FIELDWORK REPORT OF GUJARAT AND RAJASTHAN 2023

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Exam: Roll No:

LABORATORY CERTIFICATE

This is to certify that Mr. /~~Ms.~~ Sanket S. Parab Gaonkar has satisfactorily completed the course of practical for M.Sc in Applied Geology.

Experiments conducted are pertaining to paper Geological field training.

Practicals prescribed by the University for MSc part II class, during the academic year 2022- 2023

DEAN
SEOAS

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Acknowledgement

I would like to express my special thanks of gratitude to Professor Mahesh Mayekar, Professor Pooja ghadi, Dr. Niyati kalangutkar, Dr. Anthony Viegas and the other faculties of the Earth Science Department - Goa University for their assistance and guidance throughout the fieldwork days.

Last but not the least I would like to thank my parents, friends and others for their constant support and motivation throughout the course of this fieldwork.

INDEX

GEOLOGY OF INDIA

The geology of India is diverse. Different regions of India contain rocks belonging to different geologic periods, dating as far back as the Eoarchean Era. Some of the rocks are very deformed and altered. Other deposits include recently deposited alluvium that has yet to undergo diagenesis. Mineral deposits of great variety are found in the Indian subcontinent in huge quantity. Even India's fossil record is impressive in which stromatolites, invertebrates, vertebrates and plant fossils are included. India's geographical land area can be classified into the Deccan Traps, Gondwana and Vindhyan.

The Deccan Traps covers almost all of Maharashtra, a part of Gujarat, Karnataka, Madhya Pradesh and Andhra Pradesh marginally. During its journey northward after breaking off from the rest of Gondwana, the Indian Plate passed over a geologic hotspot, the Réunion hotspot, which caused extensive melting underneath the Indian Craton. The melting broke through the surface of the craton in a massive flood basalt event, creating the Deccan Traps. It is also thought that the Reunion hotspot caused the separation of Madagascar and India.

The Gondwana and Vindhyan include within its fold parts of Madhya Pradesh, Chhattisgarh, Odisha, Bihar, Jharkhand, West Bengal, Andhra Pradesh, Maharashtra, Jammu and Kashmir, Punjab, Himachal Pradesh, Rajasthan and Uttarakhand. The Gondwana sediments form a unique sequence of fluviatile rocks deposited in Permo-Carboniferous time. The Damodar and Sone river valleys and Rajmahal hills in eastern India contain a record of the Gondwana rocks.

The Indian Craton was once part of the supercontinent of Pangaea. At that time, what is now India's southwest coast was attached to Madagascar and southern Africa, and what is now its east coast was attached to Australia. During the Jurassic Period about 160 Ma (ICS 2004), rifting caused Pangaea to break apart into two supercontinents, namely Gondwana (to the south) and Laurasia (to the north). The Indian Craton remained attached to Gondwana, until the supercontinent began to rift apart about in the early Cretaceous, about 125 million years ago (ICS 2004). The Indian Plate then drifted northward toward the Eurasian Plate, at a pace that is the fastest known movement of any plate. It is generally believed that the Indian Plate separated from Madagascar about 90 Million years ago (ICS 2004), however some biogeographical and geological evidence suggests that the connection between Madagascar and Africa was retained at the time when the Indian Plate collided with the Eurasian Plate about 50

Million years ago (ICS 2004).[4] This orogeny, which is continuing today, is related to closure of the Tethys Ocean. The closure of this ocean which created the Alps in Europe, and the Caucasus range in western Asia, created the Himalaya Mountains and the Tibetan Plateau in South Asia. The current orogenic event is causing parts of the Asian continent to deform westward and eastward on either side of the orogen. Concurrently with this collision, the Indian Plate sutured on to the adjacent Australian Plate, forming a new larger plate, the Indo-Australian Plate.

The earliest phase of tectonic evolution was marked by the cooling and solidification of the upper crust of the earth's surface in the Archaean Era (prior to 2.5 billion years) which is represented by the exposure of gneisses and granites especially on the Peninsula. These form the core of the Indian Craton. The Aravalli Range is the remnant of an early Proterozoic orogen called the Aravali-Delhi Orogen that joined the two older segments that make up the Indian Craton. It extends approximately 500 kilometres (311 mi) from its northern end to isolated hills and rocky ridges into Haryana, ending near Delhi.

Minor igneous intrusions, deformation (folding and faulting) and subsequent metamorphism of the Aravalli Mountains represent the main phase of orogenesis. The erosion of the mountains, and further deformation of the sediments of the Dharwarian group (Bijawars) marks the second phase. The volcanic activities and intrusions, associated with this second phase are recorded in the composition of these sediments.

Early to Late Proterozoic(2.5 to 0.54 billion years) calcareous and arenaceous deposits, which correspond to humid and semi-arid climatic regimes, were deposited the Cuddapah and Vindhyan basins. These basins which border or lie within the existing crystalline basement, were uplifted during the Cambrian (500 Ma). The sediments are generally undeformed and have in many places preserved their original horizontal stratification. The Vindhyans are believed to have been deposited between ~1700 and 650 Ma .

Early Paleozoic rocks are found in the Himalayas and consist of southerly derived sediments eroded from the crystalline craton and deposited on the Indian platform.

In the Late Paleozoic, Permo-Carboniferous glaciations left extensive glacio-fluvial deposits across central India, in new basins created by sag/normal faulting. These tillites and glacially derived sediments are designated the Gondwanas series. The sediments are overlain by rocks resulting from a Permian marine transgression (270 Ma).

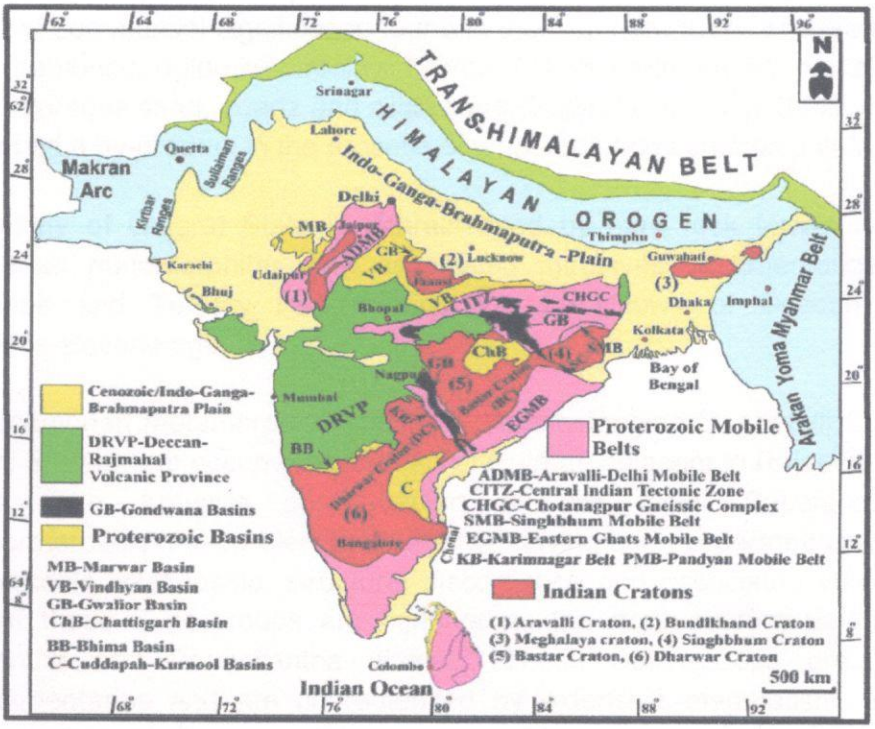
The late Paleozoic coincided with the deformation and drift of the Gondwana supercontinent. To this drift, the uplift of the Vindhyan sediments and the deposition of northern peripheral sediments in the Himalayan Sea, can be attributed.

