# Palaeogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy

Project report submitted to Christ College, Autonomous, University of Calicut in partial fulfilment of requirements for the completion of Sixth Semester in

B.Sc. GEOLOGY

SUBMITTED BY

NAME:ANTONY RAPHAEL

REGISTER NO:CCAVSGL021

**DEPARTMENT OF GEOLOGY AND ENVIRONMETAL SCIENCES**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA**

(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)

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UNDER THE JOINT SUPERVISION OF

**Dr. LINTO ALAPPAT**
**&**
**Ms. SHAIMA M.M**

# CERTIFICATE

I hereby declare that the work, which is being present in this project, entitled "**Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy**" by Mr./Ms..Antony...Raphael...Register no CC.AV.SGL02.1....submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree of Bachelor of Science in Geology is an authentic record of my own work carried out under the joint supervision of **Dr. Linto Alappat**, Assistant Professor , Dept. of Geology and Environmental sciences and **Ms. Shaima M.M**, Assistant Professor, Department of Geology and Environmental Science during the period of 2023-2024. The matter embodied in this dissertation has not been submitted for any award of degree.

Antony

**ANTONY RAPHAEL**

It is certified that the above statement made by the candidate is true to the best of me knowledge.

**Signature of project in charge**


**Ms. Shaima M.M**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous )
Irinjalakuda, Kerala-680125

**Dr. Linto Alappat**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125


Place: Irinjalakuda
Date: 17/04/24

External Examiners: Dr. Honey H. Das

# DECLARATION

I hereby declare that the dissertation work "**Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy**" is a work done by me. No part of the report is plagiarized from other resources. All information included from other sources has been duly acknowledged. I maintain that if any part of the project is found to be plagiarized, I shall take the full responsibility for it. I also understand and agree that this declaration made by me is final and irrevocable,

PLACE: Irinjalakuda

DATE: 17/04/24

ANTONY RAPHAEL

REG NO: CCAVSGL021

# ACKNOWLEDGEMENT

This report is a certified documentation of the Chervattur formation and its stratigraphy. Following the successful completion of this project, I would like to express my heartfelt appreciation to the all who stood by me through thick and thin, without whom the work would not have been possible. First and foremost, I would record my deep sense of gratitude and indebtedness to my guides Dr. Linto Alappat, Assistant Professor, Department of Geology and Environmental Science & Mrs. Shaima M M, Assistant professor, Department of Geology and Environmental science, Christ College (Autonomous) Irinjalakuda, for designing the framework of the project and providing constant support and supervision throughout the entire course of study.

I express my sincere thanks to Ms. Aleena, Research Scholar, Christ College (Autonomous) Irinjalakuda, who helped me throughout the completion of this work. I am also thankful to all the faculties of Department. of Geology and Environmental Science, Christ College, for their helping hands at times of need.

I also take this opportunity to thank all my classmates and friends who directly or indirectly helped me complete this dissertation work. I extend my gratitude to the entire Christ College family for their support, guidance, and love. I thank the authorities of the Christ College (Autonomous) Irinjalakuda for providing me the laboratory and the necessary environment for successful completion of this project.

I also acknowledge with reverence, our warm regards towards our parents and family members for their constant support and prayers in my life.

And above all, I thank with utmost sincerity to God, the Almighty for his divine benevolence and blessing showered on me. Finally, I thank all those who have directly or indirectly helped me in various stage of this work till its successful completion.

ANTONY RAPHAEL

# ABSTRACT

This report provides details of the stratigraphy of Cheruvathur formation, known for its equivalence with Tertiary Warkalli Formation of Southern Kerala. The total thickness of the section studied was 33m representing different lithologies. Stratigraphy of Cheruvathur formation exposes several meter thick successions of carbonaceous clay with lenticular units of shale and lignite. The lignite units are characterized by abundance of plant fossils in the form of plant leaves, stems, twigs and leaf impressions. Tubular sticks and planar structures of marcasite and remains of amber, followed by variegated clays and sandstone are seen in the stratigraphic records. The presence of variegated lithounits with evidences of chemical leaching provides distinct colouration to sand and clay units. Clays are often shows various shades of gray, red and purple colours and sandstone units are largely ferruginous in nature. Layers of ferricrete deposits are seen at the bottom of the clay units at distinct intervals. The sediment textural analyses reveals that the sandy lithounits in Cheruvathur formation are characterized as coarse sand to medium sand, moderately sorted unimodal distribution of aggregate grains. The average grainsizes of the studied sandy lithounits varied between 673 to 360 μm. The fluvial depositional regime in a point bar sequence of a braided stream was evidenced by the presence of parallel bedding/ lamination. Low angle trough cross stratification, graded bedding etc. The shale interbeds with lignite seams shows lenticular nature at varying levels across the section. The lignite seams contain abundant plant remains like amber, leaves, twigs, logs, and fossil impressions. These are implying to a marshy depositional setting in a reduced environment, shifting laterally to change in hydrodynamic conditions.

A PROJECT REPORT

ON

# LITHOSTRATIGRAPHY OF TERTIARY SEQUENCE OF VARKALA COASTAL CLIFFS

**Submitted in the partial fulfillment for the award of degree in**

**BACHELOR OF SCIENCE IN GEOLOGY**

**To**

## DEPARTMENT OF GEOLOGY AND ENVIRONMENTALSCIENCE, CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA

**Affiliated to University of Calicut and re accreditedby NACC with A++grade**

Submitted by

**ASWIN AJITHKUMAR (Reg No:CCAVSGL022)**

Under the guidance of

**Dr. Mahboob Alam**

**Assistant Professor, Christ College, Irinjalakuda, Kerala**

# CERTIFICATE

I hereby declare that the work, which is being presented in this project work, entitled, "LITHOSTRATIGRAPHY OF TERTIARY SEQUENCE OF VARKALA COASTAL CLIFFS" by ASWIN AJITHKUMAR (CCAVSGL022) submitted to the Department of Geology and Environmental Science, Christ College (Autonomous) Irinjalakuda, Thrissur, in partial fulfillment of the requirement for the award of the Degree of Bachelor of Science in Geology, is an authentic record of my own work carried out under the guidance of Dr. Mahboob Alam during the period of 2023-2024.

The matter embodied in this project has not been submitted for any other degree.

Tharun R

Head of the department

Dept of Geology and Env. Science

Christ College (Autonomous),

Irinjalakkuda

Project Guide

Dr. Mahboob Alam

Assistant professor

Dept of Geology and Env.science

Christ college (Autonomous),

Irinjalakkuda

Place : Irinjalakkuda

Date:

External Examiners;

1.....

## DECLARATION

I here by declare that the dissertation work "LITHOSTRATIGRAPHY OF TERTIARY SEQUENCE OF VARKALA COASTAL CLIFFS " is a original project work done by Mr. ASWIN AJITHKUMAR.The project report is not plagiarized from other resources. All information included from other sources has been duly acknowledged. I maintain that if any part of the project is found to be plagiarized, I shalltake the full responsibility for it.

ASWIN AJITHKUMAR (Reg. No. CCAVSGL022)

IRINJALAKUDA DATE: 16-04-2024

## ACKNOWLEDGEMENT

This work would not have been possible without guidance, encouragement and support of many people around us. I would like to extend my sincere gratitude to all those who helped me in this project. First and foremost, I would like to thank my project guide Dr. Mahboob Alam (Assistant Prof. Deptartment of Geology and Environment Science, Christ College Autonomous, Irinjalakuda) for designing the framework of the project, support and supervision throughout the geological field and preparation of the report. I am deeply grateful for his assistance in the fieldwork done at Varkala, constant motivation throughout the course and in giving guidance in all possible ways. I would like to mark a special gratitude to Ms. Sweeshma P. Dev for her unconditional support and assistance in the fieldwork. I would like extend my gratitude to Mr. Tharun R (Head of the Department of Geology and Environmental Science, Christ College, Autonomous), Dr. Linto Alappat, Ms. Shaima, Dr. Midhuna, Dr. Reshmi K.J., Dr. Anso M.A. (Assistant Prof., Dept. of Geology and Environmental Science, Christ College), for the guidance and support during the academics. I would like thank Dr. Father Jolly Andrews, Principal, Christ College, Autonomous for their support during my study. I would like to thank the Christ college family for their support, guidance and love. I also acknowledge with reverence, my warm regards towards my parents and my family members for their moral support and guidance. Last but not the least I extend my thanks to all of my friends who directly or indirectly helped me to complete this dissertation report.

A PROJECT REPORT

ON

# LITHOSTRATIGRAPHY OF TERTIARY SEQUENCE OF VARKALA COASTAL CLIFFS

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**BACHELOR OF SCIENCE IN GEOLOGY**

**To**

## DEPARTMENT OF GEOLOGY AND ENVIRONMENTALSCIENCE, CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA

**Affiliated to University of Calicut and re accreditedby NACC with A++grade**


Submitted by

**ELIZABETH JOLLY**

**(Reg No: CCAVSGL023)**

Under the guidance of

**Dr. Mahboob Alam**

**Assistant Professor, Christ College, Irinjalakuda, Kerala**

# CERTIFICATE

I hereby declare that the work, which is being presented in this project work, entitled, "LITHOSTRATIGRAPHY OF TERTIARY SEQUENCE OF VARKALA COASTAL CLIFFS" by ELIZABETH JOLLY (CCAVSGL023)
submitted to the
Department of Geology and Environmental Science, Christ College (Autonomous) Irinjalakuda, Thrissur, in partial fulfillment of the requirement for the award of the Degree of Bachelor of Science in Geology, is an authentic record of my own work carried out under the guidance of Dr. Mahboob Alam during the period of 2023-2024.

The matter embodied in this project has not been submitted for any other degree.

Tharun R

Head of the department

Dept of Geology and Env. Science

Christ College (Autonomous),

Irinjalakkuda

Project Guide

Dr. Mahboob Alam

Assistant professor

Dept of Geology and Env.science

Christ college (Autonomous),

Irinjalakkuda

Place : Irinjalakkuda

Date:

External Examiners;

1.....

Dept. of Geology & Environmental Science
Irinjalakuda
680 125
Christ College (Autonomous)

## ACKNOWLEDGEMENT

This work would not have been possible without guidance, encouragement and support of many people around us. I would like to extend my sincere gratitude to all those who helped me in this project. First and foremost, I would like to thank my project guide Dr. Mahboob Alam (Assistant Prof. Deptartment of Geology and Environment Science, Christ College Autonomous, Irinjalakuda) for designing the framework of the project, support and supervision throughout the geological field and preparation of the report. I am deeply grateful for his assistance in the fieldwork done at Varkala, constant motivation throughout the course and in giving guidance in all possible ways. I would like to mark a special gratitude to Ms. Sweeshma P. Dev for her unconditional support and assistance in the fieldwork. I would like extend my gratitude to Mr. Tharun R (Head of the Department of Geology and Environmental Science, Christ College, Autonomous), Dr. Linto Alappat, Ms. Shaima, Dr. Midhuna, Dr. Reshmi K.J., Dr. Anso M.A. (Assistant Prof., Dept. of Geology and Environmental Science, Christ College), for the guidance and support during the academics. I would like thank Dr. Father Jolly Andrews, Principal, Christ College, Autonomous for their support during my study. I would like to thank the Christ college family for their support, guidance and love. I also acknowledge with reverence, my warm regards towards my parents and my family members for their moral support and guidance. Last but not the least I extend my thanks to all of my friends who directly or indirectly helped me to complete this dissertation report.

# THE PETROGRAPHIC STUDY OF ROCKS OF BUILDING STONE QUARRY, MOOKKANNOOR, ERNAKULAM

Project report submitted to Christ College (Autonomous), University of Calicut in partial fulfilment of requirements for the award of degree in

BACHELOR OF SCIENCE

IN

GEOLOGY

By

GODSON JANEEF

Reg No: CCAVSGL04

(2021-2024)

DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE
CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125
(Affiliated to University of Calicut and re-accredited by NAAC with A++grade)

# THE PETROGRAPHIC STUDY OF ROCKS OF BUILDING STONE QUARRY, MOOKKANNOOR, ERNAKULAM

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IN

GEOLOGY

By

GODSON JANEEF

Reg No: CCAVSGL04

(2021-2024)

DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE
CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125
(Affiliated to University of Calicut and re-accredited by NAAC with A++grade)

UNDER THE GUIDANCE OF Dr. RESMY K J
Asst. Professor, Department of Geology and Environmental Science

# CERTIFICATE

I hereby declare that the work, which is being present in this dissertation, entitled "THE PETROGRAPHIC ANALYSIS OF HOST ROCKS OF GRANITE BUILDING STONE QUARRY" by MR. GODSON JANEEF (CCAVSGL032) submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree of Bachelor of Science in Geology is an authentic record of my own work carried out under the guidance of Dr. Resmy K.J , Assistant Professor, Department of Geology and Environmental Science during the period of 2023-2024. The matter embodied in this dissertation has not been submitted for any award of degree.

(GODSON JANEEF)

It is certified that the above statement made by the candidate is true to the best of my knowledge.

Signature of project in charge

Dr. Resmy K J
Assistant Professor
Dept. of Geology and Environmental Science
Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

Mr. Tharun R
Assistant Professor and Head
Dept. of Geology and Environmental

Christ College (Autonomous)
Irinjalakuda, Kerala-680125

Place: Irinjalakuda

Date:

External Examiner:

# LANDSLIDE SUSCEPTIBILITY MAPPING OF WAYANAD DISTRICT, KERALA, USING ANALYTICAL HIERARCHY PROCESS METHOD IN GIS ENVIRONMENT

**Project report submitted**
**in partial fulfillment of the requirement for the award of**
**BACHELOR OF SCIENCE**
**In**
**GEOLOGY**

By

**HADI MUHAMMED P A**
**CCAVSGL025**
**Under the Guidance of**
**Dr Midhuna Vinayan**


**DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125**

**(Affiliated to University of Calicut and re-accredited by NAAC with an A++ grade)**

## CERTIFICATE

I hereby declare that the work, which is being presented in this project work, entitled, **"LANDSLIDE SUSCEPTIBILITY MAPPING OF WAYANAD DISTRICT, KERALA, USING ANALYTICAL HIERARCHY PROCESS METHOD IN GIS ENVIRONMENT"** by **HADI MUHAMMED P A (CCAVSGL025)** submitted to the Department of Geology and Environmental Science, Christ College (Autonomous) Irinjalakuda, Thrissur, in partial fulfillment of the requirement for the award of the Degree of Bachelor of Science in Geology, is an authentic record of my own work carried out under the guidance of Dr. Midhuna Vinayan during the period of 2023-2024. The matter embodied in this project has not been submitted for any other degree.

**HADI MUHAMMED P A**

It is certified that the above statement made by the candidate is true to the best of my knowledge.

**Dr. Midhuna Vinayan**
**Assistant Professor and Supervisor**

**Mr. Tharun R**
**Assistant Professor and Head**

**External Examiners**

**DATE:**
**PLACE:**

# DECLARATION

I hereby declare that the work, which is being presented in this project work, entitled, "**LANDSLIDE SUSCEPTIBILITY MAPPING OF WAYANAD DISTRICT, KERALA, USING ANALYTICAL HIERARCHY PROCESS METHOD IN GIS ENVIRONMENT"** is a work done by me. No part of the report is plagiarized from other resources. All information included from other sources has been duly acknowledged. I maintain that if any part of the project is found to be plagiarized, I shall take full responsibility.

Place: Irinjalakuda

Date: ……

**HADI MUHAMMED P A**
**(CCAVSGL025)**

## ACKNOWLEDGMENT

I wish to record my deep sense of gratitude and profound respect to **Dr. Midhuna Vinayan** Assistant Professor, Department of Geology and Environmental Science, Christ College (Autonomous) Irinjalakuda, Thrissur for her impeccable guidance moral support, and constant encouragement throughout the course of my study.

I express my sincere thanks and gratefulness to Mr. Tharun R, Assistant Professor and Head in charge, Department of Geology and Environmental Science, Christ College (Autonomous) Irinjalakuda, Thrissur for his constant support and encouragement, providing facilities for the successful completion of this project

I am deeply thankful to all other faculty members of the Department of Geology and Environmental Science for their support and guidance.

I extend my gratitude to the entire Christ College family for their support, guidance, and love

I take this opportunity to thank all my classmates and friends who directly or indirectly helped me to complete this project.

**HADI MUHAMMED P A**

# GROUNDWATER POTENTIAL ZONATION USING GEOGRAPHIC INFORMATION SYSTEM IN MUKUNDAPURAM TALUK, THRISSUR DISTRICT, KERALA, INDIA

***Project report submitted***

***in partial fulfilment of requirements for the award of degree in***

**BACHELOR OF SCIENCE**

*In*

**GEOLOGY**

*By,*


**MS. KRISHNANANDANA**

**Reg No. CCAVSGL026**


***Under the guidance of***
***Mr. Tharun R Unnithan***


**DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125**

**(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)**

# CERTIFICATE

This is to certify that the project work entitled – **GROUNDWATER POTENTIAL ZONATION USING GEOGRAPHIC INFORMATION SYSTEM IN MUKUNDAPURAM TALUK, THRISSUR DISTRICT, KERALA, INDIA** by **Ms. Krishnanandana (CCAVSGL026)** submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree of Bachelor of Science in Geology is an authentic record of our own work carried out under the guidance of **Mr.Tharun R**, Assistant Professor, Department of Geology and Environmental Science during the period of 2022-2023. The matter embodied in this project work has not been submitted for any award of degree.

**Ms. Krishnanandana**

It is certified that the above statement made by the candidate is true to the best of our knowledge.

Signature of project in charge

Mr. Tharun R

Assistant Professor and Head

Dept. of Geology and Environmental Science

Christ College (Autonomous)

Irinjalakuda, Kerala-680125

Place: Irinjalakuda

Date:15/04/2024

External Examiners:

# DECLARATION

We hereby declare that the project work "**GROUNDWATER POTENTIAL ZONATION USING GEOGRAPHIC INFORMATION SYSTEM IN MUKUNDAPURAM TALUK, THRISSUR DISTRICT, KERALA, INDIA"** is a work done by us. No part of the report is plagiarized from other resources. All information included from other sources has been duly acknowledged. We maintain that if any part of the project is found to be plagiarized, we shall take the full responsibility for it.

Ms. Krishnanandana (CCAVSGL026)

IRINJALAKUDA

DATE:

# ACKNOWLEDGEMENT

This report is a certified documentation of "**GROUNDWATER POTENTIAL ZONATION USING GEOGRAPHIC INFORMATION SYSTEM IN MUKUNDAPURAM TALUK, THRISSUR DISTRICT, KERALA, INDIA**".

This would not have been possible without guidance, encouragement and support of many well-wishers and our colleagues.

First and foremost, we would record our deep sense of gratitude and indebtedness to our guide. Mr. Tharun R, HOD, Assistant Professor, Department of Geology and Environmental Science, Christ College (Autonomous) Irinjalakuda, for designing the framework of the project and providing constant support and supervision throughout the entire course of study.

We are thankful to all the other faculties of Dept. of Geology and Environmental Science, Christ College, for their helping hands at times of need.

We also take this opportunity to thank all our classmates and friends who directly or indirectly helped us complete this project work. We extend our gratitude to the entire Christ College family for their support, guidance and love.

We thank the authorities of the Christ College (Autonomous) Irinjalakuda for providing us the Laboratory, GIS LAB and the necessary environment and tools for successful completion of our degree. We also acknowledge with reverence, our warm regards towards our parents and our family members for their constant support and prayers in our life.

And above all, we thank with utmost sincerity to God, the Almighty for his divine benevolence and blessing showered on us. Last but not least, we thank all those who have directly or indirectly helped us in various stage of this work till its successful completion.

MS. KRISHNANANDANA

# GROUNDWATER POTENTIAL ZONATION USING GEOGRAPHIC INFORMATION SYSTEM IN MUKUNDAPURAM TALUK, THRISSUR DISTRICT, KERALA, INDIA

*Project report submitted*

*in partial fulfilment of requirements for the award of degree in*

**BACHELOR OF SCIENCE**

*In*

**GEOLOGY**

*By,*


**MS. SOUPARNIKA RAMESH**

**Reg No. CCAVSGL029**


***Under the guidance of***
***Mr. Tharun R Unnithan***


**DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125**

**(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)**

# CERTIFICATE

This is to certify that the project work entitled – **GROUNDWATER POTENTIAL ZONATION USING GEOGRAPHIC INFORMATION SYSTEM IN MUKUNDAPURAM TALUK, THRISSUR DISTRICT, KERALA, INDIA** by **MS. SOUPARNIKA RAMESH(CCAVSGL029)** submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree of Bachelor of Science in Geology is an authentic record of our own work carried out under the guidance of **Mr.Tharun R**, Assistant Professor, Department of Geology and Environmental Science during the period of 2022-2023. The matter embodied in this project work has not been submitted for any award of degree.

**Ms. Souparnika Ramesh**

It is certified that the above statement made by the candidate is true to the best of our knowledge.

Signature of project in charge

Mr. Tharun R

Assistant Professor and Head

Dept. of Geology and Environmental Science

Christ College (Autonomous)

Irinjalakuda, Kerala-680125

Place: Irinjalakuda

Date:15/04/2024

External Examiners:

Dept. of Geology & Environmental Science
Irinjalakuda
680 125
Christ College (Autonomous)

# DECLARATION

We hereby declare that the project work "**GROUNDWATER POTENTIAL ZONATION USING GEOGRAPHIC INFORMATION SYSTEM IN MUKUNDAPURAM TALUK, THRISSUR DISTRICT, KERALA, INDIA**" is a work done by us. No part of the report is plagiarized from other resources. All information included from other sources has been duly acknowledged. We maintain that if any part of the project is found to be plagiarized, we shall take the full responsibility for it.

MS. SOUPARNIKA RAMESH(CCAVSGL029)

IRINJALAKUDA

DATE: 15/04/2024

# ACKNOWLEDGEMENT

This report is a certified documentation of "**GROUNDWATER POTENTIAL ZONATION USING GEOGRAPHIC INFORMATION SYSTEM IN MUKUNDAPURAM TALUK, THRISSUR DISTRICT, KERALA, INDIA".**

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MS. SOUPARNIKA RAMESH

# Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy

Project report submitted to Christ College, Autonomous, University of Calicut in partial fulfilment of requirements for the completion of Sixth Semester in

B.Sc. GEOLOGY


SUBMITTED BY

NAME: TINTU BENNY

REGISTER NO: CCAVSGL031

**DEPARTMENT OF GEOLOGY AND ENVIRONMETAL SCIENCES**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA**

(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)

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**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA**

(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)

UNDER THE JOINT SUPERVISION OF

**Dr. LINTO ALAPPAT**

**&**

**Ms. SHAIMA M.M**

# CERTIFICATE

I hereby declare that the work, which is being present in this project, entitled "**Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy**" by Mr./Ms. Tintu Benny .....Register no CCAVSGL031 .....submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree of Bachelor of Science in Geology is an authentic record of my own work carried out under the joint supervision of **Dr. Linto Alappat**, Assistant Professor , Dept. of Geology and Environmental sciences and **Ms. Shaima M.M**, Assistant Professor, Department of Geology and Environmental Science during the period of 2023-2024. The matter embodied in this dissertation has not been submitted for any award of degree.

**TINTU BENNY**

It is certified that the above statement made by the candidate is true to the best of me knowledge.

**Signature of project in charge**

**Ms. Shaima M.M**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous )
Irinjalakuda, Kerala-680125

**Dr. Linto Alappat**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

Place: Irinjalakuda
Date: 17/04/24

External Examiners:

# DECLARATION

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DATE: 17/04/24

TINTU BENNY

REG NO: CCAVSGL031

# ACKNOWLEDGEMENT

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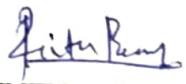

TINTU BENNY

# ABSTRACT

This report provides details of the stratigraphy of Cheruvathur formation, known for its equivalence with Tertiary Warkalli Formation of Southern Kerala. The total thickness of the section studied was 33m representing different lithologies. Stratigraphy of Cheruvathur formation exposes several meter thick successions of carbonaceous clay with lenticular units of shale and lignite. The lignite units are characterized by abundance of plant fossils in the form of plant leaves, stems, twigs and leaf impressions. Tubular sticks and planar structures of marcasite and remains of amber, followed by variegated clays and sandstone are seen in the stratigraphic records. The presence of variegated lithounits with evidences of chemical leaching provides distinct colouration to sand and clay units. Clays are often shows various shades of gray, red and purple colours and sandstone units are largely ferruginous in nature. Layers of ferricrete deposits are seen at the bottom of the clay units at distinct intervals. The sediment textural analyses reveals that the sandy lithounits in Cheruvathur formation are characterized as coarse sand to medium sand, moderately sorted unimodal distribution of aggregate grains. The average grainsizes of the studied sandy lithounits varied between 673 to 360 μm. The fluvial depositional regime in a point bar sequence of a braided stream was evidenced by the presence of parallel bedding/ lamination. Low angle trough cross stratification, graded bedding etc. The shale interbeds with lignite seams shows lenticular nature at varying levels across the section. The lignite seams contain abundant plant remains like amber, leaves, twigs, logs, and fossil impressions. These are implying to a marshy depositional setting in a reduced environment, shifting laterally to change in hydrodynamic conditions.

# THE PETROGRAPHIC STUDY OF ROCKS OF BUILDING STONE QUARRY, MOOKKANNOOR, ERNAKULAM

Project report submitted to Christ College (Autonomous), University of Calicut in partial fulfilment of requirements for the award of degree in

BACHELOR OF SCIENCE

IN

GEOLOGY

By

DEVAPRIYA SHAJU

Reg No: CCAVSGL032

(2021-2024)

DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE
CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125
(Affiliated to University of Calicut and re-accredited by NAAC with A++grade)

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(Affiliated to University of Calicut and re-accredited by NAAC with A++grade)

UNDER THE GUIDANCE OF Dr. RESMY K J
Asst. Professor, Department of Geology and Environmental Science

# CERTIFICATE

I hereby declare that the work, which is being present in this dissertation, entitled "THE PETROGRAPHIC ANALYSIS OF HOST ROCKS OF GRANITE BUILDING STONE QUARRY" by MS. DEVAPRIYA SHAJU CCAVSGL032) submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree of Bachelor of Science in Geology is an authentic record of my own work carried out under the guidance of Dr. Resmy K.J , Assistant Professor, Department of Geology and Environmental Science during the period of 2023-2024. The matter embodied in this dissertation has not been submitted for any award of degree.

(DEVAPRIYA SHAJU)

It is certified that the above statement made by the candidate is true to the best of my knowledge.

Signature of project in charge

K. J. 17/04/2024

Dr. Resmy K J
Assistant Professor
Dept. of Geology and Environmental Science
Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

17/04/2024

Mr. Tharun R
Assistant Professor and Head
Dept. of Geology and Environmental

Christ College (Autonomous)
Irinjalakuda, Kerala-680125

Place: Irinjalakuda

Date:

External Examiner:

Christ College (Autonomous) * Dept. of Geology & Environmental Science * Irinjalakuda 680 125

# Palaeogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy

Project report submitted to Christ College, Autonomous, University of Calicut in partial fulfilment of requirements for the completion of Sixth Semester in

B.Sc. GEOLOGY


SUBMITTED BY

NAME :NANDANA P D

REGISTER NO : CCAVSGL033

**DEPARTMENT OF GEOLOGY AND ENVIRONMETAL SCIENCES**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA**

(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)

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Project report submitted to Christ College, Autonomous, University of Calicut in partial fulfilment of requirements for the completion of Sixth Semester in

B.Sc. GEOLOGY


SUBMITTED BY

NAME :NANDANA P D

REGISTER NO : CCAVSGL033

**DEPARTMENT OF GEOLOGY AND ENVIRONMETAL SCIENCES**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA**

(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)

UNDER THE JOINT SUPERVISION OF

**Dr. LINTO ALAPPAT**
**&**
**Ms. SHAIMA M.M**

# CERTIFICATE

I hereby declare that the work, which is being present in this project, entitled "**Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy**" by Mr./Ms. Nandana P.D Register no CCAMSGL033 submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree of Bachelor of Science in Geology is an authentic record of my own work carried out under the joint supervision of **Dr. Linto Alappat**, Assistant Professor , Dept. of Geology and Environmental sciences and **Ms. Shaima M.M**, Assistant Professor, Department of Geology and Environmental Science during the period of 2023-2024. The matter embodied in this dissertation has not been submitted for any award of degree.

