Interpretation of Gravity Anomalies over the Continental Rise of Sri Lanka

M.M.P.M. Fernando*

Department of Physics, University of Sri Jayewardenepura, Nugegoda, Sri Lanka

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Abstract

Seven profiles of intense negative gravity anomaly over the South Western, Southern and South Eastern parts of the continental rise of Sri Lanka have been interpreted two dimensionally. Results of the interpretation of profiles were interpolated and a map of sediment thickness has been compiled. As revealed by the interpretation and the map compiled there are three noticeable sediment distributions with thickness varying from approximately 2.5 km to 3.5 km. Sediment thickness map in this study closely agree with that compiled using seismic studies by previous workers. Results of this study may have applications in the oil and gas exploration activities over the region.

Keywords: gravity anomaly, sediment thickness, Bay of Bengal, Indian Ocean, Sri Lanka

1. Introduction

One of the most prominent features of the satellite gravity anomaly map of the Indian Ocean around Sri Lanka is the intense negative anomaly situated approximately over the continental rise of Sri Lanka (Figure 1).

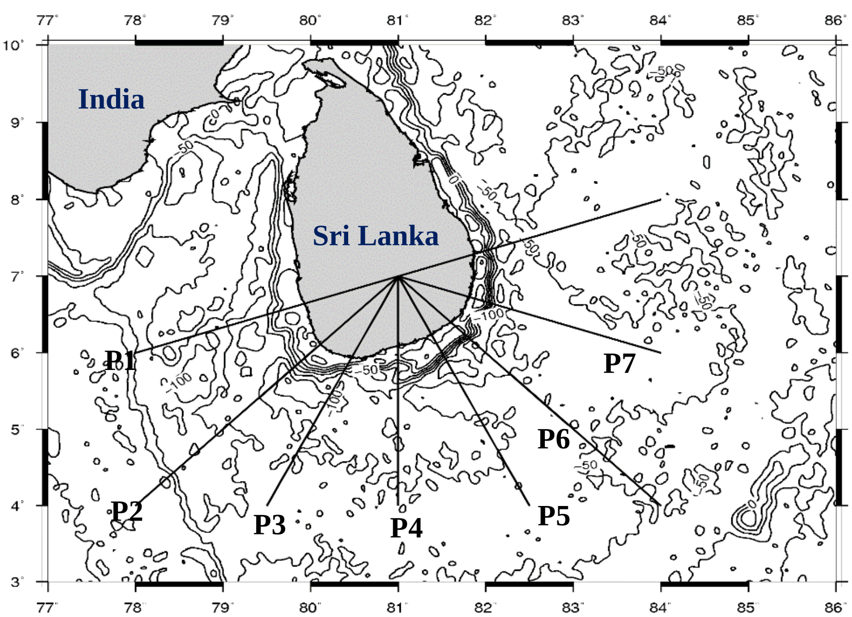

Figure 1. Gravity anomalies over the continental rise of the Sri Lanka (Contours in mGal). Straight lines give the positions of the gravity profiles subjected to interpretation.

*Correspondence: pmadhuranga@sjp.ac.lk
Tel: +94 714478729
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The anomaly, which takes the shape of a crescent, goes down to a minimum value of –70 mGal. Approximate total extent of the anomaly is 2×10^5 km^2. It is suspected that this anomaly is caused due to the sediments accumulated beyond the foot of the continental slope of Sri Lanka (Fernando, 2005; Tantrigoda, 2004). Gravity anomalies have been interpreted to estimate thickness of sediment distribution and a map of sediment thickness has been compiled. This information may be useful in claiming sea area belonging to the Sri Lanka according to the United Nation Convention on the Law of the Sea (United Nation, 1983, 1993, 1999).

2. Materials and Methods

A two dimensional interpretation of seven profiles (Figure 1) of satellite gravity anomalies over the continental rise of Sri Lanka has been carried out using the method of Talwani et al. (1959). In the interpretation it was assumed that the thickness of oceanic crust is 6.0 km and densities of seawater, oceanic sediments, oceanic crust, upper mantle and continental crust are 1,030 k gm^{-3}, 2,100 kg m^{-3}, 2,900 kg m^{-3}, 3,300 kg m^{-3} and 2,840 kg m^{-3} respectively (Woollard, 1959; Bott, 1982). Further, it was also assumed that there is a regional level of -80 mGal over the continental rise of Sri Lanka. The effect of the continental crust beneath Sri Lanka was also considered in the interpretation based on information obtained from Tantrigoda and Geekiyanage (1994, 2008) and Tantrigoda and Fernando (2013).

3. Results and Discussion

A gravity anomaly map and a bathymetry map over the continental rise of Sri Lanka have been given in Figure 2 and Figure 3. Results of the interpretation of profiles P1, P2, …, P7 given in Figure 1 are depicted in Figure 4, Figure 5, and in Figure 6a-f. The gravity profile 01 (P1) goes across Sri Lanka and results of its interpretation have been depicted in Figure 4. Left and right halves of the causative body have been shown separately in Figure 5 to indicate the boundary between oceanic and continental crust more clearly. A map of sediment thickness has been compiled combining the information given in the above figures (Figure 7).

