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

Submitted by Abhaykrishna M M

MSc II

Seat No. 21PO45002

School of Earth Ocean and Atmospheric Sciences

Goa University

Taleigao Plateau, Goa

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Acknowledgement

I would like to express my deep and sincere gratitude towards our institution Goa University, for including field studies as a compulsory part of MSc curriculum.

My humble appreciation goes to the dean of department of 'School of Earth, Ocean, and Atmospheric Sciences' Professor Chandrashekar U. Rivonkar, and special thanks go to the vice-dean Professor Anthony Arthur A. Viegas for not only making prior arrangement for the trip but also for accompanying us and providing guidance, moral support and proper understanding of what we were taught by explaining further.

I also want to thank Dr. Niyati Kalangutkar, program director for school applied geology, and Dr. Pooja Ghadi and Dr. Mahesh Mayekar for accompanying us, providing moral support, guidance and expressing concern to us. The trip became successful and enjoyable because of your company.

I thank all the people that we had the pleasure to be associated with as our guide, at different institutes like ONGC, Physical Research Lab (PRL), and Jhamarkotra Mine among others for giving us detailed information about their firms. I would like to thank the administrative staff, SEAOS, Goa University for being cooperative and providing necessary facilities needed so as to complete the field studies.

I extend my appreciation to my classmates and friends for their cooperation and company in order to make this trip a memorable one.

CONTENTS

INTRODUCTION

Geology or Earth Science is the study of the Earth, which includes its interior and exterior processes, rocks, minerals, fossils, and all the surface processes that have shaped the landscape around us and continue to shape our lives today. Geologists use evidences from fundamental units such as minerals, rocks, and fossils and recorded data from field to study the geology of an area. Based on progressive science the techniques of collection of data or information are changing rapidly from pens and compass to using space craft and satellites to explore the natural world and use the information they gain to better understand the past, present, and future. Geology being a field subject, can't be learned solely from classrooms labs and theories This report encompasses the field work which was carried out in Gujarat and Rajasthan field training which is a part of MSc. Programme started from 21/01/2023 till 30/01/2023. Programme aimed in understanding structure, mines and stratigraphy of Gujarat and Rajasthan.

STRATIGRAPHY 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 DeccanTraps ,Gondwana and Vindhyan.

The Deccan Traps covers almost all of Maharashtra, apart 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 Damodarand Sone river valleys and Raj mahal 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 apace that is the fastest known movement of any plate. It is generally believed that the 6 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 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 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.

REGIONAL GEOLOGY OF GUJARAT AND RAJASTHAN

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). 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 northeast 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. 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.

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. Rocks of these Supergroups are confined to the north-eastern part of Gujarat, in Sabarkantha and Banaskantha districts. These Supergroups are composed of meta-sedimentaries and are characterized by extensive magmatism. 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.

