

Ph.D Thesis

**RARE EARTH ELEMENTS DISTRIBUTION
IN THE SURFACE SEDIMENTS WITHIN THE
INNER SHELF OFF THE WEST COAST OF INDIA**

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**RARE EARTH ELEMENTS DISTRIBUTION
IN THE SURFACE SEDIMENTS WITHIN THE
INNER SHELF OFF THE WEST COAST OF INDIA**

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Under the Faculty of Marine Sciences

By
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CERTIFICATE

I certify that this thesis, entitled "Rare Earth Elements distribution in the surface sediments within the inner shelf off the west coast of India" is an authentic record of research work carried out by Mr. Jayaprakash.C under my supervision and guidance at the Department of Physical Oceanography, School of Marine Sciences, Cochin University of Science and Technology, Kochi, Kerala 682 016, under the Faculty of Marine Science and no part thereof has been presented for the award of any other degree in any University/Institute. All the relevant corrections and modifications suggested by the audience during the pre-synopsis seminar and recommended by the Doctoral committee have been incorporated in the thesis.

Kochi-682016

31stMarch 2017

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Declaration

I hereby declare that the thesis entitled "Rare Earth Elements distribution in the surface sediments within the inner shelf off the west coast of India" is an authentic record of research work carried out by me under my supervision and guidance of Dr. R. Sajeev, Associate Professor, Department of Physical Oceanography, School of Marine Sciences, Cochin University of Science and Technology, Kochi, Kerala towards the partial fulfilment of the requirements for the award of Ph.D. degree under the Faculty of Marine Science and no part thereof has been presented for the award of any other degree in any University/Institute.

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March 31st 2017.

(Jayaprakash.C)

Dedicated to my parents and family.....

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PREFACE

Rare Earth Elements (REE) have gained attention over the last few years due to their surprisingly large applications. The discovery of rare earth elements started at the end of 18th century. The first element to be discovered was Yttrium by Finnish chemist and mineralogist Johan Gadolin. By 1947 all elements in this group of metals were discovered. REE have similarity in physical properties and oxidation numbers. They are very good conductors of electricity, are silvery-white or grey and get tarnished on exposure to air. REE are obtained mostly from natural resources. About one percentage of the metals are also produced from recycling. Its demand is ever increasing due to its wide application in high-tech sectors.

Rare-earth elements and their alloys are used in computer memory, rechargeable batteries, precision-guided weapons, night-vision goggles, vehicle catalytic converters, magnets, fluorescent lighting, and other defence technology. Rare-earth metals are key ingredients for radar systems, avionics, and satellites. Rechargeable lanthanum–nickel–hydride batteries are gradually replacing nickel–cadmium batteries in computer and communications applications. Rare earths are used for air pollution control, illuminated screens on electronic devices, and optical-quality glass. Demand for all of these products has surged over the past two decades.

Due to their high economic significance, many countries have intensified the search for these metals both in their onshore and offshore domains. China is currently supplying more than 95 % of the REE requirement of the world. Since 2005, China has been implementing restrictions on its REE export which have caused increase in the price of REE. Under this circumstance India too has paced up its exploration programme to locate new REE deposits apart from the known heavy mineral beach placer deposits containing REE along its east and west coast.

The present study intends to identify sectors of REE enrichment within the inner shelf domain along the west coast of India. Considering the availability of heavy mineral placer deposits along the beaches off Maharashtra and Kerala and their known association with REE, the inner shelf domain along west coast was

selected for the study. Some of these heavy minerals contain REE in their crystal structure. The present study has helped in categorizing the west coast inner shelf based on REE content. REE content is found to be high within the inner shelf sediments along southern Kerala coast and very low in Gulf of Kutch and Gulf of Khambhat sediments.

The whole research work is partitioned into six chapters and is briefly described below.

Chapter I deals with the general introduction, crustal abundance of REE, major classes of REE deposits, REE in the offshore domains, uses of REE, current world status of REE and literature reviews. The objectives of the present work are given towards the end of this chapter.

Chapter 2 gives a detailed description about the geomorphology of the seafloor of the study area, about the materials and methods used in the present work, laboratory procedures, analytical processes and also about the statistical methods used to interpret the data.

Chapter 3 gives a broad picture about the various physiographic domains of the continental shelf, bathymetric map of the west coast up to a water depth of 100 m, and a detailed description about the surface sediment distribution within the inner shelf along west coast.

Chapter 4 describes the distribution pattern of REE within the inner shelf sediments. REE distribution is elucidated under three sub-heads i.e. Distribution of REE in surface sediments off Gujarat and Maharashtra coasts, distribution of REE in surface sediments off Goa and Karnataka coasts and distribution of REE in surface sediments off Kerala coast.

Chapter 5 attempts to correlate REE with heavy mineral content of the sediments based on the available data. The role of other factors such as hinterland geology, river discharge etc., are also discussed in this chapter, in controlling REE distribution.

Chapter 6 presents the summary of the research study. It also provides information about the sectors where maximum enrichment of REE is found along the west coast. At the end of the thesis, the relevant literatures cited in various chapters are furnished.

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