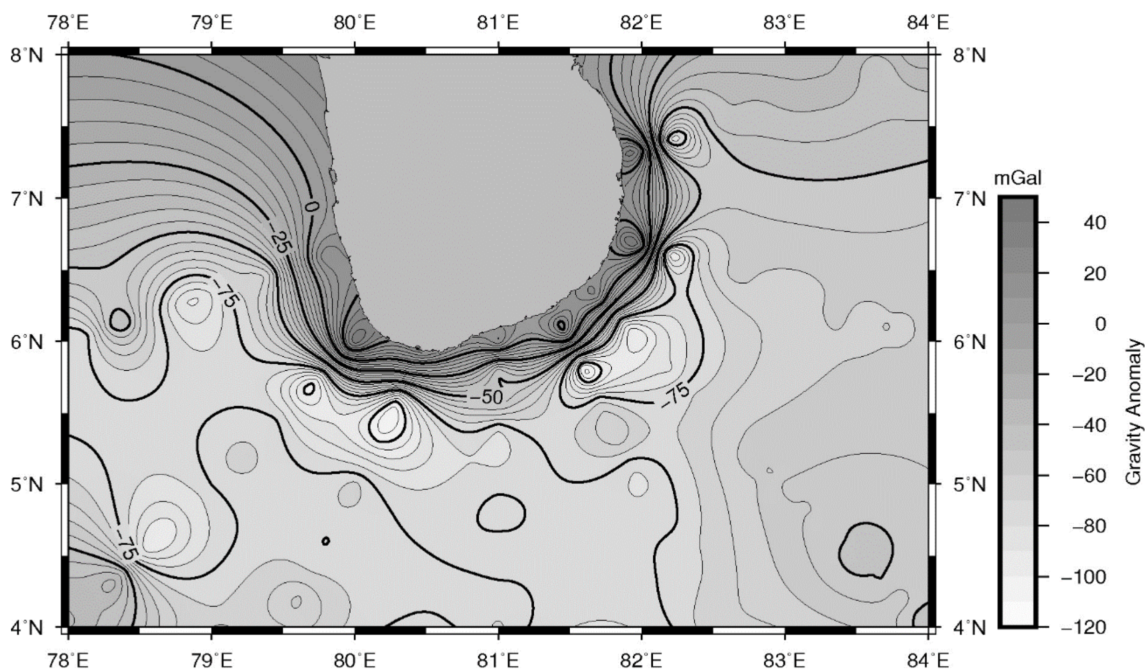


Figure 2. Gravity Anomaly Map over the continental rise of Sri Lanka based on the gravity study (Contours in intervals of 5 mGal).

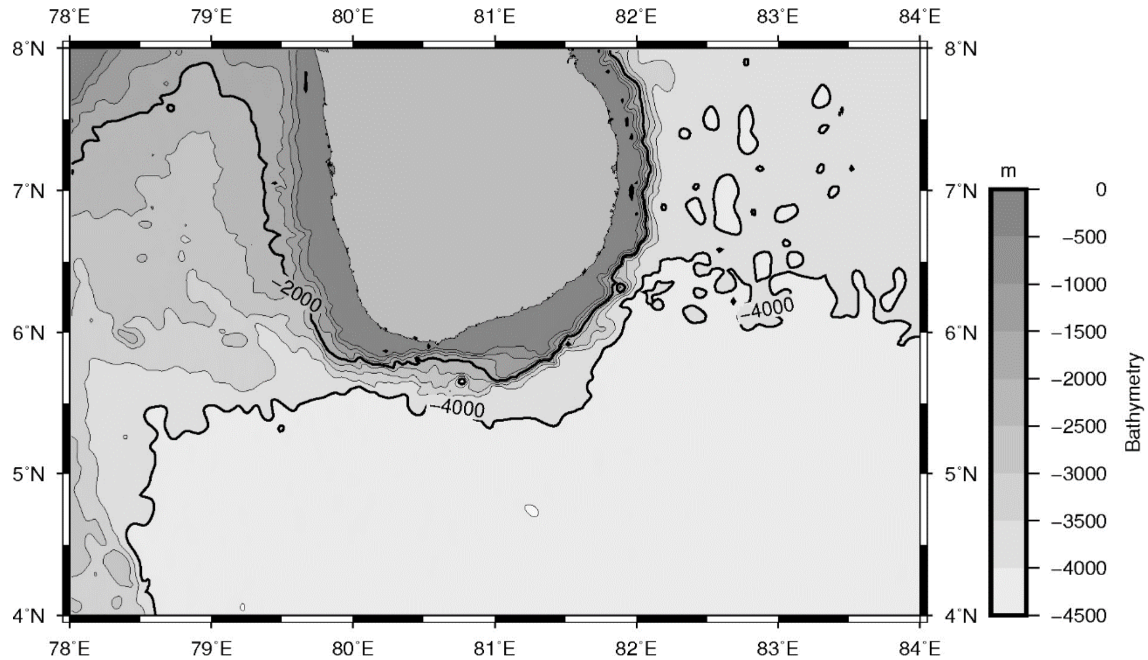
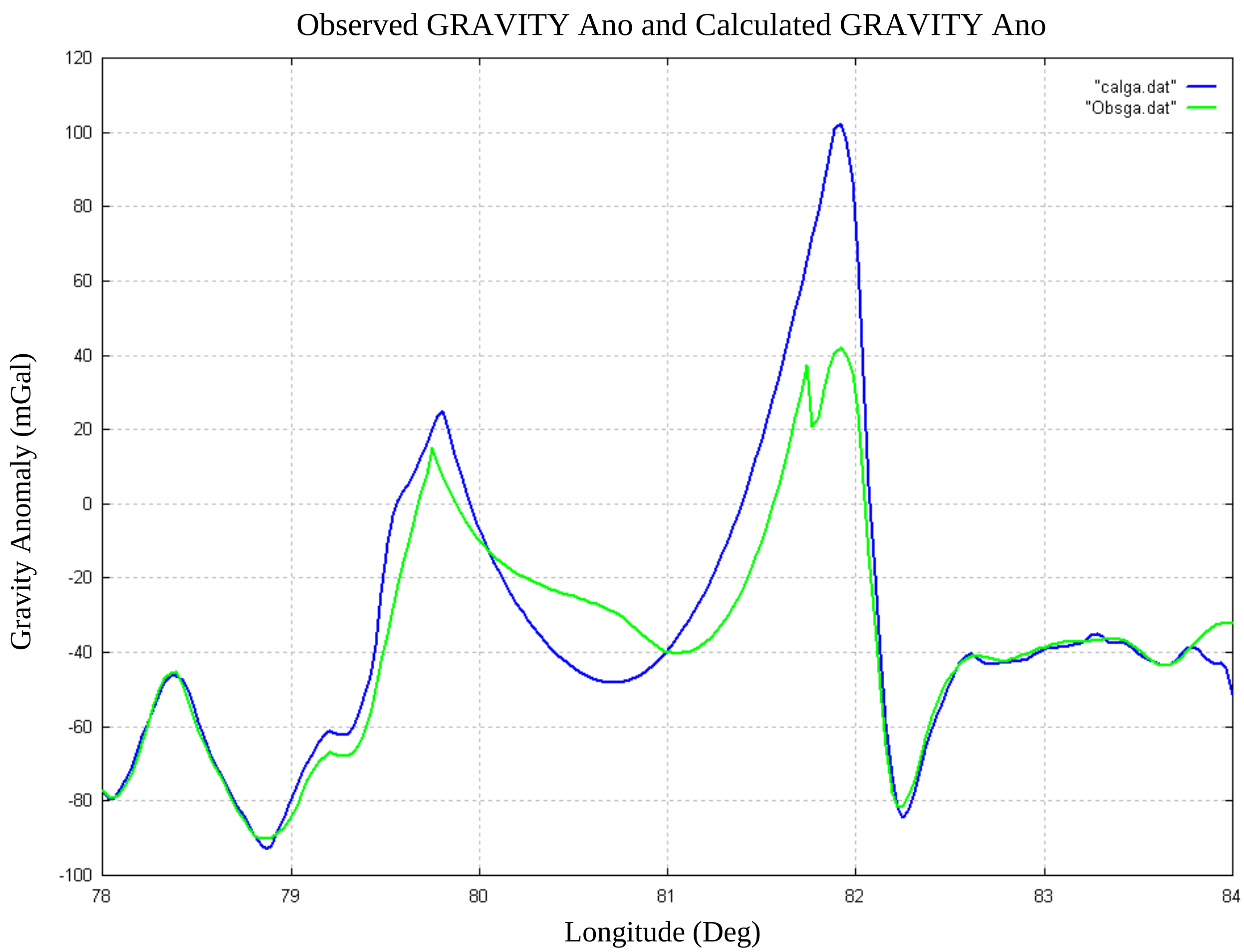


