J. Ind. Geophys. Union, 30(1) (2026), 6-20
https://doi.org/10.71122/JIGU.30(1)2026.002

Crust-mantle seismic structure along Jakhau-Mandvi DSS Profile: A geodynamic perspective

K. Chandrakala* and Prakash Kumar
CSIR- National Geophysical Research Institute, Uppal Road ,
Hyderabad- 500 007, India
*corresponding Author: chndrbhat@gmail.com

ABSTRACT

Kutch rift basin situated in the northwestern part of the Deccan volcanic province, is characterised by sustained intermediate to deep crustal earthquake activity since historical times, unheard in other global stable terrains. This region underwent through several geotectonic, thermal and magmatic episodes in the past, whose signatures are manifested in various forms including the complex and heterogeneous crust-mantle velocity structure. In order to delineate hydrocarbon-rich Mesozoic sediments and underlying basement configuration, seismic refraction and wide-angle reflection data was acquired along the four Deep Seismic Sounding profiles. In the present study, we reprocessed the seismic data along one of these profiles, shot across the southwestern part of the Kutch region, that runs from Jakhau to Mandvi on the west coast. Our study delineated occurrence of a six-layered sequence above the granitic–gneissic basement (Vp: 5.90–6.00 km/s), with their thicknesses varying from 5.5 to 8 km. It includes, Tertiary sediments (Vp: 2.0 km/s), Deccan basalts (Vp: 4.70 km/s), upper low velocity Mesozoic sediments (Vp: 3.3 km/s), Mesozoic limestone (Vp : 5.1 km/s) followed by Mesozoic volcanics (Vp: 5.50 km/s) and another low velocity Mesozoic sediments (Vp: 5.30 km/s). It is underlain by mid-crustal layer (Vp: 6.30-6.40 km/s) located at depths of around 8 to 12.5 km, which is further underlain by a relatively thinner lower crustal layer (Vp: 6.80-6.90 km/s). Below this layer, we also delineated two distinct underplated magmatic layers (Vp: 7.20 -7.50 km/s) above the Moho, characterize by velocity 7.7-8.0 km/s. Moho is delineated at an extremely shallow depths from 25 to 35 km. Conspicuously, we also depicted a frozen mantle magma chamber (Vp: 8.0 km/s), in the uppermost mantle, which coincides with the location of Katrol Hill Fault. It appears that this region has undergone persistent magmatism, massive subcrustal erosion and asthenospheric upwarping.

Keywords: Kutch seismic zone, Mesozoic sediments, Deccan volcanic province, Magmatic underplating, Frozen mantle magma chamber, Crust-mantle seismic velocity structure, Geodynamics.

INTRODUCTION

Precambrian Indian shield has been associated with a number of rifting episodes, continental breakups and multiple plume interactions that have severely modified its crust-mantle structure on a large scale, (Pandey, 2020). It contains several rift valleys, mega shear zones and lineaments, which have remained active since at least Mesoproterozoic period (Rogers and Callahan, 1987). Consequent to such changes, it has been experiencing moderate-to-large intraplate seismic activity since historical times, which is unheard in other global stable regions. GPS and seismological studies have clearly revealed high strain rates over many parts of the Indian terrain (Talwani and Gangopadhyay, 2001; Paul et al., 2001), compared to much lower strain rates elsewhere in other stable continental regions (Johnston, 1994).

Kutch rift region, located in NW part of Indian subcontinent, is one such region, which is seismically quite active and where intermediate to deep crustal earthquakes of varying magnitudes, keep on occurring. Similar events have also been reported from other global rift zones, like Amazonian (Brazil), East African (Africa), Baikal (Russia), Rio Grande (North America), Narmada-Son (India) and Reelfoot (New-Madrid, USA) (Mukherjee, 1942; Mooney et al., 1983; Prodehl et al., 1994; Johnston, 1996; Liu and Zoback, 1997; Singh et al., 1999; Kruger et al., 2002; Wilson et al., 2003; Gao et al., 2004). Nevertheless, the Kutch region remains a unique site of sustained intraplate seismicity for a long time. Rajendran and Rajendran (2001) reported some 15 historical and recent earthquakes of magnitude 5 to 6 that took place in this region earlier. This was also substantiated by paleo-seismological studies, which confirmed such occurrences since 325 BC (Rajendran et al., 2008). In fact, during last couple of hundred years alone, it has witnessed three large earthquakes (besides numerous moderate events) like, 1819 Kachchh (Mw: 7.8), 1956 Anjar (Mw: 6.0) and 2001 Bhuj (Mw: 7.7), the last one causing widespread damage and killed more than 20,000 people (Chung and Gao, 1995; Gupta et al., 2001; Rajendran and Rajendran, 2001; Rajendran et al., 2008; Mandal and Pandey, 2010, 2011; Pandey, 2020).

Geotectonically, this region severely suffered through many tectonic, thermal and magmatic episodes including Deccan volcanism, scars of which are amply manifested in the form of complex and heterogeneous crust-mantle velocity structure, as revealed by seismological and other geological and geophysical studies (Biswas, 1987; Gambos et al., 1995; Kayal et al., 2002; Mandal, 2006, 2007; Mandal and Pujol, 2006; Mandal and Chadha, 2008; Mandal and Pandey, 2010, 2011). In order to delineate Mesozoic sediment thickness, basement configuration and shallow crustal seismic structure, seismic refraction and wide-angle reflections data was acquired along four DSS profiles, (i) Jakhau-Mandvi, (ii) Mandvi-Mundra, (iii) Mundra –Adesar, and (iv) Hamipur-Halvad, by CSIR-National Geophysical Research Institute, Hyderabad (India) during 1996-1997. These profiles trend NW-S, W-E, SW-NE and N-S directions respectively and cut across several geotectonic units of the region.

Prasad et al., (2010) provided basement structure along these profiles, while preliminary seismic-reflection images of the