SCHOOL OF EARTH, OCEAN AND ATMOSPHERIC SCIENCES

GOA UNIVERSITY

Exam:

Roll No: 20P145007

LABORATORY CERTIFICATE

This is to certify that Mr. /Ms. Joshuelle Fernandes has satisfactorily completed the course of practical for M.Sc in Applied Geology.

Experiments conducted are pertaining to paper ----------

Practicals prescribed by the University for Applied Geology, Part - II class, during the academic year 2022- 2023

DEAN
SEOAS

Faculty member in-charge

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GUJARAT & RAJASTHAN GEOLOGICAL FIELD TRIP REPORT

M.Sc. Applied Geology

Abstract

Visited various mine institutes and geological areas to gain knowledge and know about the application of geology in various fields. And, studied different stratigraphy and lithologies which form one of the unique part of the Indian geology (Rajasthan and Gujarat).

Nashvelle Fernandes

Enrollment No.- 20P145007

Acknowledgement

I take this opportunity to thank the Goa University for allowing the students to go for a field trip for the fulfilment of the course MSc Applied Geology. Thank you for providing financial and allowing us not to attend lectures for two weeks. I want to pass my regards to the entire part-2 class of geology for their participation of the trip. 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 met at different institutes like ONGC, Physical Research Lab (PRL), and Jhamarkotra Mine among others for giving us detailed information about the firms. I personally learnt a lot about phosphate/open cast mines. I extend my appreciation to my classmates and friends for their cooperation in discipline and adhering to the instructions. All this made the trip the most successful one.

Finally, I want to thank our almighty father for the safe journey good health, protection and care that he gave we could not have made it by our own strength. Thank you so much.

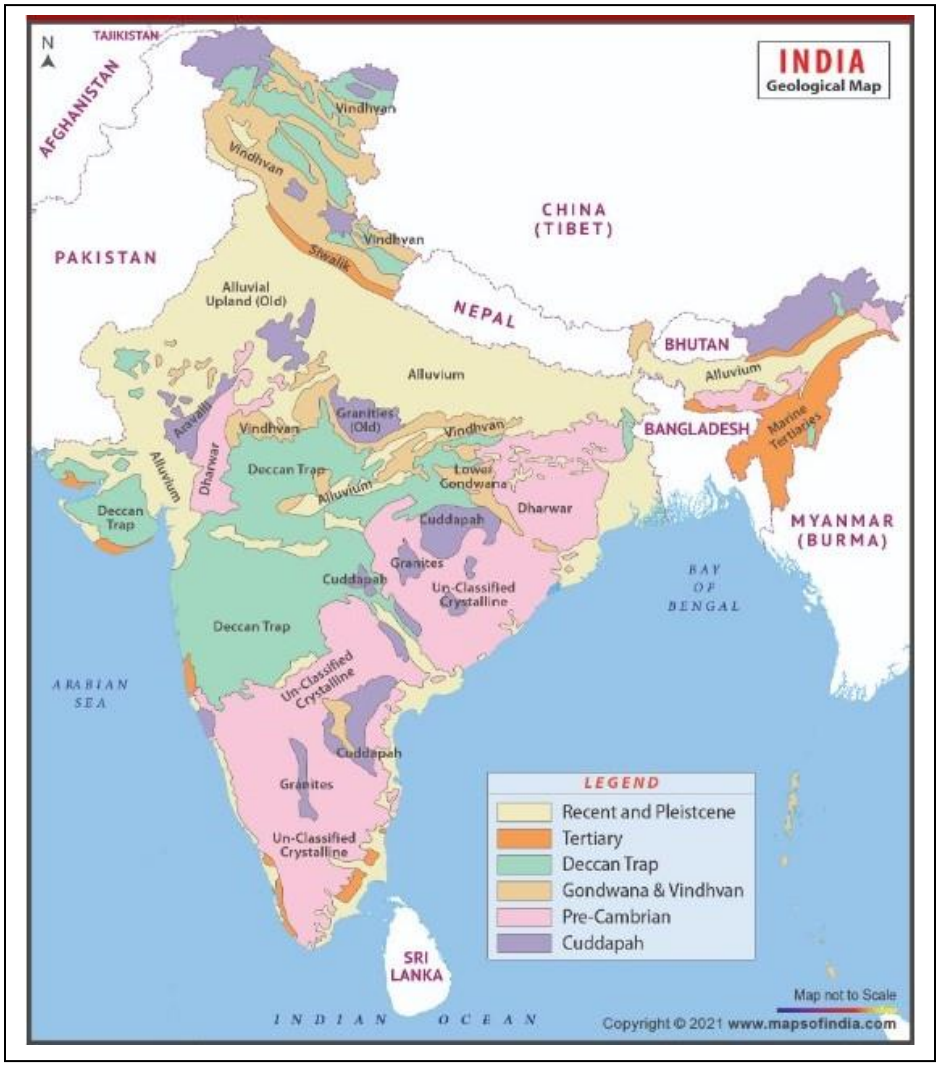
CONTENT

I) 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 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 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, rifting

caused Pangaea to break apart into two super continents, Namely Gondwana (To the south) 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 5 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 ruptured on to the adjacent Australian Plate, for 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 kilometers 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 eroded 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 coastal 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 kilometers area, the sea marks the final break from Gondwana.

