INTERPRETATION OF GRAVITY ANOMALIES OVER THE INDIAN OCEAN REGION AROUND SRI LANKA

BY

M. M. P. M. FERNANDO

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The work described in this thesis was carried out by me under the supervision of Professor D. A. Tantrigoda and a report on this has not been submitted in whole or part to any University or other institution for another degree.

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M.M.P.M. Fernando.

I certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the University for the purpose of evaluation.

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Professor D. A. Tantrigoda.

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ABSTRACT

Satellite gravity and bathymetry information covering the region 65°E - 95°E, 10°N - 10°S (≈2 x 500 000 data points) of the Indian Ocean around Sri Lanka have been downloaded from the NOAA (http://topex.ucsd.edu) Geophysical database. Gravity anomalies have been interpreted to estimate the sediment thickness and other features of the shallow subsurface structure of the region using well-established techniques in Geophysics. Most of the computer software needed for the interpretation has been developed as a part of the study. Downward migration of the oceanic crust due to the pressure exerted by nine prominent seamounts in the region has also been calculated considering the oceanic crust as a viscoelastic plate lying over an incompressible fluid half space and compared with the results of the gravity interpretations. A similar study has been carried out for the 85°E ridge situated East of Sri Lanka.

Intense negative anomalies situated close to the foot of the continental slope of Sri Lanka have been explained in terms of the density variations over the oceanic-continental

boundary and due to sediment accumulation. Downward migration of the oceanic crust below the two main members of the Afanasy-Nikiten chain of seamounts has been calculated interpreting gravity anomalies and found to have maximum depression of 5.5 km and 3.0 km. A similar study carried out over seven other smaller seamounts scattered over the central Indian Ocean shows that the maximum depression of the oceanic crust due to their pressure varies from 4.0 km to 1.0 km. This study has been extended to the 85°E ridge and it was found that the oceanic crust there has depressed from 9 – 14 km due to its pressure. Several profiles of gravity anomalies below 6°S of the equator covering the region 79°E-87°E, 2°S-8°S have been interpreted and results were used to compile an isopach map. This map shows that the thickness of sediments goes down to about 0.6 km towards the middle part of the region and then increases to 0.8 km at the periphery and again decreases towards the south.

CHAPTER 1

INTRODUCTION AND REVIEW OF PREVIOUS STUDIES

1.1 Introduction

1.1.1 Introduction

This thesis describes an interpretation of gravity anomalies carried out over the Indian Ocean around Sri Lanka. Satellite gravity anomalies and bathymetry information over the region 65°E - 95°E, 10°N - 10°S (Fig.1.1) downloaded from the http://topex.ucsd.edu website were used for this purpose. Gravity anomalies were interpreted to estimate the sediment thickness and other features of the shallow subsurface structure of this region. Two and three-dimensional interpretation of gravity anomalies were carried out using well-established techniques (Tantrigoda, 1994) in Geophysics. Development of necessary computer software has been an important phase of the study in view of the prohibitively high cost of commercially available geophysical software. Almost 60% of the study has been carried out using the computer software developed as a part of the study. Rest of the work was carried out using the software prepared by the previous workers (Tantrigoda, 1979, 1982; Bott and Tantrigoda, 1987; Tantrigoda, 1990, 1999). These software were used after modifying them to suit the present purpose.

The rationale of the project stems from its usefulness in the delimitation of the outer edge of the continental margin of Sri Lanka according to the provisions of the United

Nations Convention on the Law of the Sea (UNCLOS). Results of the project can either be used directly for this purpose or as a guide for any future seismic work needed to be carried out for the delimitation of maritime boundaries of Sri Lanka.

1.1.2 A Brief Summary of Previous Geophysical Studies carried out over the Indian Ocean region around Sri Lanka

The Indian Ocean region around Sri Lanka is a part of the world largest deep sea sediment fan known as the Bengal fan having a length of about 3000 km and width of about 1000 km (Fig 1.2, Fig. 1.3 and Fig. 1.4). This has been formed as a direct result of India-Asia collision and uplift of the Himalayas and Tibetan Plateau (Curray et al. 2003). The Bengal fan has been subjected to intense geophysical investigations by several workers (Hamilton et al. 1974; Liu et al. 1982; Bull J.M. 1990; Cochran and Stove et al.1990; Levchenko O.V. 1992; Curray, 1994; Curray et al. 2003) since nineteen sixties (Fig. 1.5). These studies mainly consist of ship-borne single channel seismic surveys and gravity and magnetic surveys. Seismic data have been collected along the cruise tracks and thickness of sediments has been computed interpreting the seismic data. Isopach maps (maps of constant sediment thickness) have been compiled interpolating the information of sediment thickness available along the cruise tracks onto a rectangular grid. Almost all the work carried out in Bengal fan has been confined to the region up to 6°S of the equator. Further, there are some discrepancies between isopach maps produced by different workers. These discrepancies can mainly be attributed to difficulties in identifying reflection horizons from poor quality single channel seismic charts, due to problems in positioning of the research vessel in the sea