**NANDANA P D**

It is certified that the above statement made by the candidate is true to the best of me knowledge.

**Signature of project in charge**


**Ms. Shaima M.M**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous )
Irinjalakuda, Kerala-680125

**Dr. Linto Alappat**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125


Place: Irinjalakuda
Date:

External Examiners:

# DECLARATION

I hereby declare that the dissertation work **"Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy"** is a work done by me. No part of the report is plagiarized from other resources. All information included from other sources has been duly acknowledged. I maintain that if any part of the project is found to be plagiarized, I shall take the full responsibility for it. I also understand and agree that this declaration made by me is final and irrevocable,

Nandana PD

PLACE: Irinjalakuda

DATE: 17/04/24

REG NO: CCAVSGL021

# ACKNOWLEDGEMENT

This report is a certified documentation of the Cheruvathur formation and its stratigraphy.

Following the successful completion of this project, I would like to express my heartfelt appreciation to the all who stood by me through thick and thin, without whom the work would not have been possible. First and foremost, I would record my deep sense of gratitude and indebtedness to my guides Dr. Linto Alappat, Assistant Professor, Department of Geology and Environmental Science & Mrs. Shaima M M, Assistant professor, Department of Geology and Environmental science, Christ College (Autonomous) Irinjalakuda, for designing the framework of the project and providing constant support and supervision throughout the entire course of study.

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Nandana P D

# ABSTRACT

This report provides details of the stratigraphy of Cheruvathur formation, known for its equivalence with Tertiary Warkalli Formation of Southern Kerala. The total thickness of the section studied was 33m representing different lithologies. Stratigraphy of Cheruvathur formation exposes several meter thick successions of carbonaceous clay with lenticular units of shale and lignite. The lignite units are characterized by abundance of plant fossils in the form of plant leaves, stems, twigs and leaf impressions. Tubular sticks and planar structures of marcasite and remains of amber, followed by variegated clays and sandstone are seen in the stratigraphic records. The presence of variegated lithounits with evidences of chemical leaching provides distinct colouration to sand and clay units. Clays are often shows various shades of gray, red and purple colours and sandstone units are largely ferruginous in nature. Layers of ferricrete deposits are seen at the bottom of the clay units at distinct intervals. The sediment textural analyses reveals that the sandy lithounits in Cheruvathur formation are characterized as coarse sand to medium sand, moderately sorted unimodal distribution of aggregate grains. The average grainsizes of the studied sandy lithounits varied between 673 to 360 μm. The fluvial depositional regime in a point bar sequence of a braided stream was evidenced by the presence of parallel bedding/ lamination. Low angle trough cross stratification, graded bedding etc. The shale interbeds with lignite seams shows lenticular nature at varying levels across the section. The lignite seams contain abundant plant remains like amber, leaves, twigs, logs, and fossil impressions. These are implying to a marshy depositional setting in a reduced environment, shifting laterally to change in hydrodynamic conditions.

# GROUNDWATER POTENTIAL ZONATION USING GEOGRAPHIC INFORMATION SYSTEM IN MUKUNDAPURAM TALUK, THRISSUR DISTRICT, KERALA, INDIA

***Project report submitted***

***in partial fulfilment of requirements for the award of degree in***

**BACHELOR OF SCIENCE**

*In*

**GEOLOGY**

*By,*


**MR. AKIL RAHMAN**

**Reg No. CCAVSGL001**


***Under the guidance of***
***Mr. Tharun R Unnithan***



**DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125**

**(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)**

# CERTIFICATE

This is to certify that the project work entitled – **GROUNDWATER POTENTIAL ZONATION USING GEOGRAPHIC INFORMATION SYSTEM IN MUKUNDAPURAM TALUK, THRISSUR DISTRICT, KERALA, INDIA** by **MR. AKIL RAHMAN (CCAVSGL001)** submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree of Bachelor of Science in Geology is an authentic record of our own work carried out under the guidance of **Mr. Tharun R**, Assistant Professor, Department of Geology and Environmental Science during the period of 2022-2023. The matter embodied in this project work has not been submitted for any award of degree.

**MR. AKIL RAHMAN**

It is certified that the above statement made by the candidate is true to the best of our knowledge.

Signature of project in charge

Mr. Tharun R

Assistant Professor and Head

Dept. of Geology and Environmental Science

Christ College (Autonomous)

Irinjalakuda, Kerala-680125

Place: Irinjalakuda

Date:15/04/2024

External Examiners:

# DECLARATION

We hereby declare that the project work "**GROUNDWATER POTENTIAL ZONATION USING GEOGRAPHIC INFORMATION SYSTEM IN MUKUNDAPURAM TALUK, THRISSUR DISTRICT, KERALA, INDIA**" is a work done by us. No part of the report is plagiarized from other resources. All information included from other sources has been duly acknowledged. We maintain that if any part of the project is found to be plagiarized, we shall take the full responsibility for it.

MR. AKIL RAHMAN (CCAVSGL001)

IRINJALAKUDA

DATE:

# ACKNOWLEDGEMENT

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MR. AKIL RAHMAN

# Contents

# *SLAKED LIME: A Solution for Turbidity in Groundwater*

***A project report submitted in partial fulfilment for Sixth Semester***

***BACHELOR OF SCIENCE in* GEOLOGY**


By,

**AKSHAY KRISHNA P**

**CCAVSGL002**

Under the guidance of

**Dr. ANSO M A**

(Assistant Professor, Department of Geology & Environmental Science) 2021-2026

DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE,

CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA

KERALA, 680125

***(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)***

## CERTIFICATE

This is to certify that the dissertation entitled - **SLAKED LIME: A Solution for Turbidity in Groundwater** is a bonafide record of work done by AKSHAY KRISHNA P (REG NO : CCAVSGL002 ) Christ College (Autonomous) Irinjalakkuda,Under my guidance in partial fulfilment of requirements for Sixth Semester BSc in Geology degree of during the period of 2021 -2024.

Tharun R

Head of the department

Dept of Geology and Env. Science

Christ College (Autonomous),

Irinjalakkuda

Project Guide

Dr. Anso M A

Assistant professor

Dept of Geology and Env.science

Christ college (Autonomous),

Irinjalakkuda

Place : Irinjalakkuda

Date:

External Examiners:

1.....

2.....

Dept. of Geology & Environmental Science * Christ College (Autonomous) * Irinjalakkuda 680 125

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Place: Irinjalakuda AKSHAY KRISHNA P

Date: 16/04/2024 CCAVSGL002

## ACKNOWLEDGEMENT

Following the successful completion of this project, I would like to express my heartfelt appreciation to following ones, without whom the work would not have been possible.

First of all I Pay my deepest thanks to god almighty who enabled me to finish the project and complete this project report successfully.

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I would like to express my sincere thanks to Mr. Jithin C F and Miss. Caren Vencilavouse those who helped me throughout the completion of this work. Similarly, I would like to thank all my classmates for their kind corporation and help during the work.

# ABSTRACT

The objective of the study was to bring the turbid groundwater into the drinking water limit. The turbidty of the collected sample is 198 NTU, whereas the WHO standard for turbidity is 5 NTU. The turbid nature of the study area is due to the close proximity to paddy field and lithology associated. Certain combinations and quantities of natural reagents were added to samples to attain the turbidity into the desired drinking water limit. This study paved a new way to control the turbid groundwater, and eventually enhanced the quality of groundwater.

# GROUNDWATER POTENTIAL ZONATION USING GEOGRAPHIC INFORMATION SYSTEM IN MUKUNDAPURAM TALUK, THRISSUR DISTRICT, KERALA, INDIA

***Project report submitted***

***in partial fulfilment of requirements for the award of degree in***

**BACHELOR OF SCIENCE**

*In*

**GEOLOGY**

*By,*


**MR. ALFIN K JOFY**

**Reg No. CCAVSGL003**


***Under the guidance of***
***Mr. Tharun R Unnithan***


**DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125**

**(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)**

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**ALFIN K JOFY**

It is certified that the above statement made by the candidate is true to the best of our knowledge.

Signature of project in charge

17/04/24

Mr. Tharun R

Assistant Professor and Head

Dept. of Geology and Environmental Science

Christ College (Autonomous)

Irinjalakuda, Kerala-680125

Place: Irinjalakuda

Date:15/04/2024

Dept. of Geology & Environmental Science ★ Christ College (Autonomous) ★ Irinjalakuda 680 125

External Examiners:

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ALFIN K JOFY (CCAVSGL003)

IRINJALAKUDA

DATE:

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ALFIN K JOFY

# LANDSLIDE SUSCEPTIBILITY MAPPING OF WAYANAD DISTRICT, KERALA, USING ANALYTICAL HIERARCHY PROCESS METHOD IN GIS ENVIRONMENT

**Project report submitted**
**in partial fulfillment of the requirement for the award of**
**BACHELOR OF SCIENCE**
**In**
**GEOLOGY**

By

**ANUSREE K M**
**CCAVSGL004**
**Under the Guidance of**
**Dr Midhuna Vinayan**


**DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE**
**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125**
**(Affiliated to University of Calicut and re-accredited by NAAC with an A++ grade)**

# CERTIFICATE

I hereby declare that the work, which is being presented in this project work, entitled, **"LANDSLIDE SUSCEPTIBILITY MAPPING OF WAYANAD DISTRICT, KERALA, USING ANALYTICAL HIERARCHY PROCESS METHOD IN GIS ENVIRONMENT"** by **ANUSREE K M (CCAVSGL004)** submitted to the Department of Geology and Environmental Science, Christ College (Autonomous) Irinjalakuda, Thrissur, in partial fulfillment of the requirement for the award of the Degree of Bachelor of Science in Geology, is an authentic record of my own work carried out under the guidance of Dr. Midhuna Vinayan during the period of 2023-2024. The matter embodied in this project has not been submitted for any other degree.

**ANUSREE K M**

It is certified that the above statement made by the candidate is true to the best of my knowledge.

**Dr. Midhuna Vinayan**
**Assistant Professor and Supervisor**

**Mr. Tharun R**
**Assistant Professor and Head**

**External Examiners**

**DATE:**
**PLACE:**

Dept. of Geology & Environmental Science * Christ College (Autonomous) * Irinjalakuda 680 125

## DECLARATION

I hereby declare that the work, which is being presented in this project work, entitled, **"LANDSLIDE SUSCEPTIBILITY MAPPING OF WAYANAD DISTRICT, KERALA, USING ANALYTICAL HIERARCHY PROCESS METHOD IN GIS ENVIRONMENT"** is a work done by me. No part of the report is plagiarized from other resources. All information included from other sources has been duly acknowledged. I maintain that if any part of the project is found to be plagiarized, I shall take full responsibility.

Place: Irinjalakuda

Date: .....

**ANUSREE K M**
**(CCAVSGL004)**

## ACKNOWLEDGMENT

I wish to record my deep sense of gratitude and profound respect to **Dr. Midhuna Vinayan** Assistant Professor, Department of Geology and Environmental Science, Christ College (Autonomous) Irinjalakuda, Thrissur for her impeccable guidance moral support, and constant encouragement throughout the course of my study.

I express my sincere thanks and gratefulness to Mr. Tharun R, Assistant Professor and Head in charge, Department of Geology and Environmental Science, Christ College (Autonomous) Irinjalakuda, Thrissur for his constant support and encouragement, providing facilities for the successful completion of this project

I am deeply thankful to all other faculty members of the Department of Geology and Environmental Science for their support and guidance.

I extend my gratitude to the entire Christ College family for their support, guidance, and love

I take this opportunity to thank all my classmates and friends who directly or indirectly helped me to complete this project.

**ANUSREE K M**

# *SLAKED LIME: A Solution for Turbidity in Groundwater*

***A project report submitted in partial fulfilment for Sixth Semester***

***BACHELOR OF SCIENCE in* GEOLOGY**


By,

**ARJUN U NAIR**

**CCAVSGL005**

Under the guidance of

**Dr. ANSO M A**

(Assistant Professor, Department of Geology & Environmental Science) 2021-2026

DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE,

CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA

KERALA, 680125

***(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)***

## CERTIFICATE

This is to certify that the dissertation entitled - **SLAKED LIME: A Solution for Turbidity in Groundwater** is a bonafide record of work done by ARJUN U NAIR (REG NO : CCAVSGL005) Christ College (Autonomous) Irinjalakkuda,Under my guidance in partial fulfilment of requirements for Sixth Semester Bachelors of science in Geology of during the period of 2021 -2024.

Tharun R

Head of the department

Dept of Geology and Env. Science

Christ College (Autonomous),

Irinjalakkuda

Project Guide

Dr. Anso M A

Assistant professor

Dept of Geology and Env.science

Christ college (Autonomous),

Irinjalakkuda

Place : Irinjalakkuda

Date:16/04/2024

External Examiners;

1.....

2.....

Dept. of Geology & Environmental Science ★ Christ College (Autonomous) ★ Irinjalakuda 680 125

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Place: Irinjalakuda

Date: 16/04/2024

ARJUN U NAIR

CCAVSGL005

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I would like to express my sincere gratitude to Dr Anso M A, Assistant professor, Department of geology and environmental science, Christ College Autonomous Irinjalakuda for his guidance and support during the entire work.

I would like to thank Mr. Tharun.R (HoD), Dr. Linto Alappat ( Research Dean), Dr. Reshmi KJ ( Assistant professor), Dr. Midhuna ( Assistant professor), Mrs. Sweeshma (Assistant professor) , Ms. Shyma Sijo ( Assistant professor), Mrs. Roshini ( Assistant professor), Dr. Sibin Sebastian ( Assistant professor) , Dr. Anto ( Assistant professor), Mr. Gopa Kumar ( Assistant professor), Dr. Sunitha ( Assistant professor) and Ms. Ivine Department of geology and environmental science, Christ College Autonomous Irinjalakuda for their guidance and support during the entire work.

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# ABSTRACT

The objective of the study was to bring the turbid groundwater into the drinking water limit. The turbidty of the collected sample is 198 NTU, whereas the WHO standard for turbidity is 5 NTU. The turbid nature of the study area is due to the close proximity to paddy field and lithology associated. Certain combinations and quantities of natural reagents were added to samples to attain the turbidity into the desired drinking water limit. This study paved a new way to control the turbid groundwater, and eventually enhanced the quality of groundwater.

# LANDSLIDE SUSCEPTIBILITY MAPPING OF WAYANAD DISTRICT, KERALA, USING ANALYTICAL HIERARCHY PROCESS METHOD IN GIS ENVIRONMENT

**Project report submitted**
**in partial fulfillment of the requirement for the award of**
**BACHELOR OF SCIENCE**
**In**
**GEOLOGY**

By

**FLOGEN BASIL**
**CCAVSGL007**
**Under the Guidance of**
**Dr Midhuna Vinayan**


**DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE**
**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125**
**(Affiliated to University of Calicut and re-accredited by NAAC with an A++ grade)**

## CERTIFICATE

I hereby declare that the work, which is being presented in this project work, entitled, **"LANDSLIDE SUSCEPTIBILITY MAPPING OF WAYANAD DISTRICT, KERALA, USING ANALYTICAL HIERARCHY PROCESS METHOD IN GIS ENVIRONMENT"** by **FLOGEN BASIL (CCAVSGL007)** submitted to the Department of Geology and Environmental Science, Christ College (Autonomous) Irinjalakuda, Thrissur, in partial fulfillment of the requirement for the award of the Degree of Bachelor of Science in Geology, is an authentic record of my own work carried out under the guidance of Dr. Midhuna Vinayan during the period of 2023-2024. The matter embodied in this project has not been submitted for any other degree.

**FLOGEN BASIL**

It is certified that the above statement made by the candidate is true to the best of my knowledge.

**Dr. Midhuna Vinayan**
**Assistant Professor and Supervisor**

17/04/24

**Mr. Tharun R**
**Assistant Professor and Head**

**External Examiners**

**DATE:** 17/4/2024
**PLACE:** IRINJALAKUDA

Dept. of Geology & Environmental Science * Christ College (Autonomous) * Irinjalakuda 680 125

# DECLARATION

I hereby declare that the work, which is being presented in this project work, entitled, **"LANDSLIDE SUSCEPTIBILITY MAPPING OF WAYANAD DISTRICT, KERALA, USING ANALYTICAL HIERARCHY PROCESS METHOD IN GIS ENVIRONMENT"** is a work done by me. No part of the report is plagiarized from other resources. All information included from other sources has been duly acknowledged. I maintain that if any part of the project is found to be plagiarized, I shall take full responsibility.

Place: Irinjalakuda

Date: ..17.4.2024

**FLOGEN BASIL**
**(CCAVSGL007)**

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I wish to record my deep sense of gratitude and profound respect to **Dr. Midhuna Vinayan** Assistant Professor, Department of Geology and Environmental Science, Christ College (Autonomous) Irinjalakuda, Thrissur for her impeccable guidance moral support, and constant encouragement throughout the course of my study.

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I extend my gratitude to the entire Christ College family for their support, guidance, and love

I take this opportunity to thank all my classmates and friends who directly or indirectly helped me to complete this project.

**FLOGEN BASIL**

A PROJECT REPORT

ON

# LITHOSTRATIGRAPHY OF TERTIARY SEQUENCE OF VARKALA COASTAL CLIFFS

**Submitted in the partial fulfillment for the award of degree in**

**BACHELOR OF SCIENCE IN GEOLOGY**

**To**


## DEPARTMENT OF GEOLOGY AND ENVIRONMENTALSCIENCE, CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA

**Affiliated to University of Calicut and re accreditedby NACC with A++grade**


Submitted by


**GAYATRI C.R (Reg No:CCAVSGL008)**


Under the guidance of

**Dr. Mahboob Alam**

**Assistant Professor, Christ College, Irinjalakuda, Kerala**

## CERTIFICATE

I hereby declare that the work, which is being presented in this project work, entitled, "LITHOSTRATIGRAPHY OF TERTIARY SEQUENCE OF VARKALA COASTAL CLIFFS" by GAYATHRI C.R (CCAVSGL008)
submitted to the
Department of Geology and Environmental Science, Christ College (Autonomous) Irinjalakuda, Thrissur, in partial fulfillment of the requirement for the award of the Degree of Bachelor of Science in Geology, is an authentic record of my own work carried out under the guidance of Dr. Mahboob Alam during the period of 2023-2024.
The matter embodied in this project has not been submitted for any other degree.

Tharun R

Head of the department

Dept of Geology and Env. Science

Christ College (Autonomous),

Irinjalakkuda

Project Guide for

Dr. Mahboob Alam

Assistant professor

Dept of Geology and Env.science

Christ college (Autonomous),

Irinjalakkuda

Place : Irinjalakkuda

Date:

External Examiner:

1.....

## DECLARATION

I here by declare that the dissertation work "LITHOSTRATIGRAPHY OF TERTIARY SEQUENCE OF VARKALA COASTAL CLIFFS " is a original project work done by Ms. Gayatri C.R. The project report is not plagiarized from other resources. All information included from other sources has been duly acknowledged. I maintain that if any part of the project is found to be plagiarized, I shalltake the full responsibility for it.

GAYATRI C.R (Reg. No. CCAVSGL008)

IRINJALAKUDA

DATE: 16-04-2024

# HEAVY MINERAL ANALYSIS OF PAPANASAM REGION IN VARKALA, KERALA

Project report submitted to Christ College (Autonomous) Irinjalakuda, Kerala

Under University of Calicut in partial fulfilment of requirements for sixth semester of

**BACHELOR OF SCIENCE**

**IN**

**GEOLOGY**


**By**

**JASMINE GIBY - CCAVSGL009**

**(2021 -2024)**

**DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125**

(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)

UNDER THE GUIDANCE OF

**SWEESHMA P DEV**

**Assistant Professor,**

**Christ College (Autonomous), Irinjalakuda, Thrissur**

# CERTIFICATE

I hereby declare that the work which is being present in this project, entitled **"HEAVY MINERAL ANALYSIS OF PAPANASAM REGION IN VARKALA, KERALA** "by **Ms. JASMINE GIBY**(CCAVSGL009) is an original work submitted to the Department of Geology and Environmental Science, ChristCollege (Autonomous), Irinjalakuda in partial fulfilment of the requirement for Sixth Semester Integrated M.Sc. in Geology. This work was carriedout under the guidance of Sweeshma P Dev, Assistant Professor, Departmentof Geology and Environmental Science during the period of 2023-2024. The matter embodiedin this project report has not been submitted for any award of degree.

JASMINE GIBY

It is certified that the above statement made by the candidate is true to the best of my knowledge

Signature of project in charge

**Mrs. Sweeshma P Dev**
Assistant Professor
Dept. of Geology and
Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

**Mr.Tharun R**
Assistant Professor and Head
Dept. of Geology and
Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

Place: Irinjalakuda

Date:17-04-2024

External Examiners

# DECLARATION

I hereby declare that the project work entitled work "**HEAVY MINERAL ANALYSIS OF PAPANASAM REGION IN VARKALA, KERALA**" is a work done by me. No part of the report is plagiarized from other sources. All information included from other source has been duly acknowledged. I maintain that if any part of the project is found to be plagiarized I shall take the full responsibity for it.

IRINJALAKUDA
DATE:17-04-2024

JASMINE GIBY
Reg No: CCAVSGL009

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I also acknowledge with reverence, my warm regards towards my parents and family members for their moral support and guidance. Last but not the least I extend my thanks to all of my friends who directly or indirectly helped me to complete this project report.

Above all I would like to express my gratitude to God almighty for showering His blessings on me to complete my project in an efficient manner.

# ABSTRACT

Papanasam Beach in Varkala, Kerala, India, features a captivating geological landscape shaped by millions of years of natural processes. The beach is situated at approximately 8.7358° N latitude and 76.7036° E longitude. The layers of sandstone and shale have been formed over time through the accumulation and compaction of sedimentary materials, often reflecting changes in environmental conditions and Common heavy minerals found at Papanasam Beach may include garnet, ilmenite, rutile, zircon, and magnetite, among others. These minerals have economic significance, as they are sometimes mined for their valuable properties.

Bromoform separation technique is used in mineral processing and to concentrate heavy minerals for analysis. Bromoform is used liquid for separating heavy and light minerals based on their density differences. The percentage of Heavy mineral concentration in Papanasam region, Varkala as analyzed from bromoform separation technique follows backshore (7.59%), middle berm (2.67%), fore shore (2.83%).The mixed proportion of samples from backshore ,middle berm and foreshore under bromoform separation technique gives the outcome percentage as 14.75%.Sieve analysis is a technique used to determine the particle size distribution of a granular material, such as sand or gravel. The grain size distribution follows as coarse sand(19.5%),medium sand(78.8%) and silt and clay size particles(0.0%). It involves passing a sample of the material through a series of sieves with progressively smaller openings, stacked one above the other. This technique was used to find out the heavy mineral content in the coarser grains

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# CHAPTER-1
# INTRODUCTION

## 1(a) General Introduction

This project mainly focuses upon heavy mineral separation from the sand samples collected from ‘Paapanasam’ beach, Varkala, Thiruvananthapuram. Three samples each are collected from Backshore, Middle Berm and Foreshore respectively. The samples are analyzed through various techniques including laboratory sieve method separation and Bromoform separation techniques. The final result is to analyze the percentage of heavy minerals present in the beach sand samples collected from a significant part of Kerala coastline.

## 1(b) Beach sediments

Beach sediments are the loose particles like sand, gravel, and shell fragments found on beaches. They are typically the result of weathering and erosion of rocks and minerals, transported by rivers or waves, and deposited along the shoreline. The size and composition of beach sediments can vary depending on factors like wave energy, the nature of the nearby coast, and the types of rocks in the area.

Beach sediment occurs as a result of various geological and environmental processes. It is typically composed of a mixture of sand, gravel, silt and clay, along with organic material such as shells and coral fragments. Sediment is often deposited on beaches by rivers, coastal currents, and wave action. The size and composition of beach sediment can vary widely depending on factors such as the local geology, wave energy, and the presence of nearby rivers or streams.

### Sand

Sand is a granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can be found on beaches, deserts, and riverbeds, among other places, and is often used in construction and landscaping. Beach sand typically ranges in size from 0.0625 mm to 2 mm in diameter. The size can vary depending on the location and the specific beach.

**Gravel**

Beach gravel refers to the small, rounded, and smooth stones that are commonly found on beaches. These stones are typically the result of erosion and weathering processes that break down larger rocks into smaller particles. Beach gravel can vary in size, shape, color, and composition depending on the geological makeup of the area. It can consist of a variety of minerals and rocks, such as quartz, limestone, granite, basalt, sandstone, shells, and coral fragments. Beach gravel plays a role in beach ecology, providing habitat for various species and influencing beach erosion and sediment transport processes.

Beach gravel can vary depending on the location, but common types include:

1. Quartz: Often found in many beach gravels, quartz is hard, durable, and comes in various colors, including white, pink, and clear.
2. Limestone: Limestone gravel can be found on beaches where there are nearby cliffs or outcroppings composed of this rock. It's typically light in color and can be smooth or angular.
3. Granite: Granite gravel is usually more common on rocky beaches. It's often gray or pinkish and is a hard, durable rock.
4. Basalt: Basalt gravel comes from volcanic rocks and is typically dark in color, ranging from black to dark gray.
5. Sandstone: In areas where sandstone cliffs erode onto the beach, you may find sandstone gravel. It can be various colors, including red, brown, or yellow, depending on the mineral content.
6. Shell: Beaches in areas with abundant marine life often have shell gravel, composed of broken shell fragments.

**Silt**

Beach silt can vary in composition depending on factors like the source of the sediment, local geology, and environmental conditions. Some common types of beach silt include:

1. Mineral silt: Composed primarily of weathered minerals such as quartz, feldspar, and mica. These minerals are often brought to the beach through erosion of rocks and sedimentary deposits.

2. Organic silt: Contains a significant amount of decomposed organic matter, such as plant material, algae, and marine organisms. Organic silt is common in areas with high biological activity, like marshes or estuaries.
3. Clay silt: Contains a high proportion of clay particles, which are very fine and have cohesive properties. Clay silt can be transported to beaches by rivers or streams and can contribute to the formation of mudflat.
4. Anthropogenic silt: Resulting from human activities, such as construction, dredging, or pollution. This type of silt can contain contaminants and may have negative impacts on beach ecosystem

These types of silt can mix together to form the beach sediment found along coastlines

**Clay**

Beach clay is a type of sediment that is commonly found along coastlines. It is composed of very fine particles, smaller than 0.002 mm in diameter, which gives it a smooth and sticky texture. Beach clay is often formed from the weathering and erosion of rocks and minerals, which are then transported by rivers or streams and deposited along the coast.

Beach clay is a type of sediment that is commonly found along coastlines. It is composed of very fine particles, smaller than 0.002 mm in diameter, which gives it a smooth and sticky texture. Beach clay is often formed from the weathering and erosion of rocks and minerals, which are then transported by rivers or streams and deposited along the coast.

In terms of color, beach clay can vary depending on its mineral content. It can range from white to gray to reddish-brown, with different colors indicating the presence of different minerals. Clay minerals, such as kaolinite, montmorillonite, and illite, are commonly found in beach clay and contribute to its properties.

## 1(c) Heavy minerals from beaches

Heavy minerals are minerals with a high density that are often found on beaches and in sedimentary environments. Some common heavy minerals found in beaches include:

1.Ilmenite: A black-to-brownish titanium-iron oxide mineral.

2.Rutile: Another form of titanium dioxide, often reddish-brown in color.

3.Zircon: A zirconium silicate mineral, typically brownish in color.

4.Garnet: A group of silicate minerals that can be red, brown, or black.

5.Magnetite: An iron oxide mineral that is strongly magnetic and often black in color.

These minerals are often concentrated by wave and current action on the beach, resulting in the formation of heavy mineral sands.