II) Geology Of Gujarat

The state of Gujarat comprises an area of approximately 1,96,000 sq.km and is enclosed within the North Latitude 20°10° to 24° 50° and East Longitude 68° 40° to 74° 40°. Geologically Gujarat provides a wide spectrum of rock types of different ages. Whereas the Aravalli in the NE is as old as 2500 million years, the unconsolidated alluvium and beach material 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.

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

a) Gujarat-Mainland:

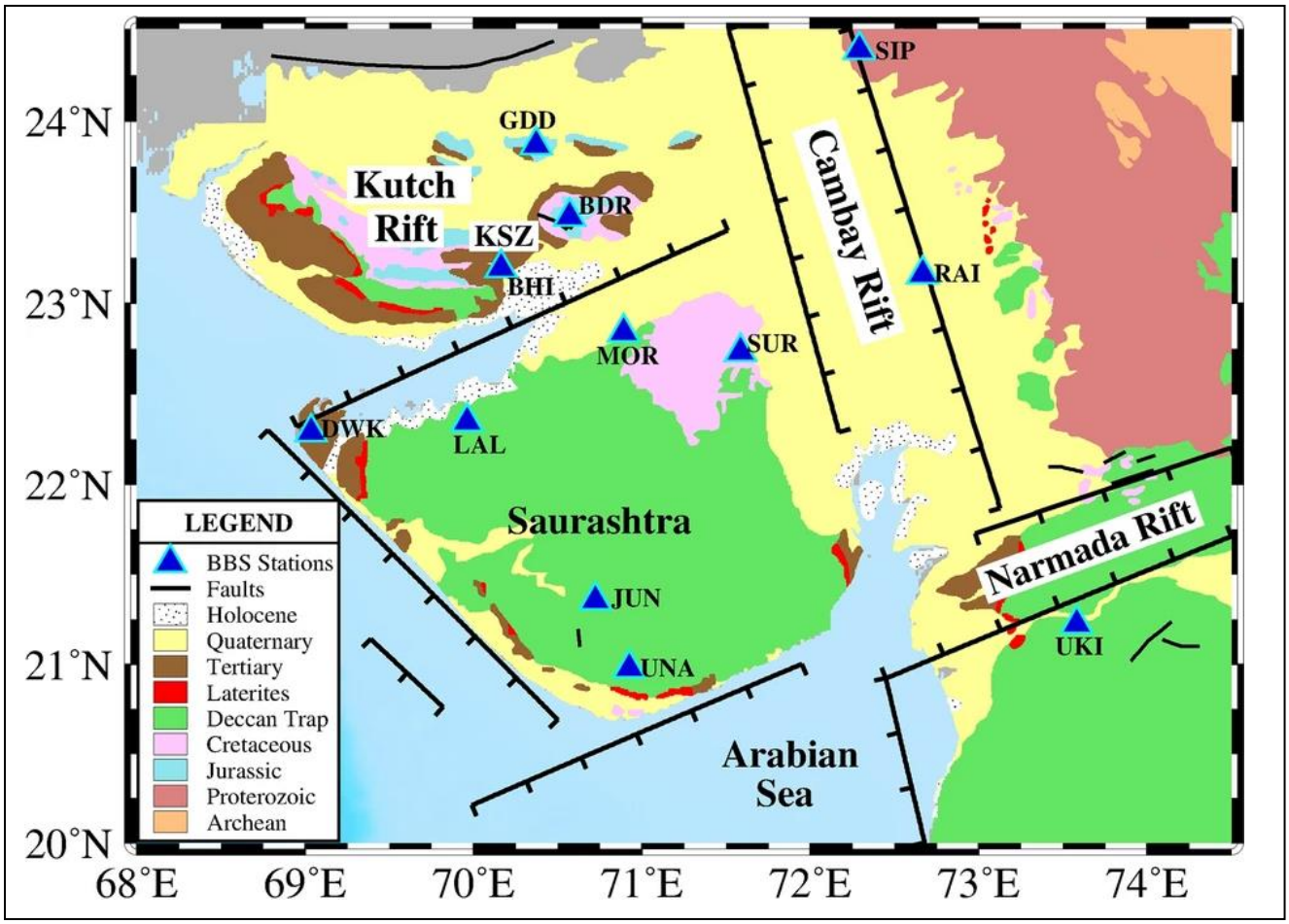
The well-known agriculturally rich alluvial basin of Gujarat rises from the estuarine tracts between Narmada and Tapi rivers and extends 402 km northwards merging into the desert plains of Rajasthan and the Rann of Kutch. It is roughly 121 km wide. The eastern border of the basin is bounded by Aravali, 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 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 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.