During the Jurassic, as Pangea began to rift apart, large grabens formed in central India filling with Upper Jurassic and Lower Cretaceous sandstones and conglomerates.

By the Late Cretaceous India had separated from Australia and Africa and was moving //////northward towards Asia. At this time, prior to the Deccan eruptions, uplift in southern India resulted in sedimentation in the adjacent nascent Indian Ocean. Exposures of these rocks occur along the south Indian coast at Pondicherry and in Tamil Nadu.

At the close of the Mesozoic one of the greatest volcanic eruptions in earth's history occurred, the Deccan lava flows. Covering more than 500,000 square kilometres (193,051 sq mi) area, these mark the final break from Gondwana.

In the early Tertiary, the first phase of the Himalayan orogeny, the Karakoram phase occurred. The Himalayan orogeny has continued to the present day.



GEOLOGY OF GUJARAT

The Gujarat State bounded by N 20°02' and 24°42' and E 68°04' and 74°30' has an aerial extent of 1,96,024 sq km. The western and southern parts of the State are bordered by the coastal tract along the Arabian Sea. The State of Gujarat has a long coastline (approx. 1550 km) from Sir Creek in the north-west to Umargao in the south-east, which forms nearly one-third of the Indian coastline. The coastal tract borders the Kachchh Peninsula, the Saurashtra Peninsula and the Central Plains of Gujarat. The south-eastern part is occupied by the Deccan Plateau whereas the southwestern part forms the Saurashtra (Kathiawar) Peninsula. In the north-east the conspicuous hill chains represent the southward continuation of the Aravalli Range. The Kachchh Peninsula and the Rann of Kachchh occupy the north-western part of the State. The area extending in north-south direction and lying between Aravalli Range and Saurashtra-Kachchh Peninsulas is covered by a alluvial tract.

The State exposes a wide variety of lithological assemblages belonging to Precambrian, Mesozoic and Cenozoic Eras and is endowed with rich mineral wealth. Extensive exploration leading to the production of oil and natural gas in Ankleshwar, Khambhat and Kalol have put Gujarat prominently on the country's oil map.

Minerals of commercial significance found in the State are those of base metals, lignite, bauxite, bentonite, dolomite, fireclay, fluorite, fuller's earth, kaolin, ball clay, limestone, chalk, calcareous sand, quartz and silica sand. Gujarat is the only State where potash is produced as a by-product in the process of manufacturing common salt from brine.

The geology of Gujarat State is characterized by hard rock terrain represented by Precambrian metamorphites and associated intrusives; sedimentaries of Jurassic, Cretaceous and Tertiary Periods and the traps/flows of Deccan Volcanics of Cretaceous-Eocene age.

The Precambrian metamorphites, viz. the rocks belonging to Aravalli Supergroup and the Delhi Supergroup occupy the NE part of Gujarat, adjacent to Rajasthan and Madhya Pradesh. The Aravallis are overlain by the Delhi Supergroup of rocks (Palaeoproterozoic-Mesoproterozoic), the two having been separated on the basis of an unconformable relationship, structural discordance and associated volcanic activities. Rocks of these Supergroups are confined to the north-eastern part of Gujarat, in Sabarkantha and Banaskantha districts. These Supergroups are composed of metasedimentaries and are characterized by extensive magmatism. The magmatic activities recorded in the Aravalli Supergroup include an early phase represented by the

rocks of Phulad Ophiolite Suite and a syn- to late orogenic phase of magmatism represented by several granitic activities such as Sendra-Ambaji granite and gneiss, Godhra granite and gneiss, Erinpura granite and gneiss and Idar granite.

After the close of Proterozoic Era a great hiatus in geological record from Cambrian to Triassic is recorded in Gujarat. The Mesozoic sequence ranging from Middle Jurassic to Lower Cretaceous is represented by fossiliferous sediments that occur in parts of Kachchh, Sabarkantha, Panchmahals, Surendranagar, Kheda, Vadodarà and Rajkot districts.

The close of the Mesozoic Era witnessed a major volcanic activity in the form of widespread outpouring of lava in parts of Saurashtra, Kachchh, southern Gujarat and eastern parts of Pançhmahals and Vadodara districts. The Deccan Trap volcanic activity continued from Cretaceous to Eocene with at least four different phases of eruption.

It is of interest to mention that older volcanics of basaltic composition have been intersected at the base of Dhrangadhra Sandstone at Lodhika (Banerjee, 1999). These older volcanics fall in the alkali basalt field of TAS diagram (Banerjee, op. cit.). The occurrence of older traps below Mesozoic sediments was also indicated earlier by Kaila et al. (1981) at Dhanduka, 150 km NE of Lodhika.

The Deccan Traps are overlain by the Tertiary rocks, which occur all along the coastal area in Saurashtra in Khambhat (Cambay) basin and in parts of Kachchh. The Khambhat basin contains Eocene and Oligocene sediments having oil/gas producing horizons. There are more than 22 oil/gas fields in the State.

The Quaternary sediments comprise alluvium, miliolite, coral reefs, calcareous sand etc.

The State of Gujarat is divisible into six physiographic units viz, a) the southern Aravallis and the adjoining hilly tract, (b) the Deccan Plateau and the adjoining tract of southeastern Gujarat, (c) the Central Plains of Gujarat, (d) the Saurashtra Peninsula, (e) the Kachchh Peninsula and (f) the Rann of Kachchh.

Southern Aravallis and adjoining hilly tract

The southernmost part of the northeast - southwest trending Aravalli Range, generally rising above 400 m (locally as much as 1000 m), above msl occupies the extreme north-eastern parts of Gujarat. Quartzite and calc-silicate rocks form the ranges whereas the valleys are underlain mostly by phyllite, schist, granite and basic rocks. All these

lithounits belong to the Proterozoic age. The Aravalli Range forms the main catchment area of some of the important rivers, viz. the Banas, the Sabarmati and the Mahi.

The Deccan Plateau and adjoining tract of southeastern Gujarat

A wide expanse of high-level dissected lava flows in the east with a low-level dissected plateau fringed by the alluvial plain and fairly broad coastal erosional plain in the west, are the dominant features of this unit. Several rivers, the most prominent ones being the Narmada and Tapi, dissect this tract in E-W direction

.

The Central Plains of Gujarat

The Central Plains of Gujarat represent the alluvial plains of the Tapi, Narmada, Mahi, Sabarmati and Banas rivers. The Banas debouches into the Rann of Kachchh whereas all other rivers join the Gulf of Khambhat. Linear stretches of terraces occur along the river valleys traversing the deltaic plains.

The Saurashtra Peninsula

The Saurashtra Peninsula comprises a high-level, dissected lava plateau and flat-top hills of sandstone in the northeast. As in south-eastern Gujarat, a broad zone of low-level dissected plateau intervenes the high level plateau and the flat, broad coastal erosional plains in Saurashtra Peninsula. In the southern part of this Peninsula, the Barda Hills, the Alech Hills, the Girnar Hills and the Gir Ranges are conspicuous features.