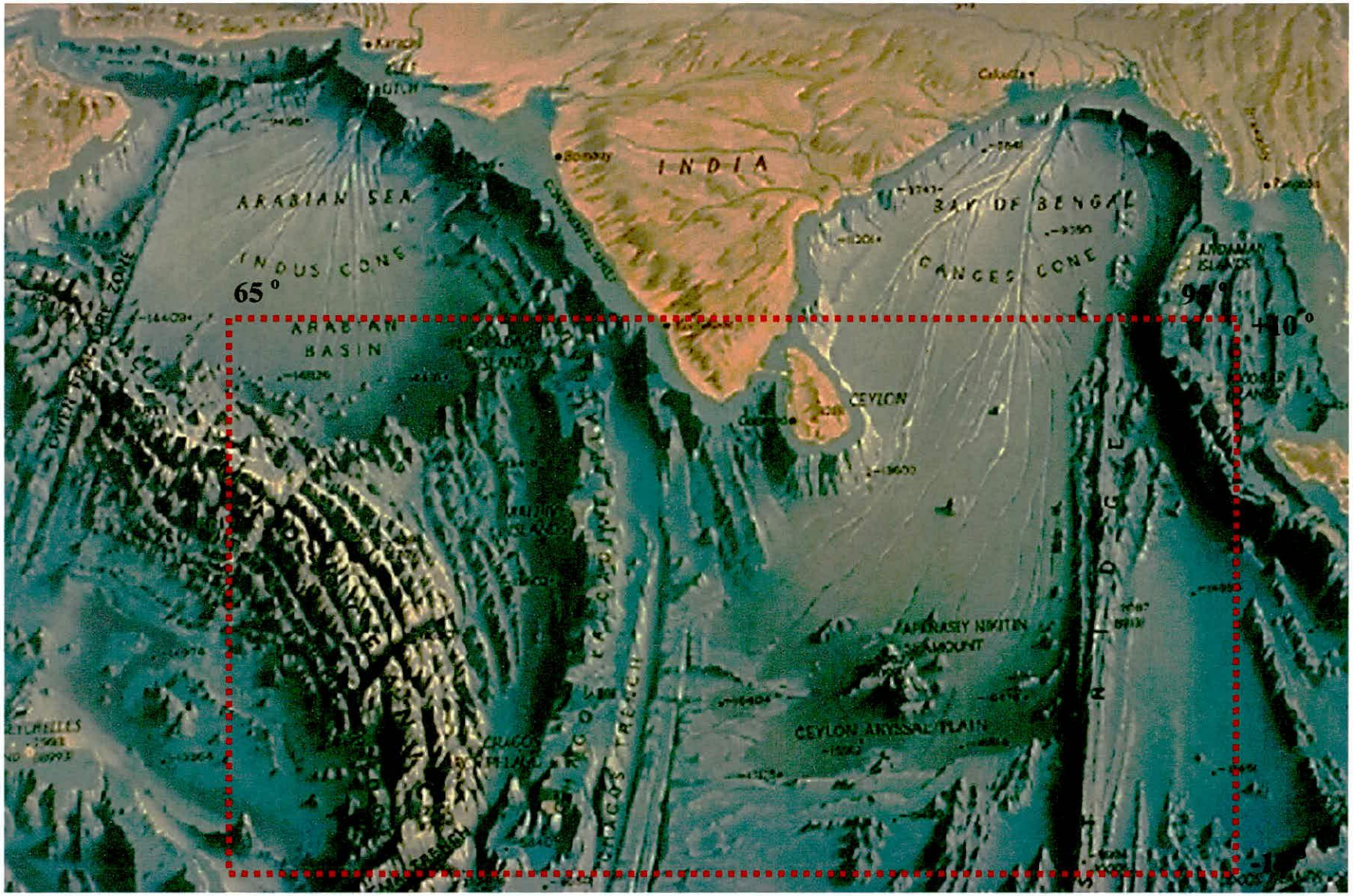

Fig. 1. 1 - Region of the Indian Ocean selected for the gravity study (65°E -95°E, 10°N-10°S)

using techniques that prevailed thirty to forty years ago and several other reasons. However, accumulation of more and more geophysical data and their careful interpretation will help to obtain an improved picture of the submarine fan. It is expected that present study will also contribute towards this end in some way. Further results of this study will provide valuable information that would be useful to delimit the outer edge of continental margin of Sri Lanka according to the United Nations convention of the Law of the Sea.

1.1.3 Bathymetry and Gravity Anomalies over the Indian Ocean Region around Sri Lanka

As shown in Fig. 1.1, Fig. 1.3 and Fig. 1.4 bathymetry of the Indian Ocean around Sri Lanka can be basically divided into two distinct regions. First is the continental margin of Sri Lanka and the second is the deep oceanic region beyond the outer limits of its continental margin. Continental margin of Sri Lanka consists of a very narrow continental shelf, which rarely goes beyond 30 nautical miles from the shore line. Fig. 1.4 indicates that the 200 m isobath around Sri Lanka is situated very close to the island. Usually 200 m isobath is considered as the edge of the continental shelf of Atlantic type of continental margins for which continental margin of Sri Lanka belongs. Then the sea floor goes down with very steep gradients from 200 m to three to four kilometres in a very short distance indicating the end of the continental margin and beginning of the deep ocean. The ocean floor is quite smooth beyond this margin except for perturbations