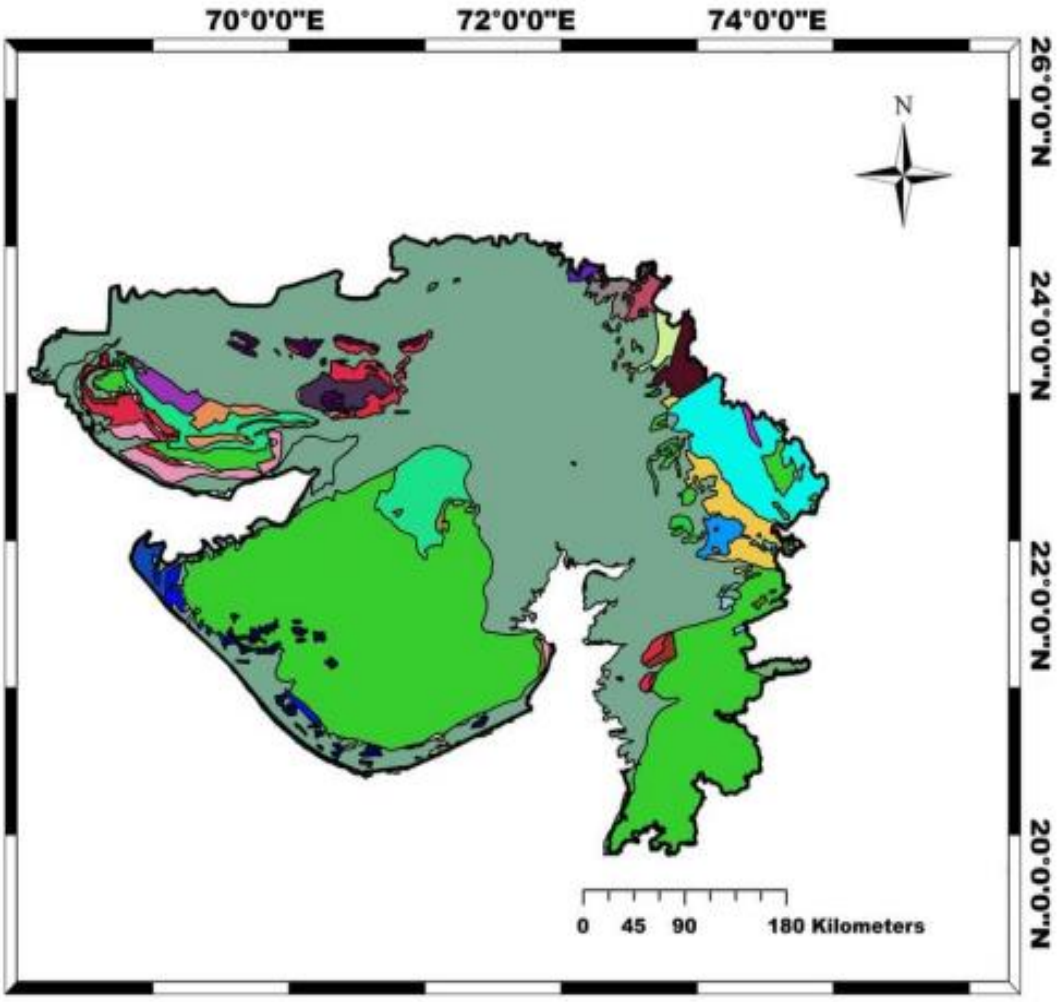
Geomorphologically, the State can be divided into three distinct divisions, viz.:

a) Gujarat-Mainland: The well-known agriculturally rich alluvial basin of Gujarat rises from the estuarine tracts between Narmada and Tapi rivers and extends 402 km northwards merging into the desert plains of Rajasthan and the Rann of Kutch. It is roughly 121 km wide. The eastern border of the basin is bounded by Aravali, Vindhya, Satpura, and Sahyadri hill ranges. The topography of the land is obviously controlled by the geological formations. 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 lavaflows 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 Banni is formed by sediments deposited by northern border of the main land and is composed of fairly good soil. 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.

