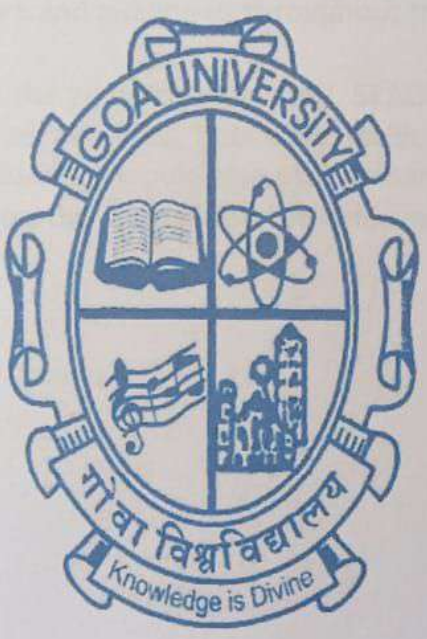
REPORT ON THE GEOLOGICAL FIELDWORK CARRIED OUT IN AND AROUND GUJARAT AND RAJASTHAN

Submitted by
Salis Abdul Gafoor Ahmed
MSc II
21P0450021



School of Earth Ocean and Atmospheric Sciences
Goa University

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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 Eo archean 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, apart of Gujarat, Karnataka, MadhyaPradesh 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 super continent of Pangaea. At that time, what is now India's south west coast was attached to Madagascar and southern Africa, and what is now its east coast was Attached to Australia. During the Jurassic Period about 160Ma(ICS 2004), rifting caused Pangaea to break apart into two super continents, Namely Gondwana (tothesouth) and Laurasia (to the north). The Indian Craton remained attached to Gondwana, until the super continent began to rift apart about in the early Cretaceous, about 125 million years ago (ICS2004). The Indian Plate then drifted northward towards 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 (ICS2004), 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 (ICS2004). This orogeny, which is continuing today, is related to closure of the Tethys Ocean. The closure of this ocean which created the Alpsin 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 Plates utured on to the adjacent Australian Plate, for minga new larger plate, the IndoAustralian 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 orogeny called the Aravali-Delhi Orogen that joined the two older segments that make up the Indian Craton. It extends approximately 500 kilometres (311mi) from its northern end to isolated hills and rocky ridges into Haryana, ending near Delhi.

Early Paleozoic rocks are found in the Himalayas and consist of southerly derived sediment seroded from the crystalline craton and deposited on the Indian platform. 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 Indian Ocean. Exposures of these rocks occur along the south Indian coastat Pondicherry and in TamilNadu. 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, the sea mark the final break from Gondwana.

Geology Of Gujarat

The state of Gujarat comprises an area of approximately 1,96,000 sq.km and is enclosed within North Latitude 200 100 to 240 500 and East Longitude 680 400 to 740 400 . Geologically Gujarat provides a wide spectrum of rock types of different ages. Whereas the Aravalli's in the NE is as old as 2500 million years, the unconsolidated alluvium and beach materials in its central and western parts, date back to a few thousand years only. All the important lithological types Igneous, Sedimentary and Metamorphic occur within the state. The Gujarat state exposes rocks belonging to the Pre- Cambrian, Mesozoic and Cenozoic era. The hard rocks cover about 49% of the total area of Gujarat, the rest being occupied by sediments of Quaternary period. The hard rock comprises Pre Cambrian metamorphosed and associated intrusive, sedimentary rocks of Mesozoic and Cenozoic eras and the traps/ flow constituting Deccan volcanic of Cretaceous Eocene age.
Geomorphologically, the State can be divided into three distinct divisions, viz.:
a) Gujarat-Mainland.
b) Saurashtra-Kathiawar Peninsula, and
c) Kutch Peninsula.