Figure 3. Bathymetry Map over the continental rise of Sri Lanka based on the gravity study (Contours in intervals of 500 m).

An isopach map over the continental rise of Sri Lanka has been compiled using results of two-dimensional interpretation of seven profiles of satellite gravity anomalies. This map closely agrees with the isopach map compiled by Levchenko et al. (1993) based on seismic studies carried out along several lines and interpolating results.

As can be seen in Figure 2, there is an intense negative anomaly adjacent to the positive anomaly over the continent. Positive anomaly over the continent is mainly due to the density contrast between seawater and continental crust of the continental shelf. Negative anomaly is due to the oceanic crust to continental crust transition and also due to replacement of upper mantle material by continental crust. Therefore, negative anomaly observed over the foot of continental slope (Tantrigoda and Fernando, 2005) cannot be explained as a result of sediment accumulation alone. Gravity variation due to change of rock type over the above mentioned boundaries has also needed to be considered.

In case of Profiles P2 and P3 intense negative anomaly discussed above is situated almost over the transition boundary. Therefore, the negative anomaly is mainly due to the density variation over the boundary. In case of profiles P1, P4, P5, P6 and P7 negative anomaly is situated reasonably away from the transition boundary towards the continent. Therefore, both sediment accumulation and density variation over the boundary may have contributed towards it. This explains why sediment thickness is low over the profile P2 and P3 even though gravity anomalies are more negative. Crescent shaped sediment accumulation suggests that the sediments coming down from the Bay of Bengal may have been trapped around the continental rise of Sri Lanka due to 85^{o} East Ridge, which curves towards west around 4^{o} S



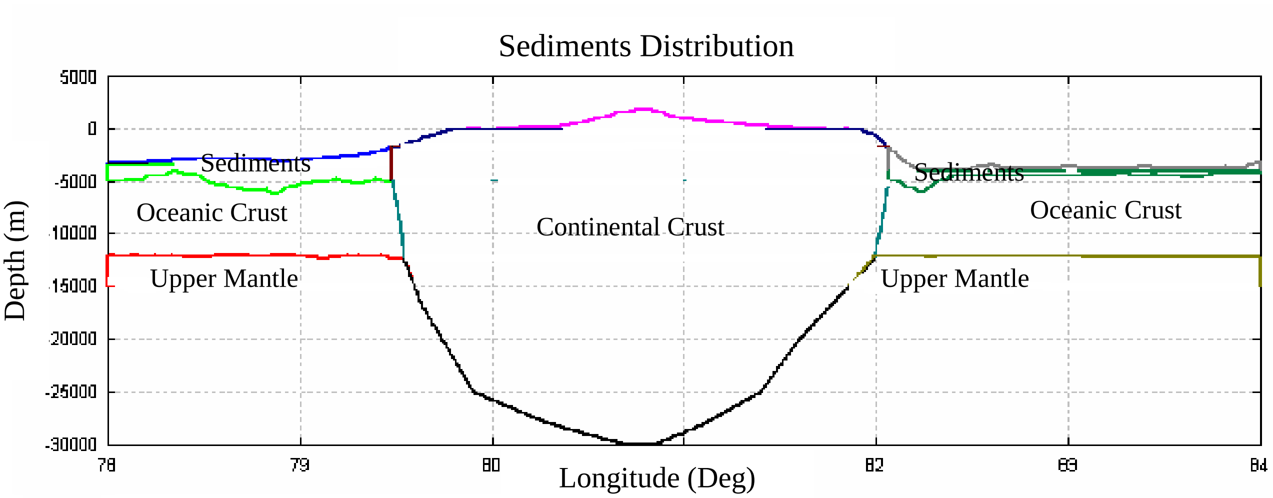


Figure 4. Interpretation of the profile P1 of Figure 1.