24°N
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Narmada Rift
JUN
UKI
UNA
Arabian
Sea
LEGEND
BBS Stations
Faults
Holocene
Quaternary
Tertiary
Laterites
Deccan Trap
Cretaceous
Jurassic
Proterozoic
Archean

Litho-Stratigraphic Table of Gujarat Region -

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.	

III) 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.

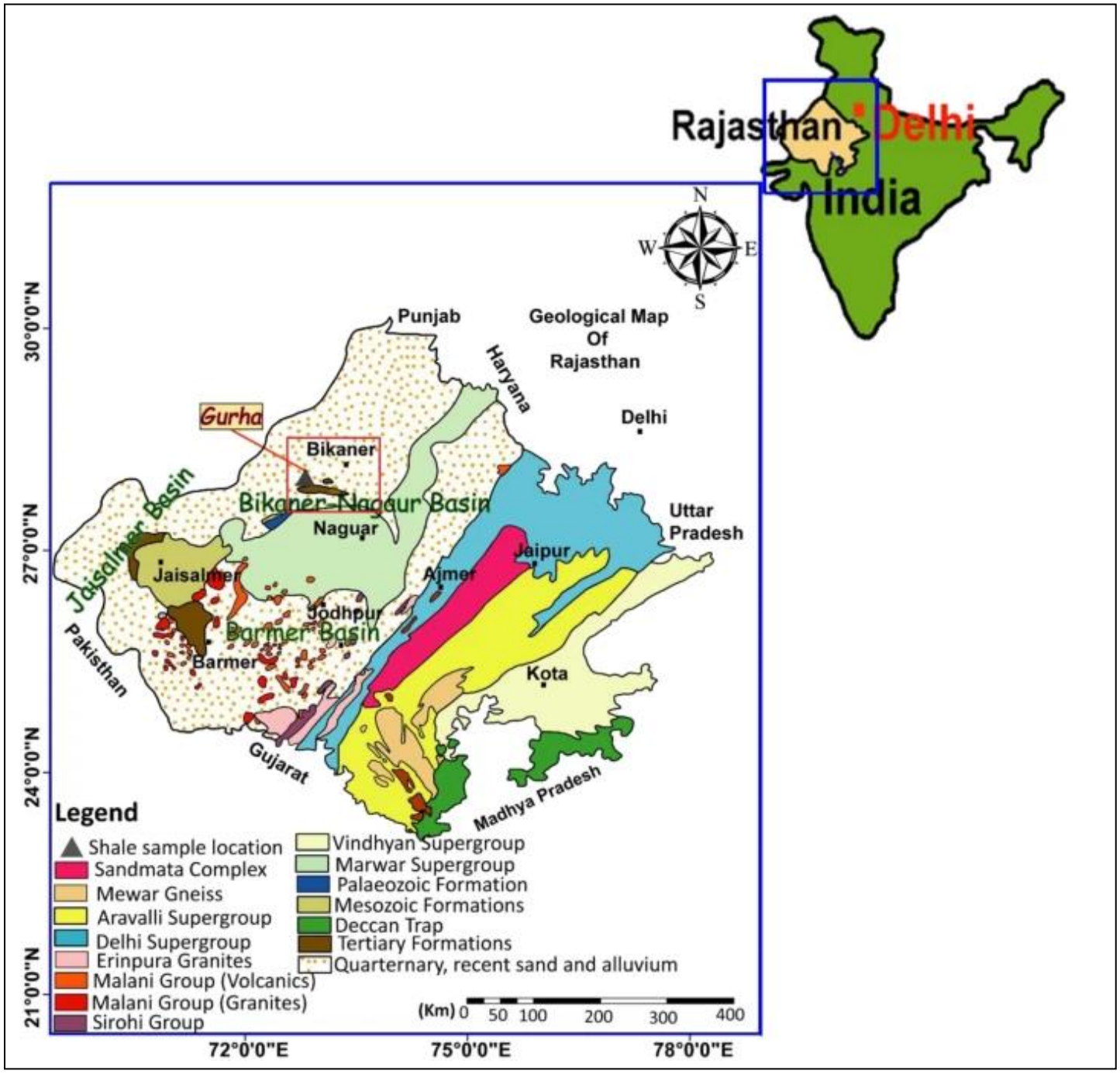
A number of base metal deposits are located in these belts as also other minerals.