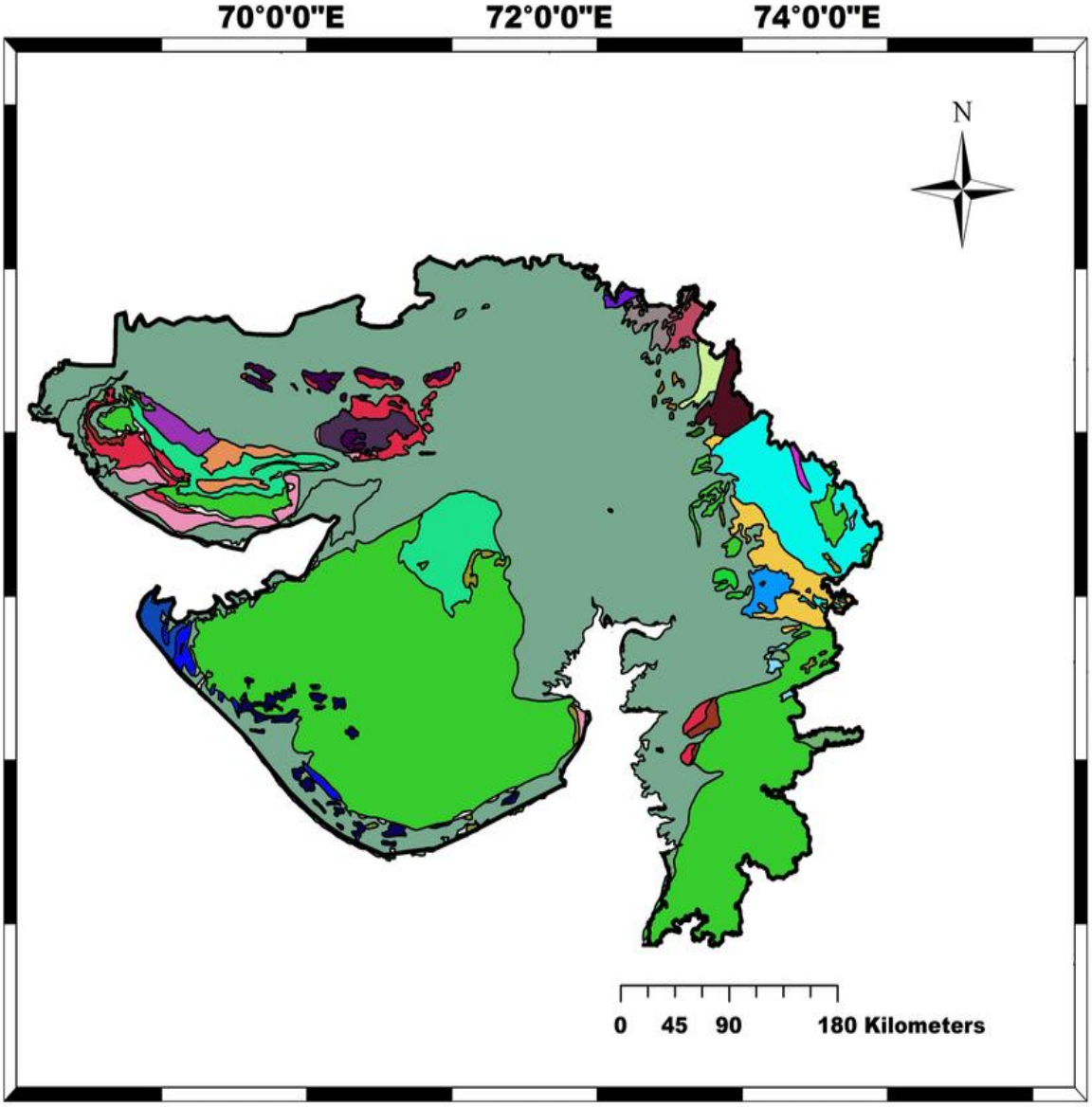
a) Gujarat-Mainland : The well known agriculturally rich alluvial basin of Gujarat rises from the estuarine tracts between Narmada and Tapi rivers and extends 250 miles (402 km) northwards merging into the desert plains of Rajasthan and the Rann of Kutch. It is roughly 75 miles (121 km) wide. The eastern border of the basin is bounded by Aravali, Vindhya, Satpura, and Sahyadri hill ranges. The eastern part of the south Gujarat bordering the alluvial tract has a typical Deccan trap scenery up to Narmada valley. The hills are formed by circumdenudation leaving wide plateau at top, and a step like feature because of horizontal lava-flows and their differential weathering.

b) Saurashtra-Kathiawar Peninsula: The Saurashtra is bounded by Gujarat plains in the East and NE, by gulf of Kutch and Little Rann on the north, and on the SE by the Gulf of Cambay. The Arabian Sea borders the entire southern seaboard. The Central part of the region forms an elevated table land, from where most of the rivers rise and flow radially. The terrain generally slopes gently towards the peninsular margin to merge into the coastal plains and the great alluvial tract stretches to NE and east. The sedimentary rocks along the coast form almost a low flat country.