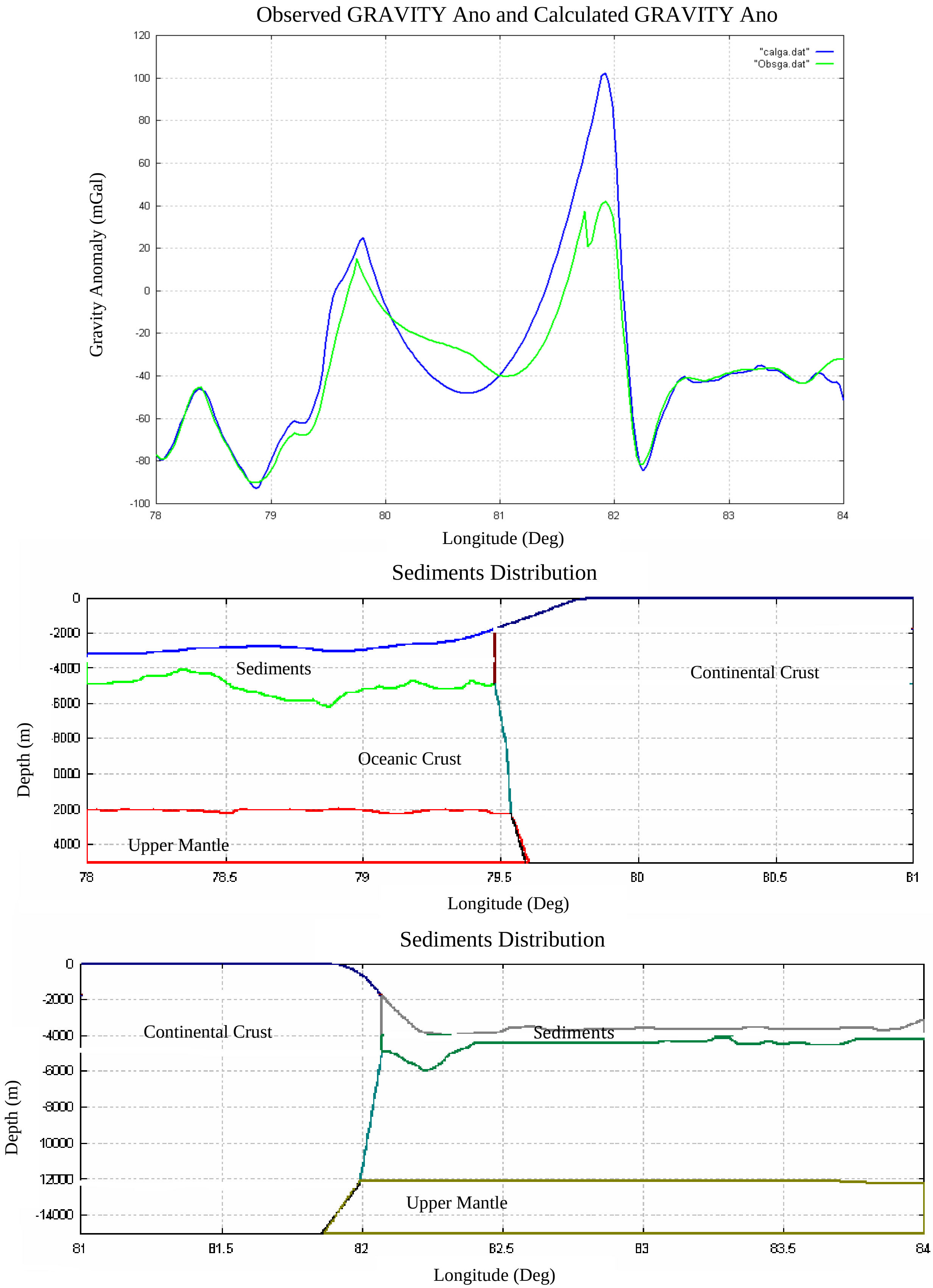


Figure 5. Interpretation of the profile P1 of Figure 1 Contd; (Top: Observed and calculated gravity anomalies; Middle: Left half of the causative body; Bottom: Right half of the causative body).

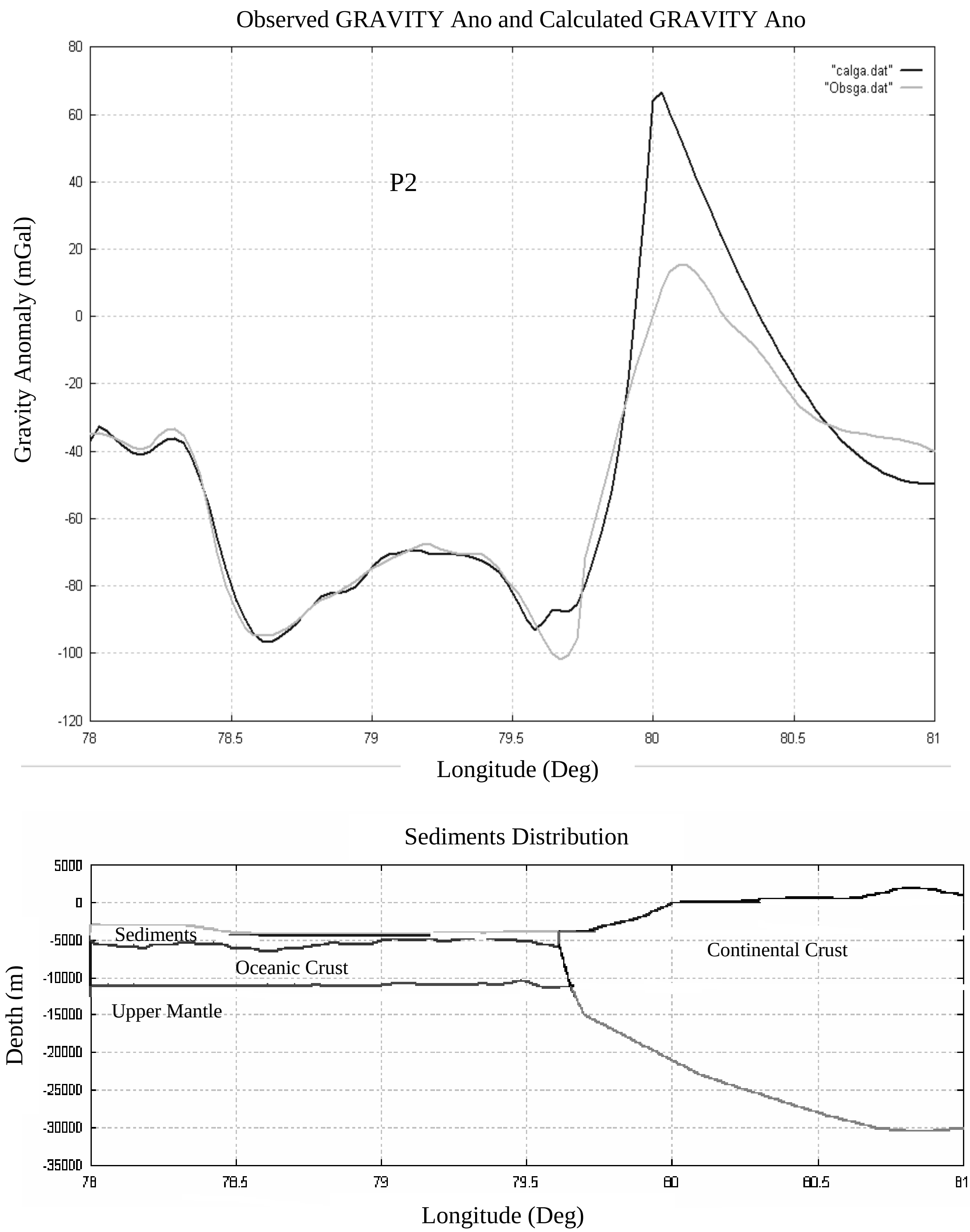


Figure 6a. Interpretation of the profile P2 of Figure 1.