The Saurashtra Peninsula has a radial drainage pattern. The prominent rivers are the Bhadar, the Shetrunji, the Machhu and the Aji. The Bhadar River flows into the Arabian Sea; the Shetrunji into the Gulf of Khambhat; the Machhu into the Little Rann and the Aji into the Gulf of Kachchh.

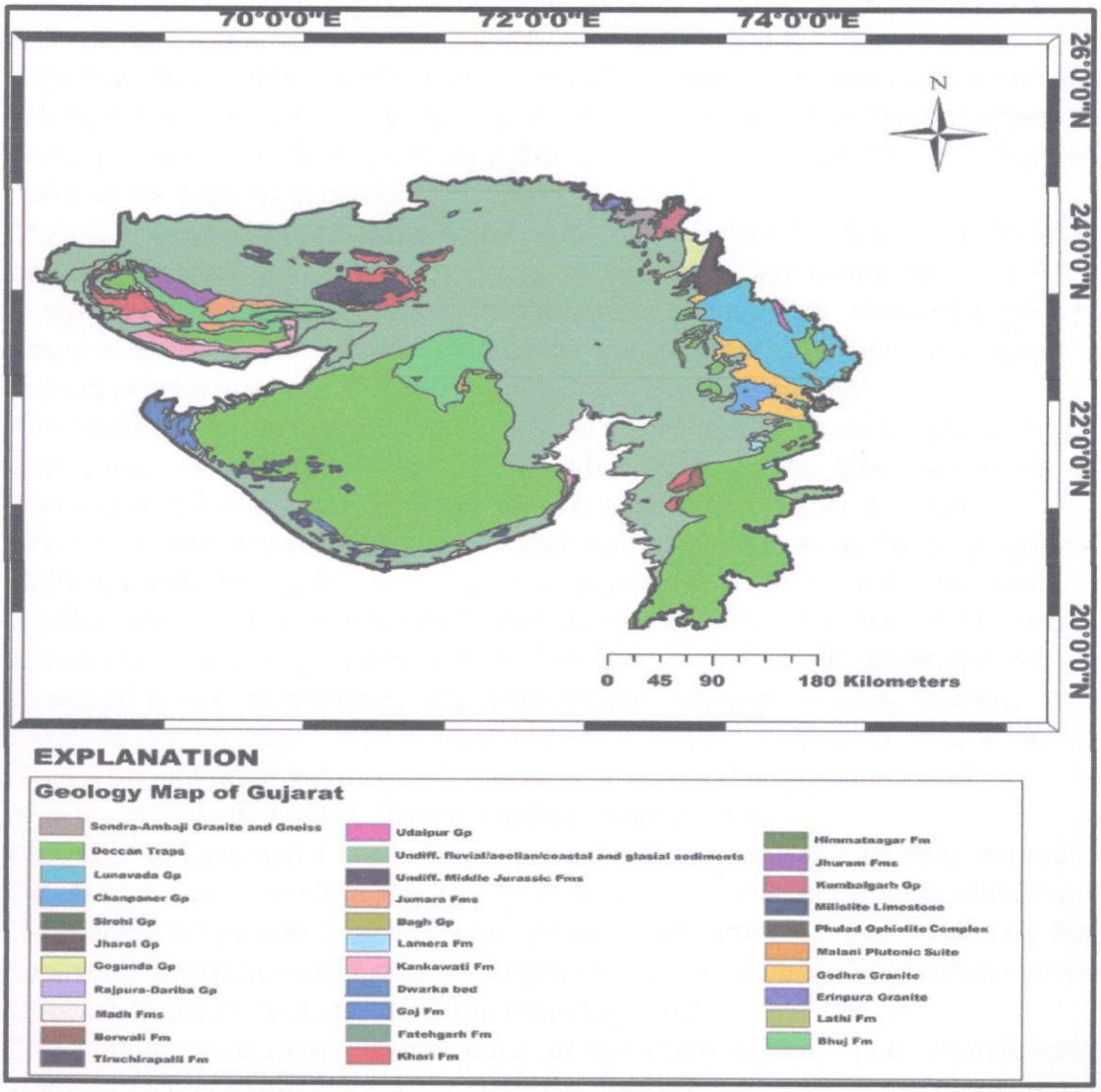
The Kachchh Peninsula

It is a central high plateau dissected on all sides except east. The hill ranges comprising Jurassic rocks in the north with steep northern slopes, followed in the south by the hills of Deccan Traps and the gently sloping peripheral coastal tract of Tertiary rocks are the important components of the Kachchh Peninsula. To the south a rather dissected coastal erosional plain, fringed successively by younger deltaic plains, tidal flats, spits and still younger marginal accretionary features constitute other geomorphological units of this peninsula.

The Rann of Kachchh

The Rann of Kachchh comprising salt-encrusted wasteland is the remnant of a very late marine transgression of Miocene Epoch which is undergoing rapid siltation. The monotony of the flat Rann surface is broken by a group of islands (Bets), prominent

among which are Pachchham, Khadir and Bela, all located in the north as east-west running hills. Three levels of silted and raised Rann surfaces (Banni plains) and a few islands (excluding the three already mentioned) rising slightly above the general level of the Rann are other noteworthy features.



GEOLOGY OF RAJASTHAN

Rajasthan is endowed with a continuous geological sequence of rocks from the oldest Archaean Metamorphic, represented by Bhilwara Super-group (>2500 m.y.) to sub-recent alluvium & windblown sand. The geological sequence of the state is highly varied and complex, revealing the co-existence of the most ancient rocks of the Pre-Cambrian age and the most recent alluvium as well as windblown sand.

Rajasthan forms north-western part of the Indian Shield. The State exposes a variety of lithological and tectonic units ranging in age from Archaean to Recent times. Before going into details of Geology of Rajasthan, let us first see, geology time in general to make sense of terms in geology.

The basement rocks – the Sandmata Complex, Mangalwar Complex and Hindoli Group of Bhilwara Super group – occupy central and south-eastern plains. They are Archaean in age and comprise in general, granulite-gneiss; amphibolites, metapelite, paragneiss, calc-silicate rocks and greywacke (the older granite-greenstone belt) and metavolcanic, met greywacke (the younger granite-greenstone belt) respectively.

The Lower Proterozoic supracrustal rocks of the Jahajpur, Rajpura-Dariba, Pur-Banera and Sawar Groups of Bhilwara Super-group rest on the basement rocks of the Mangalwar Complex and host a number of lead, zinc and copper deposits.

The Proterozoic fold belts, viz., the Aravalli fold belt (the Aravalli Super-group) and the Delhi fold belt (the Delhi Super-group) occupies the southern and south-eastern, and south-western and north-eastern Rajasthan respectively. The Aravalli Super-group is represented by metamorphosed and complexly folded clastic sediments with minor chemogenic and organogenic assemblages with interlay red basic volcanic, whereas the Delhi Super group comprises mainly carbonates, metavolcanics, metasammites and metapelite, intruded by magmatic rock of Phulad Ophiolite Suite and syn-orogenic granites of Sendra- Ambaji, Baraith, Dadikar, Harsora, etc.