c) Kutch Peninsula: The mainland of Kutch is isolated by the Great Rann of the north and east, Little Rann on the SE, Gulf of Kutch on the south and rest by the Arabian sea. The central portion of Kutch forms a table-land sloping on all sides, the shape of the region is like a tortoise and hence the name. In general, there are three hill ranges, trending almost east-west. North-flowing rivers disappear in the Rann; others join the sea. The Rann is a dry bed of the remnant of an arm of the sea, which formally connected the Narmada rift with Sind and separated Kutch from the mainland.

LITHOSTRATIGHRAPHIC TABLE

Group	System	Rock Type	Localities	Age in millions of years
Quaternary	Recent and subrecent	Alluvium, Blown sand, Silts of Rann and Banni, Tidal flats and raised beaches.	Alluvial plains of Gujarat, Rann, Banni & Coastal deposits.	0.01
	Pleistocene	Miliolites	(i) Saurashtra coast from Gopnath northwards extending beyond Porbandar. (ii) Kutch area.	1
Tertiary or Kainozoic	Pliocene	Dwarka beds, Manchhar beds, Gypsiferous clays and sandy foraminiferal limestones.	Dwarka, Okha, Piram Island, Kutch.	12
	Miocene	Gaj beds-Highly fossiliferous clays and limestones. Agate Bearing conglomerates. Kand formations.	Saurashtra coast, Kutch	25
	Oligocene	Tarkeshwar clays.	Tarkeshwar (District:Surat) and Kutch.	40
	Eocene	Nummulitic limestones and clays.	Tarkeshwar area and Kutch.	60
Secondary or Mesozoic.	Cretaceous Eocene	Deccan traps with inter trappeans.	Parts of Sabarkantha, Panchmahals, Baroda, Broach, Surat and major part of Bulsar and Dangs Districts. Major part of Saurashtra and small part of Kutch.	
	Cretaceous	Himatnagar sandstones, Lameta (limestones). Bagh beds. Songir sandstones, Nimar sandstones,Wadhavan sandstone (Infratrappeans), Bhuj and Umia series sandstones	Himatnagar, Kapadvanj, Balasinor, Parabia, Dohad, Gabat, Narmada valley, Songir.Near pavagadh. Wadhavan,Dhrangadhra,Bhuj etc.	110
	Jurassic	Katrol series, Chari series, Patcham series (sand-stones, shales and limestones).	Kutch.	150
	Purana (Algonkian & Part of Cambrian)	Erinpura granite (Post-Delhi).	Palanpur, Danta, Idar, Modasa, Taranga, Dharoi, Virpur, Wanakbori, Godhra, etc.	1500
		Delhi System-Alwar quartzites, schists, and calc-gneisses, calcschists of Ajabgarh series.	Parts of Sabarkantha and Banaskantha, and Mehsana Districts.	
Archaean or Azoic		Aravali System-Micaschists, Phyllites, quartzites, etc.	Sabarkantha, Panchmahals, Baroda, Banaskantha.	4000
		Banded gneissic complex.	Baroda District.	



EXPLANATION

Geology Map of Gujarat

- Sendra-Ambaji Granite and Gneiss
- Deccan Traps
- Lunavada Gp
- Chanpaner Gp
- Sirohi Gp
- Jharol Gp
- Gogunda Gp
- Rajpura-Dariba Gp
- Madh Fms
- Berwali Fm
- Tiruchirapalli Fm
- Udaipur Gp
- Undiff. fluvial/aeolian/coastal and glasial sediments
- Undiff. Middle Jurassic Fms
- Jumara Fms
- Bagh Gp
- Lamera Fm
- Kankawati Fm
- Dwarka bed
- Gaj Fm
- Fatehgarh Fm
- Khari Fm
- Himmatnagar Fm
- Jhuram Fms
- Kumbalgarh Gp
- Miliolite Limestone
- Phulad Ophiolite Complex
- Malani Plutonic Suite
- Godhra Granite
- Erinpura Granite
- Lathi Fm
- Bhuj Fm

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 granitegreenstone belt) and metavolcanic, met greywacke (the younger granitegreenstone belt) respectively. The Lower Proterozoic supracrustal rocks of the Jahajpur, Rajpura-Dariba, PurBanera 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 southeastern, 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 juxtaposed against the rocks of the Bhilwara Supergroup along the Great Boundary Fault.

