Tectonophysics 687 (2016) 129–138

Contents lists available at ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

Continental like crust beneath the Andaman Island through joint inversion of receiver function and surface wave from ambient seismic noise

Sandeep Gupta [a,*], Kajaljyoti Borah [b], Gokul Saha [a]

[a] CSIR-National Geophysical Research Institute, Hyderabad - 500007, India
[b] Department of Earth Sciences, Indian Institute of Science Education & Research-Kolkata, Mohanpur - 741246, India

ARTICLE INFO

Article history:
Received 17 May 2016
Received in revised form 7 September 2016
Accepted 9 September 2016
Available online 10 September 2016

Keywords:
Andaman Islands
Crustal structure
Joint inversion
Receiver function
Ambient noise
Continental crust

ABSTRACT

We study shear wave velocity structure of the crust beneath the Andaman Island through joint inversion of the teleseismic receiver function and Rayleigh wave group velocity measurements from 10 broadband seismographs over the Island. The group velocities in the periods from 5 to 21 s are obtained using cross-correlation of six month's ambient seismic noise data recorded by these seismic stations. Joint inversion results show ~2 to 6 km thick subsurface low shear velocity (*Vs* ~ 1.3–2.5 km/s) layer followed by a 12–14 km thick layer of silicic material (average *Vs* ~ 3.5 km/s). The lower crust is mapped as an 8–12 km thick mafic layer with *Vs* ~ 4.0 km/s. Uppermost mantle shear wave velocity is ~4.55 km/s. The near-surface low-velocity layer is interpreted as the Andaman flysch sediments. The crustal thickness beneath the Andaman Island varies from ~24 km in the north to ~32 km in the south. The shear wave velocity-depth results show that the crustal structure beneath the Andaman Island is akin to *continental crust*, possibly the Burma continental crust. The subducting Indian plate may lie down below this overriding plate.

1. Introduction

Understanding the origin and evolution of the continental crust in different tectonic environments is one of the vital, challenging and considerably debatable issues of the Earth Sciences. In general, the formation of the continental crust is considered to be completed in the Precambrian (*e.g.*, Taylor and McLennan, 1995; Condie, 1998). However, few studies advocate for the continental crustal growth during Phanerozoic and, primarily through either by vertical addition of basaltic magmas or by lateral accretion of intra-oceanic/island arc in a subduction environment (*e.g.*, Rudnick, 1995; Clift et al., 2009). While Island arcs are considered to be one of the principal sites of crustal genesis and growth, the available knowledge about the composition and structure of the Island arcs is inadequate for a better understanding of genesis and evolution of the continental crust. With two contrasting average bulk compositions (basalt *vs* andesite), as suggested for the Island arcs, the Island arc model for the growth of continental crust is debatable (Holbrook et al., 1999 and references within).

The Andaman-Nicobar Island arc in the NE Indian Ocean marks the eastern margin of the Indian plate and forms an important transitional tectonic link between the eastern Himalayan syntaxis in the north and Sunda arc in the south (Fig. 1a–b). The knowledge of crustal structure beneath the Andaman-Nicobar Island arc can provide a good contribution towards nature of the crust below an Island arc and its possible role in understanding the evolution of the continental crust.

Hitherto, with the available geological and geophysical studies the nature of the crust beneath the Andaman-Nicobar arc, *e.g.*, oceanic (basaltic bulk composition) or continental (andesitic bulk composition), is a matter of debate. Based on onshore structural and stratigraphic data, Acharyya (2007) advocated for a continental crust below the Andaman-Nicobar arc. While Curray (2005), using reversed seismic sections in the offshore Indo-Burma Range, argued for its oceanic character. Modeling of gravity field data suggested 40–47 km thick upper lithosphere with mainly oceanic crust below the Andaman-Nicobar arc (Radhakrishna et al., 2008). In a recent study, based on modeling of satellite gravity data, local earthquake waveform data and preliminary qualitative interpretation of receiver function, Rao et al. (2011) reported a 30 km thick oceanic double crust. The authors interpreted a double crustal column comprising the overriding Burma plate, having a thickness of about 21 km including a 5 km thick sedimentary layer, and subducting Indian crust with an apparent thickness of about 9 km. Based on the timing of Moho converted *P-to-S* wave in the receiver function, Rao et al. (2011) estimated the crustal thickness variation from 16 km in the north to 20 km in the south Andaman. In absence of any derived seismic velocity model for the region this result,

* Corresponding author.
E-mail addresses: sandeep.ngri@gmail.com, sandeepgupta@ngri.res.in (S. Gupta).