A number of base metal deposits are located in these belts as also other minerals. The isolated hillocks of western Rajasthan constitute the Upper Proterozoic Malani Igneous Suite and the Erinpura Granite pluton. Eastern Rajasthan is characterised by the vast sedimentary stretch constituting the Vindhyan, which is exposed against the rocks of the Bhilwara Supergroup along the Great Boundary Fault.

The northern and north-western parts of the State exhibit Upper Proterozoic-Early Cambrian rocks of the Marwar Super group which are overlain by sedimentary rocks of different ages of Paleozoic and Mesozoic Era. Many industrial mineral deposits are found in these rocks. The Deccan Traps are restricted to the south-eastern part of the State in Chittorgarh- Banswara area.

1. The Plains of Thar Desert
2. The Aravalli Mountains
3. The Eastern Plains
4. The Uplands of Harauti and Malwa.

1. The Plains of Thar Desert

Extending westward from the western flank of the Aravalli Mountains is the Thar Desert, which continues into the adjoining parts of Pakistan in the west, and Kachchh in the south. The total surface area of the desert is around 2,00,000 sq. km; almost two-third of which lies in Rajasthan. In the east, the desert is bounded by the Aravalli Mountains. In fact, the mountain range forms a barrier to the advancement of the desert to the central Indian region.

2. The Aravalli Mountains

The Aravalli Mountains, which crosses the state of Rajasthan diagonally for a distance of about 800 km, lies east of the Thar Desert. It is a typical ensialic mountain range of olden Proterozoic rocks having an age span between 2500 and 850 million years from today. The Archaean rocks, which form the foundation of the mountain, have a history of one billion years; the oldest rocks are believed to have originated earlier to 3300 million years ago.

3. The Eastern Plains

Lying east and southeast of the aravalli Mountains is the Eastern Plains of granite gneisses,granitoids, paragneisses, mica schists and phyllites. Heron (1953) quotes Rudyard Kipling who had described region as 'the stony plains of Mewar'. The entire plain is divided into northern Mewar Plain and the southern Chappan Plain. The dividing line of the two plains is an important water divide of the Indian shield. The divider runs east-west (more precisely, ESE-WNW) through the 'girwa" of Udaipur and south of the Udaisagar Lake.

4. The Uplands of Harauti and Malwa

East of the Mewar Plain, separated by the Great Boundary Fault, is the Harauti Upland (or Plateau). This is the westernmost fringe of the Great Vindhyan Plateau. Made dominantly of sandstones and The river system of the State can be conveniently limestones, the upland looks like an escarpment running in a northeast-southwest direction. In the south, near Chittaurgarh, there are a number of north- south trending

folds, of which the anticlines occur as linear ridges separating subparallel flat lying, 'synformal' valleys.

Archaean

BHILWARA SUPERGROUP

Sand Mata Complex, Mangalwar Complex, Hindoli Group

Proterozoic

BHILWARA SUPERGROUP

Rajpura-Dariba Group, Pur-Banera Group, Jahazpur Group, Sawar Group; Ranthambor Group

ARAVALLI SUPERGROUP

Debari Group, Udaipur Group, Bari Lake Group, Kankroli Group;Jharol Group, Dovda Group, Nathdwara Group: Lunavada Group

DELHI SUPERGROUP

Railo Group; Alwar Group, Ajabgarh Group, Gogunda Group, Kumbhalgarh Group, Sirohi Group; Punagarh Group, Sindreth Group

VINDHYAN SUPERGROUP

Lower Vindhyan Group, Upper Vindhyan Group

MALANI IGNEOUS SUITE

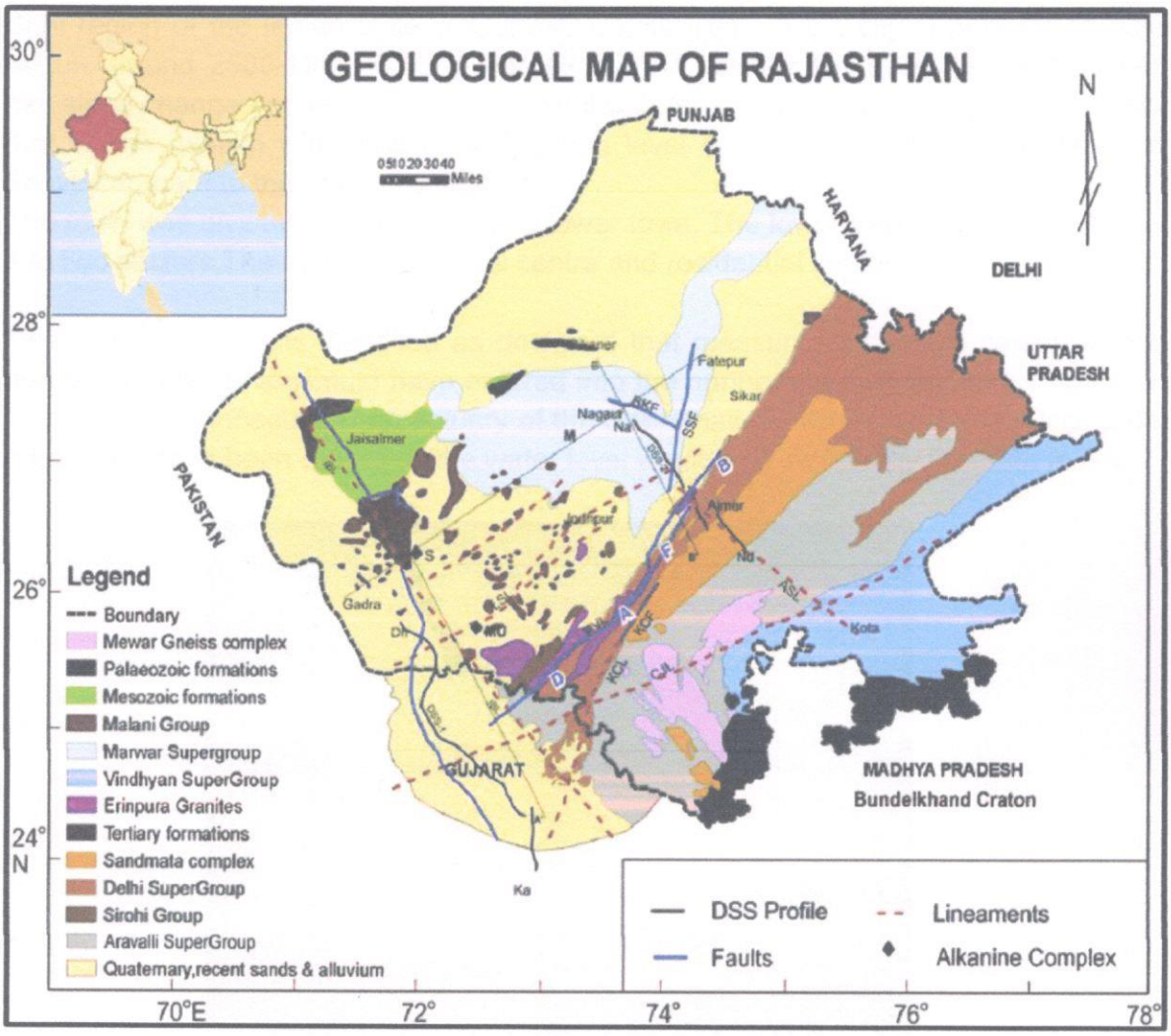
MARWAR SUPERGROUP

Jodhpur Group, Bilara Group, Nagaur Group

Palaeozoic

Mesozoic and Cenozoic

Deccan Traps; Tertiary Alkaline Complex; Sedimentaries; Quaternary


GEOLOGICAL MAP OF RAJASTHAN
N
PUNJAB
HARYANA
DELHI
UTTAR PRADESH
MADHYA PRADESH
Bundelkhand Craton
PAKISTAN
GUJARAT
Jaisalmer
Jodhpur
Ajmer
Patepur
Sikar
Nagaur
Gadra
Ka
Kota
0 50 100 200 300 400 Miles
30°
28°
26°
24° N
70°E
72°
74°
76°
78°
Legend
Boundary
Mewar Gneiss complex
Palaeozoic formations
Mesozoic formations
Malani Group
Marwar Supergroup
Vindhyan SuperGroup
Erinpura Granites
Tertiary formations
Sandmata complex
Delhi SuperGroup
Sirohi Group
Aravalli SuperGroup
Quaternary,recent sands & alluvium
DSS Profile
Faults
Lineaments
Alkanine Complex