Field Observations

Day-1

Location: Lothal

Latitude: 22.4654° N
Longitude: 72.2327° E

Lothal is an ancient city located in the state of Gujarat, India. Lothal was one of the most important ports of the Indus Valley Civilization, and was located on the banks of the Sabarmati river and Sindu. This dockyard was formed around 4500 years ago.

The city was surrounded by a massive earthen wall and was divided into two parts: the upper town and the lower town. These towns are named as Acropolis & Low level. Acropolis is located 3m above the lower town because of the warehouse for storing goods. The warehouse is covered with a wooden roof. A public toilet was there on the acropolis.

The lower town was where the port was located. Lothal was known for its production of beads, jewelry, and other items made from semi-precious stones, which were traded with other parts of the Indus Valley and beyond. A small factory was there for the production of beads on acropolis. A market was also there nearby the factory.

Archaeological excavations have revealed the presence of a dockyard at Lothal, which was one of the earliest and most impressive examples of maritime architecture in the ancient world. The dockyard was connected to the river by a channel, which allowed ships to enter and exit even during low tide. Those ancient people had clearly an idea about the flood and the flood water is being stored for the future purposes.

The city of Lothal declined in importance after the decline of the Indus Valley Civilization, but its legacy as a center of trade and commerce lives on. Today, the site is a popular tourist destination and an important archaeological site.

Figure 1 Dockyard

Figure 2 Public toilet

Figure 3 Warehouse

Figure 4 Market

Day-2

Location-1: Amrutvarshini Vav Paanchkuva

Latitude: N 23º29’11”
Longitude: E 72º35’49”

The stepwell is situated 500m away from Ahmedabad railway station.It has a three storey and is more than 50ft deep.It is one among the 5 wells which was built on 1723. The Panchkuva Vav, as it is known, had five wells and the Vav was developed in 1723 by Raghunath Das, Diwan of Haider Quli Khan, and the governor of Gujarat. It goes three storeys deep and has simple architecture with an L shape.

Figure 5 Amrutvarshini Vav Paanchkuva

Location-2: Physical Research Laboratary (PRL), Ahmedabad

Latitude: 23.1688° N
Longitude: 72.5451° E

The Geosciences Division of the Physical Research Laboratory (PRL) in India is an important research institution that focuses on the study of the earth and its various

components. It is one of the largest and most prestigious organizations in the country dedicated to the field of geosciences.

Established in 1947, the Geosciences Division of PRL is located in Ahmedabad, Gujarat, and has been instrumental in advancing our understanding of the earth's structure, composition, and dynamics. The division is home to a team of highly qualified and experienced researchers who work on various aspects of earth science, including seismology, geodynamics, geodesy, atmospheric science, oceanography, and paleoclimate.

The Geosciences Division of PRL has a wide range of research facilities and state-of-the-art equipment that are used to conduct cutting-edge research.

MC-ICPMS

MC-ICPMS stands for "multi-collector inductively coupled plasma mass spectrometry" and it is a powerful analytical technique used for high precision isotopic analysis of a wide range of elements.

Here's a brief explanation of how MC-ICPMS works:

1. Sample introduction: A small amount of sample material is introduced into an inductively coupled plasma (ICP) source, where it is vaporized and ionized.

2. Ionization: The ions produced in the ICP are extracted and focused into a beam, which is then sent through a series of magnetic fields. The magnetic fields cause the ions to bend, and the degree of bending depends on their mass-to-charge ratio (m/z).
3. Separation: 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.

4. Detection: The ion beam is then directed towards a detector system which consists of multiple collectors, each of which collects a specific isotope of interest. By measuring the isotopic ratios of the different collectors, the relative abundances of the different isotopes can be determined with high precision.

Overall, MC-ICPMS 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 samples.

TIMS

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.
Here's a brief explanation of how TIMS works:

1. Sample introduction: 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.

2. Ionization: The vaporized sample is ionized by bombarding it with electrons. The ionized sample is then accelerated through a series of electric fields and sent towards a mass spectrometer.

3. Separation: 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.

4. Detection: The ion beam is then directed towards a detector system which measures the number of ions hitting it. By measuring the isotopic ratios of the different ions, the relative abundances of the different isotopes can be determined with high precision.