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 juxtaposed against the rocks of the Bhilwara Super-group 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.

The Cenozoic rocks are manifested in Barmer and Jaisalmer basins in the west and Ganganagar-Palana shelf in the north.

The Quaternary sediments of Aeolian and fluvial origin constitute the Thar Desert of Rajasthan.



IV) Field Report

➢ Aim & Objective –

- To visit various mine institutes and geological areas to gain knowledge and know about the application of geology in various fields.
- To study different stratigraphy and lithologies which form one of the unique part of the Indian geology (Rajasthan and Gujarat).

A) Day 01

Location Name: Lothal | Geolocation: 22.4654° N, 72.2327° E

Lothal is Archaeological remains of a Harappa Port-Town, a site located in the state of Gujarat, India. Lothal was a vital and thriving trade Centre in ancient times, with its trade of beads, gems and valuable ornaments reaching the far corners of West Asia and Africa. The techniques and tools they pioneered for bead-making and in metallurgy have stood the test of time for over 4000 years.

Geological Insights: This place resides on the eastern flank of the Kathiawar Peninsula, which is a part of the Saurashtra Block, which is a tectonic block that forms a part of the Indian subcontinent, and it is bounded by the Arabian Sea to the west and the Indian mainland to the east. The geology of the Saurashtra Block is complex, with a variety of sedimentary and metamorphic rocks present in the region. The discovery foraminifera have led to enhancement in knowledge of geological history of Lothal. These are tiny marine organisms that secrete a calcareous shell, and they are commonly used as bioindicators in paleoenvironmental studies. Their presence at Lothal suggest that the site was once a marine environment, with the Indus River delta located nearby. The foraminifera also indicate that the sea level was higher in the past, and that the site was submerged under water at one point, and this info is even more ensured after noting the presence of marine sediments at the site, which contain fossils of marine animals such as mollusks and crustaceans.

According to Archaeological Survey of India (ASI), Lothal had the world's earliest known dock, connecting the city to an ancient course of the Sabarmati River. The site was once a thriving port city located in a marine environment, which was eventually submerged under water due to changes in sea level. This information helps us to better understand the history of the Indus Valley Civilization, and the ways in which humans have interacted with their environment over time.

B) Day 02

Location Name: Physical Research Laboratory, Ahmedabad
Geolocation: 23.1688° N, 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.

The Physical Research Laboratory was founded on 11 November 1947 by Dr. Vikram Sarabhai. The laboratory had a modest beginning at his residence, with research on cosmic rays. The institute was formally established at the M.G. Science Institute, Ahmedabad, with support from the Karmkshetra Educational Foundation and the Ahmedabad Education Society. Prof. K. R. Ramanathan was the first Director of the institute. 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.

PRL is involved in research, related to five major fields of science. PRL is also instrumental in the PLANEX planetary science and exploration programme. In June 2018, PRL scientists discovered exoplanet EPIC 211945201b or K2-236b, located 600 light years away from the Earth.

➢ Laboratories & Equipment Seen at PRL

- 1st Lab: 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:

- 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 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.

- 2nd Lab: 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.

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

C) Day 03

Spot 01 - Location Name: Balasinoor | Geolocation: 22°97'07'' N, 73 34' 64'' E

The main aim of field visit on this day was for learning and enhancing the geological surveying and rock lithology identification skills.

From stratigraphy we know that 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 granite is one of the granitic intrusions that took place during the closing phase of Aravalli craton. Godhra granite have intruded the Champaner and Lunavada group of Aravalli supergroup.

Godhra Granite Hand Sample

Godhra granite is porphyritic granite to granodiorite with associated pegmatite. It shows presence of feldspar, quartz, micas (biotite & muscovite) minerals. Muscovite and biotite are present as phenocryst of appx 0.5- 5cm. MMEs were also present. Mafic magma enclaves are formed due to the process of co-genetic mixing of magma. Also, perthite texture was seen.

There were xenoliths of mafic (biotite) origin. Cave structure in the outcrops can be seen which is formed due to removal of xenoliths by weathering.

Joints were seen, following are some readings:
Trend= N290°, N300°, N9°

We noticed a shear zone passing through the foliation. The geological readings are as follow:
Strike= 115°N | Dip Amount= 73°NE

Spot 02 – Location Name: Rhyoli | Geolocation: 23 05' 62'' N, 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.

