


Tourmal ine
(Loc: Jawaja, Ajmer)

Day 8

Lecture on stereographic projection with the help of field data

Date: 10th April 2019

Time: 07:30 PM

Lecture by: Prof. N K Chauhan

Venue: Gujarati Samaj Bhavan

Stereographic projection

Stereographic projection is an essential tool of structural geology. It is used to represent the orientations of planar and linear structures of an area and to find out the angular relations among them. Consider a reference sphere with a horizontal equatorial plane and with a vertical diameter intersecting the sphere at its upper and lower poles A and B. A line L passing through the centre of the sphere will meet the lower hemisphere at a point P (Fig. S.1). A line joining the point P with the upper pole A will meet the equatorial plane at some point P. P is then the lower hemisphere stereographic projection of the line L. In a similar way, a plane S passing through the center of the sphere will intersect the surface of the sphere in a great circle. If each point of this great circle in the lower hemisphere is joined to the upper pole or zenith A, the lines will intersect the equatorial plane at points which will lie on a circular arc. This arc is described as a great circle trace. This is the lower hemisphere stereographic projection of the plane S (Fig. S.2). We could no doubt project in the same way the lines and points of the upper half of the reference sphere on the equatorial plane. However, in structural geology we always use lower

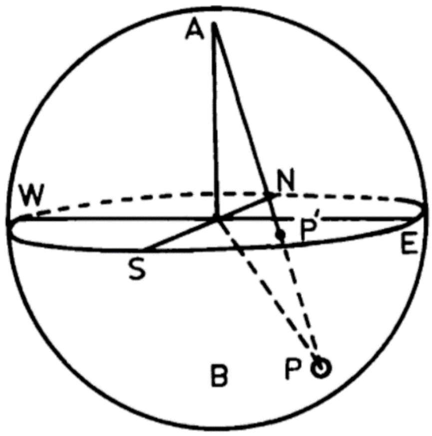


Fig. S.1

Principle of lower hemisphere stereographic projection. A line passing through the centre meets the lower hemisphere at P. The line joining P and A, the upper pole of the sphere, meets the equatorial plane at P. This is the stereographic projection of the line.

hemisphere projections. A circular cone with its apex at the center of the reference sphere intersects the sphere along a circle. Such circles are known as small circles. If each point of a small circle on the lower hemisphere is joined with the upper pole A, the lines intersect the equatorial plane at points lying along a circle. This too is referred to as a small circle. The centre of this small circle is the stereographic projection of the cone axis and the points on the circle are the projections of lines that make a constant angle with the cone axis.