Overall, TIMS is a highly sensitive and precise analytical technique that is used in a wide range of applications, from studying the geochemistry of rocks to analysing trace elements in biological samples. TIMS is often used for measuring isotopic ratios of elements that have low natural abundance, such as uranium and lead.

Figure 6 MC-ICPMS

Figure 7 TIMS

Day-3

Location-1: Mahadeva Temple

Latitude: N22˚58.240
Longitude: E73˚20.765

The place is 4 km from Balasinor town.The location is exposed with large massive, medium grained & grey in colour with rounded outcrop of granites known as Godhra granites which exhibit exfoliations weathering. It composed of Quartz, feldspar and mica in hand specimen. The trend of these granitoids is N-S. Large phenocrysts of Feldspar of about 2-5 cm were surrounded by finer matrix mainly composed of biotite and quartz. At places these euhedral feldspars were aligned in a particular direction (trains of end-to-end touching grains) which is a characteristic of magmatic flow. Some places granite is seen as weathered, because feldspar is standing out. Some places feldspar is aligned as stacks. Xenoliths are present which made of rich in biotite and at some places needles of hornblende are also seen.

Figure 8 Biotite enclaved in granite

Figure 9 Godra graniote

Figure 10 Phenocryst of feldspar

Location-2:

Latitude: N 23º20’18”
Longitude: E 73º11’25”

The location was exposed with outcrops of Conglomerate with different sized clasts ranging 2-3 cm,and Sandstone. Fine grained pinkish jaspers were found as clasts in Limestones. Teeth and Bones of Dinosaurs are found in sandstones,while their Eggs are found in Limestone.

Figure 11 Conglomerates

Location-3: Rhyoli Dinosaur Museum & Fossil Park

Latitude: N23˚ 4’ 12”
Longitude: E73˚11’35”

The Raiyoli Dinosaur Fossil Park is a dinosaur museum and fossil park in the Indian town of Balasinor. The Balasinor Dinosaur Fossil Park is another name for it. The park is roughly 80 kilometres from Ahmedabad and spans an area of about 72 acres. The Raiyoli Dinosaur Fossil Park is home to one of the world's largest dinosaur egg hatcheries as well as India's largest dinosaur fossil deposit. Dinosaurs are said to have lived in the park 65 million years ago. It houses around 10,000 dinosaur fossils discovered during excavations by the Geological Survey of India (GSI) and the Gujarat Ecological Education and Research (GEER) Foundation, including bones, eggs, and other remnants.

The place contain bone fossils of different parts of different species. Fossils present are the left ulna of sauropod, scapula coracoid of titanosaurus, adjoining caudal vertebrae of abelisauroid theropod and an indeterminate limb bone, dorsal

vertebrae abelisauroid theropod with indeterminate limb bone, left femur in medial view and caudal vertebrae of sauropod.

Figure 12 Vertebra of terapod

Figure 13 Fossilised eggs

Figure 14 Cerapod eggs

The museum presented Dinosaur family with still models and working models of different species of dinosaurs. They even had VR,3D films, Galleries. The park has a museum where visitors may examine life-sized dinosaur replicas, bones, and displays about dinosaur evolution.

Day-4

Location-1: Oil and Natural Gas Corporation

Latitude: N 23º02’8”
Longitude: E 72º32’33

Figure 15 ONGC Motera station

ONGC is the largest government-owned-oil and gas explorer and producer in the country, and produces around 70% of India's crude oil and around 84% of its natural gas. ONGC GGS Motera is a gas gathering station located in Motera, Gujarat, India, operated by the Oil and Natural Gas Corporation (ONGC). The primary function of the station is to collect and process natural gas from nearby oil fields and deliver it to various customers such as fertilizer plants, power plants, and city gas distribution networks.

We were given instructions and other informations about the plant by Mr Gaurav Kumar, safety officer. There are 59 installation wells in a radius of about 17 km which are all connected. All the pipelines are underground with 10-15 kms. These pipelines are connected to the oil wells which are then taken to the seperators to set apart oil

and gas according to the pressure. Oil is taken into 3 tanks each of 45000 litre while Gas is taken to the compressor.