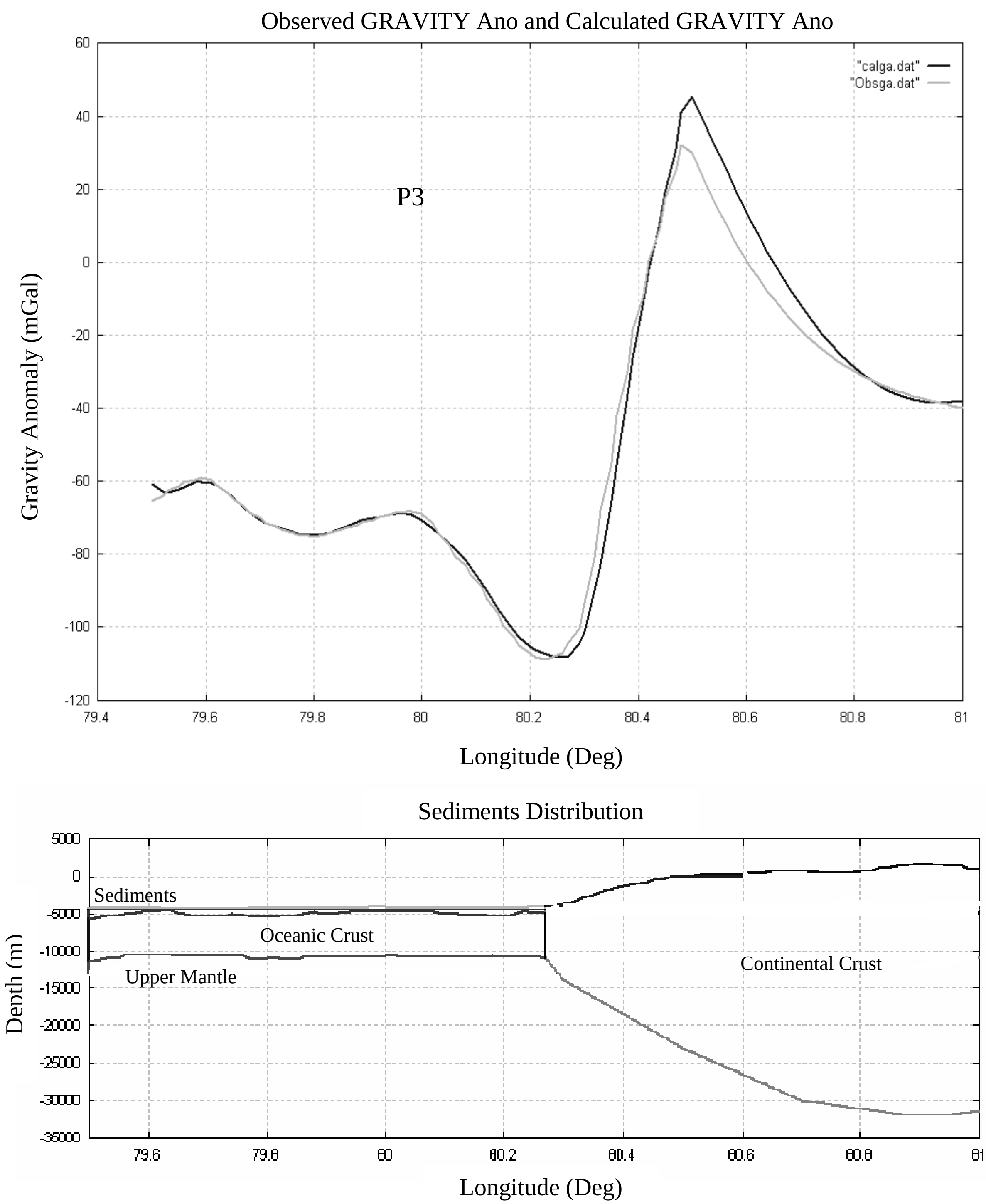


Figure 6b. Interpretation of the profile P3 of Figure 1.