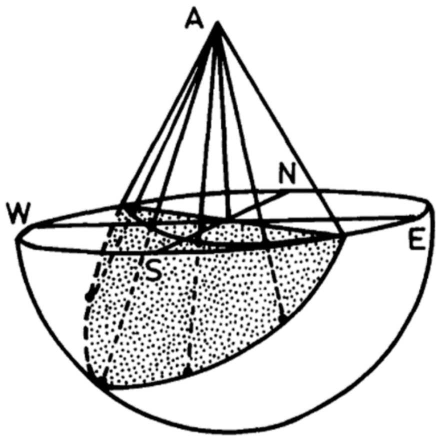


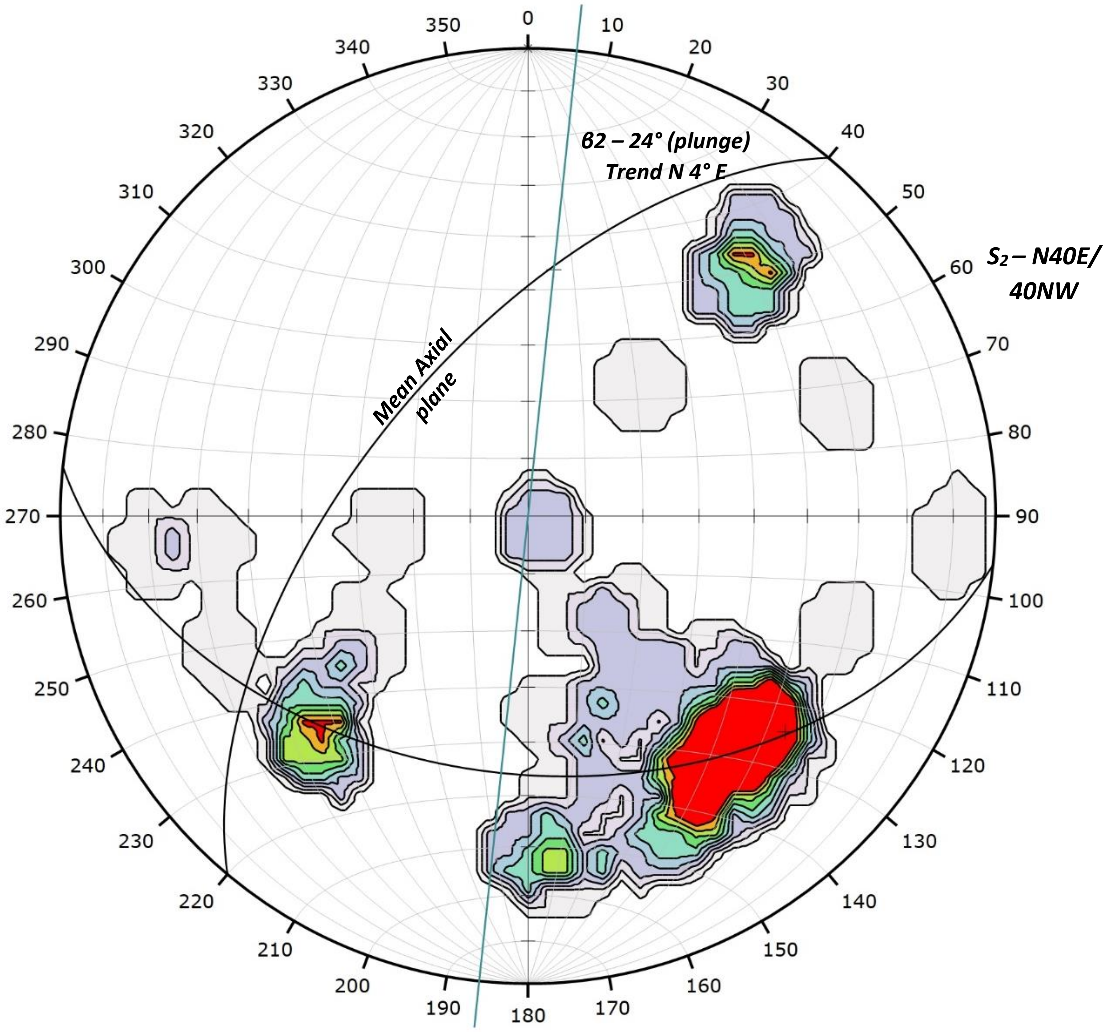
Fig. S.2

The dotted area is a plane passing through a sphere. It meets the lower hemisphere along a semicircular arc. If each point on this arc is joined to the upper pole A, the lines intersect the equatorial plane at points which define a great circle on the stereographic projection.

After adding all the data of dip and strike from the field, the following projection was prepared by our group (group no.5).

- The Plunge is 24° trending towards N 4° E.
- S2 plane is towards N 40° E.

With the help of the above data, I rebuilt the stereographic projection by using the computer software named 'Dips'.



Color	Density Concentrations
	0.00 - 1.00
	1.00 - 2.00
	2.00 - 3.00
	3.00 - 4.00
	4.00 - 5.00
	5.00 - 6.00
	6.00 - 7.00
	7.00 - 8.00
	8.00 - 9.00
	9.00 <
Maximum Density	22.22%
Contour Data	Dip Vectors
Contour Distribution	Schmidt
Counting Circle Size	1.0%

	Color	Trend	Plunge	Label
User Planes				
1	■	6	46	
2	■	130	29	Mean Axial Plane

Plot Mode	Dip Vectors
Vector Count	54 (54 Entries)
Hemisphere	Lower
Projection	Equal Area

Interpretation

Geological Field Training made me familiar with the subject practically and helped me to correlate with the knowledge that I gained in the classroom. I came across various geological features, different types of rocks, sedimentary structures and different types of landforms. I tried to identify all these features and interpret their processes of formation and also mapped the linear and planer structures of fold. I felt it is important to pen down the observations that I made in the field and interpretations that came out of them.

Rajasthan covers an area of 3, 42,239 sq. km. The Aravalli range transverses diagonally through the middle of the state. The region on the end has fertile plains while the other end it has a quarter covered essentially by sand. The areal extent of the Northwestern Rajasthan is 1, 48,600 sq. km. The Aravalli range touches the southeastern corner of the area. The northwestern Rajasthan presents a sequence of rock formations of Archean, Proterozoic, Cambrian, Upper Carboniferous, Permian, Jurassic, Lower Cretaceous, Paleocene and Eocene age. The Paleozoic, Mesozoic and lower Tertiary rock formation comprises the sedimentary sequences typically this part of Rajasthan.

In the Rajasthan as mentioned above shows that it has almost rocks of all ages and rock contents. This region is very fruitful for the students of geology for better understanding of the subject matter of geology.

Our whole tour comprised of visits to three mines (Khetri Copper Mine, Kolihan Copper Mine, Zawarwala mine), regions (Jamuniya ki Naal) with significant structural geological features, and also, we had lectures in Sukhadia university, Vedanta and Geological Survey of India. We all experienced a close view, of functioning of mines, understood their different working sections. We observed and analyzed different geological features at the surface level and also developed the stereographic projections for plannar data of folds.

References

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- Stratigraphy of India, Ravindra Kumar
- Guidance by Prof. Y.P. Sundriyal & Prof. N.K. Chauhan
- www.wikipedia.com