http://dx.doi.org/10.1016/j.tecto.2016.09.013

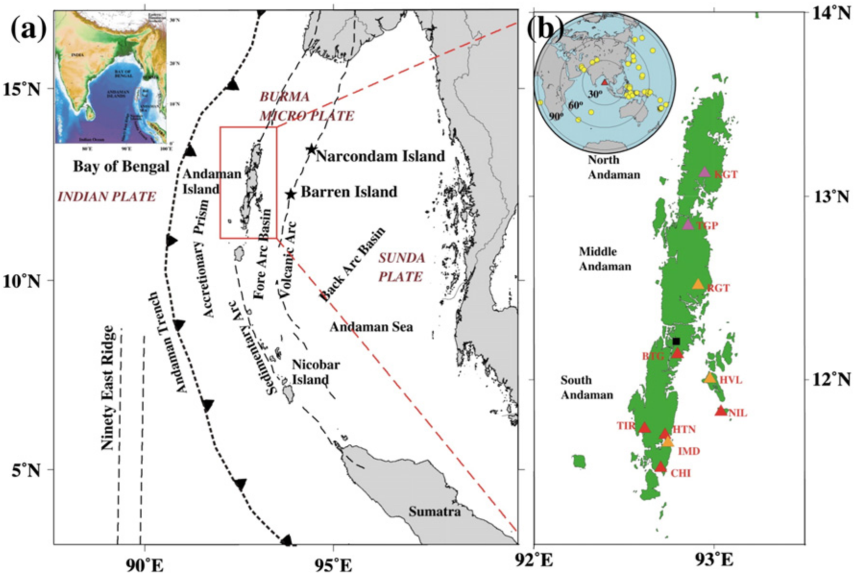

Fig. 1. (a) Simplified regional map of north-east Indian Ocean (modified from Curray, 2005) showing Andaman-Nicobar island arc along with major geological and tectonic features including different basins, arcs, and volcanic islands of Barren and Narcondam. The inset shows the location of Andaman Island (small red box) in Southeast Asia. (b) Simplified map of Andaman Island, divided into north, middle and south Andaman. The seismic stations used in this study are shown as pink (Nov 2003–Feb. 2004; phase 1) and red (Jan–May 2005; phase 2) triangles. The orange triangles show the seismic stations which were operated in both these phases. Inset figure (top left) shows epicenter locations of the earthquakes (yellow circles) which were recorded by seismic stations (red triangle) in Andaman Island and were used for receiver functions calculation. Mud volcano is shown by black square (near BTG station).

however, remains subjective. Therefore, a seismic velocity model is required which can provide constraint in understanding the nature of the crust in this region.

However, being one of the seismically active zones with complex tectonic setting, most of the seismological studies in this region were focused on study of the seismotectonics, nature of faulting and stress distribution pattern for the Andaman arc (*e.g.*, Radhakrishna and Sanu, 2002; Dasgupta et al., 2003; Mishra et al., 2007a; Mishra et al., 2007b; Ghosh and Mishra, 2008; Shapiro et al., 2008; Catherine et al., 2009; Gahalaut et al., 2010; Pesicek et al., 2010; Replumaz et al., 2010; Mishra et al., 2011; Singh et al., 2011). So far, no systematic study related to crustal and upper mantle seismic structure has been carried out particularly for the Andaman Island. In this study, we present the 1-D shear wave velocity model for the crust beneath the Andaman Island through joint inversion of Rayleigh wave group velocity calculated from ambient noise and the teleseismic receiver functions calculated at broadband seismographs operated at the best available sites in this inhospitable terrain. The obtained crustal structure is further used to know the possible nature of the crust beneath this arc and its possible implications in understanding the growth of a continental crust.

2. Tectonic setting

The Andaman-Nicobar Islands (ANI) are subaerial expressions of Andaman-Nicobar arc. In the regional tectonic framework, Andaman-Nicobar Islands form a part of the Burma-Sunda-Java double chain arc system, which is composed of inner igneous arc (towards east) and outer sedimentary Island arc (towards west). The inner arc connects the Cretaceous orogenic ranges of the Burma and Sumatra; and passes through Narcondam Island (NaI), Barren Island (BaI) (Fig. 1). The Andaman-Nicobar Islands are exposed tectono-stratigraphic units of the accretionary prism in the outer sedimentary Island arc. These Islands might have formed in Oligocene or late Eocene (~35 Ma) through subduction, which is presumed to have started in lower Cretaceous (Scotese et al., 1988; Curray, 2005). The Indian plate is obliquely subducting along the Andaman Trench and beneath the Burma micro plate; which is a northward moving sliver plate and is often considered a “break off” part of the large Eurasian plate due to oblique convergence (Curray, 2005; McCaffrey, 2009). Along with the northern tip of Sumatra, the Andaman-Nicobar Islands are located on the Burma micro plate. Along the arc, the age and thickness of the subducted crust as well as convergence rate increase from Andaman towards Java (Lay et al., 2005). This change is manifested in the increasing dip and depth of the Wadati-Benioff zone (Guzman-Speziale and Ni, 1996). Based on the geographical setting, the Andaman Island is divided into three segments: north, middle and south Andaman. The detailed tectonic framework and geology of the region have been reviewed by various researchers (*e.g.*, Guzman-Speziale and Ni, 1996; Curray, 2005; Lay et al., 2005; Acharyya, 2007; Kamesh Raju et al., 2012 and reference within).

3. Data and methodology

The data used in the present study was recorded by 10 broadband seismic stations (triangles in the right panel of Fig. 1) operated in two different phases. In phase 1 (November 2003 to February 2004), we deployed 5 stations (pink and orange triangles in the right panel of Fig. 1). Subsequently, in phase 2 (Jan to May 2005), we operated 8 seismic stations (red and orange triangles in Fig. 1b) including reoccupation of 3 sites of phase 1 (orange triangle in Fig. 1). The station's configuration included Guralp CMG-3T sensors with a flat velocity response between 0.008 and 50 Hz and REFTEK 130-01 data loggers. Data were continuously recorded at 50 samples per second along with the corresponding GPS time.

Using this data, we constructed shear wave velocity variation with depth through joint inversion of Rayleigh wave group velocity (from Green's function) and the teleseismic receiver function. We briefly describe the approaches followed by us in this study.

3.1. Green's function computation

Green's function between two recording stations is extracted through cross-correlation of ambient noise recorded simultaneously at these recording locations. Theoretical works (*e.g.*, Weaver and Lobkis, 2001; Snieder, 2004; Larose et al., 2005) demonstrated that if the sources of the ambient noise were evenly distributed and recorded by