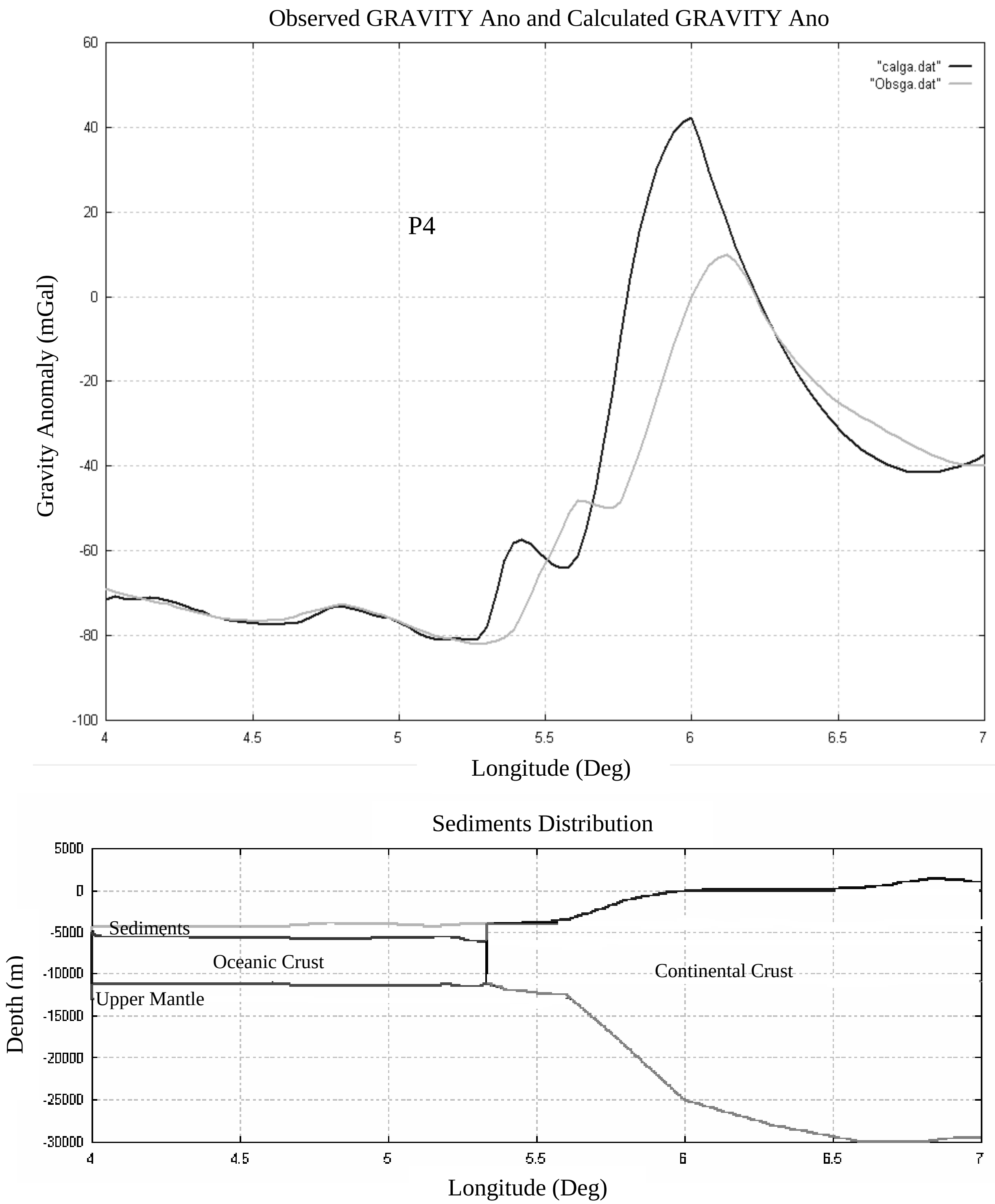
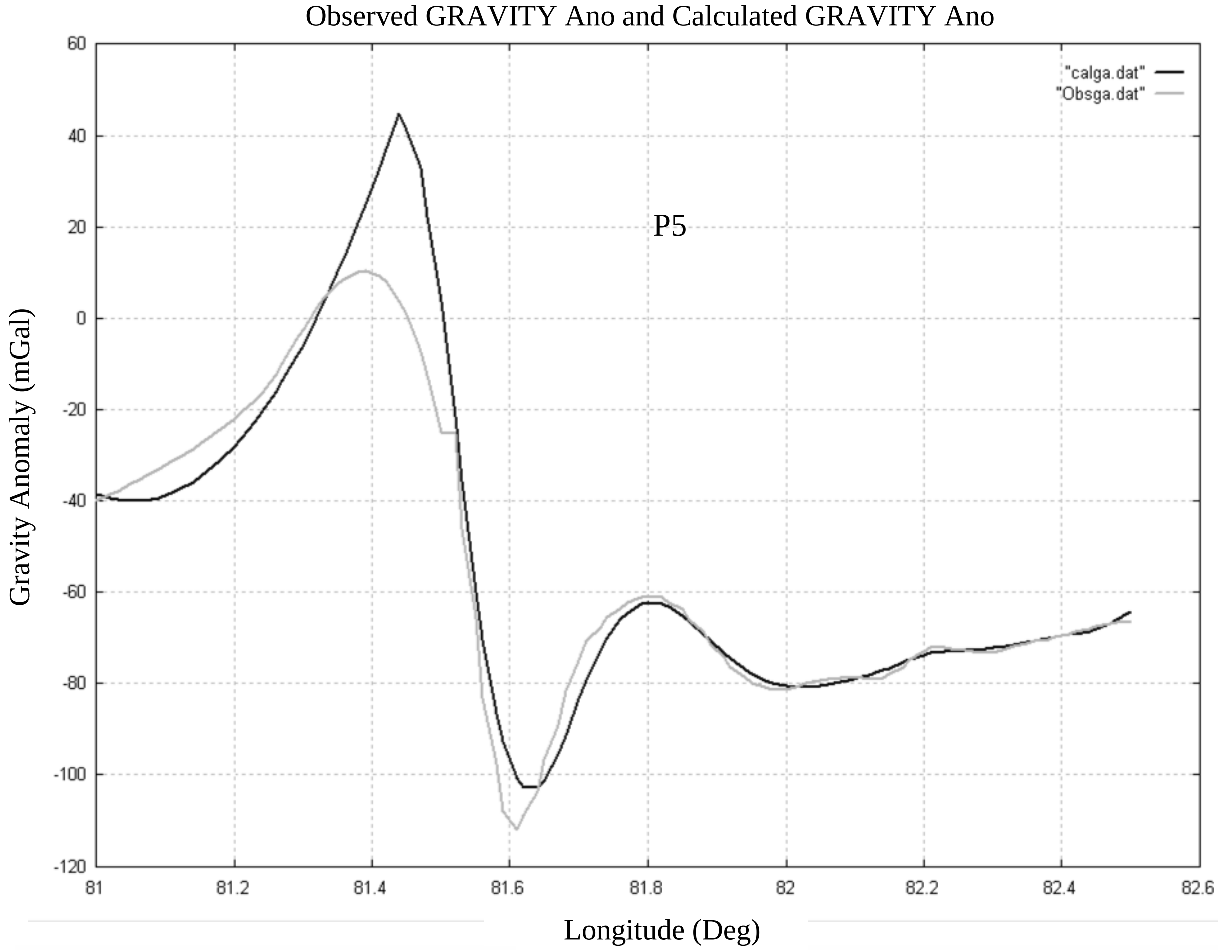


Figure 6c. Interpretation of the profile P4 of Figure 1.