## 1(d) Aim of study

1. Gain familiarity with heavy mineral separation utilizing bromoform, analytical methodology, and sediment sample preparation techniques for sieve analysis.
2. To describe the heavy mineral mineralogical component in the beach sand deposit from the Papanasam area of Varkala, Thiruvananthapuram,Kerala.
3. To understand the microscopic analysis and identification of minerals.
4. To understand the geology and geomorphology of the study area.

# CHAPTER-2

# STUDY AREA

## 2(a)Study Area

Papanasam beach lies between latitude8° 43' 57.7596" and longitude 76° 42' 21.618"N to latitude 8° 43.9627' E and longitude 76° 42.3603' is a beach in varkala, kerala.Papanasham boasts fascinating geological features. It's characterized by rugged cliffs formed from ancient sedimentary rocks, primarily consisting of laterite and limestone. These cliffs provide a stunning backdrop to the sandy shores. The beach is renowned for its natural mineral springs believed to have medicinal properties. Geologically, these springs emerge from fractures and faults within the limestone formations. Erosion plays a significant role in shaping the coastline, with the constant action of waves and weathering sculpting the cliffs and creating sea caves and other intriguing formations. Additionally, the area is part of the Western Ghats, a UNESCO World Heritage Site, contributing to its geological significance.

Fig.1 Study area visit

## 2(b) Geology of Kerala

Kerala State, bounded by north latitudes 8º17’30” and 12º47’40” and east longitudes 74º51’57” and 77º24’47” covers an area of 38,864 sq km and is located in the southwestern part of the Indian Peninsular shield. This linear strip of land is bounded by the Western Ghats on the east

and the Arabian sea on the west. The state is divisible into four broad physiographic units. They are: (i) the low-level coastal strip fringing the Lakshadweep Sea, (ii) the landforms marked by laterite capping between altitudes of 30m and 200 m, (iii) the foot hills of Western Ghats ranging in altitude from 200 to 600 m and (iv) the steeply rising Western Ghat hill ranges with altitudes reaching up to 2500 m. Of the total area, 35,955 sq km area is constituted by hard rock crystalline and the rest by soft sediments. The crystalline comprise charnockite, gneiss, granite, metasediments, gabbro and dolerite to mention the major ones. The sedimentaries occur mostly in the coastal areas. Mineral deposits of clay, bauxite, rare earth sands, glass sand, iron ore, limestone, gold, graphite, chrysoberyl etc. are known to occur in the state. (GEOLOGICAL SURVEY OF INDIA, GEOLOGY OF KERALA ,PART-IX)

## 2(c) Geology of Kerala coastline

Kerala, located on the southwestern coast of India, has a diverse geology that contributes to its unique landscape. Here are some key geological features of Kerala: 1. Western Ghats: Kerala is bordered by the Western Ghats Mountain range on the east. The Western Ghats are one of the eight “hottest hotspots” of biological diversity in the world and are known for their rich flora and fauna.

1. Coastal Plains: The state is characterized by narrow coastal plains that lie between the Western Ghats and the Arabian Sea. These plains are fertile and support agriculture.
2. Rivers: Kerala is crisscrossed by numerous rivers originating from the Western Ghats. These rivers, such as the Periyar, Pamba, and Bharathapuzha, play a crucial role in the state’s economy and ecology.
3. Laterite Soil: Much of Kerala’s soil is composed of laterite, a type of soil rich in iron and aluminum oxides. This soil is characteristic of tropical regions with high rainfall.
4. Minerals: Kerala has some mineral resources, including ilmenite, rutile, monazite, and zircon. These minerals are found in the coastal areas of the state.
5. Natural Hazards: Kerala is prone to natural hazards such as landslides, floods, and coastal erosion, partly due to its unique geology and heavy rainfall.

The coastline of Kerala is influenced by its geological history, which has resulted in the formation of unique beaches and coastal landforms. Here are some key aspects of the geology of Kerala’s coastline and beaches:

1. Formation: The Kerala coastline is primarily composed of sedimentary rocks, which were formed over millions of years through geological processes such as deposition and lithification. These rocks include sandstones, shales and limestones.
2. Beach Sands: The beaches of Kerala are known for their unique black sands, which are rich in minerals like ilmenite, rutile, and zircon. These minerals are heavy and resistant to weathering, leading to their accumulation on the beaches.
3. Coastal Landforms: Kerala's coastline features a variety of landforms, including sandy beaches, rocky cliffs, and tidal flats. The interaction of waves, tides, and currents has shaped these landforms over time.
4. Erosion and Accretion: The Kerala coastline is dynamic, with processes of erosion and accretion constantly reshaping its features. Erosion is more pronounced in areas with softer rocks, leading to the formation of cliffs and headlands, while accretion results in the formation of beaches and spits
5. Coastal Features: The coastline is also characterized by natural features such as lagoons, estuaries, and mangrove forests, which are important habitats for a variety of flora and fauna.
6. Human Impact: Human activities such as sand mining, coastal construction, and pollution have had a significant impact on the geology and ecology of Kerala's coastline, leading to concerns about coastal erosion and habitat destruction

## 2(d) Geology of Varkala

Peninsular India displays a variable geologic milieu, with rock formations ranging in age from Precambrian to Recent and grouping under different geologic regimes, such as Deccan Volcanic Province (DVP), Peninsular Gneissic Complex (PGC), andseveral crustal blocks to the south including Coorg, Nilgiri, Madurai, Trivandrum and Nagercoil, in addition to the major khondalite belts in Mercara and Trivandrum (Santosh, 2020). Voluminous Tertiary and Quaternary sediments skirt the continental margins (Nair, Padmalal, & Kumaran, 2006). The Indian coastline of 7517 km exhibits diverse geomorphic features like rocky and sandy beaches, deltas, spits and bars, and tombolo. However, sedimentary coastal cliffs are a few and are mainly confined between Edava and Poovar for a length of 23.25 km (Kumar, Seralathan, & Jayappa, 2009). These cliffs mainly expose the Tertiary Warkalli Formation and at a few places,

the older Tertiary Quilon Formation. Thus, the coastal cliffs find a unique place in the geology as well as the geomorphology of Peninsular India.

## 2(e) Geology of Varkala cliff

Areas east of Varkala form a part of Kerala Khondalite Belt (KKB) of the Southern Granulite Terrain (SGT) of Indian Peninsula,

and the Tertiary Warkalli Formation unconformably overlies the Precambrian crystalline basement with no representation of rocks of Paleozoic and Mesozoic age. Varkala Cliff is the type area for the Warkalli Formation of Mio-Pliocene age (King, 1882), where the cliff exposes all the lithounits of this formation such as ferruginous and nonferruginous sandstones and grit, variegated clays, white plastic clays and carbonaceous sandy clays enclosing intermittent thin seams and lenses of lignite (GSI, 2005). These beds are almost horizontal in nature. Carbonaceous clays, carrying lenses and laminae of lignite, often contain sticks and nodules of marcasite indicating a reducing environment (Soman, 2002). Warkalli Formation is also a source of organic remains, which are useful in the study of fossil DNA (Shukla, Kumar, prakash, Srivastava, & Kumar, 2000; Srivastava, Shukla, Kumar, Kumar, &

Prakash, 2006). Based on the lithology and spatial distribution, Rao (1968) suggested the Warkalli Formation as a shallow water shoreline littoral deposit. The Cenozoic sedimentary succession in the onshore part of the Kerala Basin is dominated by si-liciclastic sediment (Reuter et al., 2011).

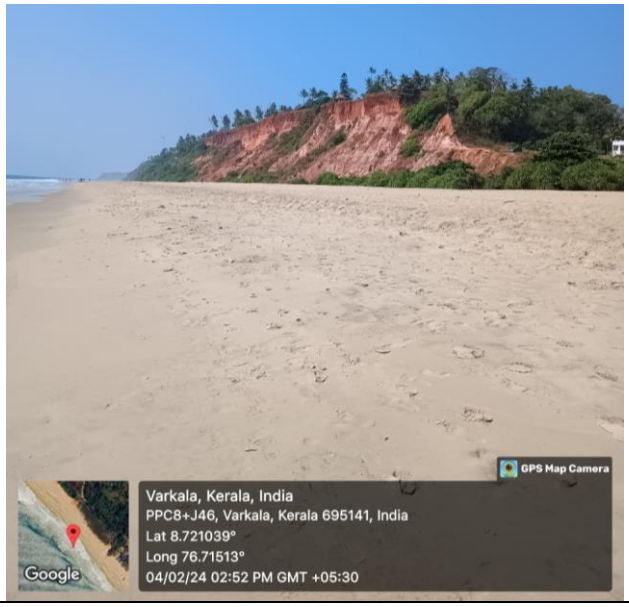



Fig.2 Varkala cliff

## 2(f) Unique geomorphologic features of varkala

The Varkala Cliff, a part of the cliffed shoreline of Kerala with a land-fast beach, stands as an edifice on otherwise flat coastal plains . Almost a couple of meters above the toe of the cliff, but at the contact between the carbonaceous clay and super-jacent ferruginous sandstone, there is a cluster of springs, the discharge forming rivulets flowing across the beach to join the Arabian Sea . These rivulets swing their flow direction based on the tidal influence. The citadel-like morphology of the cliffs in other parts of the world has provided advantageous for construction for forts and palace (Mascarenhas, 2006), like the Bekal Fort in the north of Kerala. This cliff is at the intersection of the fluvial and marine processes driven by tectonic forces, which has led to the landward retreat of the cliff between 10 and 40 m, over a 100-year interval (1915–2015) (Sajinkumar, Kannan, Indu, Muraleedharan, & Rani, 2017). The retreat was highest during the last three decades, the time-span when prolific tourism activities were at the zenith along the cliff. Kappil lagoon, a scenic backwater at the confluence of Ayiroor River with the Arabian Sea, located a short distance north of
Varkala, has potential for facilitating recreational water sport. The several islands in the lagoon (e.g., the verdant Golden Island)are home to a vibrant ecosystem composed of a variety of flora and fauna. A spit, separating Kappil lagoon or backwater from the Arabian Sea, often gets breached during the southwest monsoon season.

## 2(g) Embodiments of heavy minerals (Beach placers)

The beach sand of Varkala qualifies as black sand placer deposit, as it is enriched in ilmenite, rutile, zircon, monazite, sillimanite and garnet. Rejith, Sundararajan, Gnanappazham, and Loveson (2020) reported a total heavy minerals content of 52.33%. The black beach (Fig. 3i), which marks the northern end of the North Cliff, derived its name from the abundance of these placers.Though not mined, the area remains an enclave for geoscientists to study one or the other aspects of the deposit. The provenance of this assemblage is the charnockite and khondalite suites of rocks, as well as the laterites, from which the detritus was brought to the sea as river sediment load and later concentrated by marine action. Monazite is the radioactive mineral in these sediments,of 0.1–0.3% uranium and 5–7% thorium (Divya, Kaliprasad, Narayana, & Prakash, 2019), although Kulkarni, Pillai, and Ganguly (1974) reported higher concentration of these radioactive elements in the beach placers of Kerala. Divya et al. (2019) reported that the significantly higher activity of 232Th present in monazite, which could have adverse effects on the inhabitants of the region. Jayaprakash, Sajeev, and Kumar (2016) identified high concentration of rare earth elements (REE) in the sediments off the coast of this region and attributed it to t he beach placers

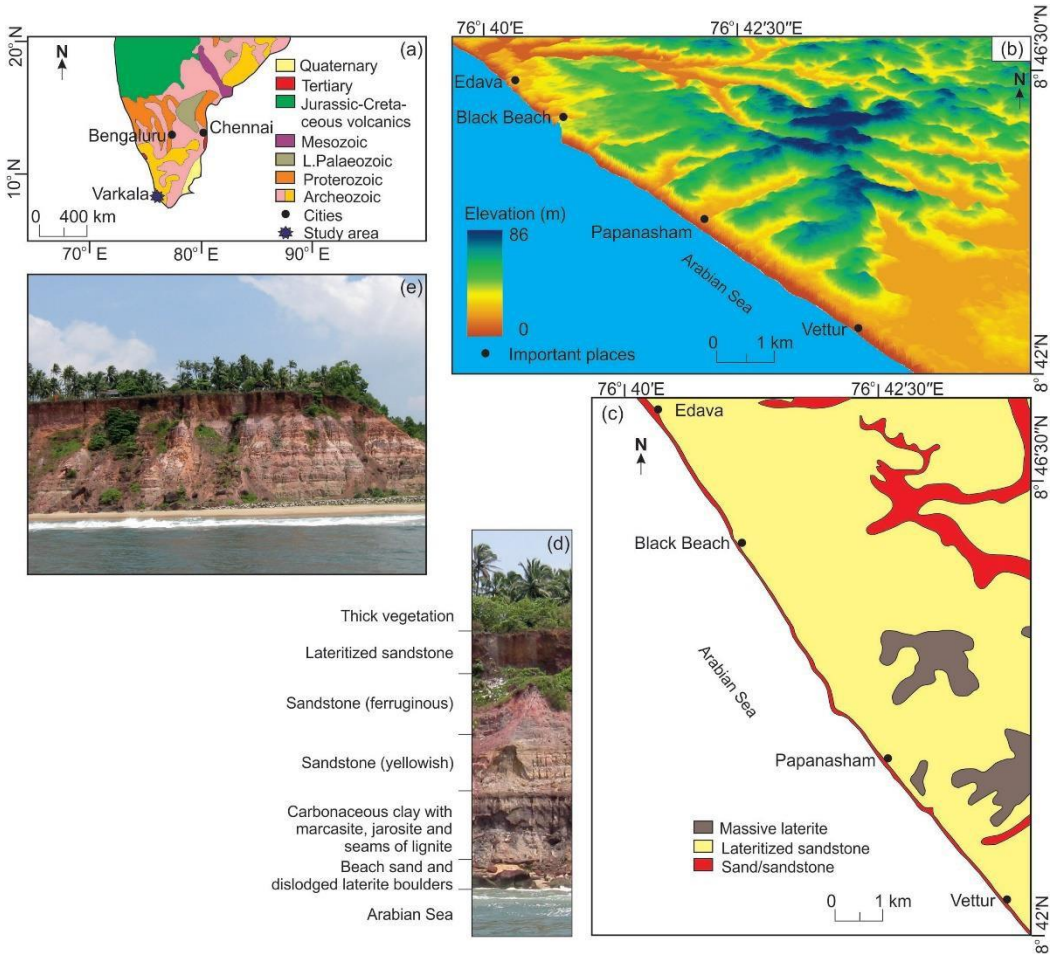



Fig.3 Geological map of southern India depicting different litho units ranging from Archean to Recent. (b) ALOS PALSAR Digital Elevation Model (DEM), draped over hill shade, is shown to provide a bird's eye view of Varkala and adjacent area. (c) Geological map of Varkala cliff and adjacent area. (d) A field photo depicting the entire litho-stratigraphic units of Varkala Cliff. (e) A part of Varkala coastal sedimentary cliff, exposed near Papanasam.

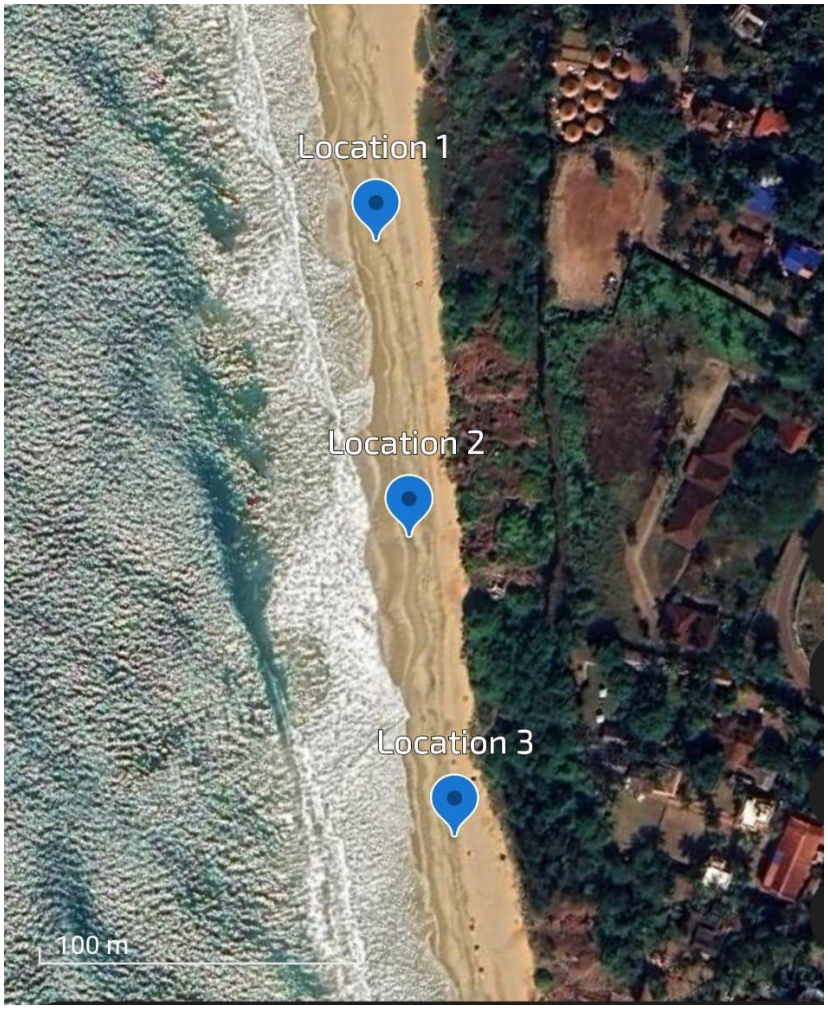



Fig.4 Geological map of Papanasam region, Varkala showing Location 1, Location 2 and Location 3.

# CHAPTER-3
# REVIEW OF LITERATURE

- Attanasi, E.D.; DeYoung, J.H,1987 conducted a study assessing the commercial viability offshore titanium-bearing heavy-mineral placer deposits based on physical characteristics and extends these insights to offshore deposits. Statistical discriminant analysis reveals that the most influential factors predicting a deposit's commercial status are the grades of titanium minerals and deposit size. Heavy-mineral grade or combined grades without specific constituent mineral information are less effective predictors. He concluded that the accuracy in predicting commercial status is observed when analysing data from homogeneous regions separately.
- Ramasamy, V; Sundarrajan, M; Suresh, G; Paramasivam, K; Meenakshisundaram, V ,2014 conducted a study on Kerala beach sediments highlights elevated concentrations of natural radionuclides (238U, 232Th, and 40K) and radiological parameters, surpassing recommended values. These findings indicate a significant radiation hazard for residents, tourists, sailors, and fishermen in the region. Fourier transform infrared spectroscopy identified major minerals such as quartz, microcline feldspar, kaolinite, and calcite. Quartz predominates, as revealed by extinction co-efficient calculations. Heavy mineral separation uncovered nine predominant heavy minerals, including monazite, zircon, magnetite, and ilmenite. Variability in major light and heavy mineral quantities across sites is attributed to dynamic sandy beach environments. They concluded that multivariate statistical analysis (Pearson correlation, cluster, and factor) explores the influence of mineralogy on radionuclide concentrations.
- Sergio Andò 2020, conducted a study based on the significance based on utilizing the modern sample preparation protocol in heavy mineral studies for enhancing the accuracy of provenance analysis. The classical gravimetric separation method, based on detrital mineral properties, relies on grain size and density. He concluded that the focus on a narrow grain-size window in the sand fraction may introduce bias, overlooking significant portions of the heavy-mineral spectrum in the sample.
- Commeau, Judith A.; Poppe, Lawrence J.; Commeau, R.F,1992 conducted a study of silt-sized minerals based on specific gravity utilizes a nontoxic medium of sodium

polytungstate and water. Following separation, the silt-sized heavy- mineral fraction is analysed with a scanning electron microscope equipped with an automatic image analyser and energy-dispersive spectrometer. Users can define chemical categories to simulate distinct mineral groups, and polymorphs with overlapping compositions are differentiated by X-ray diffraction. They concluded that the efficient technique allows rapid sizing and classification of hundreds of particles, applicable to sediments from various environments.

•Mu. Ramkumar a, R. Nagarajan b.c, P. Athira a, Anupam Sharma d, P. Gopika a, AL Fathima a, G. Sugavanam a, A. Manobalaji b, R. Mohanraj, 2023 conducted a study on Assessment of heavy metal contamination of sediments in popular tourist beaches of the Kerala State, southern India: Implications on textural and mineralogical affinities and mitigation. Based on the enrichment of TiO 2 and SiO 2 concentrations, the samples were grouped into ilmenite-rich samples (IRS) and quartz-rich samples (QRS) respectively and the geochemical signatures are significantly different. Mineralogically, the IRS group is dominated by ilmenite, quartz, sillimanite, zircon and rutile while the QRS group consists of quartz, spinel and calcite and garnets are common in both groups of sediments. Thus, the metal pollution from the beach sediments of Thiruvananthapuram coastal region was investigated based on several pollution indices.

•R.S. Chaudhri,Humayun M.M.Khan and S.Kaur 1981, conducted a study on Sedimentology of Beach sediments of the West coast of India . Sedimentological studies of 390 samples from Dwarka, Okha and Bombay beaches indicate that the overall size of the beach sediments varies from very coarse to fine sand; the sediments have bimodal and polymodal distribution; sandsilt ratios are high; the sediments are moderately sorted to moderately well sorted; a majority of the beach sediments have a negatively skewed distribution and kurtosis values fluctuate within a wide range. A sizable number of samples bear negative mean-cubed deviation values

.

•R. B. Sooryaa, Varsha Bhadrana, M. V. Vincy b, Brilliant Rajana, 2015 conducted a study on Rare earth elements and heavy metals in coastal springs of southern Kerala: a hydrogeochemical analysis. Multiparameter, AgNO3 titrimetric method, flame photometer. Atomic Absorbtion spectrophotometer, ICAP Qc were used for the study. The present study evaluated the water quality of spring water and its seasonal changes

(pre-monsoon and post- monsoon) in hydro geochemical and trace elements analysis of coastal springs of varkala cliff. According to heavy metals analysis, all samples comparatively low heavy metal concentrations. The exceptions were Al, Fe, Ba and Mn were present in high concentrations in some of the samples than other analysed heavy metals.

•M. Z. Kabir, F. Deeba, M. G. Rasul, R. K. Majumder, M. I. Khalil and M. S. Islam, 2018 conducted a study on Heavy Mineral Distribution and Geochemical Studies of Coastal Sediments at Sonadia Island, Bangladesh.The heavy mineral is seperated by bromoform. Result of mineralogical composition suggests that garnet is the dominant mineral component followed by ilmenite, magnetite, rutile and zircon. The source of the heavy minerals observed in the Sonadia Island is possibly from the Miocene sedimentary rocks exposed along the Cox's Bazar beach, which have been distributed along the beach by the long shore current, waves and winds.

•K.S. Sajinkumar, M. Santosh, V.R. Rani , Subhash Anand , A.P. Pradeepkumar , Anil Chavan K.P. Thrivikramji , P.V. Ramachandran,2022, done a study on The Tertiary sequence of Varkala coastal cliffs, southwestern India: An ideal site for Global Geopark. This work also aims at propagating, not only the need for converting the geologically prominent areas to a geopark, but also attaining SDG, whatever is possible through geoparks. The initiative by the Geological Survey of India (GSI), during the 48th CGPB, in identifying and developing geologically important places as 'National Geoparks' has led to designating the entire coastal cliffs of Varkala as a 'National Geoheritage Site' on May 28, 2014.

•V. Ramaswamy and P. S. Rao,2006, study on Grain Size Analysis of Sediments from the NorthernAndaman Sea: Comparison of Laser Diffraction and Sieve-Pipette Techniques.Using this calibration relationship, the clay-silt boundary for laser data has been fixed at 6.2 m. Taking

6.2 m as the clay-silt boundary, clay and silt percentages and sediment texture maps based on the two techniques are nearly identical.

•Bulgariu, D.; Bulgariu, L,2009, focuses on forms of heavy metals in glasshouse soils involves a combination of solid-liquid sequential extraction (SPE) and extraction in aqueous polymerinorganic salt two-phase systems (ABS). The goal was to assess the applicability and analytical limits of the proposed method based on the chemical-mineralogical and physical-chemical characteristics of the soils. The heavy metals

under investigation were cadmium, lead, and chromium, known for their high toxicity.This research contributes to the understanding and management of heavy metal contamination in glasshouse soils, offering a method that selectively separates and differentiates speciation forms, crucial for evaluating the biodisponibility of these metals in agricultural settings.

• Zaman, Mashrur; Schubert, Michael; Antao, Sytle,2016 focuses a study based on elevated levels of environmental radioactivity present in heavy mineral deposits located along a 120km coastal section of Cox's Bazar on the eastern panhandle of Bangladesh. This study investigates activity concentrations in bulk beach sands (six representative samples) and in five mineral fractions separated from the beach sands in order to assess potential radio-ecological effects and the possible use of the mineral deposits as a source for uranium and thorium.. In the mineral fractions, the highest activity concentrations were found in the zircon fraction followed by garnet, rutile, ilmenite and magnetite. They concluded that determination of the radium activity, several radiation hazard indices and adsorbed and effective gamma doses allowed to assess the related exposure of the environment and the local population to elevated radioactivity.

# CHAPTER-4

# METHODOLOGY

## 4(a)Sample collection

A total of nine sediments samples from the surface of Papanasham in Varkala[Fig.5 & Fig.6].At each location, the samples were collected perpendicular to the foreshore to backstreet at a distance of 10m. The samples were collected at every at 150cm using uncontaminated plastic scoops and transferred to plastic zip-lock covers. Then the sample covers were labelled and taken to the laboratory.


Fig.5 Sample collection


Fig.6 Sample collection

## 4(b)Apparatus required

1.Stack of test sieves (2000 microns,1400 microns,1000 microns,700 microns,500 microns and < 500 microns)

2. Balance (with accuracy to 0.01g)

3.Agate mortar (for crushing the test material if lumped or conglomerated)

4.Sieve shaker and Hot air oven

## 4(c)Sample processing

1.Cone and Quartering [Fig.7]

The cone and quartering method is a technique used to obtain a representative sample from a larger bulk material.

The bulk material, such as soil or aggregate, is thoroughly mixed to ensure uniformity of composition.

The mixed material is poured onto a clean surface and formed into a cone shape. The apex of the cone is flattened, and the material is divided into four equal quadrants using a straight edge or spatula.

Two opposite quadrants are removed and set aside. The remaining material is then spread out to form a new, smaller cone. Again, the apex is flattened, and the material is divided into four equal quadrants.

The process of removing two opposite quadrants, spreading out the material, and dividing it into four quadrants is repeated until the desired sample size is obtained.

The cone and quartering method is used when it's impractical or impossible to collect a sample using other methods, such as when dealing with large quantities of material or when the material is too coarse for sieving. While it's a simple and quick technique, care must be taken to ensure that the sample is adequately mixed and that the quartering process is conducted properly to obtain a representative sample.

2.Removing moisture content

To remove the moisture content of the all samples. The samples are kept in the hot air oven in 150°C for 1 hour.

After that the sample is taken from the oven and measure the weight of the sample.

3.Slime removal

The samples are first washed with normal water for 3 times and later with distilled water for 3 times. Then again the samples are dried in hot air oven and measured the weight.

4.Shell removal (using dil.HCl)[Fig.9]

Conc. HCl and distilled water taken at the proportion of 1:10 to make a dilute HCl solution. Each sample kept in the solution for 2 hours. After every 30 minutes stir the mixture with glass rod. After two hours washed off with distilled water for 3 times and dried out then measured the weight. 5.Sieve Analysis

After the shell removal samples of initial weight 120g is sieved through vibratory sieve shaker[Fig11] for 10 minutes. There are 6 plates of different microns, 2000, 1400, 1000, 700 500, <500 respectively[Fig.10]. After 10 minutes samples are distributed into each plates of different grain size. Samples of each plates are collected and measured.

6.Heavy mineral separation using Bromoform[Fig.8]

Determining heavy mineral content in beach sand samples using heavy liquid, such as bromoform.