Day 1- 22/01/2023

location 1 : 22°31'18"NL
72°14'58"EL
Lothal, Archaeological remains of a Harappan Port-Town

was one of the southernmost sites of the ancient Indus Valley civilisation, located in the Bhal region of the Indian state of Gujarat. Construction of the city is believed to have begun around 2500-1900 BCE. It was excavated besides the river Sabarmati, which has since changed course. The steatite seal was found during archeological excavation that shows relation with arab trade.The sea level during that point of time was 6 m above compare to the present sea level.
The town was divided into acropolis and lower town. The lower town was further divided into two sectors.The main commercial centre and residential sector.

One of the remains is identified as dockyard that measure 214×36 m. constructed of fine burnt brick. Ships could have entered into the northern end of the dock through an inlet channel connected to an estuary of the Sabramati during high tide. The lock gates could then have been closed so the water level would rise sufficiently for them to float.

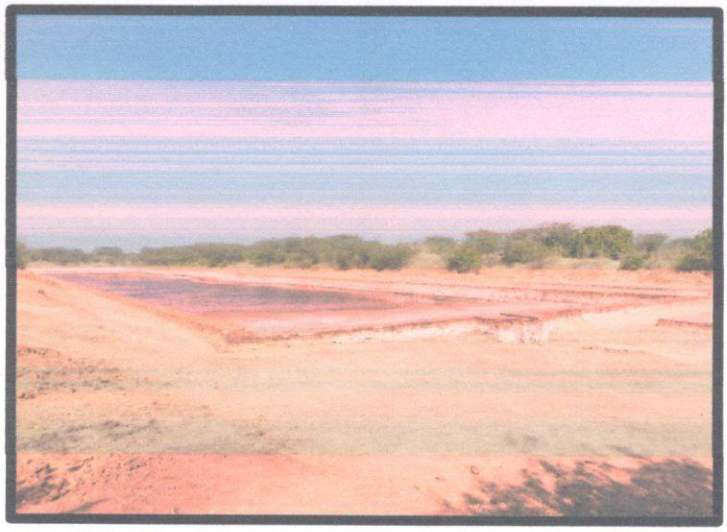


fig 1:Dockyard

The other important structure is warehouse, built for the storage of cargo. originally there were 64 cubical blocks of bricks.

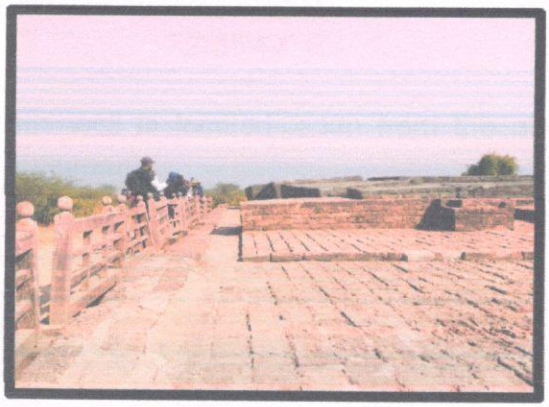


fig 2: warehouse

fig 3. precious stone beads processing

4. well: It was well planned , the bricks used were 4 inch in the inner side and 6 inch in outer side of the well

fig 5: structure used to be bathroom with proper drainage system.

fig

Day 2- 23/01/2023

Location 1 : 23°29'11" N
72°35'49" E

This well is located 2 km from the ahmedabad station and is one of the historical monument.

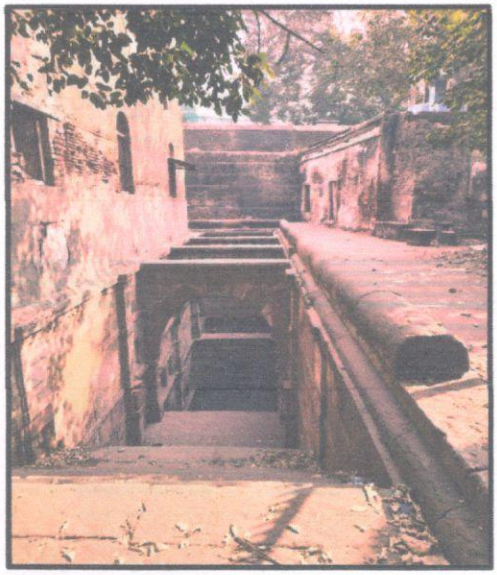


fig 6: step well

Location 2 : 23.1688° N,
72.5451° E.

PRL (Physical Research Laboratory) Ahmedabad, Gujarat

Founded by Dr. Vikaram Sarabhai in 1947.
The Physical Research Laboratory is a National Research Institute for space and allied sciences, supported mainly by Department of Space, Government of India. PRL carries out fundamental research in selected areas of Physics, Space & Atmospheric Sciences, Astronomy, Astrophysics & Solar Physics, and Planetary & Geo-Sciences.

MC-ICPMS stands for "multi-collector inductively coupled plasma mass spectrometry" and is a highly sensitive and precise analytical technique that is used in a wide range of

applications, from studying the geochemistry of rocks to analyzing trace elements in biological sample.

TIMS stands for "thermal ionization mass spectrometry" and it is a powerful analytical technique used for high precision isotopic analysis of a wide range of elements.A small amount of sample material is loaded onto a filament, which is then heated to a high temperature. The heat causes the sample to vaporize and form ions. The vaporized sample is ionized by bombarding it with electrons and accelerated through a series of electric fields and sent towards a mass spectrometer. The ion beam is separated into its various isotopes by a mass spectrometer. This allows the different isotopes of an element to be measured separately. The ion beam is then directed towards a detector system which measures the number of ions hitting it.