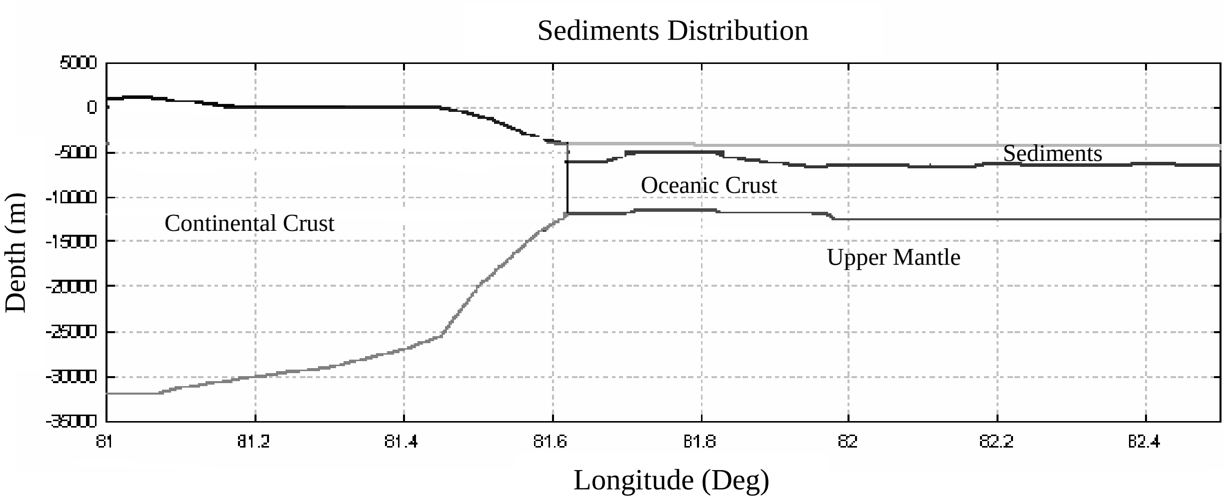
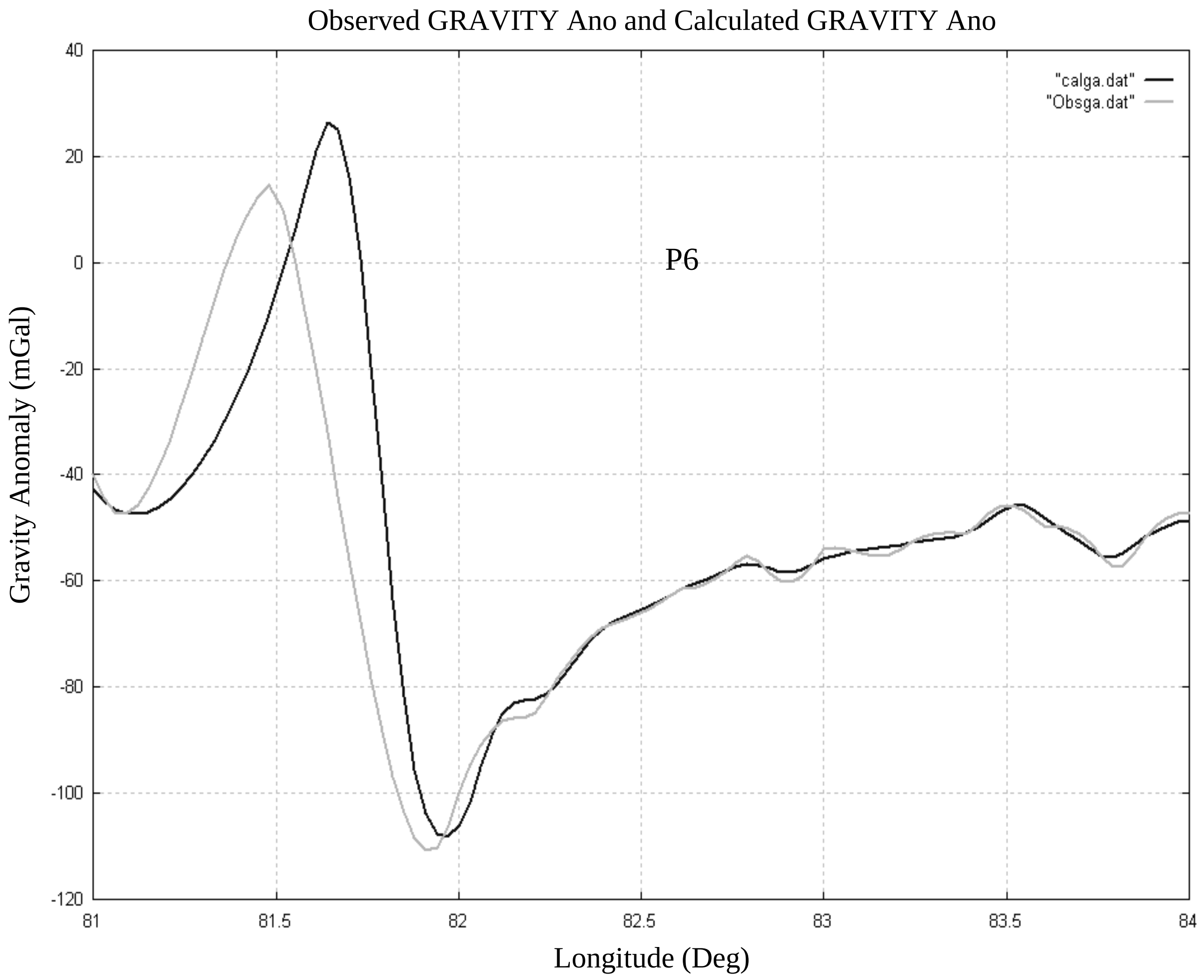


Figure 6d. Interpretation of the profile P5 of Figure 1.



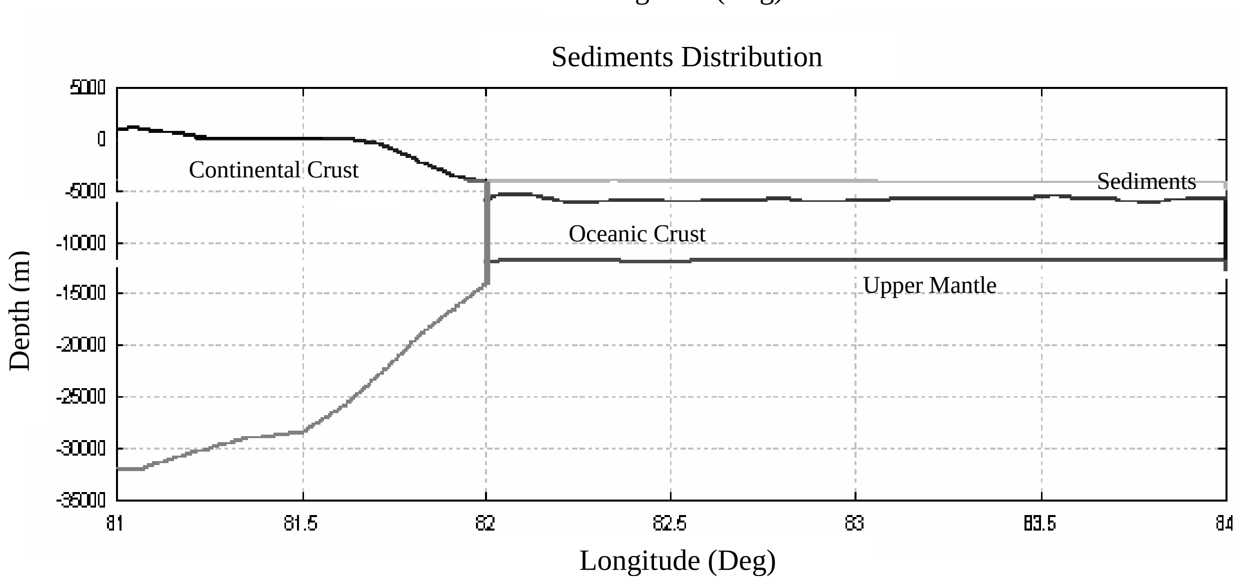


Figure 6e. Interpretation of the profile P6 of Figure 1.