Prepare a heavy liquid solution, often made of bromoform, which has a high density. Heavy minerals sink in this liquid while lighter minerals float. Pour the prepared sample into the heavy liquid and stir gently. Allow the heavy minerals to settle at the bottom.

After the heavy minerals have settled, carefully decant the lighter minerals and sediment floating on top of the heavy liquid. Then, collect the heavy mineral fraction from the bottom using a filter paper.

Wash the collected heavy and light minerals with acetone for three times to remove the broform. Then, dry the heavy mineral concentrate thoroughly to remove any residual moisture. Then measured the weight of heavy and light mineral.

7.Preparation of slide[Fig.12]

The heavy mineral that collected are followed by the cone and quartering method to get the representative sample for slide preparation.

A drop of glycerine is added to the slide and add the representative sample and add another drop of glycerine. Then cover it with cover glass and viewed through ore microscope.

## 4(d) Grain Size Analysis

Grain size analysis is a technique used in geology to determine the size distribution of grains in a sediment or rock sample. It's crucial for understanding properties like permeability and porosity, which affect things like groundwater flow and oil reservoir characteristics. Techniques include sieving, sedimentation, and microscopy.

Grain size analysis involves determining the distribution of particle sizes within a sediment or rock sample.

Sampling: A representative sample of the material is collected from the field or core samples are taken from boreholes.

Sample Preparation: The sample is cleaned and dried to remove any contaminants or moisture that could affect the analysis.

Sieving: This is the most common method for coarse-grained sediments. The sample is passed through a series of sieves with progressively smaller mesh sizes. The mass of material retained on each sieve is measured, allowing for the calculation of the grain size distribution.

Sedimentation: This method is used for fine-grained sediments such as clay or silt. The sample is suspended in water, and the settling velocities of the particles are measured. Stokes' Law is then used to calculate the particle size distribution.

Microscopy: For very fine-grained materials or for detailed analysis of individual grains, microscopy techniques such as optical microscopy or scanning electron microscopy (SEM) can be employed.

Data Analysis: Once the size distribution is determined, various statistical parameters can be calculated, including mean grain size, sorting (the uniformity of grain sizes), and skewness (the degree of asymmetry in the distribution).

Grain size analysis is essential for understanding sedimentary processes, interpreting depositional environments, and assessing the potential for fluid flow in subsurface reservoirs.

## 4(e)Sieve analysis

Sieve analysis is a method used to determine the particle size distribution of coarse-grained soils and aggregates.

Preparation: The soil or aggregate sample is dried to remove moisture and then weighed. Stack of Sieves: A stack of sieves with progressively smaller openings is assembled, with the coarsest sieve on top and the finest on the bottom. The sieves are usually stacked in order of decreasing mesh size.

Agitation: The sample is placed on the top sieve, and the entire stack is mechanically shaken for a specified period. This causes the particles to separate based on size, with the larger particles retained on the coarser sieves and the smaller particles passing through to the finer sieves.

Weighing: After shaking, the material retained on each sieve is carefully collected, dried, and weighed. The weight of material retained on each sieve is recorded.

Calculations: The percentage of material retained on each sieve is calculated by dividing the weight retained by the total weight of the sample. This data is used to plot a grain size distribution curve, which shows the percentage of material finer than each sieve size.

Sieve analysis is commonly used in geotechnical engineering and construction to assess the suitability of soils and aggregates for various applications, such as road construction, foundation design, and concrete production.

## 4(f) Procedure

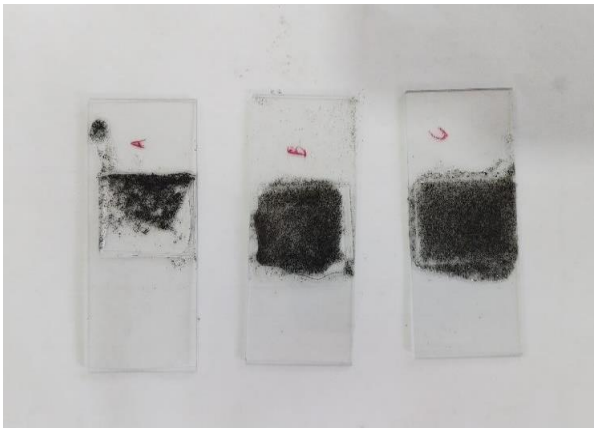
1. 120g of the sample was taken initially for the sieve analysis. The sample should be Large enough to provide statistically meaningful results.
2. The samples were first air dried and later dried in an oven at 150˚c overnight to remove Moisture content.
3. The sample was weighed again in order to obtain the percentage of moisture content.
4. Prepare a series of sieves with different mesh sizes arranged in descending order, Starting from the largest sieve at the top to the smallest at the bottom. The mesh size Of each sieve should be known.
5. The samples were then added to the top sieve and covered it with a lid.
6. The sieve shaker was tightened to ensure that the sieve stack was held firmly in the Shaker assembly.
7. After 10 minutes remove the lid and weigh the material retained on each sieve


Fig.7 Cone and quartering method


Fig.8 Bromoform separation


Fig.9 Slime removal using dil.HCl

Fig.10 Sieve stacks



| | |
|---|---|
| Fig.11 Sieve shaker | Fig.12 Slide preparation |

# CHAPTER-5
# RESULT AND DISCUSSION

The data generated from the grain size analysis data was used to compute textural parameters like graphic mean size, graphic standard deviation, graphic skewness and graphic kurtosis.

**Representation of data collected from sieve analysis**

| **Samples** | **Initial weight(g)** | **Weight(g) in 2000 microns** | **Weight(g)in 1400 microns** | **Weight (g)in 1000 microns** | **Weight(g) in 700 microns** | **Weight (g)in 500 microns** | **Weight(g) <500 microns** |
|---|---|---|---|---|---|---|---|
| PV(A) | 100 | 0.014 | 0.412 | 1.418 | 6.039 | 14.009 | 81.124 |
| PV(B) | 100 | 0 | 0.007 | 0.072 | 0.485 | 1.812 | 103.265 |
| PV(C) | 100 | 0 | 0.053 | 0.295 | 1.275 | 7.081 | 83.953 |

**(Table no.1 Representation of data collected from sieve analysis)**

The data collected from the sieve analysis are plotted in a table. Graphical representation of these data was made using Gradistat

**SAMPLE STATISTICS**

SAMPLE IDENTITY: **Backshore** ANALYST & DATE: ,

SAMPLE TYPE: Unimodal, Very Well Sorted TEXTURAL GROUP: Slightly Gravelly Sand

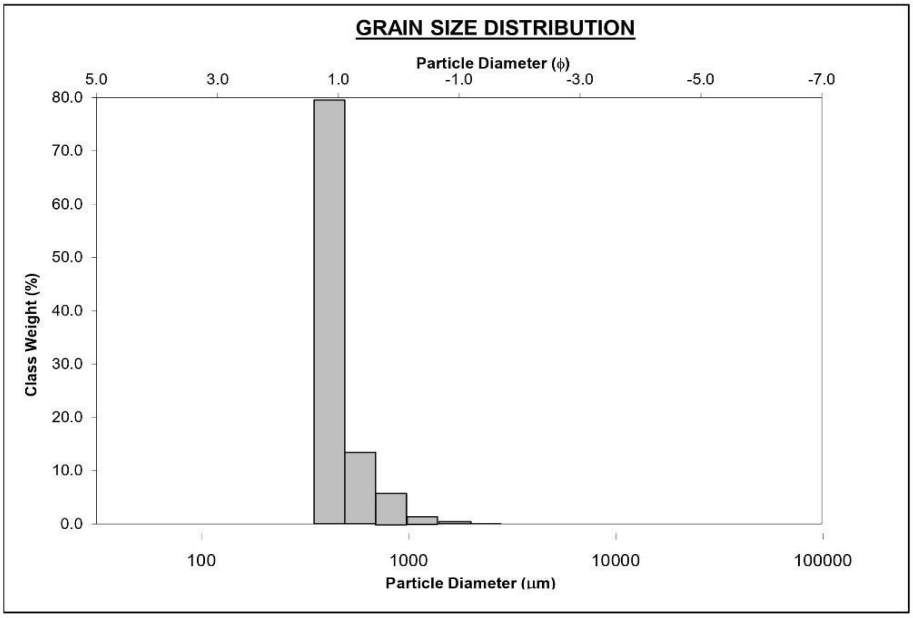
SEDIMENT NAME: Slightly Very Fine Gravelly Medium Sand

| | μm | ϕ |
|---|---|---|
| MODE 1: | 427.5 | 1.247 |
| MODE 2: | | |
| MODE 3: | | |
| $D_{10}$: | 370.8 | 0.581 |
| MEDIAN or $D_{50}$: | 441.2 | 1.180 |
| $D_{90}$: | 668.3 | 1.431 |
| ($D_{90}$ / $D_{10}$): | 1.802 | 2.462 |
| ($D_{90}$ - $D_{10}$): | 297.5 | 0.850 |
| ($D_{75}$ / $D_{25}$): | 1.243 | 1.306 |
| ($D_{75}$ - $D_{25}$): | 96.13 | 0.314 |

GRAIN SIZE DISTRIBUTION

| | | | |
|---|---|---|---|
| GRAVEL: | 0.0% | COARSE SAND: | 19.5% |
| SAND: | 100.0% | MEDIUM SAND: | 78.8% |
| MUD: | 0.0% | FINE SAND: | 0.0% |
| | | V FINE SAND: | 0.0% |
| V COARSE GRAVEL: | 0.0% | V COARSE SILT: | 0.0% |
| COARSE GRAVEL: | 0.0% | COARSE SILT: | 0.0% |
| MEDIUM GRAVEL: | 0.0% | MEDIUM SILT: | 0.0% |
| FINE GRAVEL: | 0.0% | FINE SILT: | 0.0% |
| V FINE GRAVEL: | 0.0% | V FINE SILT: | 0.0% |
| V COARSE SAND: | 1.8% | CLAY: | 0.0% |

| | METHOD OF MOMENTS | | | FOLK & WARD METHOD | | |
|---|---|---|---|---|---|---|
| | Arithmetic μm | Geometric μm | Logarithmic ϕ | Geometric μm | Logarithmic ϕ | Description |
| MEAN ($\bar{x}$): | 492.7 | 469.2 | 1.092 | 458.1 | 1.126 | Medium Sand |
| SORTING ($\sigma$): | 161.1 | 1.266 | 0.340 | 1.255 | 0.328 | Very Well Sorted |
| SKEWNESS ($Sk$): | 3.732 | 2.466 | -2.466 | 0.401 | -0.401 | Very Coarse Skewed |
| KURTOSIS ($K$): | 21.93 | 9.352 | 9.352 | 1.558 | 1.558 | Very Leptokurtic |




**(Table no.2 Backshore-Sample Statistics and Grain Size distribution)**

## 5(a) Sample Statistics of Backshore

Mean size of the sediments is about 458 μm which means it is medium sand. According to Folk and Ward method, we can define that the grains are very well sorted. It's logarithmic sorting is about 0.328 ϕ. Skewness is - 0.401 ϕ which means the sediments are very coarse skewed and its kurtosis is 1.558μm. Therefore it is very leptokurtic.

## SAMPLE STATISTICS

SAMPLE IDENTITY: **Berm** ANALYST & DATE: ,

SAMPLE TYPE: Unimodal, Very Well Sorted TEXTURAL GROUP: Sand

SEDIMENT NAME: Very Well Sorted Medium Sand

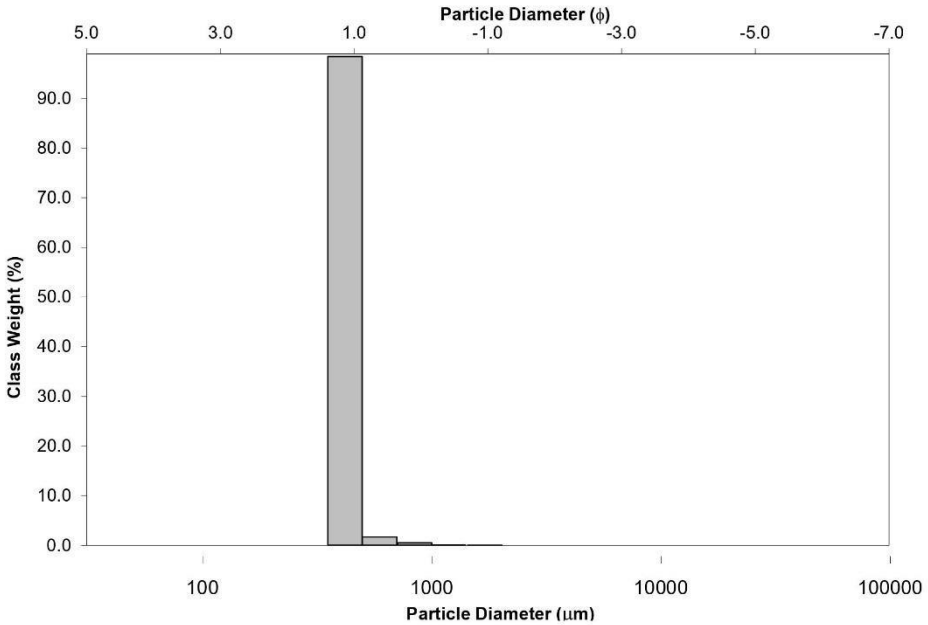
| | μm | ϕ |
|---|---|---|
| MODE 1: | 427.5 | 1.247 |
| MODE 2: | | |
| MODE 3: | | |
| $D_{10}$: | 367.7 | 1.039 |
| MEDIAN or $D_{50}$: | 423.0 | 1.241 |
| $D_{90}$: | 486.6 | 1.444 |
| ($D_{90}$ / $D_{10}$): | 1.324 | 1.389 |
| ($D_{90}$ - $D_{10}$): | 118.9 | 0.404 |
| ($D_{75}$ / $D_{25}$): | 1.191 | 1.227 |
| ($D_{75}$ - $D_{25}$): | 74.19 | 0.253 |

GRAIN SIZE DISTRIBUTION

| | | | |
|---|---|---|---|
| GRAVEL: | 0.0% | COARSE SAND: | 2.2% |
| SAND: | 100.0% | MEDIUM SAND: | 97.8% |
| MUD: | 0.0% | FINE SAND: | 0.0% |
| | | V FINE SAND: | 0.0% |
| V COARSE GRAVEL: | 0.0% | V COARSE SILT: | 0.0% |
| COARSE GRAVEL: | 0.0% | COARSE SILT: | 0.0% |
| MEDIUM GRAVEL: | 0.0% | MEDIUM SILT: | 0.0% |
| FINE GRAVEL: | 0.0% | FINE SILT: | 0.0% |
| V FINE GRAVEL: | 0.0% | V FINE SILT: | 0.0% |
| V COARSE SAND: | 0.1% | CLAY: | 0.0% |

| | METHOD OF MOMENTS | | | FOLK & WARD METHOD | | |
|---|---|---|---|---|---|---|
| | Arithmetic | Geometric | Logarithmic | Geometric | Logarithmic | Description |
| | μm | μm | ϕ | μm | ϕ | |
| MEAN ($\bar{x}$): | 433.1 | 425.5 | 1.233 | 423.0 | 1.241 | Medium Sand |
| SORTING ($\sigma$): | 43.15 | 1.073 | 0.102 | 1.113 | 0.155 | Very Well Sorted |
| SKEWNESS ($Sk$): | 10.88 | 8.481 | -8.481 | 0.000 | 0.000 | Symmetrical |
| KURTOSIS ($K$): | 163.5 | 87.26 | 87.26 | 0.738 | 0.738 | Platykurtic |

## GRAIN SIZE DISTRIBUTION




**(Table no.3 Berm- Sample Statistics and Grain Size distribution)**

## 5(b) Sample Statistics of Berm

Mean size of the sediments is about 423µm which means it is medium sand. According to Folk and Ward method, we can define that the grains are very well sorted. It's logarithmic sorting is about 0.155 ϕ. Skewness is 0 which means the sediments are symmetrically skewed and it's kurtosis is 0.738 µm. Therefore, it is platykurtic.

**SAMPLE STATISTICS**

SAMPLE IDENTITY: **Foreshore** ANALYST & DATE: ,

SAMPLE TYPE: Unimodal, Very Well Sorted TEXTURAL GROUP: Sand

SEDIMENT NAME: Very Well Sorted Medium Sand

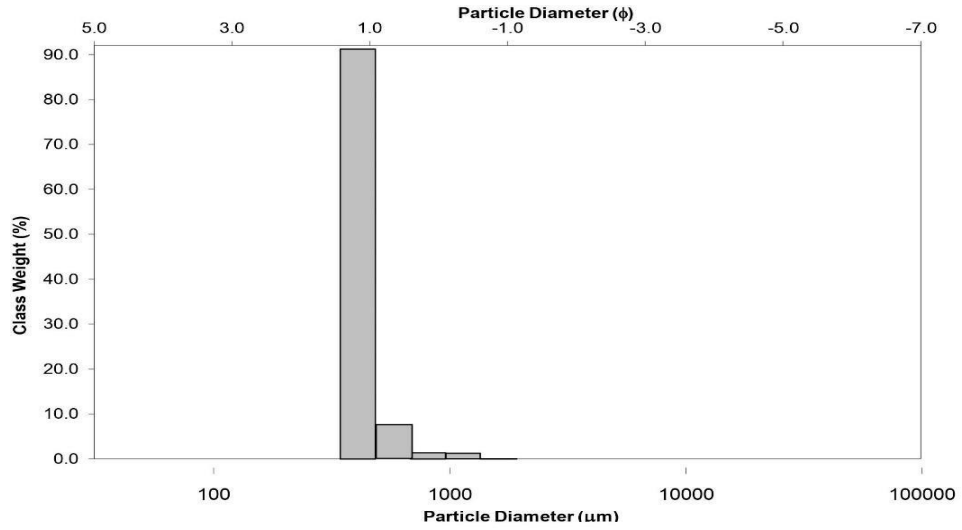
| | µm | ϕ |
|---|---|---|
| MODE 1: | 427.5 | 1.247 |
| MODE 2: | | |
| MODE 3: | | |
| $D_{10}$: | 368.7 | 1.003 |
| MEDIAN or $D_{50}$: | 428.9 | 1.221 |
| $D_{90}$: | 498.9 | 1.440 |
| ($D_{90}$ / $D_{10}$): | 1.353 | 1.435 |
| ($D_{90}$ - $D_{10}$): | 130.2 | 0.436 |
| ($D_{75}$ / $D_{25}$): | 1.208 | 1.251 |
| ($D_{75}$ - $D_{25}$): | 81.17 | 0.273 |

GRAIN SIZE DISTRIBUTION

| | | | |
|---|---|---|---|
| GRAVEL: | 0.0% | COARSE SAND: | 9.0% |
| SAND: | 100.0% | MEDIUM SAND: | 90.6% |
| MUD: | 0.0% | FINE SAND: | 0.0% |
| | | V FINE SAND: | 0.0% |
| V COARSE GRAVEL: | 0.0% | V COARSE SILT: | 0.0% |
| COARSE GRAVEL: | 0.0% | COARSE SILT: | 0.0% |
| MEDIUM GRAVEL: | 0.0% | MEDIUM SILT: | 0.0% |
| FINE GRAVEL: | 0.0% | FINE SILT: | 0.0% |
| V FINE GRAVEL: | 0.0% | V FINE SILT: | 0.0% |
| V COARSE SAND: | 0.4% | CLAY: | 0.0% |

| | METHOD OF MOMENTS | | | FOLK & WARD METHOD | | |
|---|---|---|---|---|---|---|
| | Arithmetic µm | Geometric µm | Logarithmic ϕ | Geometric µm | Logarithmic ϕ | Description |
| MEAN ($\bar{x}$): | 450.1 | 438.5 | 1.189 | 428.9 | 1.221 | Medium Sand |
| SORTING ($\sigma$): | 85.07 | 1.146 | 0.197 | 1.155 | 0.208 | Very Well Sorted |
| SKEWNESS ($Sk$): | 5.923 | 4.102 | -4.102 | 0.176 | -0.176 | Coarse Skewed |
| KURTOSIS ($K$): | 53.78 | 23.27 | 23.27 | 1.139 | 1.139 | Leptokurtic |

**GRAIN SIZE DISTRIBUTION**




(Table no.4 Foreshore- Sample Statistics and Grain Size distribution)

## 5(c) Sample Statistics of Foreshore

Mean size of the sediments is about 428.9μm which means it is medium sand. According to Folk and Ward method, we can define that the grains are very well sorted. It's logarithmic sorting is about 0.208 ϕ. Skewness is -0.176 ϕ which means the sediments are coarse skewed and it's kurtosis is 1.139 μm. Therefore, it is leptokurtic.

## 5(d)Mineralogy

In this study, the total heavy mineral weight percentage shows that the higher concentration present in the backshore region followed by foreshore region and berm.

**Heavy mineral concentration**

The sediments from foreshore, berm and backshore are generally composed of low percentage of heavy minerals and a high percentage of light minerals with small percentage of shell fragments.

| **Samples** | **Initial weight(g)** | **Weight after slime removal(g)** | **Weight after HCL action(g)** | **Weight after Bromoform separation(g)** | | **Heavy mineral Percentage (%)** |
|---|---|---|---|---|---|---|
| | | | | **Light minerals** | **Heavy minerals** | |
| PV (A) | 26.098 | 24.026 | 23.745 | 21.181 | 1.981 | 7.59 |
| PV(B) | 26.739 | 18.746 | 18.379 | 7.684 | 0.715 | 2.67 |
| PV(C) | 31.589 | 23.056 | 22.504 | 15.544 | 0.893 | 2.83 |
| PV(A,B, C) | 85.067 | 66.828 | 65.628 | 45.409 | 4.23 | 14.75 |

**(Table no.5 Percentage of heavy minerals in Papanasam region, Varkala)**

From the above table, it is clear that the greater proportion of heavy mineral are present in backshore region (7.59%) followed by foreshore (2.83%) and berm (2.67%).

The amount of heavy mineral in foreshore, berm and foreshore is 14.75%.

| **Sample 1**<br>**PV(A), PV(B), PV(C)**<br>**Foreshore, Berm, Backshore** | **Sample 1**<br>**PV (A, B, C)**<br>**Total Heavy mineral in Papanasam region** |
|---|---|
| Initial weight 1 = 84.426<br><br>After bromoform separation<br><br>The heavy mineral percentage = 7.59+2.67+2.83 = 13.09% | Initial weight 1 = 85.067<br><br>After bromoform separation<br><br>The heavy mineral percentage = 14.75% |

**( Table no.6 Average percentage of heavy minerals in Papanasam region, Varkala)**

Average HM percentage = (13.09+14.75)/2= 13.92%.

The average percentage of Heavy minerals present in the Papanasam region in Varkala is about 13.92%

## Textural analysis

| Sample | Sieve size(microns) | Weight of samples retained(g) | Weight after Bromoform Separation(g) | Heavy mineral Percentage (%) |
|---|---|---|---|---|
| Fore shore. PV(C) | 2000 | - | - | - |
| | 1400 | 0.053 | - | - |
| | 1000 | 0.295 | - | - |
| | 700 | 1.275 | 0.0159 | 1.247 |
| | 500 | 7.081 | 0.384 | 5.43 |
| | <500 | 83.953 | 9.822 | 1.117 |
| Berm PV(B) | 2000 | - | - | - |
| | 1400 | 0.007 | - | - |
| | 1000 | 0.072 | - | - |
| | 700 | 0.485 | 0.004 | 0.85 |
| | 500 | 1.812 | 0.006 | 0.38 |
| | <500 | 103.265 | 1.48 | 1.44 |
| Backshore PV(A) | 2000 | 0.014 | - | - |
| | 1400 | 0.412 | - | - |
| | 1000 | 1.418 | - | - |
| | 700 | 6.089 | 0.059 | 0.98 |
| | 500 | 14.904 | 0.067 | 0.45 |
| | <500 | 81.124 | 1.135 | 1.4 |