GEOLOGICAL MAP OF GUJARAT



EXPLANATION

Geology Map of Gujarat

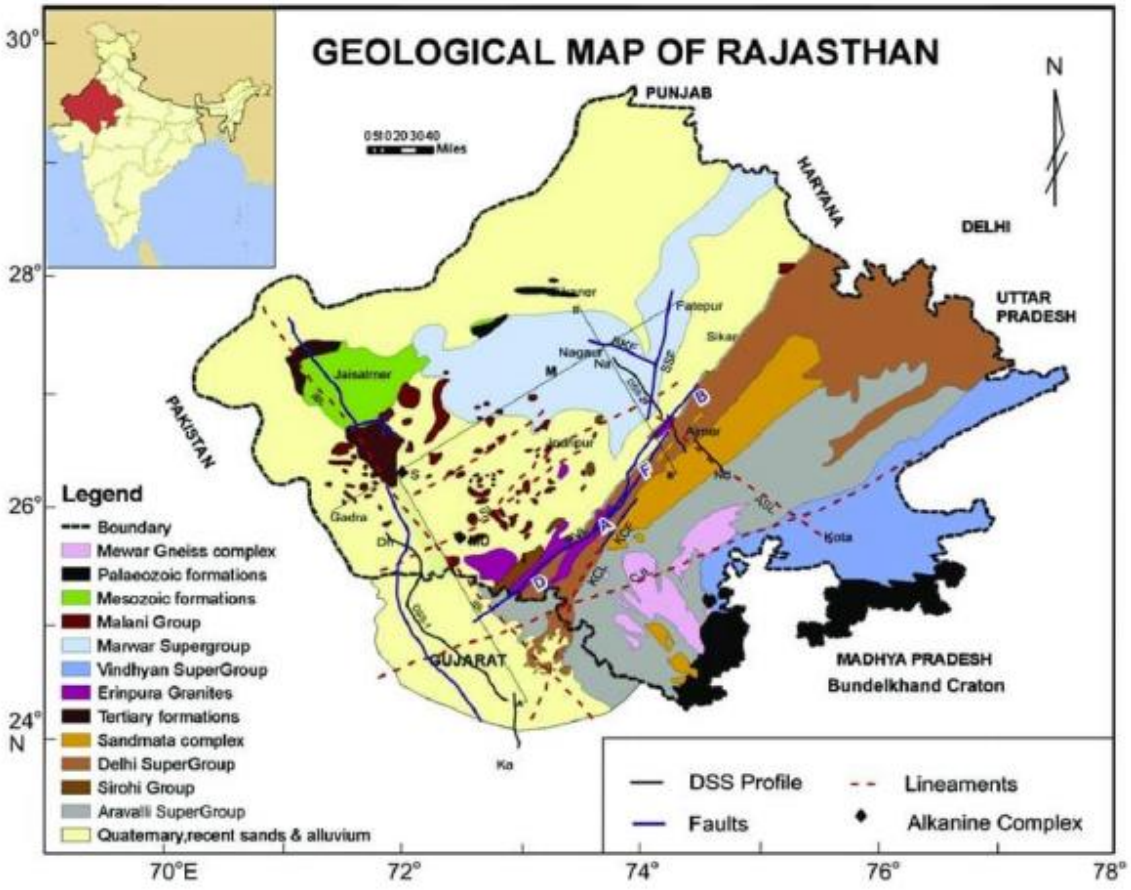
- Sendra-Ambaji Granite and Gneiss
- Deccan Traps
- Lunavada Gp
- Champaner Gp
- Sirohi Gp
- Jharol Gp
- Gogunda Gp
- Rajpura-Dariba Gp
- Madh Fms
- Berwali Fm
- Tiruchirapalli Fm
- Udaipur Gp
- Undiff. fluvial/aeolian/coastal and glacial sediments
- Undiff. Middle Jurassic Fms
- Jumara Fms
- Bagh Gp
- Lamera Fm
- Kankawati Fm
- Dwarka bed
- Goj 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

Group	System	Rock Type	Localities	Age in millions of years
Quaternary	Recent and subrecent	Alluvium, blown sand and Silts of Rann and Banni, Tidal flats and raised beaches.	Alluvial plains of Gujarat, Rann, Banni & Coastal deposits.	0.01
	Pleistocene	Miliolites	1) Saurashtra coast from Gopnath onwards extending beyond Porbandar. 2) Kutch area.	1
Tertiary or Kainozoic	Pliocene	Dwarka beds, Manchhar beds, Gypsiferous clays and sandy foraminiferal limestones.	Dwarka, Okha, Piram Island and 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
	Paleocene	Madh series- Supratrapean	Kutch	
	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 sand – stones, Lameta (limestones). Bagh beds (sandstones, Limestones and shales). Songir sandstones, Nimar sandstones, Wadhavan sandstone (Infratrappeans), Bhuj and Umia series sandstones.	Himatnagar, Kapadvanj, Balasinor, Parabia, Dohad, Gabat, Narmada valley, Surpan Vanji, etc. Songiri near pavagadh. Wadhavan, Dhrangadhra, Bhuj etc.	110
Secondary or Mesozoic	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, calc- schists of Ajabgarh series.	Parts of Sabarkantha and Banaskantha, and Mehsana Districts.	
Archaean or Azoic		Aravalli system-Mica-schists, Phyllites, quartzites, etc.	Sabarkantha, Panchmahals, Baroda, Banaskantha.	4000
		Banded gneissic complex	Baroda District.	