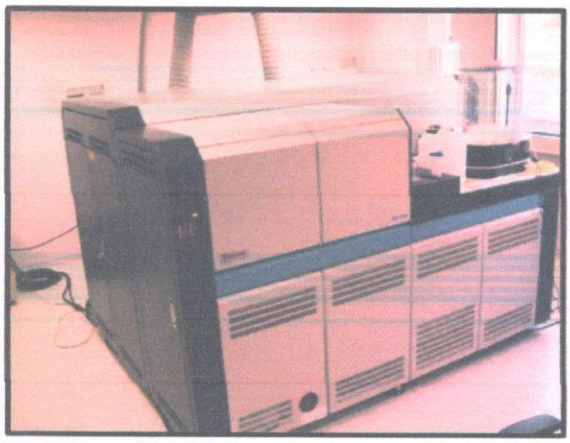


fig 7: MC-ICPMS

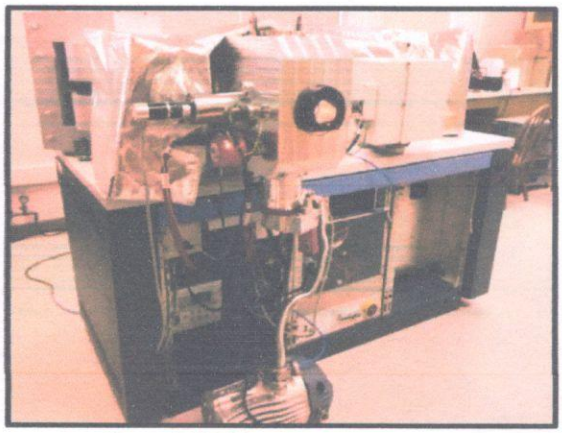


fig 8: TIMS

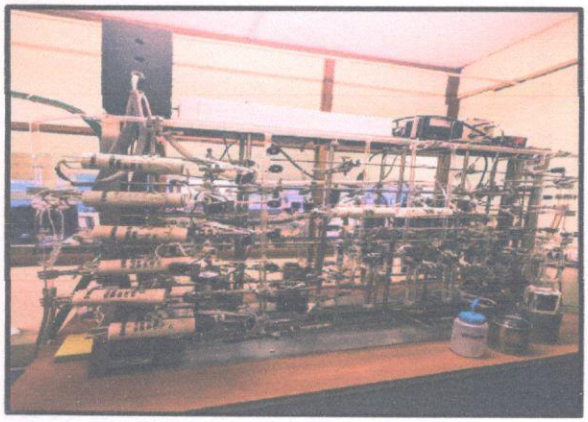


fig 9: Radiometric carbon dating

Day 3- 24/01/2023

Location 1: Godhra Granite, Ahmedabad (near mahadev temple)

Latitude: 22.970785
Longitude: 73.346296

Location is 4 km from balasinor town. Granite shows tors and domes topography. Tors are large rounded boulders of granite that may be formed from the action of weathering and erosion. The presence of exfoliated domes caused by expansion of rock due to change in temperature. The colour of the rock is greyish and grain size range between medium to coarse, is crystalline in nature, rock consist dominantly of feldspar and quartz minerals classify as essential minerals and biotite as accessory mineral. segregated quartz and biotote fragments were seen in the rock at several places. euhedral crystals of plagioclase can also be seen oriented in particular direction. The rock is classified as plutonic felsic igneous rock. named as Grey Granite.

fig 10: biotite in granite

fig 11: biotite and quartz

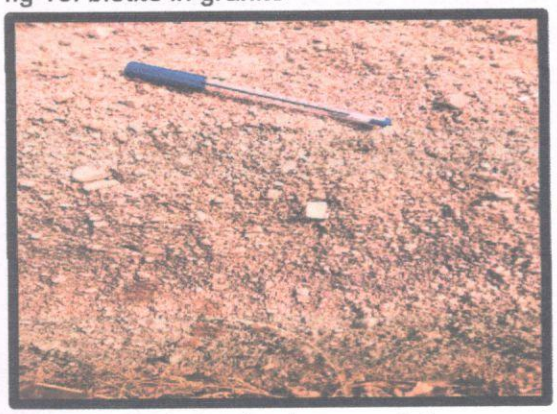


fig 12: Euhedral orthoclase crystals

fig 13: grey granite

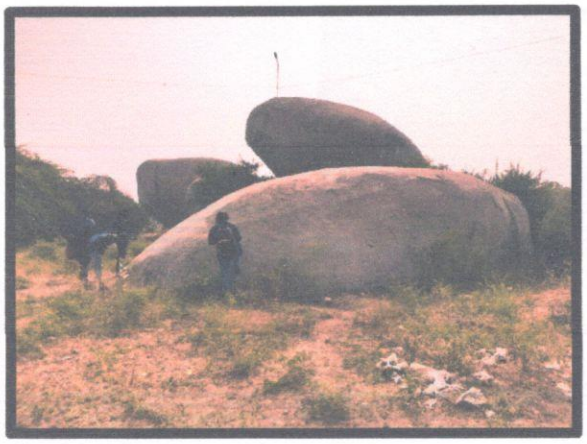


fig 14: torse

Loaction 2: Dinosaur Fossil Park- Raioli

Latitude:23.056218
Longitude:73.342891

The Park is at a distance of 16 km from Balasinor city, in Raiyoli and 100 km from Ahmedabad.

Spot 1: within the distance of 200 m of the main fossil park, shows the conglomerate lithology with mostly jasper fragments. The conglomerate can be further classified as paraconglomerate as it was matrix supported.

spot 2: The park spread over the area of 72-hectare. The discovery of dinosaur fossil in 1980 has made this town of Balasinor very much popular. Dinosaur eggs and fossils of atleast 13 species were unearthed. One of the most significant discoveries that were made here was that of a carnivorous dinosaur named Rajasaurus Narmadenis. The rocks are embedded with various parts of bones that include ulna, vertebrae, scapula coracoid, limb, femur, hem.

