Abstract

The evolution and modification of the crust and lithospheric mantle continually provide opportunities to better understand the ongoing geological process of the Earth's outermost structure. India's geological history, spanning around 3 billion years, is characterized by the assembly of ancient cratons such as Dharwar, Bastar, Aravalli, and Singhbhum, through various geological processes. The subcontinent structure evolved significantly with the formation of suture zones and mobile belts in the Proterozoic eon, and later the Pan-African Orogeny reshaped the Southern Granulite Terrain. Key events like the breakup of the Gondwana supercontinent, rifting, mantle plume activities, and the Deccan volcanic eruptions, followed by the Indian plate's collision with Eurasia forming the Himalayas, have all dramatically transformed India's lithospheric landscape. The increasing number of seismic investigations has significantly enhanced our understanding of the Indian crust and lithospheric structure, as well as their diverse characteristics. Controlled source seismic investigations are among the most successful geophysical tools for delineating both deeper and shallow crustal structures. Receiver functions have been extremely successful in unraveling the structure underneath a seismic station. However, seismic stations in the Indian region were predominantly located in the southern peninsula and the Himalayas area. Nonetheless, seismic station spacing remains high in other regions, including central India, the Indo-Gangetic plains, the Eastern Ghats, and other cratons such as Bundelkhand and Bastar, with persistent data gaps. As a result, utilizing potential field methods to characterize the crustal and mantle structure is always a feasible option for bridging data-deficient locations. In the first part of my thesis, we address an integrated view of the Indian crust and lithospheric mantle derived from the combined modeling of sedimentary-corrected topography data, geoid. The

method involves local isostasy with a temperature-dependent density in the lithospheric mantle. The seismic Moho depth data of 440 data points from receiver function (RFs) and Deep seismic sounding (DSS) have been utilized in the modeling procedure. Further, we computed the 3-D regional Bouguer gravity anomaly that is based on the lithospheric structure derived from our combined modeling of geoid and topography data. Consequently, we ascertain the residual gravity anomaly by subtracting the calculated regional field from the measured Bouguer anomaly. The crustal variation in the Indian region mainly varies from 34 to 70 km and generally follows the regional topography variation. The lithosphere-asthenosphere boundary thickness map shows the variation between 140 to 250 km, with maximum values lying along the Indo-Gangetic plain. An average LAB depth of around 170 km is revealed in the southern Indian shield. A modest decrease in LAB depth from eastern to western Dharwar is observed, which may be due to the combined effect of the plume activity and thermo-chemical erosion associated with widespread metasomatism over the period. However, in Western and Central India, a thinner lithosphere is observed, ranging from 140 to 170 km. This is particularly evident along with the Central Indian Tectonic Zone, suggesting linked to subduction-collision dynamics. In contrast, Western India shows signs of a shallower lithosphere and elevated heat flow values, possibly imprinted by the Reunion plume activity. The lithosphere beneath Eastern India, specifically beneath the Eastern Ghats Mobile Belt and Singhbhum, shows a distinct thinning trend with depths varying between 150 and 200 km. This modification can be traced back to India's separation from Australia and Antarctica about 140 million years ago, influenced by plume activities and paleo-subduction events. Additionally, the residual anomaly aligns well with the structural divisions across India's various geological areas, providing information about subsurface structures. Notable observations in residual anomalies reveal low gravity readings in sediment-rich areas such as the Ganga and Godavari basins, while areas with dense rock formations display high gravity, suggesting subduction zones and associated volcanic activities. The initial phase of our study in estimating crustal structure encountered certain constraints, such as relying on assumptions of local isostatic balance and thermal equilibrium, assumptions that may not hold true universally. To address these issues, our study progressed to the second part of the thesis. Here, we constructed a more robust Moho model. This model was developed through meticulous gravity data analysis combined with a comprehensive inversion methodology. Our improvement of the Indian subcontinent's Moho structure was achieved by inverting the EIGEN-6C4 gravity model. This progress is particularly vital for areas with scarce seismological data, enhancing our understanding of continental crustal structures. Our distinctive approach also includes applying a non-linear inversion method. This method not only integrates seismic data but also considers the Earth's curvature by employing tesseroids in the forward modeling process, further enhancing our model's accuracy and relevance. The inversion result shows that the Moho throughout the Indian subcontinent varies from a minimum of 30 km to a maximum of 72 km in depth. The crust is at its thinnest beneath northwest and eastern India. The Cenozoic continental collision between the Eurasian and Indian plates has been ascribed to the presence of the thickest crust, measuring approximately 50–72 km beneath the Himalayas and the Tibetan plateau. Similarly, the thicker Moho is found to be distributed predominantly within the southern India shield, which also exhibits convergence and collision of cratons during the late Archean period. A comparison of the Moho depth from our study and the isostatic Moho model shows a varying buoyancy effect in the upper mantle under the region. The interior of the Tibetan plateau is mostly compensated, but its margins with steep topography are partially under-compensated. On the other hand, the region under southern India and the Indo-Gangetic plain is overcompensated. Most seismic events are observed in areas where the compensation rate amplitude suddenly changes. This observation led us to believe that isostasy may impact seismic activity in the regions.