LITHOSTRATIGRAPHIC OF GUJARAT

GEOLOGY OF RAJASTHAN

Rajasthan is an important segment of the Indian shield, containing varied geological and tectonic features. Its Precambrian geology is typified by multistage reworking of the Archaean basement (BGC), a feature that has created problems concerning basement-cover relations and has led to repeated development of Mesoproterozoic and Neoproterozoic fold-thrust belts of the Aravalli and the Delhi Supergroups, having austal rifting and probable suturing history. The extensive Malani Magmatic Suite is a unique feature of Indian geology. Rajasthan has a special place in the metal scenario of India, for it contains world class deposits of lead, zinc and copper (Agucha, Zawar, Dariba, Khetri etc.), and a host of non-metallic mineral deposits, all contained in the Proterozoic fold belts. The Proterozoic paratectonic cover sequences of the Vindhyan and evaporitic Marwar hold promise for defining the Precambrian Cambrian boundary. The Precambrian geologic and tectonic polarity in this region was toward west, which appears to have persisted in the Phanerozoic, since the truncated Mesozoic and the Cenozoic sequences are developed only in the western part of Rajasthan. The Quaternary and Recent geology is characterised by the frequent climatic fluctuations, disorganisation of the drainage systems (lost Saraswati river) and development of the Thar desert. All these and other features make the geology of Rajasthan interesting on many counts.



FIELD OBSERVATIONS

DAY-1

LOCATION ; LOTHAL **LAT 22°31'18"**
LONG 72°14'58"

Lothal is the name of the ancient mound situated in the revenue jurisdiction of Saragwala Village in Dholka Taluka of Ahmedabad District, Gujarat. The word 'Lothal' meaning 'place of the dead' in Gujarati is said to have been derived by combining the words Loth and thal (sthal).

SITE-1 DOCKYARD

The dominant sight at Lothal is the massive dockyard which has helped make this place so important to international archaeology. The dock was tidal dock and was connected to the sea by the tributary of Sabarmathi river which is now dried up and was functional even till mid 19th century. Spanning an area 37 meters from east to west and nearly 22 meters from north to south.

The structure's design shows a thorough study of tides, hydraulics, and effect of sea water on bricks. 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 for them to float. After a ship would have unloaded its cargo, the gates would have opened and allowed it to return to the Arabian sea waters in the Gulf of Combay. The hydraulic knowledge of the ancient Harappans can be judged by the fact that boats could dock at Lothal in the 1850's

Fig ;1 DOCKYARD

SITE 2 UPPERTOWN

Near to the warehouse lies the acropolis or the upper main city. Built on a raised ground which indicates the fear of flood which led to proper town planning. Building consists of small houses built with brick and stone masonary. Drainage system is a peculiar feature seen leading away from the houses. These drainage system characterise the town planning

of the civilisation. Many wells were built across the upper city along which ensured supply of fresh water for the houses.

SITE 3 LOWERTOWN

The lower town contains a commercial and residential areas. The arterial streets running from north to south were flanked by shops, merchant dwellings and artisan's workshops. Streets running from east to west .

SITE 4 BEAD FACTORY

The main ornaments of harappan civilization is made up of by beads, these consists of microbeads of steatite. Seals are also produced which are used to label imports and exports passing through the dock.

SITE 5 WAREHOUSE

Long wharf connected the dockyard to the main warehouse, which was located on a plinth some 3.5 meters above the ground. The whole town was situated on a patch of high ground The warehouse was divided into 64 rooms of around 3.5 square meters each, connected by 1.2 meter wide passages. Twelve of these cubical blocks are visible today.

BEAD FACTORY

KITCHEN AREA

WELL

MARKET

DAY 2

Location Name: Physical Research Laboratory, Ahmedabad

Lat 23.1688° N,

Long 72.5451° E

The Physical Research Laboratory (PRL) is a National Research Institute for space and allied sciences, supported mainly by Department of Space, Government of India. This research laboratory has ongoing research programmes in astronomy and astrophysics, atmospheric sciences and aeronomy, planetary and geosciences, Earth sciences, Solar System studies and theoretical physics. It also manages the Udaipur Solar Observatory and Mount Abu InfraRed Observatory. The PRL is located in Ahmedabad, Gujarat.

Established in 1947, by Dr. Vikram sarabhai. 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 and faculties who work on various aspects of earth science, including seismology, geodynamics, geodesy, atmospheric science, oceanography, and paleoclimate. The initial focus was research on cosmic rays and the properties of the upper atmosphere. Research areas were expanded to include theoretical physics and radio physics later with grants from the United States Atomic Energy Commission.

We thank the faculty for guiding us around the labs of the PRL.

MC-ICPMS "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.

- Sample introduction: minute part of sample is placed into an inductively coupled plasma (ICP) source, where it is vaporized and ionized.

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).

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.

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.