ONGC GGS Motera uses advanced technology and equipment to ensure safe and efficient gas gathering and transmission. Some of the key technologies used at the station are:

• Gas Chromatography: Gas chromatography is used to separate and analyze the various components of the natural gas mixture. This technology helps to determine the quality and 17 composition of the gas being processed, which is critical for maintaining the efficiency and safety of the gas gathering process.

• Compressors: Compressors are used to increase the pressure of the natural gas so that it can be transmitted through pipelines to various customers. The compressors used at ONGC GGS Motera are designed to operate at high efficiency and with minimal maintenance requirements.

• SCADA System: SCADA (Supervisory Control and Data Acquisition) system is used to monitor and control the various components of the gas gathering and transmission process. This system provides real-time data on gas flow rates, pressure levels, and equipment status, allowing operators to make adjustments and ensure safe and efficient operations.

• Pipeline Inspection: Regular inspection of pipelines is critical to ensure safe and reliable gas transmission. ONGC GGS Motera uses various inspection technologies, including smart pigs (devices that travel inside pipelines to detect defects) and remote sensing techniques, to detect and repair any pipeline damage.

• Environmental Monitoring: ONGC GGS Motera also uses advanced environmental monitoring systems to track air and water quality around the station. This helps to ensure compliance with regulatory requirements and minimize the impact of the station's operations on the environment.

Day-5

Location- 1: Jhamar Kotra Mine Udaipur

Latitude: N 24º28’21”
Longitude: E 73º51’34”

Figure 16 Jhamarkotra Mines, Udaipur

Rajasthan State Mines & Minerals Ltd (RSMML) is a public sector firm of the Government of Rajasthan that principally produces and markets high-grade rock phosphate, lignite, limestone, and gypsum (non-metallic minerals) from mines situated throughout Rajasthan. BGL took over operations at Jhamarkotra mines in 1969, following the discovery of rock phosphate at Jhamarkotra (Udaipur).

RSMML's primary business is the mining of rock phosphate ore. It runs one of the country's largest and most mechanised mines in Jhamarkotra, 26 kilometres from Udaipur. Jhamarkotra is noteworthy since it contributes 98% of India's rock phosphate output. Jhamarkotra is possibly India's largest open cast mine outside of the steel and coal sectors, with an annual rock handling capacity of over 20 million tonnes. Because of the geometry of the ore body, which is thin and sharply dipping, long and narrow pits with tremendous depth extension have resulted in a very high stripping ratio with high lead and lift for waste and mineral. If an entity starts falling down the 12m bench stops it from rolling further down.

The rock phosphate is found in Aravalli Supergroup metasedimentary rocks (Precambrian age). It is derived from algae. The deposit has a strike length of 16

kilometres and an average thickness of 15 metres. On the basis of 60,000 mts. of drilling in 500 boreholes, a reserve of 77 million tonnes of rock phosphate has been established. The majority of these 17 million tonnes are +30% P2O5 grade, with the remainder being 12 0 30% P2O5 grade. To enhance the low-grade phosphate ore, a 1500 TPD (Tonnes Per Day) beneficiation facility has been installed.

Extent of Jhamarkotra Deposit

Total lease area is 13sqkm2. In Jhamarkotra, the strike length of the phosphorite bed including the discontinuous outcrop extending over a linear distance of 16 km. The highest point of the phosphate bed outcrop at 600 MRL at Jhamarkotra and along the downdip direction the extension of the phosphate has been proved up to a little below 250 MRL. Ore body dips at angle of 45-55°.The phosphate bed shows an extremely variable thickness showing persistence only over a limited strike length. Thus, in Jhamarkotra, the 15 km average thickness of the phosphate bed could be traced over 6 km of continuous strike length. In some portions, ore body shows pinching and swelling structure, hence the thickness of ore body varies from 5-35m. For the sake of convenience in prospecting and mining the deposit has been divided into 12 blocks viz. A-Extension, A, B, C, D, E, F, G, H, I, J and K. The ore to overburden ratio in the Jhamarkotra Phosphate Mine is kept as 1:16.

Grade of the Deposit

At Jhamarkotra deposit, generally a Bi-modal grade distribution pattern viz.+30 % (37- 38%) P2O5 designated as High-Grade Ore (HGO) and 16 to 22 % P2O5 designated as Low-Grade Ore (LGO) could be deciphered. However, at places near the contacts of the above grade of phosphate bed, some transitional zones exist which are designated as Mixed / Medium Grade Ore (MGO). The marketable grade of ore is 31.5% & 30% P2O5, but a large resource of low-grade ore also occurs in the area. Looking at great demand of phosphate fertilizer and to reduce its import, the low-grade ore is being upgraded through froth flotation in beneficiation plant.