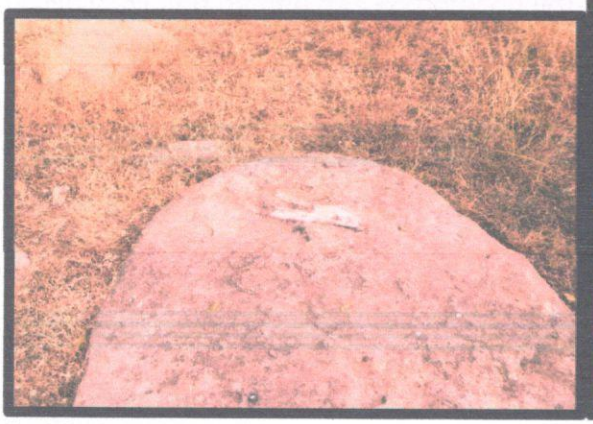


fig 15: dinosaur fossil

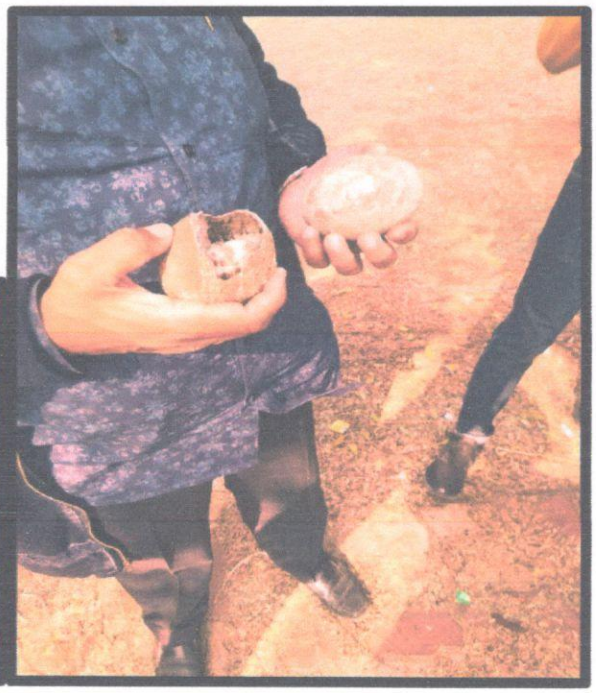


fig 16: fossillised egg

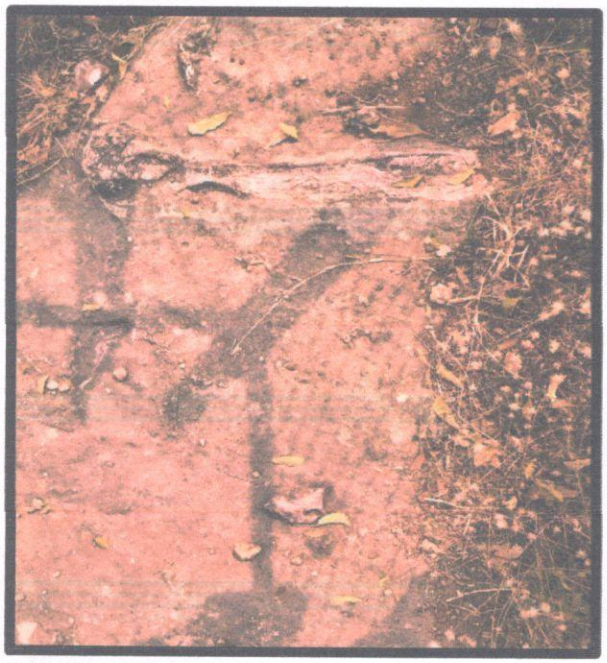


fig 17: fossil bone

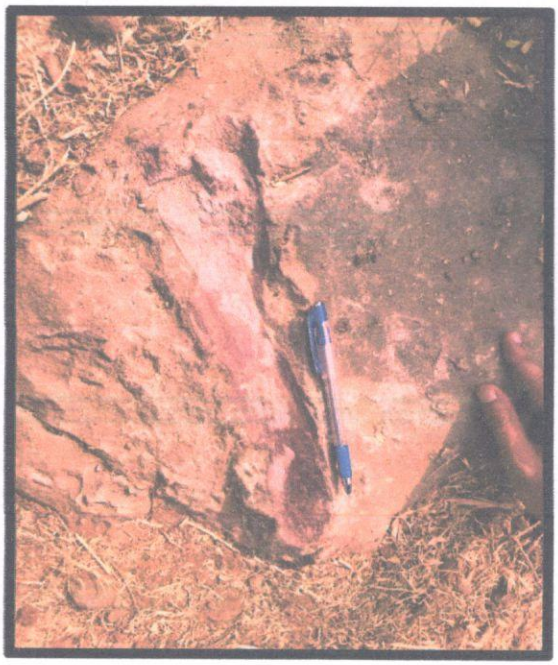


fig 18: fossil bone

Day 4- 25/01/2023

Location 1:

ONGC(oil and natural gas corporation ltd)
GGS- MOTERA
The mine code was 100180

We visited a oil and crude treatment plant which was connected to 59 oil wells through underground pipelines.

Mister Gaurav kumar who was Safety Officer, guided us and shared information about the working of the plants present there.

We went to the main processing plant where oil and gas is recieved through underground pipelines which comes to a booster gas compressor plant which passes to the low pressure seperator which seperate Oil and Gas based on the density. Which is directly stored in a tanker.

Based on the pressure received there are two seperator present.
Low pressure seperator (20.60kg/cm2)
Hydro test pressure - 9.0 kg/cm2
Safety valve test pressure -6.-kg/cm2

High Pressure seperator (40 kg/cm2)
Hydro test pressure- 60 kg/cm2
Safety valve test pressure- 43 kg/cm2

Through this seperator, oil and gas is directly stored in the storage tank.
Corrosion inhibitor are used to prevent rusting of pipelines. 2 liters per day in each pipeline.

There are 2 new gas booster plants with high capacity. This are 2 stage compressor which makes the machine smaller in size.
The bath heaters are used to increase the temperature of crude so that it flows smoothly without getting solidifies in the pipelines which works on the principle of heat exchanges.
This new booster plant have a fire safery measure which floods with CO_2 incase if any fire ignites.

They used SCADA software maintain the pressure temperature and flow meter.

fig 19: ONGC GGS MOTERA AHMEDABAD

Day 5- 27/01/2023

Location 1 :Latitude: 24° 58' 25'' N
Longitude: 73° 51' 71'' E

spot 1: Rajasthan state mines and minerals, Jhamarkotra

In 1969 after discovery of rock phosphate in Jhamarkotra (Udaipur), BGL took over operations at Jhamarkotra mines. The major activity of RSMML is the mining of Rock phosphate ore.
If an entity starts falling down the 12m bench stops it from rolling further down. The rock phosphate occurs in metasedimentary rocks of Aravalli Supergroup (Precambrian age). It is of algal origin. The deposit extends over a strike length of 16 kms in horse-shoe shape with average thickness of 15 meters. A reserve of 77 million tonnes of rock phosphate has been proved on the basis of 60,000 mts. drilling in 500 boreholes. Out of these 17 million tonnes is of +30% P2O5 grade and rest is of 12 0 30% P2O5 grade. A beneficiation plant of 1500 TPD (Tonnes Per Day) capacity has been installed to upgrade the low-grade phosphate ore.

Genesis of rock phosphate at Jhamarkotra
The mineral phase of apatite, which makes phosphorite, is considered to have formed by three mechanisms (i) direct inorganic precipitation, (ii) primary biogenic precipitation, and (iii) diagenetic precipitation/replacement. Diagenetic precipitation of apatite is considered as an important mechanism involved in phosphorite formation. Apatite of this origin commonly occurs as void filling and cementing material in the associated sediments. It is said that the organic matter, which collects on the shelf regions, on decay, causes very high concentration of phosphorous below the sediment water interface, leading to precipitation of apatite. During this process carbonate constituents of the sediment are also phosphatised due to the replacemen.

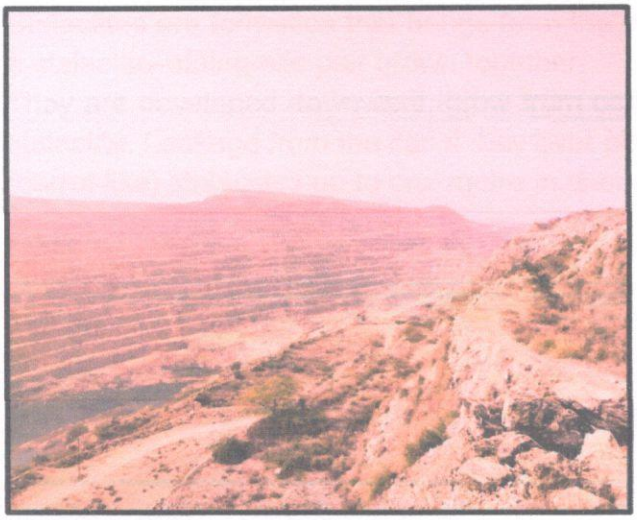


fig 20: jhamakotra mine open pit

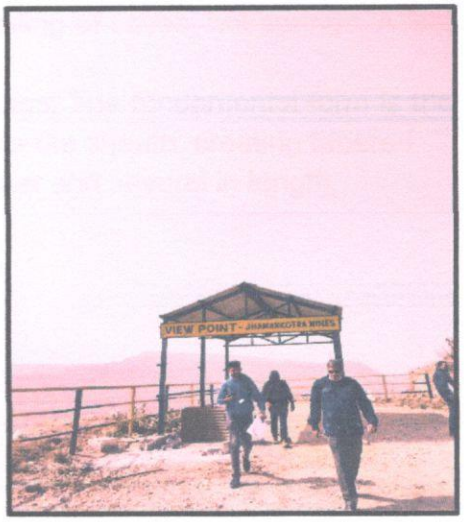


fig 21: view point

fig 22: boitriodal structure apatite

spot 2: Jhameshwar Mahadev Temple, Jhamarkotra

Stalactites are formation that hangs from the ceiling of caves, hot springs. A 'column' is a stalactite–stalagmite pair grown together.
They are developed downward, grow from ceilings. The fundamental form is the 'straw' stalactite, Leakage from the canal may over plate the sheath, creating tapered (carrot-like) stalactites up to one metre in diameter and several in length.