MC-ICPMS

TIMS It 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:

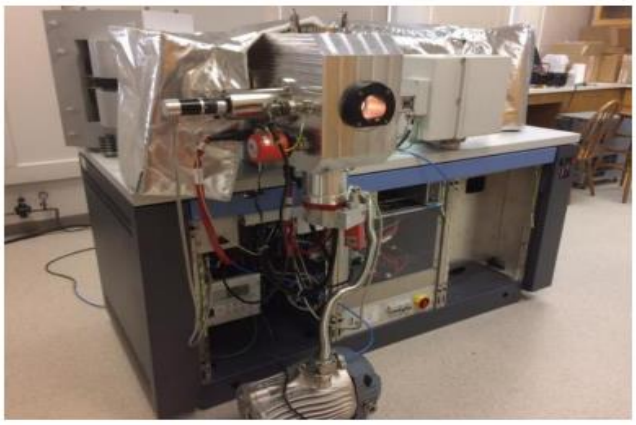
- Sample introduction: small amount of sample material is loaded onto a filament, which is then heated to a high temperature. The heat causes the sample to vaporize and form ions.

- 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.

- 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.

- 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 analyzing 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.



TIMS

My humble gratitude goes to the Researchers/Scientists Dr. Kumar, Dr. Kadlagi and Dr. Goswami of PRL who explained us the instruments.

Day 3 – BALASINOOR

Spot 1

Lat 22°97’07’’ N,

Long73° 34’ 64’’

Aravalli craton covers almost entire state of Rajasthan, part of Gujarat, Madhya Pradesh and fringes of Delhi and Haryana. This supergroup is ~2.5Ga old. General trend of Aravalli sediment is NE-SW. The closing phase o Aravalli craton is marked with large scale granitic activity. Most of Granitic bodies have intruded in the time span of 730 to 830 Ma, as evidenced by a cluster of Rb- Sr ages.

Godhra granites are exposed as Inselberg which is an isolated hillock rose abruptly in a plain. The rock is white in colour, leucoclastic, coarse grained and holocrystaline. The rock exhibits porphyritic textures in which phenocrysts of plagioclase is about 5cm. Surrounded by Biotite(1 set of cleavage, pearly lustre), quartz(vitreous lustre). Xenoliths are fine grained and mafic in composition. Sheets of biotite flacks are in segregating which show crenulation. Many small exposures of boulders are present one above the other forming Tors structure. Minor joints are seen which have undergone spheroidal weathering gives rise to present day structure.
Joints were seen, following are some readings: Trend= N290°, N300°, N9°

GODHRA GRANITE

GODHRA GRANITE HAND SAMPLE

Spot 02- Rhyoli

Lat: 23 05’ 62’’ N,

Long; 73 34 35’’ E

This place is Raiyoli Dinosaur Fossil Park with a dino and fossil museum located in Balasinor, Gujarat, India. It is also known as the Balasinor Dinosaur Fossil Park. This place is about 80 km from Ahmedabad and covers an area of approximately 72 acres. It is home to one of the largest dinosaur egg hatcheries in the world, and the largest dinosaur fossils site in India, believed to have been inhabited by dinosaurs about 65 million years ago.

The area is part of lemeta beds of cretaceous age. 3 units of lithology is present where 1.5 m thick conglomerate layer is the oldest followed by 2m thick coarser sandstone with fossils of bone, teeth & angiosperm. The youngest unit is 12m thick of limestone horizon with chert. The fossil present are of mature dinosaur, no trace of juvenile dinosaur are found. A guide was hired to enlighten us with many interesting aspects of Rhyoli , Balasinor fossil park. The park is spread across 72 hectares of land which has been fenced by the government of Gujarat. A huge Titanosaurus stands at the gates and across the road is the Rajasaurus narmdensis. Balasinor is one of the largest reservoirs of Dinosaur fossils in the world. Gujarat Tourism has been continuously being maintaining and protecting it. This area contains eggs, bones and remains of Dinosaurs which is exposed all over the park. Fossils exposed of extinct Dinosaur are much welled preserved by building fence around them. Balasinor is also known as one of the world’s largest Dinosaurs egg hatcheries site after the Mongolian Gobi desert and Aixen Provence in France. Similar fossils are found in countries like Brazil and Madagascar.