It has over 10,000 dinosaur fossils, including bones, eggs, and other remains that were found during excavations conducted by the Geological Survey of India (GSI) and the Gujarat Ecological Education and Research (GEER) Foundation.

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 park offers a unique experience for visitors to explore the prehistoric world and learn about the history of these magnificent creatures.

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 is spread in an area of over 25,000 sq. feet with 10 galleries spread in the basement and the ground floor depicting various forms of displays (films and exhibitions). An exclusive 3-D film is prepared on Rajasaurus Narmadensis. The state government has not only catered to those seeking information on dinosaurs and their fossils.

D) Day 04

Location Name: ONGC Ahmedabad | Geolocation: 23 11 31 N, 72 59 79 E

ONGC GGS Motera is a gas gathering station located in Motera, Gujarat. Its primary function 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.

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.

In addition to gas gathering, ONGC GGS Motera also undertakes maintenance and repair work on pipelines and other equipment, as well as implementing various environmental and safety measures to minimize the impact of its operations on the surrounding environment.

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

My sincere gratitude to Mr. Gaurav Kumar, Safety Officer at this facility for his kind initiative to show us around and explain the kind of work that they undertake.

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.

E) Day 05

Location name: Jhamarkotra Opencast Mine | Geolocation: 24 58 25 N, 73 51 71 E

The major activity of RSMML (Rajasthan State Mines & Minerals Limited) is the mining of phosphate ore. It operates one of the largest and fully mechanized mines in the country at Jhamarkotra, 26 Kms. from Udaipur and Kanpur Group of Mines located 15 Kms. from Udaipur.

In India the economy being predominantly based on agriculture, the fertiliser production plays a pivotal role. Only about 35% to 40% of the requirement of raw material for phosphatic fertilser production are being met through indigenous sources and the rest is met through import in the form of rock phosphate, phosphoric acid & direct fertilisers. In such a situation Jhamarkotra plays an important role by contributing 98% of rock phosphate production of India.

Mining operations began from 1968, Rock Phosphate mines at Jhamarkotra & Kanpur Group of Mines are complex deposits. Mining these rock phosphate deposits is far more difficult than that in most parts of the world. Despite the complexities of the deposit, excellent results have been achieved by continuous innovations. 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. On technical fronts the problem of ground water had affected the mining operations, until an effective dewatering scheme was evolved and implemented. 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. Despite all these problems Jhamarkotra project could sustain the very difficult periods because of its commitment towards scientific approach for exploitation of the deposit with planned development of the pits.

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 tube-wells constructed on periphery of the pit limit.

Four strategic units – Phosphate, Limestone Lignite and Gypsum. In which Phosphate is used for chemical fertilization. 16 km Strike, has a zigzag string and the ore body is situated in East-West Direction. Ore body is assumed that it is not ending since similar pattern is found in Jabuar Madhya Pradesh Stromatolites.

Further Notes: Jhamarkotra plays an important role by contributing 98% of rock phosphate production of India. 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. 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.

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

Spot 02 – Location Name: Jhameshwar Mahadev Temple, Jhamarkotra

This ancient temple is made inside a cave made up of uniquely structured but characteristic for stalactites, a type of formation that hangs from the ceiling of caves, hot springs. They are developed downwards, grow from dripping walls and ceilings. 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.

F) Day 06

Spot 01 - Location Name: Chittor | Geolocation: 24 47' 40'' N, 73 51' 71'' E

This is the Chittorgarh district in Rajasthan, characterized by undulating topography with hills belonging to the Aravalli range. The district comprises of rocks of Bhilwara supergroup, Vindhyan supergroup and Deccan traps. The field area is occupied by Vindhyan sediments like conglomerates and rocks of Bilwara supergroup, both separated from each other by great boundary fault. 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

Folding Sequence

Suket Shale-Phyllite

Spot 02 - 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.

The geological readings taken from limestone outcrops are as follow:
Strike= 115°N | Dip Amount= 40° W

G) Day 07

Location Name: Nathwara Limestone/Marble | Geolocation: 25°05'76"N, 73°85'08"E

This area showed an outcrop of marble lithology. Plagioclase not mixing out with calcite so, they are standing out. Sinsodal structure were also, observed in marbel. Structural data about the outcrop's strike and dip is as follows;
Strike= 131°N | Dip Amount= 32°

Some places in the outcrop showed Chloride mica shchist, and at places distinct augan structure seen with 130°-140° strike direction 28°-32° amount of dip.

Alignment was seen. Tremolite were also green in color.

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