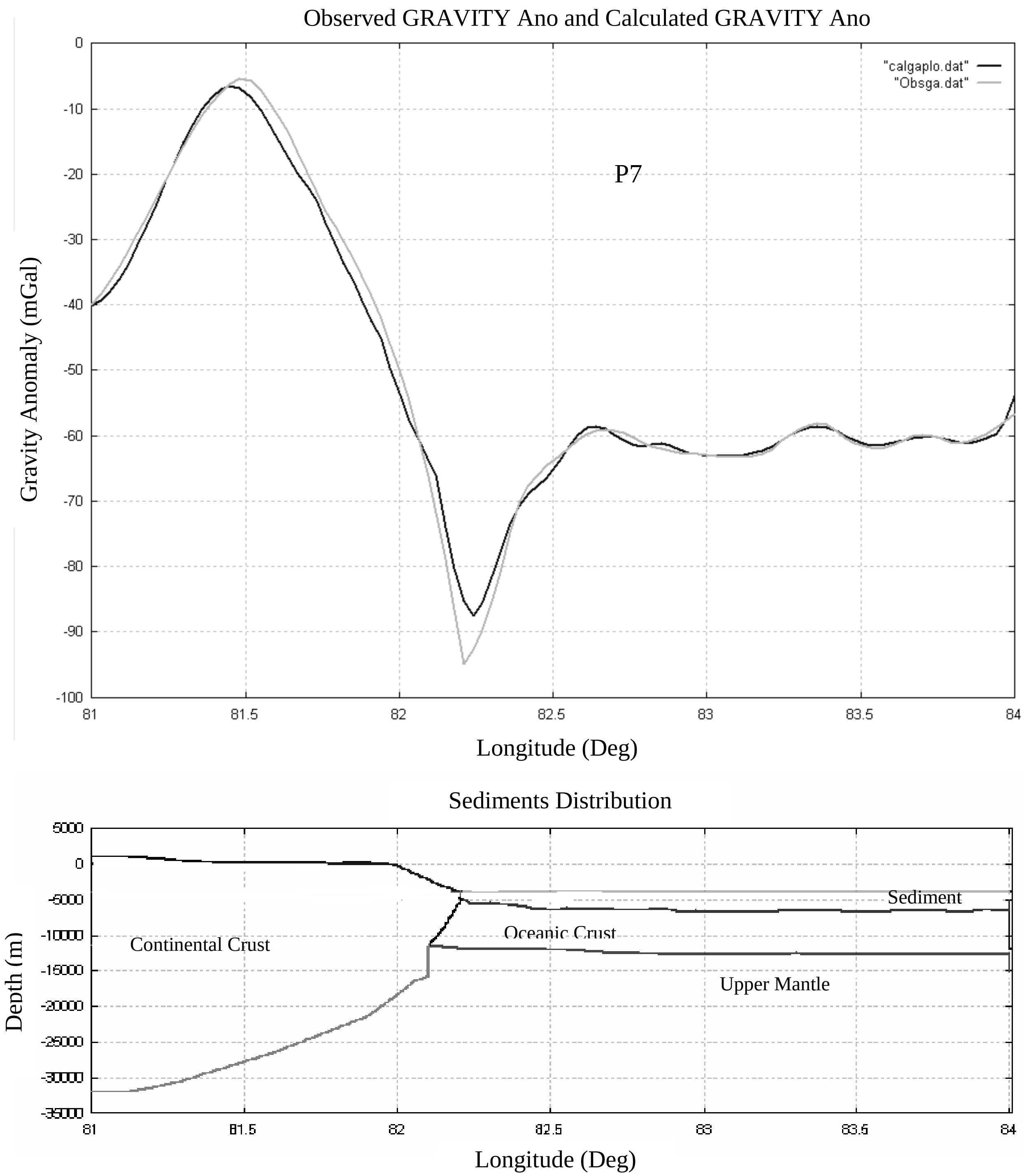


Figure 6f. Interpretation of the profile P7 of Figure 1.

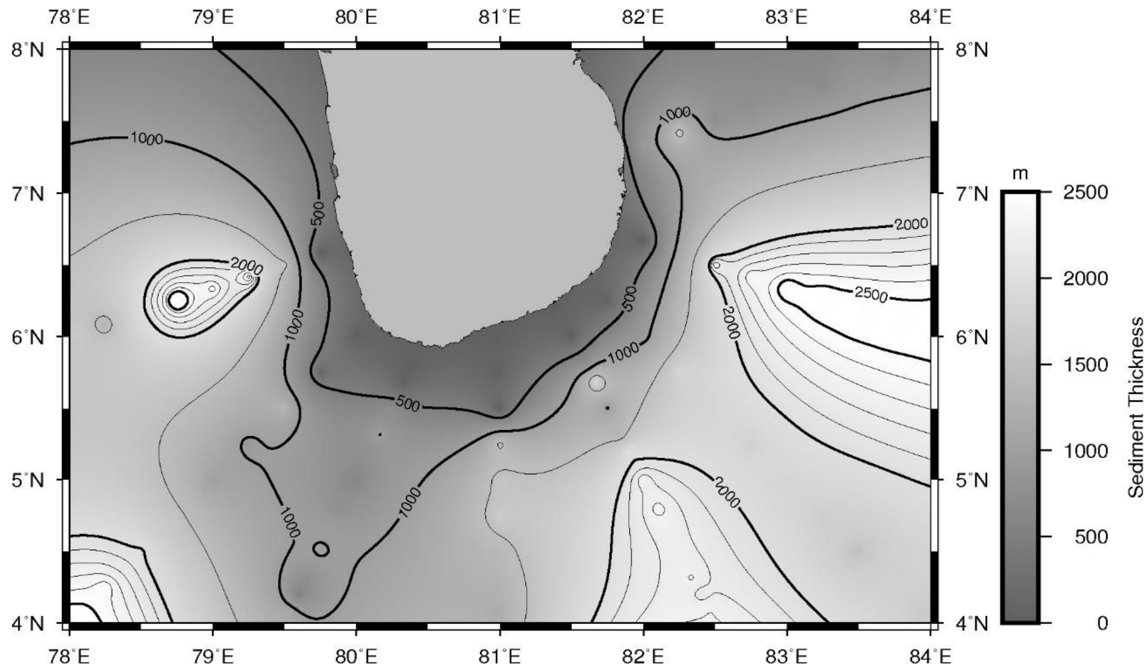


Figure 7. Sediment Thickness map over the continental rise of Sri Lanka based on the gravity study. Contours in intervals of 100 m.

4. Conclusion

It can be concluded from the study that there is a rich distribution sediments over the deep sea region over the just continental of Sri Lanka. Three distinct sedimentary basins can be demarcated in this distribution whose maximum thickness of sediments vary from 2.5 km to 3.5 km fulfilling first requirement for the possible accumulation of hydrocarbon.

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