EGGS

TERAPOD VERTEBRA

CERAPOD VERTEBRA

CERAPOD EGGS

RIB

EMBRYO PART

The Rhyoli Dinosaur Fossil Park is a popular tourist attraction in Gujarat and draws visitors from all over the world. It provides a unique opportunity for visitors to witness the rich and diverse geological history of India and explore the ancient world of dinosaurs.

Rhyoli Dinosaur Museum

It was in 1980s when Paleontologists accidently came across the fossil remains and bones in the village of Rayioli in Balasinor. Further excavations have found that a squat, thick-legged, heavy-bodied carnivorous dinosaur with a crested horn, Rajasaurus Narmandensis, King of Narmada, (the first half of the name comes from Raja or King due to the crested horn and the second half of the name originates due to its geographical location which was near the river Narmada). This creature belonged to the carnivore family of Tyrannosaurus Rex.

The museum hosts life-sized dinosaur models, skeletons, and various exhibits about the evolution of dinosaurs. Visitors can also take a guided tour of the park to see the actual excavation sites and learn about the different types of dinosaurs that once roamed the area. The museum offers a unique experience for visitors to explore the prehistoric world and learn about the history of these magnificent creatures.

EGGS IN MUSEUM

BODY PARTS IN MUSEUM

DAY-4

ONGC

ONGC GGS Motera is a natural gas processing plant located in Motera, Gujarat, India. It is owned and operated by Oil and Natural Gas Corporation Limited (ONGC), which is a state-owned oil and gas exploration and production company in India.

The plant has a capacity to process around 6.5 million standard cubic meters of natural gas per day and is one of the major gas processing plants in India. It plays a crucial role in meeting the energy needs of the country by processing and distributing natural gas to various industries and households.

The gas gathering process involves separating the natural gas from crude oil and water, compressing it to increase its pressure, and then transmitting it through pipelines to various consumers. The station is equipped with advanced technology and equipment to ensure safe and efficient operations.

Apart from the gas processing facilities, ONGC GGS Motera also has a gas compression station, gas dehydration unit, and a sulfur recovery unit. The plant is equipped with modern technologies and is designed to operate efficiently while ensuring the safety of its workers and the environment.

This ONGC (Oil and Natural Gas Corporation) hub uses advanced technology and equipment to ensure safe and efficient gas gathering and transmission. These technologies are:

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

- 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: (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: This place 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.

My sincere thanks to Mr. Gaurav Kumar, Safety Inspector at this facility was kind enough to show us around and explain the kind of work that they undertake.

DAY-5

Location name: Jhamarkotra Opencast Mine

Lat 24 58 25 N

Long 73 51 71 E

Jhamarkotra Mines is the largest and one of the most important rock phosphate mines in India. It is owned and operated by the Rajasthan State Mines and Minerals Limited (RSMML), a state-owned company of the Government of Rajasthan.It was discovered in 1968 and began operations in 1972. The mines are located in the Udaipur district of Rajasthan and cover an area of about 3.33 square kilometers. The mining operation is carried out through open-cast mining, which is a surface mining technique.The Jhamarkotra Mines are known for their high-quality rock phosphate, which is a key raw material used in the production of fertilizers. The mines have an estimated reserve of about 150 million tonnes of rock phosphate.In addition to rock phosphate, the Jhamarkotra Mines also produce other minerals such as barytes, copper, and silver. The mining operation at Jhamarkotra has a significant impact on the local economy, providing employment opportunities to thousands of people in the region.

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. It operates one of the largest and fully mechanised mines in the country at Jhamarkotra, 26 Kms. from Udaipur. Jhamarkotra plays an important role by contributing 98% of rock phosphate production of India. With an annual rock handling of about 20 million tonnes, Jhamarkotra is probably the largest open cast mine in India outside the steel and coal sectors. The geometry of the ore body i.e thin and sharply dipping had resulted in long and narrow pits with great depth extension, which involves very high stripping ratio with high lead and lift for waste and mineral.

Method of Mining Used: open pit mining method is being followed. The working levels are kept dry by continuous pumping of ground water through tube-wells constructed on periphery of the pit. 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).