fig 23: stalactite

Day 6- 29/01/2023

Location 1: Berech river, Chittorgarh, Rajasthan

Latitude: 24 47 40 N,
Longitude: 73 51 71 E.

spot 1
The expose rock was highly folded. fold are asymmetrical with alternate anticline and syncline.
The river moves along the strike line and one limb of the bed dip towards the river. There were 2 series of folds, The primary folds are refolded by the force acting parallel to the hinge of the primary fold , this led to the formation of plunge. The plunge of an anticline fold is measured to be 12° with a hinge oriented in N 192°and that of a syncline to be 10° with hinge orientation of N 195°. This folds has the influence of formation of himalayas. 2 sets of joints can be seen prominently cutting across each other.
The rock exposure is a part of vindhyan basin and called as suket shale

Strike direction- N 45°
Dip direction- N 140
Amount of true dip- 53°

Strike direction- N 43°
Dip direction- N 133°
Amount of true dip- 49°

Strike direction- N 40°
Dip direction- N 135
Amount of true dip- 60°

Strike direction- N 48°
Dip direction- N 135
Amount of true dip- 40°

The reading shows variation in hinge orientation between 192-195° which indicate that there was uneven compressional force acting on the rocks.

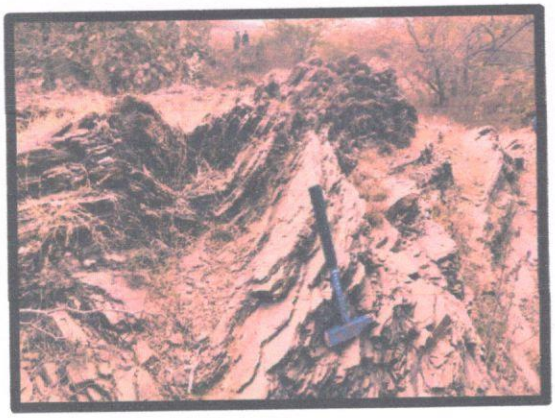


fig 24: suket shale fold

fig 25: fold

spot 2

Across the river with in the distance of 50m . Consist of same lithology of suket shale and was overlain by clast supported onglomerate.

1. Strike direction- N 46°
   Dip direction- N 140
   Amount of true dip- 54°

spot 3

fine grained rock dipping towards the river, strike along the river.
identified as Nimbara Limestone

1. Strike direction- N 180°
   Dip direction- N270
   Amount of true dip- 42°

Day 7
Location: Nimbara limestone/ marble

Latitude: 25 05' 76" N
Longitude: 73 85 08" E

spot 1:
Large beds of marble and Mica chloride schist were seen which were dipping at a dip of 30° to 40°. The dipping beds of marble and mica chloride schist were seen at a larger scale. The mica chloride schist was highly metamorphosed and weathered in which Biotite can be seen prominently throughout the bed. At places distinct Augen structures were seen. Sinsodal structure were observed in marble. Termolite and Actinolite were seen in the marble.The marble strata were inclined with the overlying bed of schist. The schist present was heavily weathered. The marble bed which was inclined had minor crenulation folding sequence which initiated few joints present in the marble. The recrystallised silica grains in the marble suggested the following sequence have undergone contact metamorphism. The schist present had alternate augen gneiss structure with minerals like chlorite and tremolite dominating into the rock, which suggested the name of the schist as mica schist. Elongated acicular structure is also seen in the mica schist in which the needle like structure consists of tremolite.

1.Strike direction: N130
Dip direction:N 220
Amount of dip: 32°

2. Strike direction: N360
Dip direction: N90
Amount of dip: 26°

spot 2:
50 m from spot 1

1.Strike direction: N135°
Dip direction: N227
Amount of dip: 35

2. Strike direction: N135°
Dip direction: N 225

Amount of dip: 30°

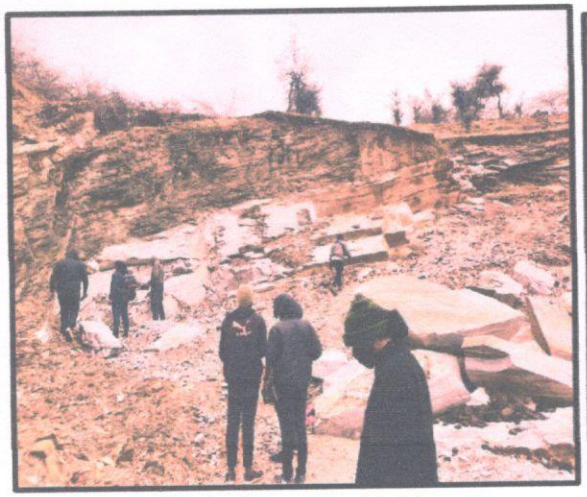


fig 26: marble between schist layer

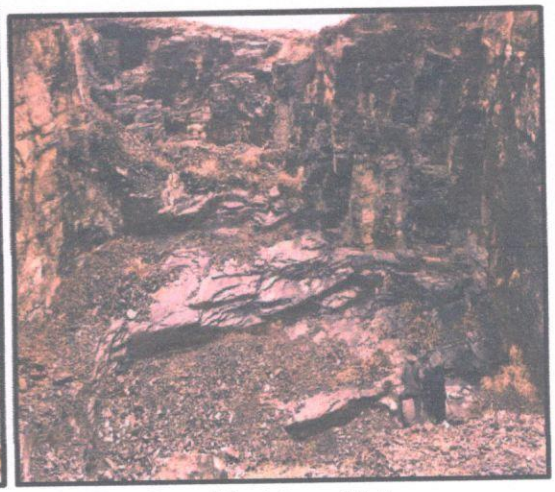


fig 27: mica chloride schist

Reference

Geology of Rajasthan (Northwest India) Precambrian to recent
-A. B. ROY & S. R. JAKHAR

Geology and Mineral Resources of Gujarat, Daman and Diu
Geological Survey of India

Radhakrishna, B. P., & Naqvi, S. M. (1986). Precambrian continental crust of India and its evolution. The Journal of Geology, 94(2), 145-166.

Roy, K.S., Sharma, J., Kumar, S. et al. Effect of coronavirus lockdowns on the ambient seismic noise levels in Gujarat, northwest India. Sci Rep 11, 7148 (2021). https://doi.org/10.1038/s41598-021-86557-9