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Volume, mass of sediments and igneous crustal thickness below the Arabian Basin, northwest Indian Ocean

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ABSTRACT

Evolutionary history of the Arabian Basin has been complex. It has evolved due to complex processes of seafloor spreading and ridge propagation along the paleo Carlsberg Ridge in the early Tertiary under the influence of Reunion hotspot. Although the crystalline crust of the basin is considered similar to a normal oceanic crust, basement depth anomalies are reported in the basin. Above complexity necessitates estimation of sediment and igneous crustal load below the seafloor of the basin in order to provide constraints for the evolution of the basin. In order to do so, ship-borne as well as satellite altimetry derived bathymetry and free-air gravity anomaly data, have been analyzed in the light of available seismic information. The purpose is to investigate spatial distribution of sediment thickness, igneous crustal thickness and depth to the Moho derived from 2D forward gravity modeling as well as 3D gravity inversion. The study shows that northwestern region of the Arabian Basin is carpeted with thick Indus fan sediments (~3.5 km), whereas northeastern flank of the Carlsberg Ridge is covered with a thin veneer of sediments (~500 m). Sediment gravity values are calculated from the parabolic density function obtained from P-wave seismic velocities. The Moho depth in the basin ranges from 9 km near the flanks of the Carlsberg Ridge to 13 km in northern part of the basin filled with thick sediments, whereas igneous crustal thickness varies between 3 km and 8 km. These results can be used as constraints to refine the tectonic evolution of the basin. These results may also be useful for investigating thermal subsidence in the oceanic lithosphere as well as paleo-bathymetry of the basin.

Keywords: Arabian Sea Basin, Sediment thickness, Igneous crustal thickness, Gravity inversion, Gravity modeling, Moho depth.

INTRODUCTION

The Arabian Basin is a triangular basin bounded by various morphological features (Figure 1). To the northwest, it is bounded by the Owen fracture zone which offsets the Carlsberg and Sheba ridges. In the northwards, it is bounded by the Murray Ridge which is considered as an extension of the Owen fracture zone, although it shows a slightly different orientation. To the south-west, it is bounded by the active Carlsberg Ridge which acts as a barrier to the sediments flow and is segmented by a NE-SW oriented fracture zones. To the northeast, the basin is bounded by the aseismic Laxmi and Laccadive ridges. Seabed topography undulations have shown that the bathymetry in the basin varies from ~3.4 km in the north to ~4.4 km in the south. The basin is covered by huge amounts of sediments deposited by the Indus River which shows continuous progradation of the Indus fan southward. Several studies (Naini and Talwani, 1983; Miles and Roest, 1993; Miles et al., 1998; Chaubey et al., 1993, 1995, 1998, 2002a; Dyment, 1998; Royer et al., 2002) have identified well developed sea-floor spreading type magnetic anomalies in the basin and concluded that the basin is underlain by oceanic crust.

There are several studies about the evolutionary history of the basin. It is well established that Arabian and Eastern Somali basins are conjugate basins, created by seafloor spreading along the paleo Carlsberg Ridge in the early Tertiary (McKenzie and Sclater, 1971; Whitmarsh, 1974; Norton and Sclater, 1979; Naini and Talwani, 1983; Chaubey et al.,1993, 1995; Miles and Roest, 1993). More recent research advancements in these basins have accentuated the theory of the evolution of the basins and explained that the evolution was primarily dominated by a complex pattern of spreading-ridge propagation between ~63 and 42 Ma (Dyment, 1998; Chaubey et al., 1998, 2002a; Royer et al., 2002). The systematic episodes of propagation of spreading ridges have resulted in an asymmetric crustal accretion in conjugate basins. Evolutionary episodes of these basins were also affected by two major geodynamic events- movement of Indian plate over Reunion hotspot and the Indo-Eurasian continental collisions.

Indus Fan, which extends from continental shelf off Pakistan in the north to the active Carlsberg Ridge in the south, is the second largest deep-sea fan and one of the largest sediments bodies in modern ocean basins (Kolla and Coumes, 1987). The fan mainly comprises material which got deposited due to erosion from the western Himalaya, Karakoram and Hindu Kush (Clift et al., 2002). Huge amounts of sediments deposited by the Indus River shows continuous progradation of the Indus Fan southward. The sediments, in general, are thicker in the western part of the Arabian Basin than that of eastern part.