Figure 17 High grade ore

Figure 18 Low grade ore

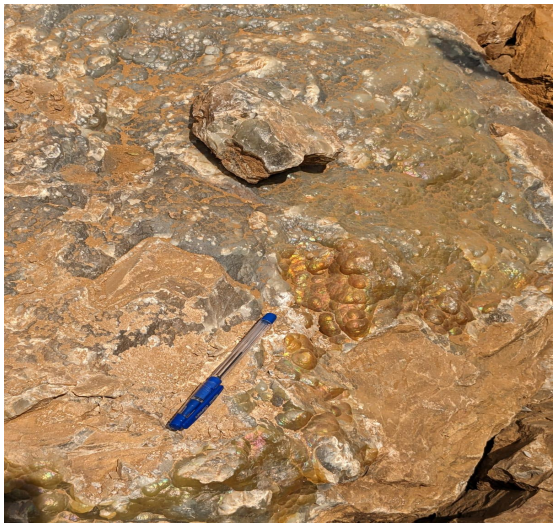


Figure 19 Mineral Apatite

Figure 20 Stromatolites(grey) and Phosphate(white)

Mining Method

The open pit mining method is being followed at Jhamarkotra Mine for exploitation of the mineral. The working levels are kept dry by continuous pumping of ground water through tubewells constructed on periphery of the pit limit. The bench height in this extent of mine is given at 7m consecutively for a couple of times with alternating 12 m heighted bench. (7m,7m,12m).

Location 2: Jhameshwar Mahadev temple

Stalactites are type of formation that hangs from the ceiling of caves, hot springs. They are developed downwards, grow from dripping walls and ceilings. The 'straw' stalactite is a monolayer crystal sheath covering a feedwater channel and developing downwards exclusively. Leakage from the canal can cause tapering (carrot-like) stalactites up to one metre in diameter and many metres in length. A ‘column’ is a stalactite–stalagmite pair grown together.

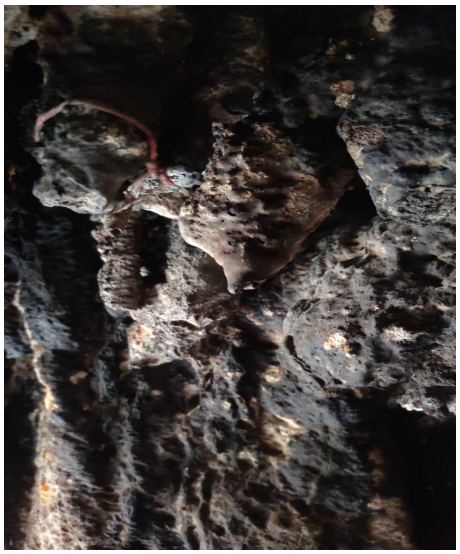


Figure 21 Stalactites

Day-6

Location-1: Banks of Berach river

Latitude: N 24˚ 54’13”
Longitude: E74˚37’23”

Suket shales were found belonging to the Semri group of Vindhyan Supergroup. These are exposed near river Ghamberi. The rocks were highly folded and highly compressed joints.The river flows parallel to the great boundary gault.Strikes varies from place to place.The area is highly deformed and had multiple joints.

Figure 22 Suket shale

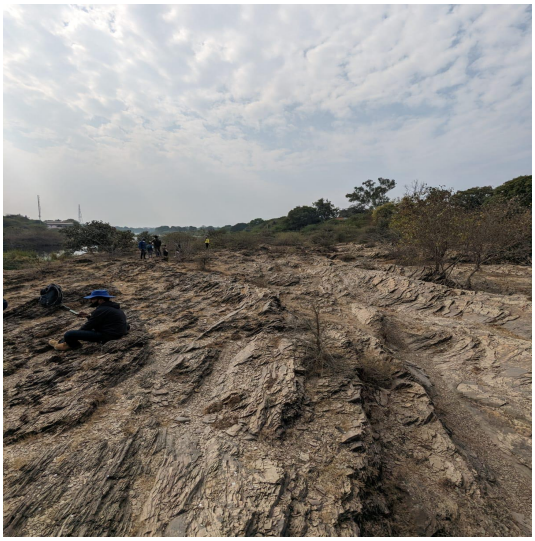


Figure 23 Suket shale

Figure 24 Folding sequence

Given below are the geological data obtained from there.