**(Table no.7 Textural Analysis)**

## Heavy mineral identification

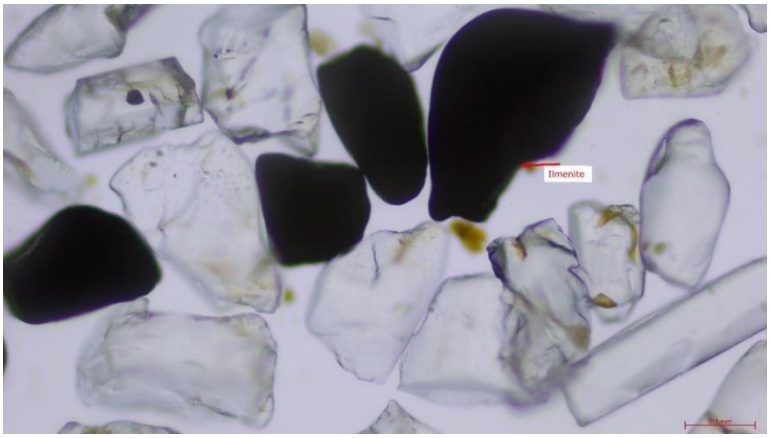



Fig.13 Ilmenite in open nicols

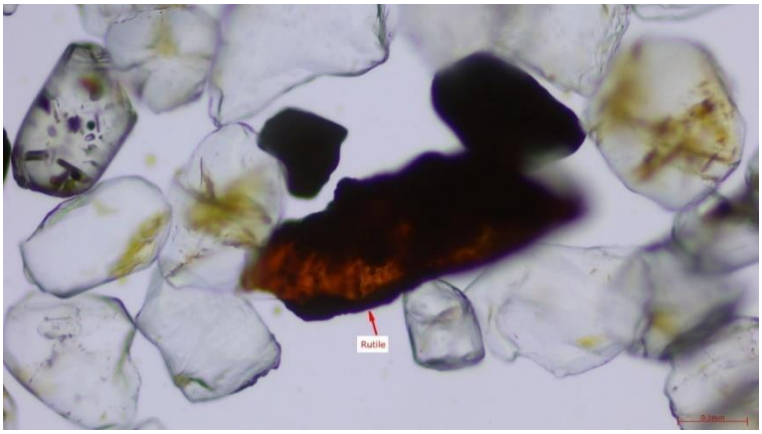



Fig.14 Rutile in open nicols

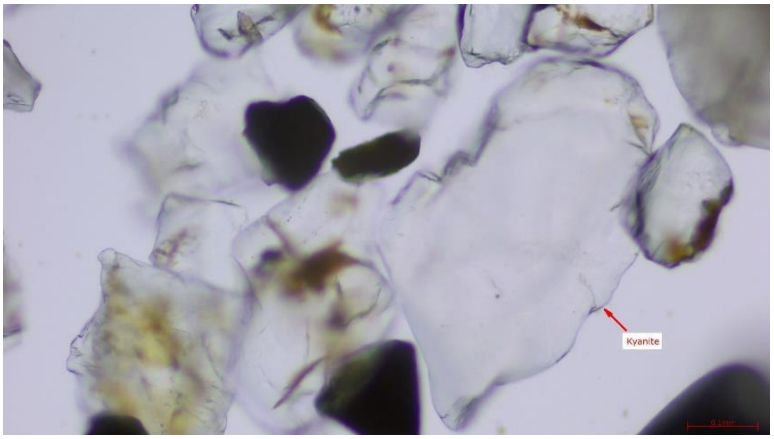



Fig.15 Kyanite in open nicols


Fig.16 Sillimanite in open nicols

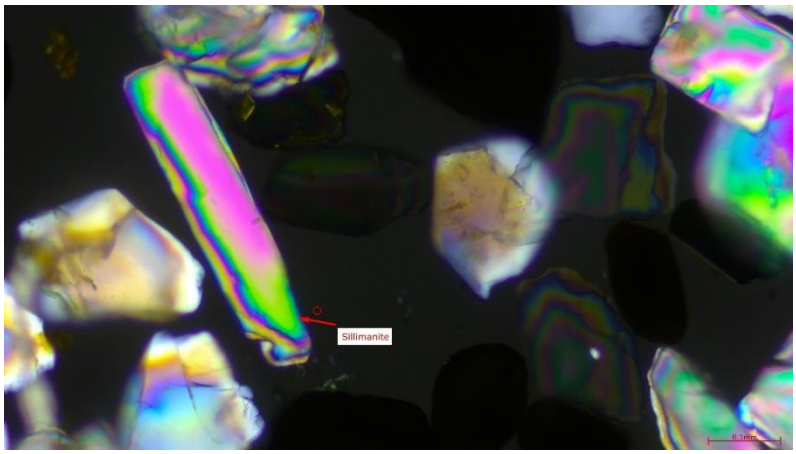



Fig.17 Sillimanite in cross nicols

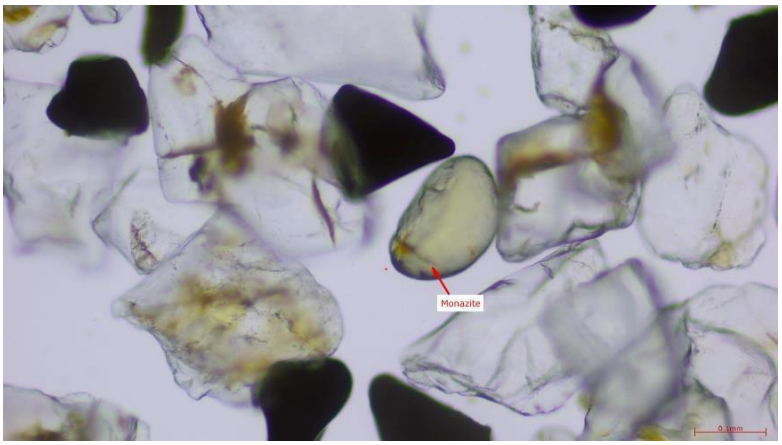



Fig.18 Monazite in open nicols

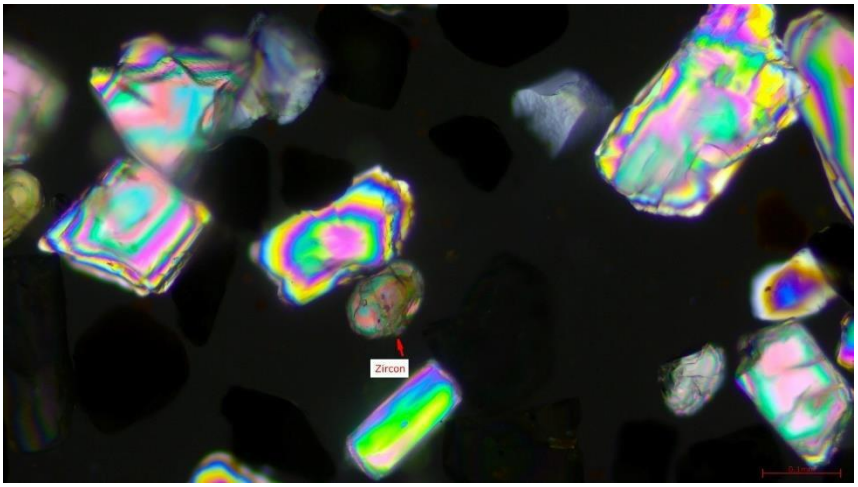



Fig.19 Zircon in cross nicols

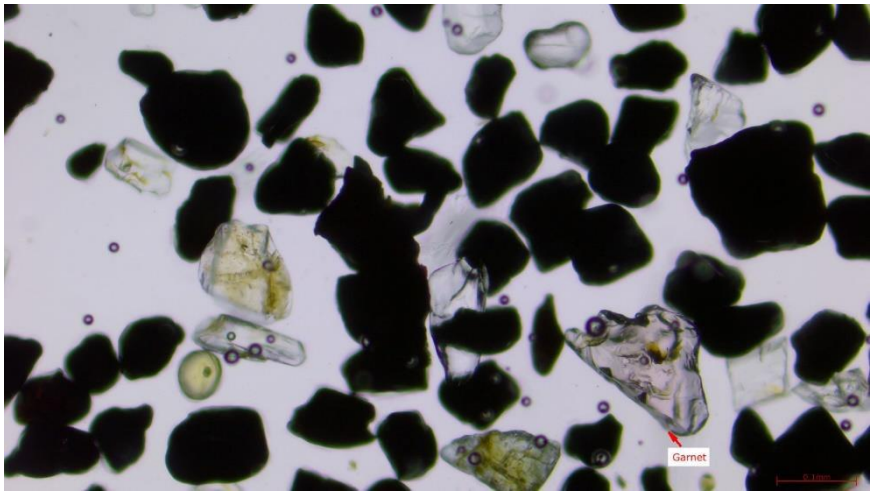



Fig.20 Garnet in open nicols

The identified heavy minerals are ilmenite, sillimanite, garnet, zircon, kyanite, leucoxene, monazite, rutile, magnetite and hornblende. Ilmenite can exhibit various textures. It is a hexagonal crystal which exhibits sub rounded grains and moderate grain size. Garnet shows high angularity.

The proportion of heavy minerals present in Papanasam region, Varkala is as follows; ilmenite followed by zircon, sillimanite, monazite, leucoxene, rutile, garnet, magnetite and traces of other heavy minerals such as kyanite, hornblende were also reported. The high concentration of ilmenite, zircon, rutile indicates that Papanasam area have experienced erosion and high energy condition.

| | PROPERTIES IN PLANE POLARISED LIGHT | | | | | | PROPERTIES IN CROSSED NICOLS | | |
|---|---|---|---|---|---|---|---|---|---|
| MINERAL | DEGREE OF TRANSPARENCY | SHAPE | CLEAVAGE | COLOUR | OTHER PROPERTIES | REFRACTIVE INDICES | ISOTROPIC/ ANISOTROPIC | INTERFERENCE COLOUR | EXTINCTION |
| ILMENITE | OPAQUE | SUBROUNDED | NONE | BLACK | YELLOWISH BROWNISH WEATHERED TRACKS | | | | |
| RUTILE | OPAQUE<br>TRANSCLUCENT | SUBROUNDED PRISMATIC | NONE | BLACK<br>FOXY RED | RARELY TWINNED X'LS | VERY HIGH | ANISOTROPIC | FOXY RED | PARALLEL |
| LEUCOXENE | OPAQUE | SUBROUNDED | NONE | REDDISH BROWN YELLOW | CONTAIN BLACK EMMBEDDED GRAINS | | | | |
| MONAZITE | TRANSPARENT | SUBROUNDED EGG SHAPED | NONE | YELLOW | PITTED SURFACE | HIGH M>G | ANISOTROPIC | YELLO THIN YELLOW BLUE RINGS ON EDGES | PARALLEL |
| ZIRCON | TRANSPARENT | SUBROUNDED PRISMATIC | NONE | GREY | RARELY SHOW CONCOIDAL SURFACE | HIGH Z>M | ANISTROPIC | GREY AS IN PLANE POL LIGHT | PARALLEL |
| GARNET | TRANSPARENT | ANGULAR | NONE | COLOURLESS LIGHT GREEN , RED | CRACKS, INCLUSIONS CONCOIDAL SURFACE | HEDIUM G>SI | ISOTROPIC | | |
| SILLIMANTE | TRANSPARENT | TABULAR PRISAMTIC PLATY | ONE DIRECTION PARALLEL TO ELONGATION | COLOURLESS | | SIL>Q | ANISOTROPIC | HIGH ORDER YELLOW BLUE BANDS | PARALLEL TO ELONGATION |
| KYANITE | TRANSPARENT | TABULAR | TWO DIRECTIONAL | COLOURLESS LIGHT BLUE | | KY>SILL | ANISOTROPIC | HIGH ORDER BLUE YELLOW RED | INCLNED |
| QUARTZ | TRANSPARENT | SUBROUNDED | NONE | COLOURLESS | | LOW (QTZ<SILL) | ANISOTROPIC | HIGH ORDER GREY, YELLOW, BLUE | WAVY |

**(Table no.8 Properties for identification of beach sand minerals in transmitted light polarising microscope)**

# CHAPTER-6

# CONCLUSION

The sediment particles that make up beaches in Kerala can vary in size, shape and composition depending on the geological features of surrounding area. Nine surface sediment samples collected off Papanasam beach, varkala, Kerala during the filed survey were analysed for identifying the textural characteristics of sediments in the area. The sediment samples were separated according to their particle size using sieve analysis method. The sizes of sediment particles vary from 400μm to 2mm.

Papanasam region in Varkala form a part of Kerala Khondalite Belt (KKB) of the Southern Granulite Terrain (SGT) of India. The study area is a remanant of Gondwana supergroup fromed as a result of detachment of Indian peninsula from the Mascarene plateau during early Tertiary.

From the textural analysis, In backshore, berm and foreshore area sediments showing medium sand in texture (average: 436.63 μm) and very well sorted to well sorted (0.230), this sediment is a reflection of the depositional environment which is corroborated by the strong wave divergence prevailing in this region. The area is generally experiencing erosional environment which is evident from negative skewness (average: -0.288ϕ). The sample of backshore and foreshore comes under leptokurtic expect in berm where it is platykurtic in nature, suggesting that extreme high or low values of kurtosis involve the part of the sediments achieving its sorting elsewhere in a high energy environment. All the samples are unimodal. The unimodality at this location reflects the lack of sediment deposition from the rivers. From above we can say that sediments were deposited in a high energy condition.

Heavy mineral of each sample is analysed, average of which has more than 13 % of heavies. The proportion of heavy mineral in Papanasam region mainly contains ilmenite followed by monazite, sillimanite, zircon, rutile, leucoxene garnet, magnetite and traces of other heavy minerals such as kyanite, hornblende were also reported. Greater proportion of heavy mineral is present in Coarse sand followed by in medium sand and absent in Very coarse sand.

The present study provides that sediments in Papanasam region deposited in an high energy condition and experiencing an erosional environment. Heavy mineral compositions in the study area indicate a mixed provenance of igneous, metamorphic rocks.

# CHAPTER-7

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# CERTIFICATE

I hereby declare that the work, which is being present in this project, entitled "**Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy**" by Mr./Ms..nelwin...shaju.....Register no ...CCAVSC21010....submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree Bachelor of Science in Geology is an authentic record of my own work carried out under the joint supervision of **Dr. Linto Alappat**, Assistant Professor , Dept. of Geology and Environmental sciences and **Ms. Shalma M.M**, Assistant Professor, Department of Geology and Environmental Science during the period of 2023-2024. The matter embodied in this dissertation has not been submitted for any award of degree.

**NELWIN SHAJU**

It is certified that the above statement made by the candidate is true to the best of me knowledge

**Signature of project in charge**


**Ms. Shalma M.M**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous )
Irinjalakuda, Kerala-680125

**Dr. Linto Alappat**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125


Place: Irinjalakuda
Date:

External Examiners:

# HEAVY MINERAL ANALYSIS OF PAPANASAM REGION IN VARKALA, KERALA

Project report submitted to Christ College(Autonomous) Irinjalakua,Kerala

Under University of Calicut in partial fulfilment of requirements for sixth semester of

**BACHELOR OF SCIENCE**

**IN**

**GEOLOGY**


**By**

**NIVEDYA.K**

**Reg No: CCAVSGL011**

**(2021-2024)**

**DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125**

(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade

UNDER THE GUIDANCE OF

**SWEESHMA P DEV.**

**Assistant Professor,**

**Christ College(Autonomous) Irinjalakua,Thrissur**

# CERTIFICATE

I hereby declare that the work which is being present in this project, entitled **"HEAVY MINERAL ANALYSIS OF PAPANASAM REGION IN VARKALA, KERALA** "by **Ms. NIVEDYA.K**(CCAVSGL011) is an original work submitted to the Department of Geology and Environmental Science, ChristCollege (Autonomous), Irinjalakuda in partial fulfilment of the requirement for Sixth Semester Integrated M.Sc. in Geology. This work was carriedout under the guidance of Sweeshma P Dev, Assistant Professor, Departmentof Geology and Environmental Science during the period of 2023-2024. The matter embodiedin this project report has not been submitted for any award of degree.

NIVEDYA.K

It is certified that the above statement made by the candidate is true to the best of my knowledge

Signature of project in charge

**Mrs. Sweeshma P Dev**
Assistant Professor
Dept. of Geology and
Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

**Mr.Tharun R**
Assistant Professor and Head
Dept. of Geology and
Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

Place: Irinjalakuda

Date:17-04-2024

External Examiners

# DECLARATION

I hereby declare that the project work entitled work "**HEAVY MINERAL ANALYSIS OF PAPANASAM REGION IN VARKALA, KERALA**" is a work done by me. No part of the report is plagiarized from other sources. All information included from other source has been duly acknowledged. I maintain that if any part of the project is found to be plagiarized I shall take the full responsibity for it.

IRINJALAKUDA
DATE:17-04-2024

NIVEDYA.K
Reg No: CCAVSGL011

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I express my sincere thanks **to Mr. Ayyappadas C. S (**Research Fellow, Christ College (Autonomous) Irinjalakuda), who helped me throughout the completion of this work. I am thankful to all the faculties of Dept. of Geology and Environmental Science, Christ College, for their helping hands at times of need.I extend my gratitude to the entire Christ College family for their support, guidance, and love.

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Above all I would like to express my gratitude to God almighty for showering His blessings on me to complete my project in an efficient manner.

# ABSTRACT

Papanasam Beach in Varkala, Kerala, India, features a captivating geological landscape shaped by millions of years of natural processes. The beach is situated at approximately 8.7358° N latitude and 76.7036° E longitude.The sedimentary rocks
millions of years. Layers of sandstone and shale have been formed over time through the accumulation and compaction of sedimentary materials, often reflecting changes in environmental conditions and Common heavy minerals found at Papanasam Beach may include garnet, ilmenite, rutile, zircon, and magnetite, among others. These minerals have economic significance, as they are sometimes mined for their valuable properties.

Bromoform separation technique is used in mineral processing and to concentrate heavy minerals for analysis .Bromoform is used liquid for separating heavy and light minerals based on their density differences.The percentage of Heavy mineral concentration in Papanasam region,Varkala as analysed from bromoform seperation technique follows backshore(7.59%),middle berm(2.67%),fore shore(2.83%).The mixed proportion of samples from backshore ,middle berm and foreshore under bromoform seperation technique gives the outcome percentage as 14.75%.Sieve analysis is a technique used to determine the particle size distribution of a granular material, such as sand or gravel. The grain size distribution follows as coarse sand(19.5%),medium sand(78.8%) and silt and clay size particles(0.0%). It involves passing a sample of the material through a series of sieves with progressively smaller openings, stacked one above the other.This technique was used to find out the heavy mineral content in the coarser grains

# CERTIFICATE

I hereby declare that the work which is being present in this project, entitled **"HEAVY MINERAL ANALYSIS OF PAPANASAM REGION IN VARKALA, KERALA** "by **Ms/Mr JASMINE GIBY, SHAUN MJ, NIVEDYA K & ANGELEENA LOUIS** is an original work submitted to the Department of Geology and Environmental Science, Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for Sixth Semester B.Sc. in Geology. This work was carried out under the guidance of Sweeshma P Dev, Assistant Professor, Department of Geology and Environmental Science during the period of 2023-2024. The matter embodied in this project report has not been submitted for any award of degree.

SHAUN MJ

It is certified that the above statement made by the candidate is true to the best of my knowledge

Signature of project in charge

**Mrs. Sweeshma P Dev**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

**Mr.Tharun R**
Assistant Professor
Dept of Geology and Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

Place: Irinjalakuda

External Examiners

Date:17-04-2024

# THE PETROGRAPHIC STUDY OF ROCKS OF BUILDING STONE QUARRY, MOOKKANNOOR, ERNAKULAM

Project report submitted to Christ College (Autonomous), University of Calicut in partial fulfilment of requirements for the award of degree in

BACHELOR OF SCIENCE

IN

GEOLOGY

By

SREENANDANA T B

Reg No: CCAVSGL013

(2021-2024)

DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE
CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125
(Affiliated to University of Calicut and re-accredited by NAAC with A++grade)

# THE PETROGRAPHIC STUDY OF ROCKS OF BUILDING STONE QUARRY, MOOKKANNOOR, ERNAKULAM

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BACHELOR OF SCIENCE

IN

GEOLOGY

By

SREENANDANA T B

Reg No: CCAVSGL013

(2021-2024)

DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE
CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125
(Affiliated to University of Calicut and re-accredited by NAAC with A++grade)

UNDER THE GUIDANCE OF Dr. RESMY K J
Asst. Professor, Department of Geology and Environmental Science

# CERTIFICATE

I hereby declare that the work, which is being present in this dissertation, entitled "THE PETROGRAPHIC ANALYSIS OF HOST ROCKS OF GRANITE BUILDING STONE QUARRY" by MS. SREENANDANA T B (CCAVSGL013) submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree of Bachelor of Science in Geology is an authentic record of my own work carried out under the guidance of Dr. Resmy K.J , Assistant Professor, Department of Geology and Environmental Science during the period of 2023-2024. The matter embodied in this dissertation has not been submitted for any award of degree.

(SREENANDANA T B)

It is certified that the above statement made by the candidate is true to the best of my knowledge.

Signature of project in charge

Dr. Resmy K J
Assistant Professor
Dept. of Geology and Environmental Science
Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

Mr. Tharun R
Assistant Professor and Head
Dept. of Geology and Environmental

Christ College (Autonomous)
Irinjalakuda, Kerala-680125

Place: Irinjalakuda

Date:

External

Examiners:

## CERTIFICATE

This is to certify that the dissertation entitled - **SLAKED LIME: A Solution for Turbidity in Groundwater** is a bonafide record of work done by PUNNYA ASHOK (REG NO : CCAVSGL014) Christ College (Autonomous) Irinjalakkuda,Under my guidance in partial fulfilment of requirements for Sixth Semester Bachelors of science in Geology of during the period of 2021 -2024.

Tharun R

Head of the department

Dept of Geology and Env. Science

Christ College (Autonomous),

Irinjalakkuda

Project Guide

Dr. Anso M A

Assistant professor

Dept of Geology and Env.science

Christ college (Autonomous),

Irinjalakkuda

Place : Irinjalakkuda

Date:16/04/2024

External Examiners;

1.....

2.....

Dept. of Geology & Environmental Science ★ Christ College (Autonomous) ★ Irinjalakuda 680 125

# *SLAKED LIME: A Solution for Turbidity in Groundwater*

***A project report submitted in partial fulfilment for Sixth Semester***

***BACHELOR OF SCIENCE in* GEOLOGY**


By,

**ADITHYA K A**

**CCAVSGL015**

Under the guidance of

**Dr. ANSO M A**

(Assistant Professor, Department of Geology & Environmental Science) 2021-2026

DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE,

CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA

KERALA, 680125

***(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)***

## CERTIFICATE

This is to certify that the dissertation entitled - **SLAKED LIME: A Solution for Turbidity in Groundwater** is a bonafide record of work done by ADITHYA K A (REG NO : CCAVSGL015) Christ College (Autonomous) Irinjalakkuda,Under my guidance in partial fulfilment of requirements for Sixth Semester Bachelors of science in Geology of during the period of 2021 -2024.

Tharun R

Head of the department

Dept of Geology and Env. Science

Christ College (Autonomous),

Irinjalakkuda

Project Guide

Dr. Anso M A

Assistant professor

Dept of Geology and Env.science

Christ college (Autonomous),

Irinjalakkuda

Place : Irinjalakkuda

Date: 16/04/2024

External Examiners:

1.....

2.....

## DECLARATION

I hereby declare that this dissertation work – **SLAKED LIME: A Solution for Turbidity in Groundwater**, is a work done by me. No part of the report is reproduced from other resources. All information included from other sources has been duly acknowledged. I maintain that if any part of the report is found to be plagiarized, I shall take the full responsibility for it.

**Place:** Irinjalakuda

**Date:** 16/04/2024

ADITHYA K A

CCAVSGL015

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I would like to express my sincere thanks to Mr. Jithin C F and Miss. Caren Vencilavouse those who helped me throughout the completion of this work. Similarly, I would like to thank all my classmates for their kind corporation and help during the work.

# ABSTRACT

The objective of the study was to bring the turbid groundwater into the drinking water limit. The turbidty of the collected sample is 198 NTU, whereas the WHO standard for turbidity is 5 NTU. The turbid nature of the study area is due to the close proximity to paddy field and lithology associated. Certain combinations and quantities of natural reagents were added to samples to attain the turbidity into the desired drinking water limit. This study paved a new way to control the turbid groundwater, and eventually enhanced the quality of groundwater.

# Palaeogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy

Project report submitted to Christ College, Autonomous, University of Calicut in partial fulfilment of requirements for the completion of Sixth Semester in

B.Sc. GEOLOGY


SUBMITTED BY

NAME : ALEN JOSEPH

REGISTER NO : CCAVSGL016

**DEPARTMENT OF GEOLOGY AND ENVIRONMETAL SCIENCES**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA**

(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)

# Palaeogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy

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UNDER THE JOINT SUPERVISION OF

**Dr. LINTO ALAPPAT**
**&**
**Ms. SHAIMA M.M**

# CERTIFICATE

I hereby declare that the work, which is being present in this project, entitled "**Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy**" by Mr./Ms. Alen Joseph .....Register no CCAVSC016.....submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree Bachelor of Science of in Geology is an authentic record of my own work carried out under the joint supervision of **Dr. Linto Alappat**, Assistant Professor , Dept. of Geology and Environmental sciences and **Ms. Shaima M.M**, Assistant Professor, Department of Geology and Environmental Science during the period of 2023-2024. The matter embodied in this dissertation has not been submitted for any award of degree.

**ALEN JOSEPH**

It is certified that the above statement made by the candidate is true to the best of me knowledge.

**Signature of project in charge**

**Ms. Shaima M.M**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

**Dr. Linto Alappat**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

Place: Irinjalakuda
Date:

External Examiners:

Dept. of Geology & Environmental Science * Christ College (Autonomous) Irinjalakuda 680 125

# DECLARATION

I hereby declare that the dissertation work "**Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy**" is a work done by me. No part of the report is plagiarized from other resources. All information included from other sources has been duly acknowledged. I maintain that if any part of the project is found to be plagiarized, I shall take the full responsibility for it. I also understand and agree that this declaration made by me is final and irrevocable,

PLACE: Irinjalakuda

DATE: 17/04/2024

ALEN JOSEPH

REG NO: CCAVSGL016

# ACKNOWLEDGEMENT

This report is a certified documentation of the Cheruvathur formation and its stratigraphy. Following the successful completion of this project, I would like to express my heartfelt appreciation to the all who stood by me through thick and thin, without whom the work would not have been possible. First and foremost, I would record my deep sense of gratitude and indebtedness to my guides Dr. Linto Alappat, Assistant Professor, Department of Geology and Environmental Science & Mrs. Shaima M M, Assistant professor, Department of Geology and Environmental science, Christ College (Autonomous) Irinjalakuda, for designing the framework of the project and providing constant support and supervision throughout the entire course of study.

I express my sincere thanks to Ms. Aleena, Research Scholar, Christ College (Autonomous) Irinjalakuda, who helped me throughout the completion of this work. I am also thankful to all the faculties of Department. of Geology and Environmental Science, Christ College, for their helping hands at times of need.

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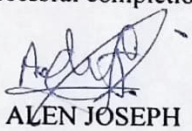
I also acknowledge with reverence, our warm regards towards our parents and family members for their constant support and prayers in my life.

And above all, I thank with utmost sincerity to God, the Almighty for his divine benevolence and blessing showered on me. Finally, I thank all those who have directly or indirectly helped me in various stage of this work till its successful completion.



ALEN JOSEPH

# ABSTRACT

This report provides details of the stratigraphy of Cheruvathur formation, known for its equivalence with Tertiary Warkalli Formation of Southern Kerala. The total thickness of the section studied was 33m representing different lithologies. Stratigraphy of Cheruvathur formation exposes several meter thick successions of carbonaceous clay with lenticular units of shale and lignite. The lignite units are characterized by abundance of plant fossils in the form of plant leaves, stems, twigs and leaf impressions. Tubular sticks and planar structures of marcasite and remains of amber, followed by variegated clays and sandstone are seen in the stratigraphic records. The presence of variegated lithounits with evidences of chemical leaching provides distinct colouration to sand and clay units. Clays are often shows various shades of gray, red and purple colours and sandstone units are largely ferruginous in nature. Layers of ferricrete deposits are seen at the bottom of the clay units at distinct intervals. The sediment textural analyses reveals that the sandy lithounits in Cheruvathur formation are characterized as coarse sand to medium sand, moderately sorted unimodal distribution of aggregate grains. The average grainsizes of the studied sandy lithounits varied between 673 to 360 μm. The fluvial depositional regime in a point bar sequence of a braided stream was evidenced by the presence of parallel bedding/ lamination. Low angle trough cross stratification, graded bedding etc. The shale interbeds with lignite seams shows lenticular nature at varying levels across the section. The lignite seams contain abundant plant remains like amber, leaves, twigs, logs, and fossil impressions. These are implying to a marshy depositional setting in a reduced environment, shifting laterally to change in hydrodynamic conditions.

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# CHAPTER 1

## 1.1 INTRODUCTON

### 1.1.1 GEOLOGICAL INVESTIGATION

The geological investigation of the Cheruvathur Formation reveals crucial insights into its composition, structure, and geological history. The formation primarily consists of sedimentary rocks, indicative of its depositional environment over time. Through field observations and laboratory analyses, key lithological characteristics have been identified, including sandstone, shale, and clay layers, suggesting a diverse depositional setting ranging from terrestrial to marine environments. Petrological studies further elucidate the mineralogical composition and diagenetic processes that have influenced the formation's development. Additionally, stratigraphic correlations and age dating techniques would provide essential chronological constraints, aiding in understanding the temporal framework of the Cheruvathur Formation within the broader geological context. Overall, this investigation contributes significantly to our comprehension of the geological history and paleoenvironmental conditions, of the Cheruvathur Formation, essential for both academic research and applied geological studies.

### 1.1.2 COASTAL LANDFORMS

The coastal landforms exhibit a diverse range of features shaped by various geological processes over time. Along its coastline, notable landforms include beaches, spits, bars, and estuaries, which reflect the dynamic interactions between marine and terrestrial environments. Beaches are prominent features characterized by sandy shores, often shaped by wave action and longshore drift. Spits are elongated coastal landforms formed by the deposition of sediment carried by longshore currents, extending into the sea and often enclosing sheltered lagoons or estuaries. Bars, similar to spits, are submerged or partially submerged ridges of sediment parallel to the shoreline, influencing coastal dynamics and sediment transport. Estuaries, on the other hand, are semi-enclosed coastal bodies of water where freshwater from rivers meets and mixes with seawater, resulting in unique ecosystems and sedimentary environments. These coastal landforms within the Cheruvathur Formation represent dynamic interfaces between

land and sea, shaped by geological processes such as erosion, deposition, and sea-level fluctuations, contributing to the region's geological and ecological diversity.

### 1.1.4 GRANULOMETRIC STUDIES

Granulometry serves as a foundational analytical technique with broad applications across the realms of earth and archaeological sciences. The study of particle or grain size encompasses essential attributes and physical properties inherent in particulate samples, sediments, and sedimentary rocks. By examining factors such as size distribution, textural maturity, surface texture, and shape characteristics, valuable insights are gained into sediment properties and environmental conditions. The size and shape of particles directly influence various sediment, soil, or material properties, including texture, density, porosity, and permeability.

Particle size is intricately linked to environmental settings, transportation mechanisms, and depositional conditions, making it a valuable environmental proxy. Through grain size analysis, researchers can discern the provenance of particles, the processes they've undergone during transport, their depositional environments, and other pertinent physical and chemical factors. This analytical approach is typically a foundational step in laboratory procedures for sediment and soil samples, aiming to deepen understanding of paleo-environmental features, reconstruct sedimentary transport histories, and analyze events such as tsunamis or hurricanes with precision.

## 1.2 STUDY AREA

### 1.2.1 BACKGROUND INFORMATION

Cheruvathur is situated in the coastal region of Kerala, which is characterized by a variety of geological formations. The region's geology is primarily composed of sedimentary rocks, including sandstones, shales, and laterites, which were formed over millions of years through processes such as sedimentation, compaction, and lithification.