Genesis of Phosphate Rocks: The mineral phase of apatite, which makes phosphorite, is considered to have formed by three mechanisms

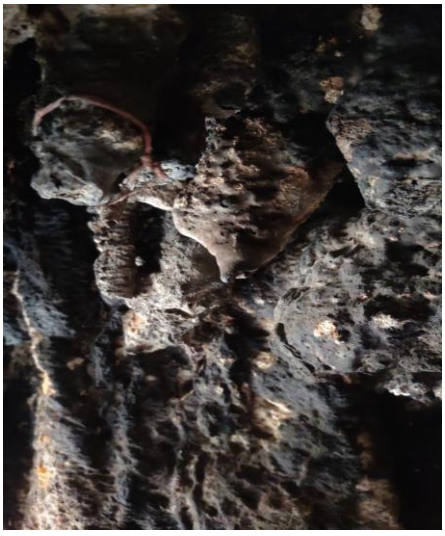
(i) direct inorganic precipitation,
(ii) primary biogenic precipitation, and
(iii) diagenetic precipitation/replacement of apatite (an important mechanism).

Commonly occurs as void filling and cementing material in the associated sediments. 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 phosphatized due to the replacement.

JHAMARKOTA MINES

Spot 02 –

Location Name: Jhameshwar Mahadev Temple, Jhamarkotra



STALACTITES

Stalactites are type of formation that hangs from the ceiling of caves, hot springs. They are developed downwards, grow from dripping walls and ceilings. This ancient temple is made inside a cave made up of uniquely structured but characteristic of stalactites. The fundamental form is the 'straw' stalactite, a monolayer crystal sheath enclosing a feedwater canal and growing downwards only. Leakage from the canal may over plate the sheath, creating tapered (carrot-like) stalactites up to one meter in diameter and several in length. Accelerated deposition on protuberances can add a myriad of subsidiary forms such as crenulations, corbels, drapes and lesser stalactites.

DAY-06

- Location Name: Chittor

LAT: 24 47’ 40’’ N

LONG: 73 51’ 71’’ E

Chittorgarh is a district in a Rajasthan characterised by having undulating topography with hills belonging to Aravalli range. The district comprises of rocks of Bhilwara supergroup, Vindhyan supergroup and Deccan traps. The great boundary fault which is present separates Vindhyan sediments like conglomerates and rocks of Bilwara supergroup. Berach River flows parallel to the great boundary fault. Bilwara supergroup is present at the west side of the river. Bilwaa supergroup is divided into 3 tectono-stratigraphic units which are Hindoli group, Mangalwar complex together with isolated mineralised belts and Sandmata complex. Hindoli group mainly consists of greywackes and phyllites. These phyllites haves been folded into large- scale low plunging folds trending parallel to the GBF. Increase in the tightness and asymmetry of the folds near the fault suggests that these are fault related folds. They are highly compressed and joint sets are closely spaced than the joints present away from the river that is away from the GBF. Slicken sides are observed, which indicates the presence of fault and quartz veins are also present which may be either syngenetic or post genetic. The Suket Shale-Phyllite shows various stages of predominant folding from which possible readings were taken with respect to the hinge plane;

	Strike Direction	Dip Amount with Direction
Hinge plane	200° N	29° N (Plunge)
Limb 1	200° N	36° E
Limb 2	125° N	54° W

Continuous folds are seen which are highly deformed.

Anticline shows a plunge of N20°
Syncline shows a plunge of 18° & 19°

Joints are observed in 2 sets.

	Strike Direction
Joint 1	145° N
Joint 2	100° N

Anticlinal plunging Hinge

slaty cleavage of phyllite

Folds

SPOT 2

NIMBARA LIMESTONE

This 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. We had the opportunity to take the readings of the Nimbara Limestone near Chittorgarh Fort and here are some readings: -

Strike Dir : N180° E

Dip Dir : N 270° E

Dip Amount: 41°

Nimbara limestone

DAY-7

Location Name: Nathwara Limestone/Marble

LAT: 25°05’76”N

LONG: 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. . Plagioclase not mixing out with calcite so, they are standing out. Sinsodal structure were also, observed in marble. This marble is physically weathered. The outer layer is fully weathered,and also foliated surface. Mylonitic structure is observed. fine-grained, compact metamorphic rock produced by dynamic recrystallization of the constituent minerals resulting in a reduction of the grain size of the rock. Mylonites can have many different mineralogical compositions; it is a classification based on the textural appearance of the rock. Stress indicators also seen. The green coloured mica schist is highly weathered. Folds are also seen in some areas. Elongated acicular structure is also seen in the mica schist in which the needle like structure consists of tremolite.

Weathered Mica Schist layer in between Marble

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