Sl No.	Strike	Dip
1	N 55°E	42°
2	N 45°E	49°
3	N 52°E	56°
4	N 45°E	59°
5	N 54°E	52°

Minor folding are observed in these area.Lithology is mainly fine grained with slaty cleavage. Quartz veins are observed. In some area of the exposure ripple marks are observed .Continuity of the strata is barely seen across the area. Vertical and horizontal folds are clearly seen. Some parts are highly weathered. In SE direction of the field a fault vein can be clearly seen. Joint sets are seen with a general trend of N40˚E. Assymetrical fold is observed with anticline plunging 25˚ and syncline 35˚.

In the other bank of the river,an unconformity between the contact of shale and conglomerate was observed. STRIKE: N42°, DIP AMOUNT: 47°.

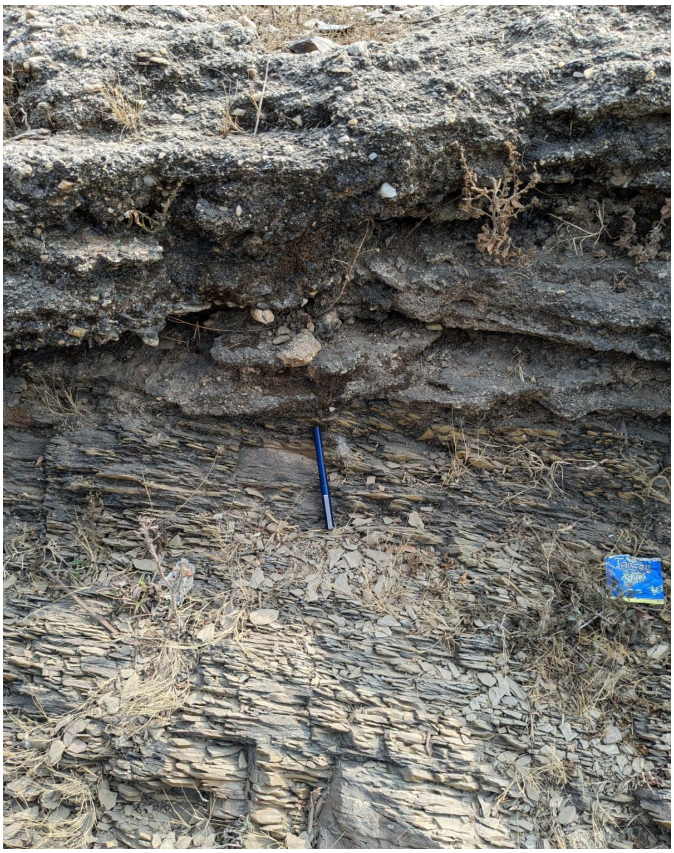


Figure 25- Conglomerates

Location-2

Latitude: N 24.8740
Longitude: E 74.6332

The outcrop observed here is Nimbara Limestone. It is light grey in colour. Nimbara Limestone is a type of sedimentary rock that is primarily composed of calcium carbonate. It is commonly found in the Nimbara region of Rajasthan, India, and is a popular building material due to its durability, strength, and natural beauty. This limestone is typically light gray in color and contains fossilized marine organisms, including shells and corals, which are visible on its surface. It is formed through the accumulation of calcium carbonate-rich sediment that has been compressed over millions of years, often in marine environments.

Day-7

Location: Nathwara

Latitude: 25 05’ 76” N
Longitude: 73 85 08” E

Nathwara Limestone is a type of limestone that is found in the state of Rajasthan, India. It is named after the town of Nathwara, which is located in the Udaipur district of Rajasthan. This limestone is a light-colored, fine-grained rock that is composed mainly of calcium carbonate. It is quarried extensively in the Nathwara area and is used in a variety of construction and decorative applications.

The marble strata were inclined with the overlying bed of schist which 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.

Figure 26 Weathered Mica Schist layer in between Marble

Figure 27 Augen gneiss structure

Geological data:

Sl No.	Strike	Dip amount
1	135˚SE	N30°
2	N120˚	N36˚

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