### TERITARY SEDIMENTARY ROCKS

Mio-Pliocene sedimentary rocks are found in the southern coastal belt, with noticeable remnants in central and northern coastal areas. These rocks include clay, sandstones, lignite seams (Warkalli Formation), compact marly sands with shells, and limestone layers (Quilon Formation). The Tertiary sediments have a gentle dip towards west. The Warkalli Formation

extends in a narrow belt from Thiruvananthapuram (8°28'30": 76°57'20") to Kasaragod (12 ° 30'00": 74°59'00") between coastal and midland regions with intervening promontories of the crystalline rocks.

TERITIARY ROCKS OF KERALA

The Tertiary period, which spanned from approximately 66 million to 2.58 million years ago, marked a significant chapter in Earth's history characterized by dynamic geological processes and profound environmental changes. One of the prominent features of Kerala's Tertiary rocks is their diverse composition, reflecting the varied depositional environments and geological processes that prevailed during this period. These rocks encompass a range of formations including sedimentary, igneous, and metamorphic rocks. Sedimentary rocks, such as sandstones, shales, and limestones, dominate Kerala's Tertiary geology, indicating the presence of ancient seas, rivers, and terrestrial environments. These rocks contain a rich fossil record, offering clues about the flora and fauna that thrived millions of years ago.

Furthermore, igneous rocks, particularly basaltic lava flows, are also prevalent in certain regions of Kerala, attesting to volcanic activity during the Tertiary period. These volcanic rocks not only add to the geological diversity of the region but also highlight the dynamic nature of Earth's crust and the processes that shaped Kerala's landscape over millions of years. Additionally, the presence of metamorphic rocks in Kerala's Tertiary formations underscores the tectonic forces and geological upheavals that occurred during this period. Through processes like regional metamorphism, these rocks underwent transformations under high temperature and pressure.

HOW TO STUDY TERITIARY FORMATIONS AND METHOD USED TO STUDY TERITIARY FORMATIONS.

The study of tertiary formations encompasses a broad spectrum of geological processes and phenomena that occurred during the Tertiary period, roughly spanning from 66 to 2.6 million years ago. Understanding these formations is crucial for unraveling Earth's geological history, identifying resources, and comprehending past environmental changes. This essay delves into the methods and approaches used in the study of tertiary formations, shedding light on the interdisciplinary nature of this field.

**Field Surveys and Mapping**: Fieldwork remains fundamental in studying tertiary formations. Geologists conduct detailed surveys, mapping out geological features, sedimentary

deposits, and structural elements. This hands-on approach allows for direct observation and collection of data essential for subsequent analysis.

**Stratigraphy and Sedimentology**: Stratigraphic analysis involves studying the layering of rock formations to decipher their chronological order and depositional environments. Sedimentological methods aid in interpreting the characteristics and origins of sedimentary rocks, offering insights into past climates, sea levels, and tectonic activities.

**Paleontology and Biostratigraphy**: Fossil remains embedded within tertiary formations provide invaluable clues about past life forms and ecosystems. Paleontologists examine fossil assemblages to establish bio stratigraphic correlations and reconstruct evolutionary trends, contributing to the refinement of geological timelines.

**Geochemistry and Isotopic Analysis**: Geochemical techniques enable the investigation of elemental compositions, mineralogy, and isotopic signatures within tertiary formations. Isotopic analysis, including radiometric dating, helps determine the absolute ages of rocks and discern past environmental conditions, such as temperature variations and ocean chemistry.

**Remote Sensing and Geophysical Surveys**: Remote sensing technologies, such as satellite imagery and LiDAR (Light Detection and Ranging), aid in mapping large-scale geological features and identifying subtle surface patterns indicative of underlying structures. Geophysical surveys, including seismic profiling and ground-penetrating radar, provide insights into subsurface geology and geological processes.

**Modeling and Simulation**: Computational modeling techniques, such as numerical simulations and geostatistics, facilitate the integration of diverse datasets and the reconstruction of past geological scenarios. These models help visualize geological processes, predict subsurface characteristics, and test hypotheses regarding tertiary formations' evolution.

**Interdisciplinary Approaches:** The study of tertiary formations often requires collaboration across multiple disciplines, including geology, paleontology, climatology, and oceanography. Interdisciplinary research fosters a holistic understanding of geological phenomena and enhances the interpretation of complex data sets.

**Stratigraphic Study**:

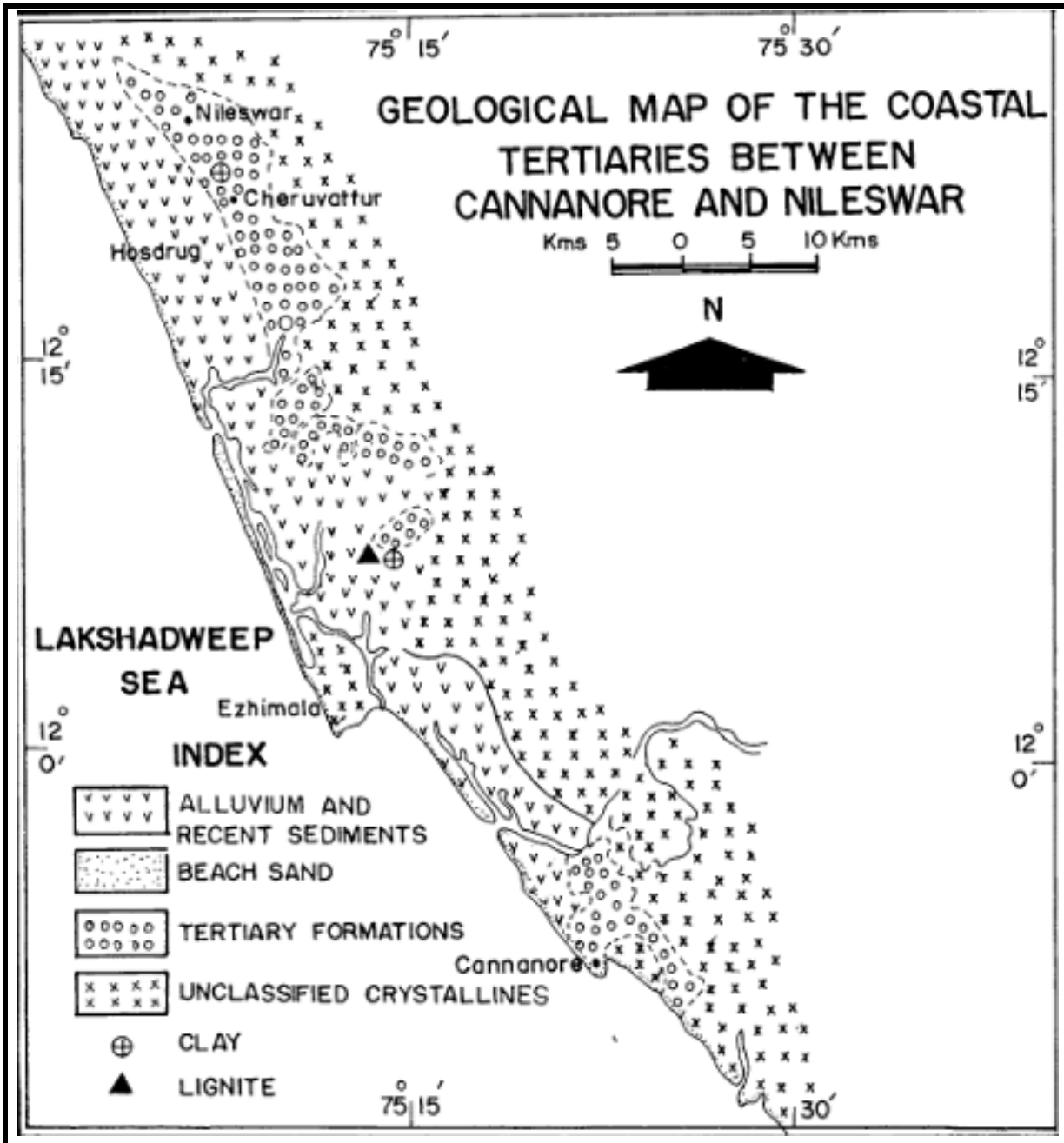
At the heart of understanding tertiary formations lies the discipline of stratigraphy. By meticulously deciphering the layering and arrangement of sedimentary deposits, geologists unravel the chronology of events that sculpted Earth's surface during the Tertiary period. Stratigraphic study provides a roadmap through time, offering insights into ancient environments, climatic fluctuations, and tectonic upheavals that shaped the landscapes we see today.

**Field Mapping:**

Complementing the insights gleaned from stratigraphy, field mapping ventures into the tangible realm of geological landscapes. Armed with keen observation and precise measurements, geologists traverse terrain, documenting geological features, structural complexities, and sedimentary sequences. Field mapping not only provides a visual representation of tertiary formations but also fosters a deeper understanding of the spatial relationships and geological processes at play.

**Sediment Characterization through Grain Size Analysis**:

Delving further into the composition of tertiary formations, sediment characterization through grain size analysis unveils the granular intricacies of sedimentary deposits. By sieving and analyzing sediment samples, geologists discern the distribution of particle sizes, revealing clues about depositional environments, sediment transport mechanisms, and the dynamics of past sedimentary systems. Grain size analysis serves as a window into the depositional history encoded within tertiary formations, offering valuable insights into sediment provenance, depositional energy, and paleoenvironmental conditions.




Geological map of the coastal tertiaries between Kannur and Nileswar (Rajendran, 1987)

WARKALLI FORMATION

The Warkalli Formation of Mio-Pliocene age extends all along the Kerala coast. The type section of the Warkalli Formation described by King (1882) is from the sea cliff at Varkala. The exposed section at Varkala cliff is 28-30 m thick consisting of unconsolidated sands of variegated clays, white plastic clays, and carbonaceous sandy clays enclosing impersistent seams and lenses of lignite. The carbonaceous clays and lignite are often impregnated with nodules of marcasite. Fairly thick beds of carbonaceous clays with lignite seams occur around Nadayara kayal, Tamarakulam (908': 7637'), Puliyur (9°18'00": 76°35'00"), Payangadi (12°00'20": 75°15'40"), Nileswaram (12°15'00": 75°07'00"), Kanhangad (12 ° 17'40': 75 ° 05'00") and in the cliff sections near Cheruvathur (12°13'00": 75°09'50"). The most characteristic feature of the Warkalli Formation is the impersistent nature of the constituent beds, suggestive of shallow basin margin deposits.

1.2.2 GEOLOGY

Tertiary rocks, including clay, sandstones, grits, and lignite, overlay weathered basement rocks composed of Charnockitic gneisses and granulates. These basement rocks consist of high-grade metasedimentary and schistose gneissic rocks of Sargurs age. Additionally, various other rock formations can be found, such as dolerite and basalt dykes, granite gneiss, pegmatite, and aplite vein gabbro’s and granophyre’s.

Good exposures of Warkalli formation are seen all along the coast. Interbedded lignite – clay rocks representing marshy conditions of deposition are seen near the coast or about 3 km. from the coast in Kannur Meenkunnu, Palayangadi and kadankote areas. Carbonaceous clay, lignite and clay association is also met with in well sections as well as boreholes in Akkaleridevan area about six kms. East of Nileshwar coast. Interbedded loose and friable sandstone, white and variegated clay sequence representative or deposition along the river mouth is noticed along road cuttings in Perumba, Vellur, Karivellur, Cheruvattur and Nileshwar areas. Ferruginous grit and laterites overlay vein quartz pebbles on weathered schistose rocks in Valarpatnam and Andur.

## 1.2.3 GENERAL STRATIGRAPHY OF CHERUVATHUR FORMATION

Cheruvathur, Kerala lies within the sedimentary basins of southwestern India and exhibits a stratigraphy dominated by Tertiary formations of Neogene age.

**Uppermost Layer (Youngest):** Warkalli Formation (Miocene-Pliocene): This formation consists of a series of layered sandstones and clays containing plant remains. It can also include isolated pockets (lenticles) of lignite, a low-grade coal. The Warkalli Formation can reach thicknesses of up to 80 meters.

**Underlying Layer**: Quilon Formation (Miocene): This formation lies beneath the Warkalli Formation and is characterized by denser sands and clays. It may also contain fragments of shells and even thin limestone beds. The Quilon Formation is estimated to be thicker than the Warkalli Formation.

**Basement Rocks (Not visible at surface):** Beneath the sedimentary layers lie the weathered crystalline rocks of the Precambrian basement. These are much older and geologically distinct from the overlying Neogene formations.

The Warkalli Formation rests unconformably on the Quilon Formation, meaning there was a period of erosion or uplift before the deposition of the younger layer.

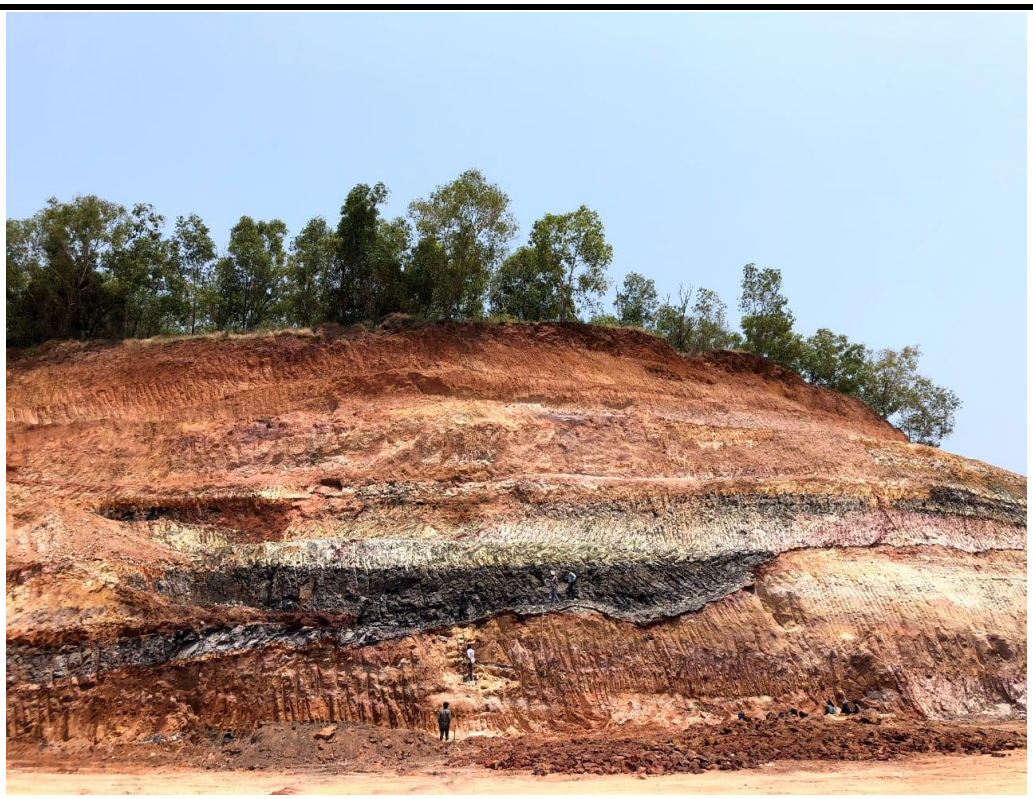


Fig – 1 stratigraphy of Cheruvathur formation.

1.2.4 GEOMORPHOLOGY

The area is divided into three natural divisions: low land near the sea, mid land with undulating country, and high land ranging from 30m to 210m. The low land consists of sandy and alluvial flats, sand bars, and river terraces. The width of the low land varies from 4 to 10 kms and is mostly made of laterites. These divisions extend from Kannur to Nileshwar. The region has several rivers, like Nileshwar, Kavvai, Perumba, Kuppam, and Valarpatnam, originating from high mountains. These rivers are tidal up to 10-20 kms from the coast, with the Karingote river dividing into distributaries before meeting the sea at Tiruti. Valarpatnam river flows into the Arabian Sea with a wide mouth. The coastal plains of Kerala are dotted with remnant hills, backwaters, lagoons, wetlands/ marshes, rivers and sand dunes/ beach-ridges.

## 1.2. CLIMATE AND RAINFALL

The region has a tropical to sub-tropical climate with four seasons. Winter is from January to February, hot weather from March to May, southwest monsoon from June to September, and northeast monsoon from October to November. Average temperatures range from 17°C to 37°C. Annual average rainfall is 3350mm, mostly concentrated in June to August. Wind speed is high from March to June and low from September to December.

## 1.3 AIM &OBJECTIVE

1. To Understand Geological History: Investigate the Cheruvathur Formation to unravel its geological history and evolution through the analysis of sedimentary rocks and primary sedimentary structures.
2. Stratigraphy of the area: Identify and characterize the lithological units of the Cheruvathur Formation, including sandstone, shale, and limestone layers, to discern past depositional environments and sedimentary processes.
3. Paleoenvironmental Reconstructions: Utilize sedimentary characteristics and stratigraphic information to reconstruct past paleoenvironments and understand the interplay between terrestrial and marine settings during the formation's deposition.

# CHAPTER 2

## REVIEW OF LITERATURE

Paulose and Narayanaswamy (1968) identified two main deposition basins in Kerala: one in the south, with a maximum width of 16 km, and the other in the north, with a maximum width of 10 km. Sand, clay, and lignite seams can be found in various locations, including Varkala, Vettur, Kundara, Puliyur, Kottayam, Cannanore, and Palayangadi. Ferruginous hard compact gritty sandstones with clay-sandstone intercalations are present in Karuchal, Cheruvathur, Nileswar, Kottayam, and Thiruvalla. The Karuchal, Varkala, and Cheruvathur sections are braided streams. These sandstones are well cemented and are found in Karuchal, Kottayam, Cheruvathur, and Nileswar areas.

Quaternary Sediments comprising of sand and alluvium occupying the sea shore, back waters and Paddy fields; red loamy soil ("Teries") covering the laterite top and alluvium. The Chief economic minerals in the Warkalli sediments include different types of clays Like ball clay, fire clay etc., lignite, bauxite and laterite.(K. B. Nair & R. P. S. Chauhan).The quaternary formation seen mainly occurs in the paddy fields on the low Lands the general lithology from the bottom is Black mud with hard and semi compact shell bed ( of lamellibranches and gastropods) Followed by black sticky clay barren of shells, layered, loosely compact shells beds With bigger Ostrea shells in bottom and smaller shells on the top, black clay; compact, Oxidized, reddish, yellowish sands, and recent alluvium of about 2m thickness.(K. B. Nair & R. P. S. Chauhan). In the area between Cochin and Cannanore the Tertiaries occur only as small Patches as near Trikkahara, Manjummel, Parakad, in the area and south-west of Edapal, near Kadalur, Puduppanam, and north of Tellicherry. But from Cannanore the Tertiaries extend almost continuously to Nileshwar and approaches a width of about 8 To 10 kms. In the Cheruvathur area. The scarp all around Cheruvathur exposes good sections of the Tertiary clays and sandstones capped by laterite. In the Palayangadi and Cheruvathur areas there is predominance of clays, probably deposited in more still water. (K.V. Poulose). two main deposition basins in Kerala: one in the south, with a maximum width of 16 km, and the other in the north, with a maximum width of 10 km. Sand, clay, and lignite seams can be found in various locations, including Varkala, Vettur, Kundara, Puliyur, Kottayam, Cannanore, and Palayangadi. Ferruginous hard compact gritty sandstones with clay-sandstone intercalations are present in Karuchal, Cheruvathur, Nileswar, Kottayam, and Thiruvalla. The Karuchal, Varkala, and Cheruvathur sections are braided streams. These sandstones are well cemented and are found in Karuchal, Kottayam, Cheruvathur, and Nileswar areas (P. RAJENDRAN,

M.SC.MAY 1987)

Mio-Pliocene sedimentary rocks are found along the southern, central, and northern coastal areas of Kerala. These rocks consist of clay, sandstone, lignite seams, marly sands with shells, and limestone layers. The sediments slope gently westward, and the Warkalli Formation stretches from Thiruvananthapuram to Kasaragod. It is characterized by unconsolidated sands, clays, and carbonaceous sandy clays, with lignite seams and marcasite nodules. The formation is known for its shallow basin margin deposits. (T.N Rajan and P.S Anil Kumar May,2005 ). The general geology of Peninsular India includes diverse rock formations ranging from Precambrian to Recent, with Tertiary and Quaternary sediments prevalent along the continental margins. The Tertiary Warkalli Formation overlies the Precambrian crystalline basement without representation of Paleozoic and Mesozoic rocks. Varkala Cliff serves as the type area for the Mio-Pliocene-aged Warkalli Formation, exposing various Lith units such as ferruginous and non-ferruginous sandstones and grit, variegated clays, white plastic clays, and carbonaceous sandy clays containing intermittent lignite seams and lenses. The presence of marcasite nodules in carbonaceous clays suggests a reducing environment. The occurrence of ichnofossils like Skolithos linearis and Planolite beverleyensis suggests deposition in a shallow water near-shore marine environment with moderate to high energy conditions. (K.S. Sajin Kumar, M. Santosh, V.R. Rani, Subhash Anand, A.P. Pradeepkumar, Anil Chavan, K.P. Thrivikramji, P.V. Ramachandran). The presence of laterite underlying Tertiary sediments is a common feature in Kerala. Laterite has been reported from various locations in Kerala, associated with faulting in the Western Ghats. Three spells of laterization have been suggested, with the first one underlying Tertiary sediment, the second one overlying them, and the third one overlying Quaternary sediments. Recent findings around Cheruvathur and Nileswar in north Kerala reveal laterite sandwiched between Tertiary sediments, with distinct detrital, residual components and relict textures of the parent rock (C. P. RAJENDRAN AND NARAYANASWAMY).

(T.N Rajan and P.S Anil Kumar May,2005)

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# CHAPTER 3

## 3.1 MATERIALS AND METHODS

Various methods were employed in the collection and analysis of data.

### 3.1.1 FIELD STUDY

The Cheruvathur area detailed field survey of formation typically involves mapping out rock type sedimentary Structure. This will outline the key components and methodologies involved in such a survey, highlighting its importance in understanding the formation's depositional history and geological significance.

This area primarily composed of alternating layers of sedimentary beds. On top there is a top soil lies above the laterite having around 10ft thick. This top soil overlies up on laterite with lower portion is laterite and clay. The whole bed thickness is about 27ft. The laterite over lies up on ferruginous sandstone with grit like root penetrating structure. It is about 9ft thick. Below the sandstone there is a 9ft 2inch thickness of laterite bed.

After that laterite bed there is a layer of clay about thickness 5ft 10 inches. At upper

part of the bed is clay with kaolin and lower part is variegated clay about the thickness 5ft. The next layer about 5ft 11inch thick. It is vertically partitioned by first part is shale next is shale with peat woody fragments and next is fully clay. This partitioned layer is overlying up on grey clay at thickness 15ft.

The grey clay lies above shale with 12ft thickness after that there is a sandstone bed, it has 6ft thick. The next layer is clay with thickness 8ft and the exposed last layer is sandstone about the thickness 5ft 1inch.

The Cheruvathur formation represent a significant unit in the Kerala region, characterized by its diverse lithology and abundant fossil content. This survey aims to provide a comprehensive overview of the formation's structure, highlighting its key lithology characteristics and paleoenvironmental significance.

### 3.1.2 SAMPLE COLLECTION

For sample collection, the exposed layers were cleaned to get a fresh sample. The samples were collected from the top to bottom.

During the sample collection phase, meticulous care was taken to ensure the integrity of the samples and the accuracy of their representation. The process began by cleaning the exposed layers by using a chisel and a scraper to remove dirt and debris from the rock surface

to obtain fresh samples. Starting from the uppermost layer, which consisted of topsoil, the collection progressed systematically downward.

Beneath the topsoil, a laterite bed was encountered, from which two Optically Stimulated Luminescence (OSL) samples were extracted, labeled as OSL 1 and OSL 2. Moving further down, another OSL sample, OSL 3, was retrieved from a sandstone bed. A representative sample was also gathered from the underlying laterite bed. The representative samples were collected with the help of a geological hammer.

Continuing the collection, two representative samples were obtained from the underlying clay layer. Below this, a variegated clay layer was identified, with a shale lens within it. Eight samples were meticulously collected from this shale lens, each spaced 10 cm apart, starting from the top and progressing downwards.

Moving deeper into the layers, a representative sample was secured from the grey clay bed situated below the variegated clay layer. Subsequently, a shale bed was encountered, yielding 27 samples collected at 10 cm intervals from top to bottom.

Further down, a ferricrete layer was identified, from which a representative sample was procured. Transitioning to the next layer, another sandstone bed was found. From this, OSL 4 was taken from the top layer, OSL 5 was taken from the middle layer and OSL 6 was taken from the bottom layer.

Finally, the bottom bed, underlying the clay bed, consisted of another sandstone layer, from which three OSL samples were collected naming OSL 7, OSL 8, OSL 9. Completing the comprehensive sampling process across the various geological layers.

The collected rock samples were meticulously stored in designated sample bags, ensuring proper labeling and documentation for each sample to maintain accuracy and traceability throughout the project. Simultaneously, sand-sized particles were carefully preserved in zip lock bags, emphasizing the need for detailed examination and analysis in subsequent stages of the project. This systematic approach to sample storage and organization serves as a foundation for comprehensive and reliable data interpretation and scientific investigation.

Fig - 2 shale samples taken in 10cm interval

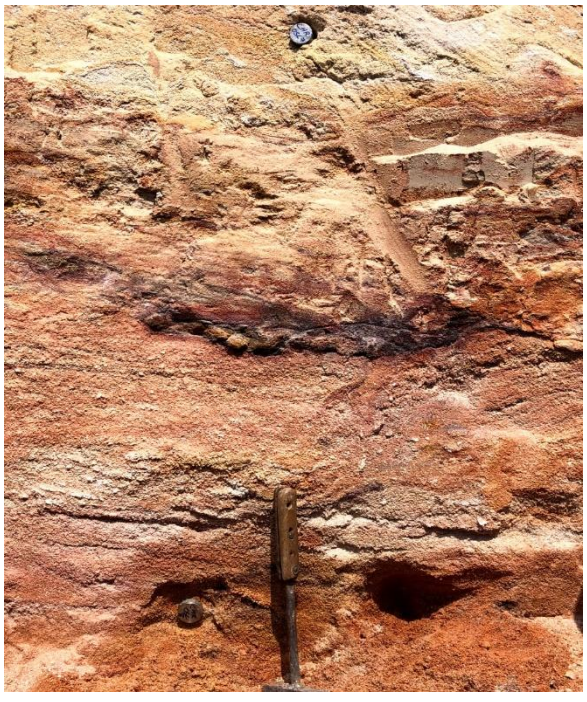


Fig – 3 OSL samples 7& 8

### 3.1.3 Grain Size (Folk and Ward 1957)

Sieving was carried out in (+14 to -230 mesh) American Standard Testing Mesh. The sediment samples were dried and sieved for the fractions 1000µ, 710µ, 500µ, 355µ, 250µ, 180µ, 125µ, 90µ, 63µ and 45µ (ASTM at ½ φ interval). The sieve sets, stacked in the descending order of their sizes, were shaken using +Georg Fishers+ of 4188 sieve shaker continuously for about 15 minutes. During sieving, proper attention was paid to minimize the sand loss from the sieve sets. The sieved materials were collected separately for weighing. Weight of the individual fractions was tabulated for further granulometric studies for computation of Mean, Standard Deviation, Skewness and Kurtosis.

Grain size less than 4 Ø is determined by conventional pipette method by following condition. After ½ φ interval Sieving sediment sample transfer into 1 lit cylinder and the suspension were stirred and sample withdraw will carry out in following conditions.

| Temp | 30 | Depth | 10cm | |
|---|---|---|---|---|
| **Phi** | **mm** | **Hours** | **Min** | **Sec** |
| 4 | 0.0625 | | | 23 |
| 4.5 | 0.0442 | | | 46 |
| 5 | 0.0313 | | 1 | 31 |
| 5.5 | 0.0221 | | 3 | 3 |
| 6 | 0.0156 | | 6 | 5 |
| 7 | 0.0078 | | 24 | 21 |
| 8 | 0.0039 | 1 | 37 | 25 |
| 9 | 0.0020 | 6 | 29 | 40 |

### 3.1.4 LABORATORY ANALYSIS

**1.Drying of sediments**

The collected samples were first dried in an oven at 50°C for a time of 48 hours and later cooled to room temperature.

**2. Grain size analysis**

Granulometry/particle size analysis is a basic analytic technique that has wide applications in various geological studies and research. The size of grains is a key characteristic of siliciclastic sedimentary rocks, giving valuable insights into their properties. Particle size in

a deposit is indicative of the processes of weathering and erosion, producing particles of varying sizes and the nature of subsequent transport processes. An analysis of grain size not only considers clastic, bioclastic or chemical particles but also encompasses overall size distribution, percentages of size fractions, sediment textural maturity, sorting patterns, surface textures and the sphericity/angularity and morphology of particles.

Sieving method is used here for grain size analysis. It involves the passage of sediment through a series of stacked sieve meshes with defined openings through agitation. Each sieve captures particles larger than its mesh size, gradually breaking down the sample into smaller size fractions. Weighing the sediment retained in each sieve allows for percentage determination relative to the entire sample. Sieving is adaptable for both dry and wet conditions.

**Apparatus Required: -**

1.Oven

2.Balance (with accuracy to 0.01g)

3.Stack of test sieves

4.Sieve shaker

**Procedure**

The sieve analysis procedure involved the use of specific apparatus, including an oven and a sieve shaker. Initially, 100 grams of the sample were placed in a beaker for analysis. The sample underwent drying in an oven at 50°C to eliminate moisture content. Sieves ranging from 2mm to 90μm, organized in a half phi interval, were utilized for the analysis. These sieves were arranged in descending order, with the smallest sieve at the bottom and a pan placed below it. The sample was then introduced onto the topmost sieve, which was of 2mm size. To ensure stability, the sieve shaker was securely tightened to hold the sieve stack in place. Subsequently, the sieve shaker was activated, vibrating for 10 minutes (600 seconds). After this vibration period, the material retained on each sieve was collected and weighed for further analysis.


Fig-4 grain sieving analysis

# CHAPTER 4

## 4.1 RESULTS

The results of field based stratigraphic mapping and textural analyses of arenaceous units in the laboratory are summarized as follows:

### 4.1.1 STRATIGRAPHIC LOG

Laterite occupies the upper part of the sedimentary sequence, having a vertical thickness of about 8.2m. This was overlain by 3m thick lateritic soil formation with plant root penetration structures. The laterite was intercalated with ferruginous gritty sandstone unit having a thickness of 2.7m. This was followed by intercalated units of shale, clay and sandstone with variable thickness. The total thickness of the upper clay-shale- lignite unit was about 10 m and was followed by a 2 m think sandstone. The sandstone was capped by a dark brown ferricrete layer. The lower part of the section was characterized by a 2.5m think clay layer and a sand unit beneath this layer having a thinkness of about 1.5m. The characteristic feature of the section was that the litho-units were varied laterally with thinning and thickening of the shale, clay and sandy litho-units across the outcrop. The sandstone unit exposed at the southern part of the outcrop was thicker than the northern side.

Cheruvathur Formation exhibits a diverse array of sedimentary structures, reflecting its depositional environment and geological history. The primary sedimentary structures are observed in various litho-units, mainly in the sandstone unit was planar horizontal bedding, planar and trough cross stratification, migration of beds in ripples, graded bedding etc.

Cross-bedding, characterized by inclined layers of sediment within larger beds, suggests deposition in environments with migrating currents or dunes, indicative of fluvial or aeolian settings. Graded bedding, where sediment grains become progressively finer upwards within a bed, reflects periods of waning current energy or decreasing sediment supply, often associated with turbidity currents or debris flows. Ripple marks, both symmetric and asymmetric, offer evidence of past water or wind movement, with their size and shape providing clues about flow velocity and direction. Mud cracks, formed as fine-grained sediments desiccate and shrink, signify periods of exposure to air and drying, suggesting alternations between wet and dry conditions within the depositional environment. Together, these sedimentary structures within the Cheruvathur Formation contribute to our understanding of ancient depositional

environments and the processes that shaped them.

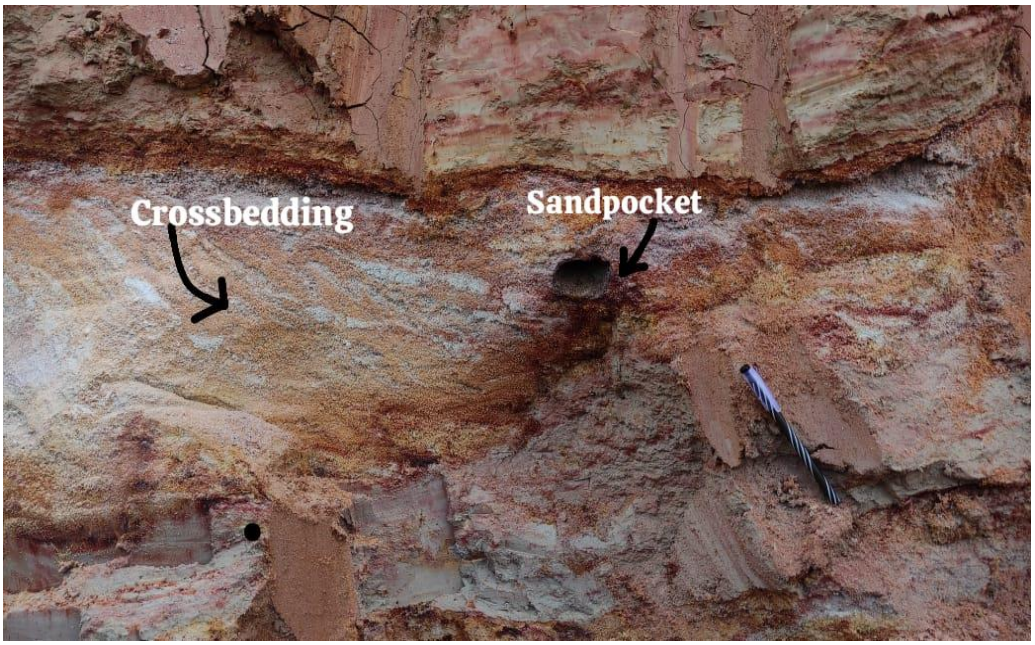



Fig – 5 sand pocket and cross bedding structures seen in the formation.

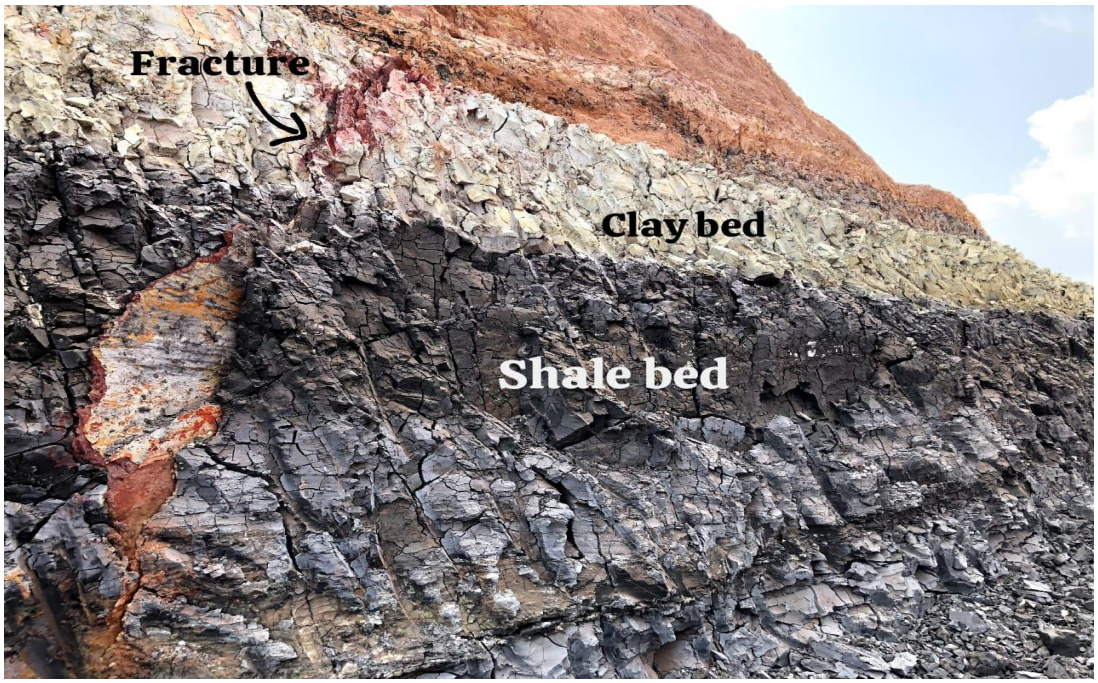



Fig –6 fractures, clay bed, layer and shale bed present in the formation.

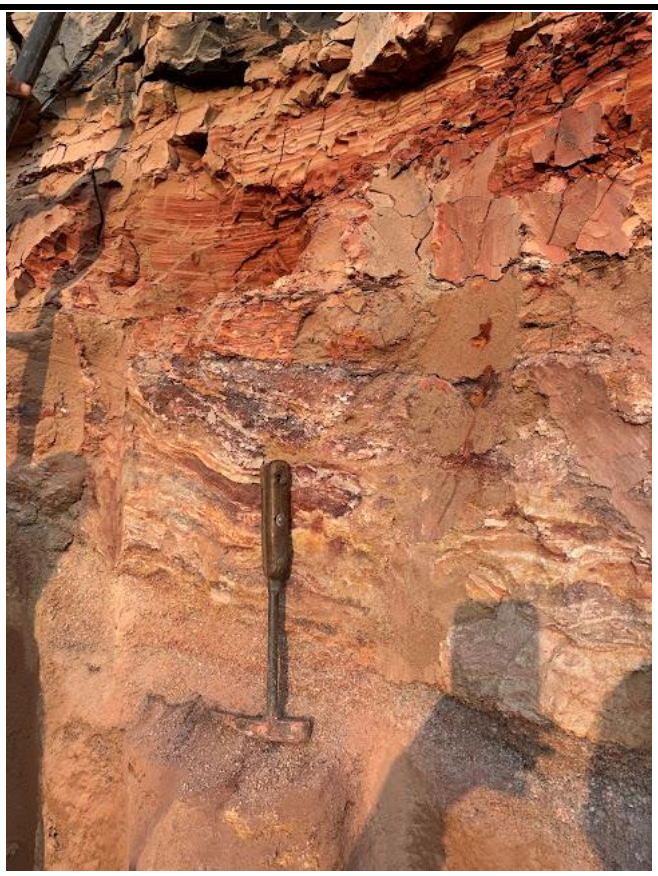
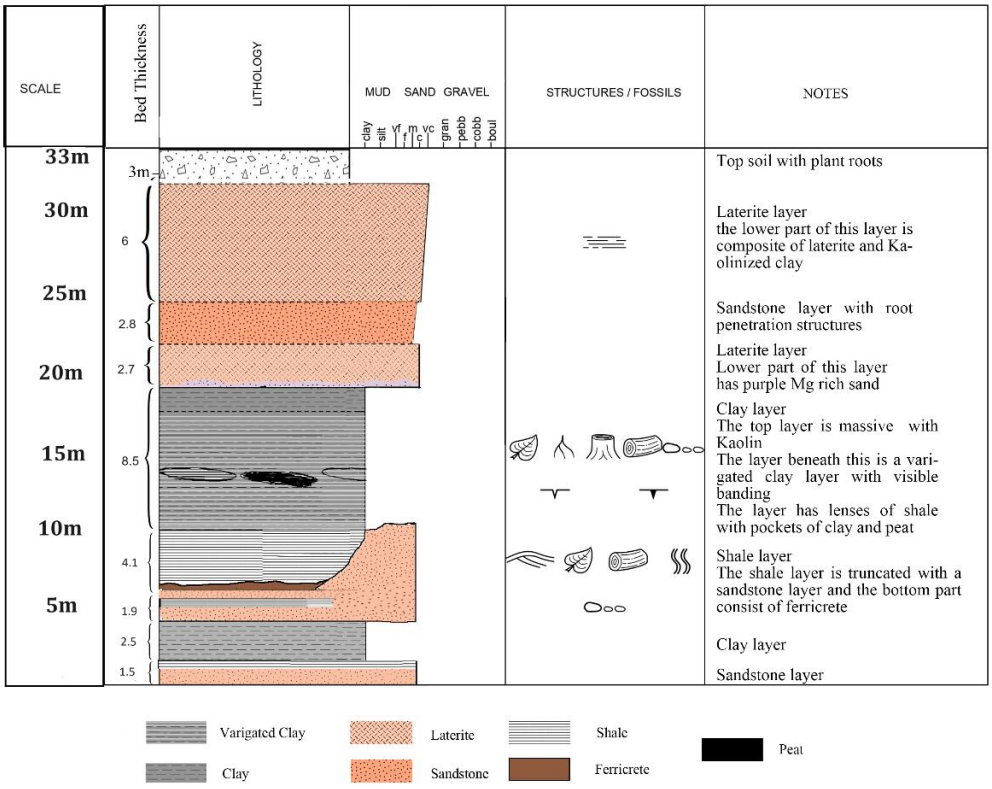


Fig- 7 cross bedding seen




**Stratigraphic Log of Cheruvathur Formation based on the field observation.**

4.1.2 GRAIN ANALYSIS

GRAIN SIZE ANALYSIS WAS DONE BY **Folk and Ward** METHOD

Nine samples from different lithounits were subjected to grainsize analyses. The sediment textural analyses reveals that the sandy lithounits in Cheruvathur formation are characterized as coarse sand to medium sand, moderately sorted unimodal distribution of aggregate grains. The average grainsizes of the studied sandy lithounits varied between 673 to 360 μm. The grainsize characteristics and sample statistics are given in the table below.

| Aperture | Class Weight Retained (g or %) in Different Samples | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| (microns) | | | | | | | | | | |
| Sample Identity: | CH GS-1 | CH GS-2 | CH GS-3 | CH GS-4 | CH GS-5 | CH GS-6 | CH GS-7 | CH GS-8 | CH GS-9 | |
| Analyst: | | | | | | | | | | |
| Date: | | | | | | | | | | |
| Initial Sample Weight: | 100.59 | 97.575 | 95 | 95 | 99.77 | 97.615 | 98.125 | 94.285 | 87.34 | |
| 2000 | 1.259 | 0.087 | 0.052 | 1.294 | 0 | 0.347 | 0.122 | 0.762 | 0.035 | |
| 1400 | 11.694 | 0.207 | 0.201 | 2.48 | 0.372 | 4.695 | 0.332 | 6.652 | 0.957 | |
| 1000 | 14.945 | 0.304 | 1.212 | 6.913 | 2.319 | 9.572 | 2.282 | 13.032 | 9.334 | |
| 710 | 18.177 | 1.972 | 3.582 | 20.254 | 12.889 | 23.312 | 12.872 | 24.462 | 17.872 | |
| 500 | 13.737 | 16.872 | 12.722 | 26.184 | 24.767 | 19.873 | 27.192 | 22.552 | 18.637 | |
| 355 | 10.442 | 37.012 | 30.052 | 18.589 | 24.687 | 14.693 | 28.452 | 13.542 | 17.257 | |
| 250 | 7.854 | 22.492 | 26.782 | 7.932 | 17.562 | 11.69 | 16.622 | 6.162 | 13.566 | |
| 180 | 6.102 | 5.552 | 9.432 | 4.002 | 8.574 | 5.994 | 4.972 | 3.115 | 4.882 | |
| 125 | 4.985 | 2.702 | 2.972 | 2.33 | 4.069 | 2.924 | 2.452 | 1.462 | 2.534 | |
| 90 | 2.215 | 1.062 | 1.402 | 1.075 | 1.155 | 0.887 | 0.57 | 0.767 | 0.77 | |
| 63 | 4.202 | 2.082 | 2.552 | 1.573 | 0.996 | 0.649 | 0.822 | 0.555 | 0.817 | |

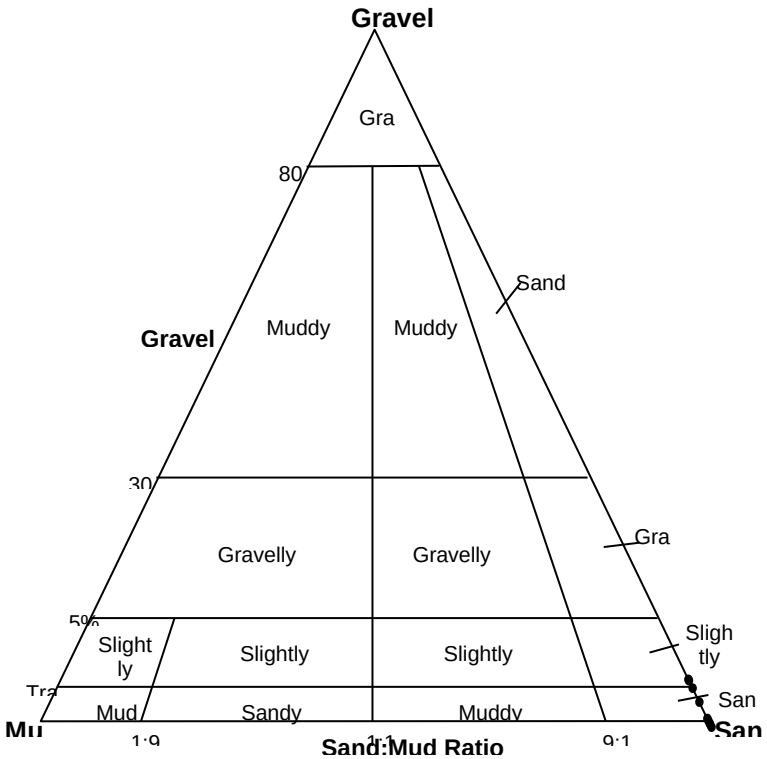
## SAMPLE STATISTICS

| | | CH GS-1 | CH GS-2 |
|---|---|---|---|
| | SAMPLE TYPE: | Bimodal, Poorly Sorted | Unimodal, Moderately Well Sorted |
| | TEXTURAL GROUP: | Slightly Gravelly Sand | Slightly Gravelly Sand |
| | SEDIMENT NAME: | Slightly Very Fine Gravelly Coarse Sand | Slightly Very Fine Gravelly Medium Sand |
| METHOD OF | MEAN ($\bar{x}_a$): | 775.6 | 413.1 |
| MOMENTS | SORTING ($\sigma_a$): | 525.9 | 179.2 |
| Arithmetic (μm) | SKEWNESS ($Sk_a$): | 0.724 | 2.559 |
| | KURTOSIS ($K_a$): | 2.892 | 23.61 |
| FOLK AND | MEAN ($\bar{x}_g$): | 585.1 | 385.5 |
| WARD METHOD | SORTING ($\sigma_G$): | 2.430 | 1.516 |
| (μm) | SKEWNESS ($Sk_G$): | -0.291 | -0.181 |
| | KURTOSIS ($K_G$): | 1.001 | 1.265 |
| FOLK AND | MEAN ($M_Z$): | 0.773 | 1.375 |
| WARD METHOD | SORTING ($\sigma_I$): | 1.281 | 0.601 |
| (ϕ) | SKEWNESS ($Sk_I$): | 0.291 | 0.181 |
| | KURTOSIS ($K_G$): | 1.001 | 1.265 |
| FOLK AND | MEAN: | Coarse Sand | Medium Sand |
| WARD METHOD | SORTING: | Poorly Sorted | Moderately Well Sorted |
| (Description) | SKEWNESS: | Fine Skewed | Fine Skewed |
| | KURTOSIS: | Mesokurtic | Leptokurtic |

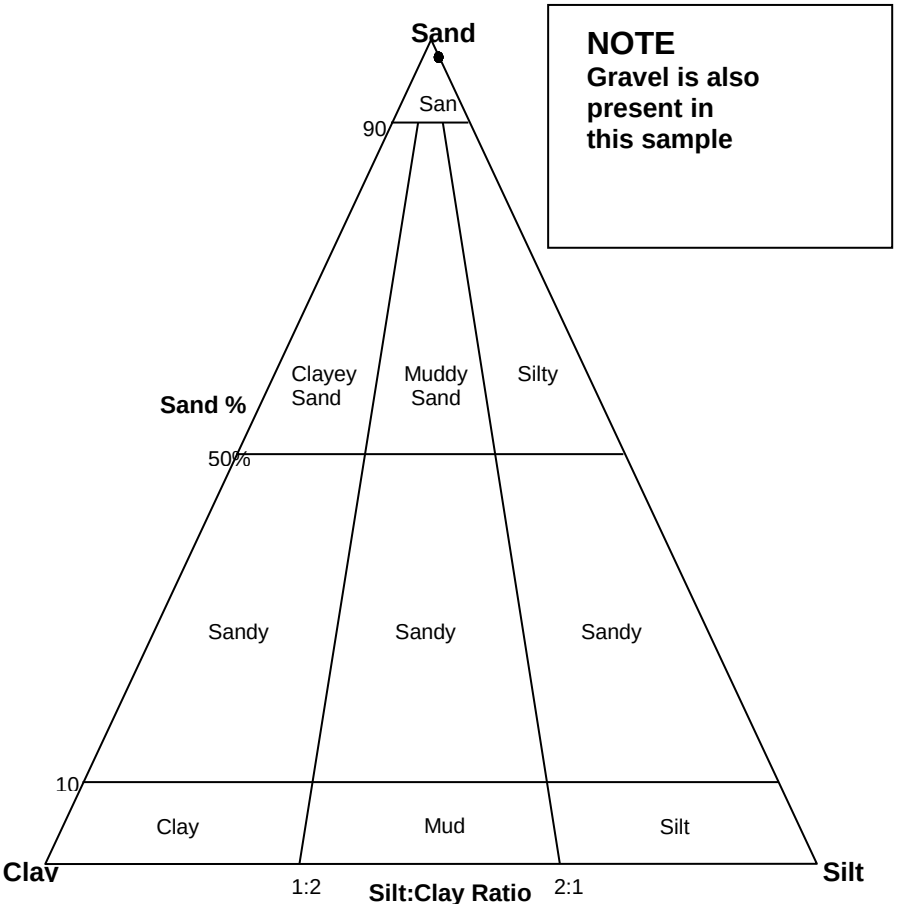
| CH GS-3 | CH GS-4 | CH GS-5 |
|---|---|---|
| Unimodal, Moderately Well Sorted | Unimodal, Moderately Sorted | Unimodal, Moderately Sorted |
| Slightly Gravelly Sand | Slightly Gravelly Sand | Sand |
| Slightly Very Fine Gravelly Medium Sand | Slightly Very Fine Gravelly Coarse Sand | Moderately Sorted Medium Sand |
| 400.8 | 654.0 | 492.3 |
| 203.5 | 385.1 | 246.6 |
| 2.171 | 1.766 | 1.041 |
| 13.68 | 8.041 | 4.950 |
| 360.3 | 558.7 | 431.4 |
| 1.601 | 1.781 | 1.693 |
| -0.104 | -0.139 | -0.124 |
| 1.269 | 1.192 | 1.000 |
| 1.473 | 0.840 | 1.213 |
| 0.679 | 0.833 | 0.759 |
| 0.104 | 0.139 | 0.124 |
| 1.269 | 1.192 | 1.000 |
| Medium Sand | Coarse Sand | Medium Sand |
| Moderately Well Sorted | Moderately Sorted | Moderately Sorted |
| Fine Skewed | Fine Skewed | Fine Skewed |
| Leptokurtic | Leptokurtic | Mesokurtic |

| CH GS-6 | CH GS-7 | CH GS-8 |
|---|---|---|
| Unimodal, Moderately Sorted | Unimodal, Moderately Well Sorted | Unimodal, Moderately Sorted |
| Slightly Gravelly Sand | Slightly Gravelly Sand | Slightly Gravelly Sand |
| Slightly Very Fine Gravelly Coarse Sand | Slightly Very Fine Gravelly Medium Sand | Slightly Very Fine Gravelly Coarse Sand |
| 675.8 | 515.2 | 773.7 |
| 392.3 | 242.1 | 415.1 |
| 1.083 | 1.521 | 1.046 |
| 4.431 | 9.127 | 4.337 |
| 555.9 | 457.7 | 672.9 |
| 1.862 | 1.597 | 1.786 |
| -0.174 | -0.094 | -0.113 |
| 0.973 | 1.072 | 1.151 |
| 0.847 | 1.128 | 0.571 |
| 0.897 | 0.675 | 0.837 |
| 0.174 | 0.094 | 0.113 |
| 0.973 | 1.072 | 1.151 |
| Coarse Sand | Medium Sand | Coarse Sand |
| Moderately Sorted | Moderately Well Sorted | Moderately Sorted |
| Fine Skewed | Symmetrical | Fine Skewed |
| Mesokurtic | Mesokurtic | Leptokurtic |

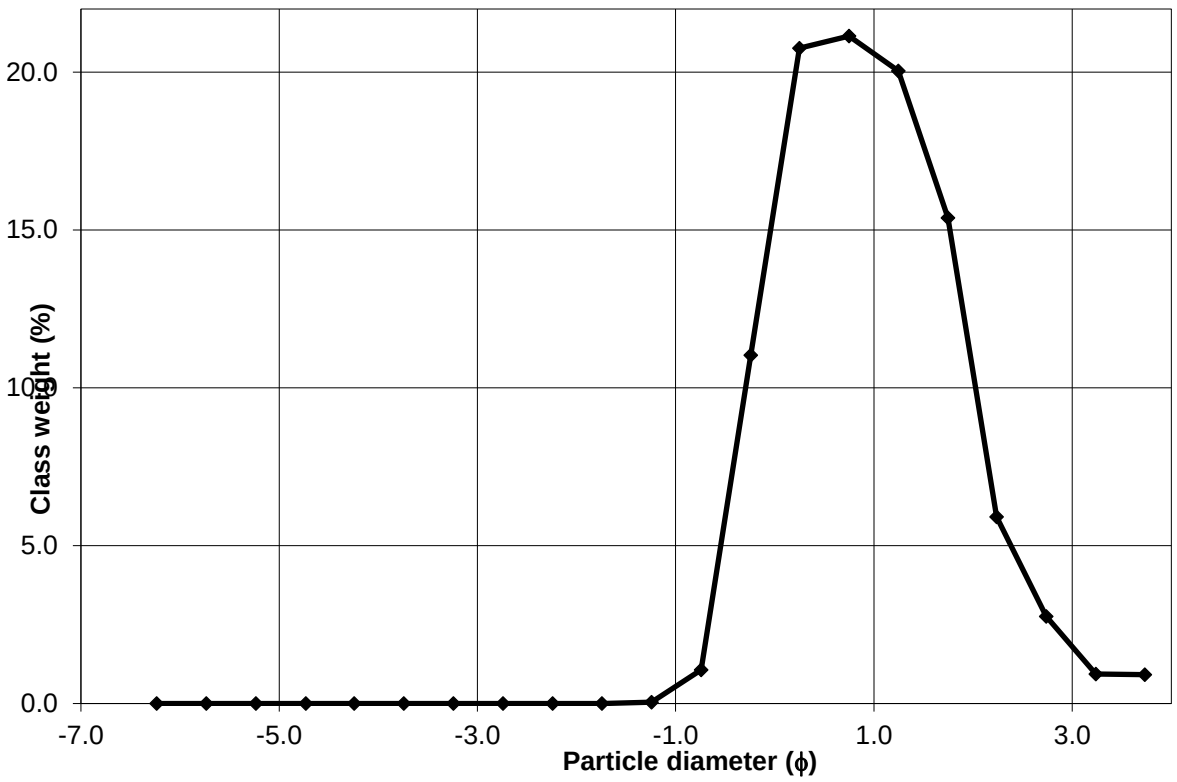
| CH GS-9 |
|---|
| Unimodal, Moderately Sorted |
| Slightly Gravelly Sand |
| Slightly Very Fine Gravelly Coarse Sand |
| 606.2 |
| 324.9 |
| 0.828 |
| 3.551 |
| 521.1 |
| 1.801 |
| -0.091 |
| 0.933 |
| 0.940 |
| 0.849 |
| 0.091 |
| 0.933 |
| Coarse Sand |
| Moderately Sorted |
| Symmetrical |
| Mesokurtic |



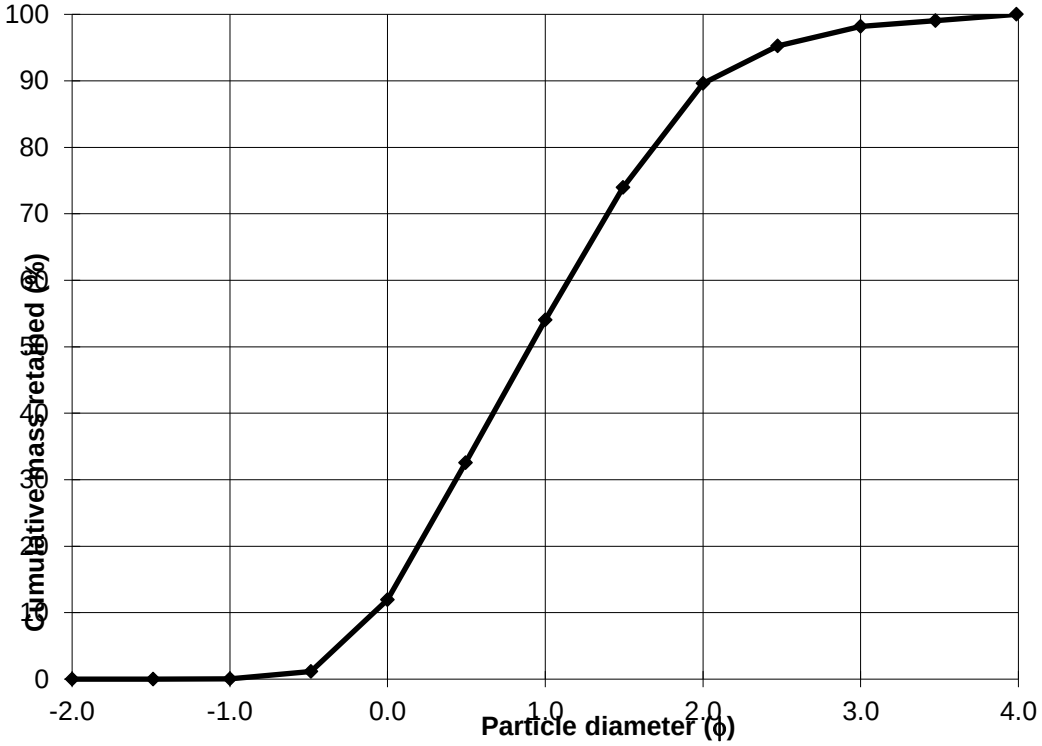

Gravel Sand Mud Diagram



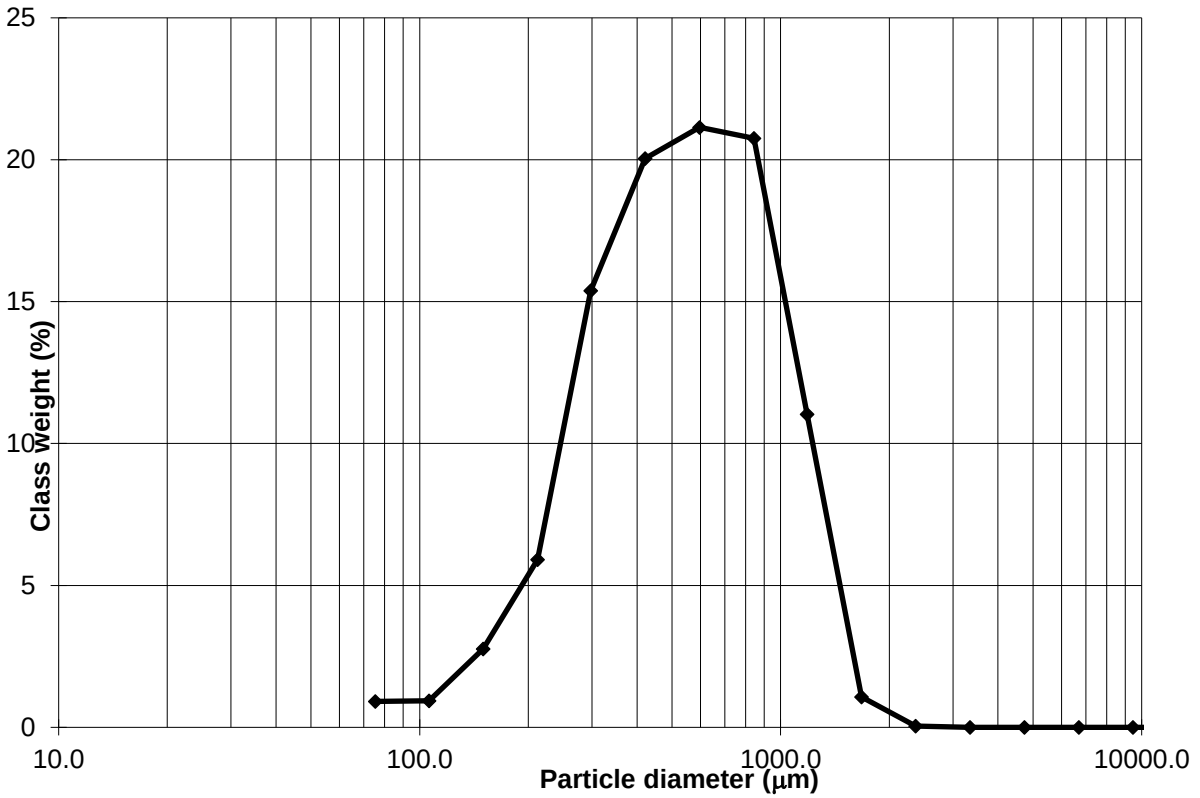
Sand Silt Clay Diagram



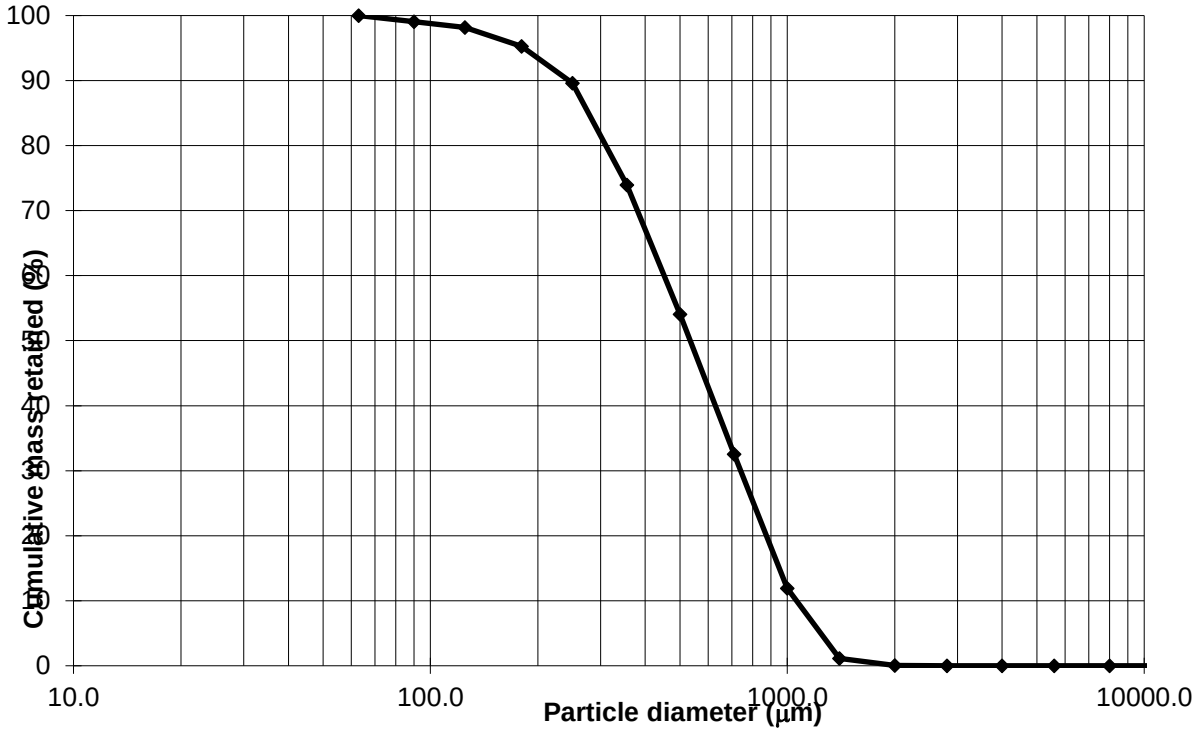

Distribution (phi) curve




**Cumulative (phi) curve**




**Distribution (microns)**




**Cumulative (microns)**

# CHAPTER 5

## 5.1 DISCUSSIONS AND CONCLUSIONS

Stratigraphic log was created based on the outcrop studies and the information were synthesized to assess the palaeogeographic significance of lithounits. Laterites are seen at two distinct levels, one at the contact with the host rock, preserving textures of the country rock, mainly charnockite. The upper laterite capping in the sedimentary sequence at the top is having more detrital components with root penetration structures. The formation of laterite may imply an intense chemical weathering conditions with alternate warm and wet climate cycles in a tropical settings. Laterization in the area was reported as happened during the Neogene-Quaternary boundary (Rajendran, 1987). Dark brown to blackish angular coarse to medium ferruginous gritty sand stone is typically formed at the base of shale/ lignite units and clay interbeds.

Fig – 8 ferruginous layer

The shale interbeds with lignite seams shows lenticular nature at varying levels across the section. The lignite seams contain abundant plant remains like amber, leaves, twigs, logs, and

fossil impressions. These are implying to a marshy depositional settings in a reduced environment, shifting laterally to change in hydrodynamic conditions.

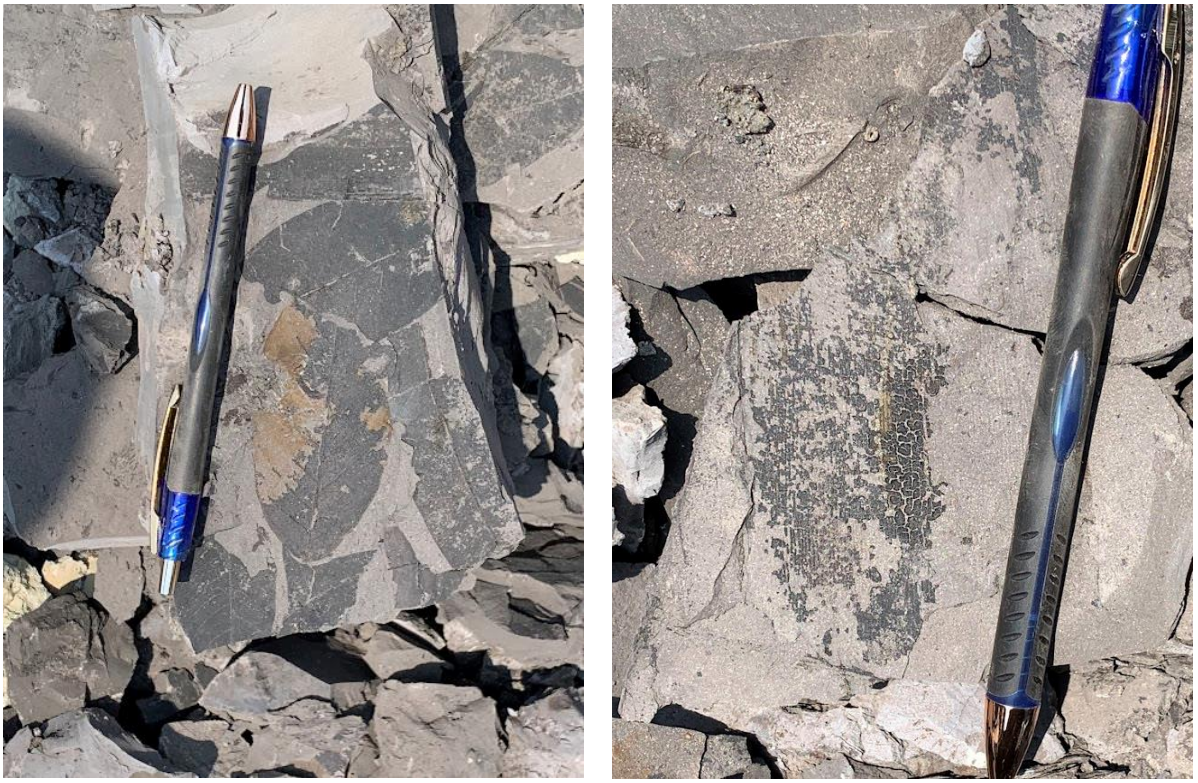


Fig -9, 10 leaf impressions found in shale.

Fig – 11 peat / lignite

The variegated clay in the section shows thin laminations are seen wrapping around the shale lithounits. The laminations are yellow to brownish red in colour in an argillaceous lithology, implying deposition in a lake marginal/ low energy oxidizing condition. The white clay unit in the lower part of the section shows purple mottled appearance, possibly indicating intense geochemical leaching it the unit.

Fig -12 claystone

The sedimentary structures in the stratigraphic units of Cheruvathur formation is useful in deciphering the palaeoenvironment of deposition of various lithounits. The primary sedimentary structures like cross bedding indicates deposition in braided streams as point bar or channel fill deposits. The syn-sedimentary, primary sedimentary structures are seen in clastic sedimentary units, mainly in the arenaceous lithounits, giving indication of their depositional process. Planar horizontal bedding is seen in the sandy units, with clay intercalations. These strata are interbedded with cross-bedding sandy lithounits. The section also showing bedding with normal grading, exhibiting textural change with decreasing grain size from bottom of the strata to the top. The lower strata is represented by coarse to medium sand, whereas the upper part is fine to very fine sand/ silt units, implying change in stream velocity from bed load to suspended load deposition. These structures are commonly found in fluvial point bar and over bank deposits. The cross bedding is seen in migration of ripples/ sand units, either in aeolian dunes or fluvial point bar deposits. Cross laminations are seen in deposition of sediments during moderate to low flow conditions, mostly in a braided stream.

Fig -12 samples taken in 10cm interval.

Fig – 13 OSL-8

The shift in the course of the current flow is evidenced by the lateral shift of tabular sedimentary units. The lenticular shale units with peaty interbeds are seen shifting laterally in N-S direction. The lithounits also give evidence of vertical accretion of sediments with lateral migration. This implies the change in baselevel of the streams in response to change in hydrodynamic conditions, which are mainly observed in the lenticular shale units, interbedded with ferrugionous sandstone and grey clay deposits with lignite seams.

Fig -14 crossbedding and sand pocket

A shift in hydrodynamic conditions is evidenced from the change in depositional pattern where the organic plant remains are overlain by fine grained argillaceous lithounits and sand lithounits.

The arrangement of soil and rock layers provides insights into the vertical succession of geological units and their relationships within the subsurface of Cheruvathur. The presence of diverse soil types and sedimentary rock formations suggests a complex geological history. The sequence of laterite, clay, sandstone, shale, and lignite indicates different depositional environments and processes over time.

Weathering and Alteration: The reddish coloration of laterite indicates weathering and oxidation of iron and aluminum minerals. The presence of kaolin suggests secondary

mineralization and alteration processes within the soil and rock layers.

Environmental Conditions: Layers such as shale with lignite and woody fragments suggest past wetland environments, while variations in clay coloration and composition reflect changes in depositional conditions and sediment sources.

Iron Enrichment: The presence of ferruginous layers and kaolin-containing clay indicates enrichment in iron minerals, which may have been influenced by weathering, sedimentation, and hydrothermal processes.

In conclusion, the geological investigation of Cheruvathur reveals a complex interplay of geological processes and environmental factors that have shaped the landscape over time. Further research and analysis, including laboratory studies of soil and rock samples, can provide a more detailed understanding of the area's geological history and dynamics. Such knowledge is valuable for land use planning, resource management, and environmental conservation efforts in the region**.**

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# Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy

Project report submitted to Christ College, Autonomous, University of Calicut in partial fulfilment of requirements for the completion of Sixth Semester in

B.Sc. GEOLOGY


SUBMITTED BY

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**DEPARTMENT OF GEOLOGY AND ENVIRONMETAL SCIENCES**

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UNDER THE JOINT SUPERVISION OF

**Dr. LINTO ALAPPAT**

**&**

**Ms. SHAIMA M.M**

# CERTIFICATE

I hereby declare that the work, which is being present in this project, entitled "**Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy**" by Mr./Ms...Anakha:S.....Register no ....CCAVSGL017..submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree Bachelor of Science in Geology is an authentic record of my own work carried out under the joint supervision of **Dr. Linto Alappat**, Assistant Professor , Dept. of Geology and Environmental sciences and **Ms. Shaima M.M**, Assistant Professor, Department of Geology and Environmental Science during the period of 2023-2024. The matter embodied in this dissertation has not been submitted for any award of degree.

**ANAKHA S**

It is certified that the above statement made by the candidate is true to the best of me knowledge.

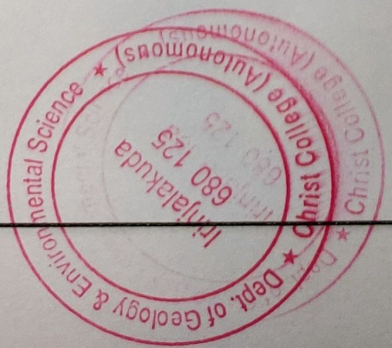
**Signature of project in charge**


**Ms. Shaima M.M**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous )
Irinjalakuda, Kerala-680125

**Dr. Linto Alappat**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125


Place: Irinjalakuda
Date: 17/04/24

External Examiners: Dr. Honey H. Das



# DECLARATION

I hereby declare that the dissertation work "**Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy**" is a work done by me. No part of the report is plagiarized from other resources. All information included from other sources has been duly acknowledged. I maintain that if any part of the project is found to be plagiarized, I shall take the full responsibility for it. I also understand and agree that this declaration made by me is final and irrevocable,

PLACE: Irinjalakuda

DATE: 17/04/24

ANAKHA S

REG NO: CCAVSGL017

# ACKNOWLEDGEMENT

This report is a certified documentation of the Cheruvathur formation and its stratigraphy. Following the successful completion of this project, I would like to express my heartfelt appreciation to the all who stood by me through thick and thin, without whom the work would not have been possible. First and foremost, I would record my deep sense of gratitude and indebtedness to my guides Dr. Linto Alappat, Assistant Professor, Department of Geology and Environmental Science & Mrs. Shaima M M, Assistant professor, Department of Geology and Environmental science, Christ College (Autonomous) Irinjalakuda, for designing the framework of the project and providing constant support and supervision throughout the entire course of study.

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ANAKHA S

# ABSTRACT

This report provides details of the stratigraphy of Cheruvathur formation, known for its equivalence with Tertiary Warkalli Formation of Southern Kerala. The total thickness of the section studied was 33m representing different lithologies. Stratigraphy of Cheruvathur formation exposes several meter thick successions of carbonaceous clay with lenticular units of shale and lignite. The lignite units are characterized by abundance of plant fossils in the form of plant leaves, stems, twigs and leaf impressions. Tubular sticks and planar structures of marcasite and remains of amber, followed by variegated clays and sandstone are seen in the stratigraphic records. The presence of variegated lithounits with evidences of chemical leaching provides distinct colouration to sand and clay units. Clays are often shows various shades of gray, red and purple colours and sandstone units are largely ferruginous in nature. Layers of ferricrete deposits are seen at the bottom of the clay units at distinct intervals. The sediment textural analyses reveals that the sandy lithounits in Cheruvathur formation are characterized as coarse sand to medium sand, moderately sorted unimodal distribution of aggregate grains. The average grainsizes of the studied sandy lithounits varied between 673 to 360 μm. The fluvial depositional regime in a point bar sequence of a braided stream was evidenced by the presence of parallel bedding/ lamination. Low angle trough cross stratification, graded bedding etc. The shale interbeds with lignite seams shows lenticular nature at varying levels across the section. The lignite seams contain abundant plant remains like amber, leaves, twigs, logs, and fossil impressions. These are implying to a marshy depositional setting in a reduced environment, shifting laterally to change in hydrodynamic conditions.

# HEAVY MINERAL ANALYSIS OF PAPANASAM REGION IN VARKALA, KERALA

Project report submitted to Christ College (Autonomous) Irinjalakuda, Kerala

Under University of Calicut in partial fulfilment of requirements for sixth semester of

**BACHELOR OF SCIENCE**

**IN**

**GEOLOGY**


**By**
**ANGELEENA LOUIS- CCAVSGL018**

**(2021 -2024)**

**DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125**

(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade


UNDER THE GUIDANCE OF


**SWEESHMA P DEV**

**Assistant Professor,**

**Christ College (Autonomous), Irinjalakuda, Thrissur**

# CERTIFICATE

I hereby declare that the work which is being present in this project, entitled **"HEAVY MINERAL ANALYSIS OF PAPANASAM REGION IN VARKALA, KERALA** "by **Ms/Mr JASMINE GIBY, SHAUN MJ, NIVEDYA K & ANGELEENA LOUIS** is an original work submitted to the Department of Geology and Environmental Science, Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for Sixth Semester B.Sc. in Geology. This work was carried out under the guidance of Sweeshma P Dev, Assistant Professor, Department of Geology and Environmental Science during the period of 2023-2024. The matter embodied in this project report has not been submitted for any award of degree.

ANGELEENA

LOUIS

It is certified that the above statement made by the candidate is true to the best of my knowledge

Signature of project in charge

**Mrs. Sweeshma P Dev**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

**Mr.Tharun R**
Assistant Professor
Dept of Geology and Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

Place: Irinjalakuda

External Examiners

Date:17-04-2024

# DECLARATION

I hereby declare that the project work entitled work "**HEAVY MINERAL ANALYSIS OF PAPANASAM REGION IN VARKALA, KERALA**" is a work done by me. No part of the report is plagiarized from other sources. All information included from other source has been duly acknowledged. I maintain that if any part of the project is found to be plagiarized, I shall take the full responsibility for it.

IRINJALAKUDA ANGELEENA LOUIS

DATE: 17-04-2024

# ACKNOWLEDGEMENT

This work would not have been possible without guidance, encouragement and support of many people. I would like to extend my sincere gratitude to all those who helped me in this project. First and foremost, I would record my deep sense of gratitude and indebtedness to my guide Mrs **Sweeshma P Dev** (Assistant professor, Department of Geology and Environmental science, Christ College (Autonomous) Irinjalakuda for designing framework of the project, support and supervision throughout the work. I am deeply grateful to **Dr. Linto Alappat** (Dean of Research and Development of TLC and former HoD), **Mr.Tharun R** (Head of the Department), and **Dr. Anto Francis K** ( Co-ordinator, Geology Self-financing) of Department of Geology and Environmental Science for their constant motivation throughout the course and in giving guidance in all possible way to carry out the analysis.

I express my sincere thanks **to Mr. Ayyappadas C. S (**Research Fellow, Christ College (Autonomous) Irinjalakuda, who helped me throughout the completion of this work. I am thankful to all the faculties of Dept. of Geology and Environmental Science, Christ College, for their helping hands at times of need. I extend my gratitude to the entire Christ College family for their support, guidance, and love.

I also acknowledge with reverence, my warm regards towards my parents and family members for their moral support and guidance. Last but not the least I extend my thanks to all of my friends who directly or indirectly helped me to complete this project report.

Above all I would like to express my gratitude to God almighty for showering His blessings on me to complete my project in an efficient manner.

# Palaeogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy

Project report submitted to Christ College, Autonomous, University of Calicut in partial fulfilment of requirements for the completion of Sixth Semester in

B.Sc. GEOLOGY


SUBMITTED BY

NAME : ANITA JOHNSON

REGISTER NO : CCAVSGL019

**DEPARTMENT OF GEOLOGY AND ENVIRONMETAL SCIENCES**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA**

(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)

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NAME : ANITA JOHNSON

REGISTER NO : CCAVSGL01 9

**DEPARTMENT OF GEOLOGY AND ENVIRONMETAL SCIENCES**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA**

(Affiliated to University of Calicut and re-accredited by NAAC with A++ grade)

UNDER THE JOINT SUPERVISION OF

**Dr. LINTO ALAPPAT**

**&**

**Ms. SHAIMA M.M**

# CERTIFICATE

I hereby declare that the work, which is being present in this project, entitled "**Paleogeography of Cheruvathur Formation, Northern Kerala, South India: Inferences from Sediment Texture and Stratigraphy**"" by Mr./Ms..Anita Johnson.Register no .CCAVSGL019.....submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of the Degree Bachelor of Science in Geology is an authentic record of my own work carried out under the joint supervision of **Dr. Linto Alappat**, Assistant Professor , Dept. of Geology and Environmental sciences and **Ms. Shaima M.M**, Assistant Professor, Department of Geology and Environmental Science during the period of 2023-2024. The matter embodied in this dissertation has not been submitted for any award of degree.

**ANITA JOHNSON**

It is certified that the above statement made by the candidate is true to the best of me knowledge.

**Signature of project in charge**

**Ms. Shaima M.M**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous )
Irinjalakuda, Kerala-680125

**Dr. Linto Alappat**
Assistant Professor
Dept. of Geology and Environmental Science
Christ College (Autonomous)
Irinjalakuda, Kerala-680125

Place: Irinjalakuda
Date: 17-04-2024

External Examiners:

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Anita Johnson

PLACE: Irinjalakuda

NANDANA P D

DATE: 17-04-2024

REG NO: CCAVSGL16019

# ACKNOWLEDGEMENT

This report is a certified documentation of the Cheruvathur formation and its stratigraphy. Following the successful completion of this project, I would like to express my heartfelt appreciation to the all who stood by me through thick and thin, without whom the work would not have been possible. First and foremost, I would record my deep sense of gratitude and indebtedness to my guides Dr. Linto Alappat, Assistant Professor, Department of Geology and Environmental Science & Mrs. Shaima M M, Assistant professor, Department of Geology and Environmental science, Christ College (Autonomous) Irinjalakuda, for designing the framework of the project and providing constant support and supervision throughout the entire course of study.

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~~NANDANA P D~~ Anita Johnson

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# SEDIMENT CHARACTERIZATION OF RAISED MARINE TERRACE AT THE EAST COAST OF TAMIL NADU: IMPLICATIONS OF HIGH ENERGY EVENTS

Project report submitted to Christ College (Autonomous), University of Calicut in partial fulfilment of requirements for the completion of sixth semester in

**B.Sc. GEOLOGY**

**By**

**ANJO JOSE**

**Reg No:CCAVSGL020**

**(2023-2024)**

**DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE,**

**CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA, KERALA, 680125**

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**(**Affiliated to University of Calicut and re-accredited by NAAC with $A^{++}$ grade)

UNDER THE SUPERVISION OF

**Dr. LINTO ALAPPAT**

# CERTIFICATE

I hereby declare that the work, which is being present in this project, entitled "SEDIMENT CHARACTERIZATION OF RAISED MARINE TERRACE AT THE EAST COAST OF TAMIL NADU: IMPLICATIONS OF WAVE PROCESS" submitted to the Department of Geology and Environmental Science Christ College (Autonomous), Irinjalakuda in partial fulfilment of the requirement for the completion of sixth semester in M.Sc. Integrated Geology is an authentic record of our project team carried out under supervision of Dr. Linto Alappat, Dean of Research and Development of TLC and Assistant Professor, Dept. of Geology and Environmental Sciences and during the period of 2023-2024. The matter embodied in this dissertation has not been submitted for any award of degree.

ANJO JOSE

It is certified that the above statement made by the candidate is true to the best of my knowledge.

Signature of project in charge

**Dr. Linto Alappat**
Dean of Research and Development of TLC

Assistant Professor, Dept. of Geology and Environmental science

Christ College (Autonomous) Irinjalakuda,

Kerala-680125

Place: Irinjalakuda

Date:

External Examiners:

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IRINJALAKUDA ANJO JOSE

DATE: Reg No: CCAVSGL020