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Myanmar-Andaman-Sumatra Subduction Margin Revisited: Insights of Arc-Specific Deformations

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ABSTRACT: We address the role of the concave and convex arcs (as observed from the subducting plate) on the deformation occurring along the Myanmar-Andaman-Sumatra margin. We categorize the pre- and post-seismic deformations of the lithosphere using earthquake database occurring either prior to 26th December 2004 M_w 9.3 off-Sumatra mega-event or after the incidence. Analysis under pre-seismic domain shows that area near Sumatra records highest seismicity, which largely drops in the area past the North Andaman, and further increases towards north. Shallowest depth and minimum dip of the subducting lithosphere is recorded at the central segment where the arc transformed into concave shape. The annual moment energy release during earthquake decreases to more than two orders of magnitude past the North Andaman towards north under post-seismic deformation phase. Higher depths of continuity of events are presumably associated with more dipping Benioff zones in both the Indo-Myanmar and Andaman-Nicobar convex arcs. These observations obviously account for tectonic subdivision of the margin near concave shape arc around the central part. Absence of volcanism, presence of splay faults in the back-arc, sharp reduction in seismicity near central segment are interpreted to be caused by major tectonic impact of the NNE-ward converging buoyant Ninety-east Ridge against the Asian Plate. Shallowest dip, small elastic thickness, weak converging Indian lithosphere, and evidences of series of en-echelon blocks off the eastern side of the broken northern Ninety-east Ridge might be incapable of generating great earthquake in this area.
KEY WORDS: Myanmar-Andaman-Sumatra margin, double arc, Ninety-east Ridge, buoyancy.

0 INTRODUCTION

The Mayanmar-Andaman-Sumatra subduction margin, concerning of the present study, extends over ~3 000 km with a lateral dimension of ~200 km (Fig. 1). It is apparently a transitional tectonic domain between the zones of frontal subduction of the Indian Plate below the Himalayan orogen and the Australian Plate below the Sunda arc (Dasgupta et al., 2003; McCaffrey et al., 2000; Maung, 1987; Le Dain et al., 1984). Sharp changes in convergence rate and increasing slab-pull force along Sunda-Java margin since ~44 Ma allowed counter clockwise rotation of the Indian Plate with respect to Asia (Patriat and Achache, 1984). Late Tertiary clockwise rotation of western Yunnan, Indo-China, North Malaysia and southern Sumatra margin and counter-clockwise rotation of South Malaysia and northern Sumatra (Hall, 1997; Holt and Haines, 1993; Holt et al., 1991; Ninkovich, 1976), growth in sedimentation of the 3 000×100 km^2 deep-sea area of Bengal fan (Curray and Moore, 1971), renewed convergence of the Indian Plate and subsequent northward shearing along the Chaman and Sagaing faults concomitant with east-west compression (Yin, 2006; Patriat and Achache, 1984) and coeval development of evenly spaced undulation near the foothills of the Himalayas (Dasgupta et al., 1987; Valdiya, 1976; Rao, 1973; Sastri et al., 1971), double-arc formation along the Mayanmar-Andaman-Sumatra margin (Maung, 1987), clockwise rotation and indentation of the northern part of the Ninety-east Ridge against Sunda margin (Curray et al., 1982), intraplate deformation of the central Indian Basin were proposed to be linked genetically with major tectonic events in the collision between India and Asia (Levchenko, 1989; Weissel et al., 1980).

Under the backdrop of such regional and margin tectonics, the repeated occurrences of great earthquakes towards north and south of the Myanmar-Andaman-Sumatra margin in general and the incidences of 2004 off-Sumatra mega-event in particular motivates us to delineate the geometry of the descending Indian oceanic lithosphere along this margin (Fig. 1). Issues like arc-controlled rupture characteristics, tsunami generation, co- and post-seismic deformation, etc. noted during 2004 event were apparently resolved through different studies (Khan, 2011, 2007; Khan and Chakraborty, 2009; Sibuet et al., 2007; Ammon et al., 2005; Ishii et al., 2005; Lay et al., 2005). It was reported elsewhere (Khan and Chakraborty, 2009, 2005 and references therein) that the processes underpinning the occurrences of great earthquakes along subduction margins are normally understood in terms of dip and age of subducting

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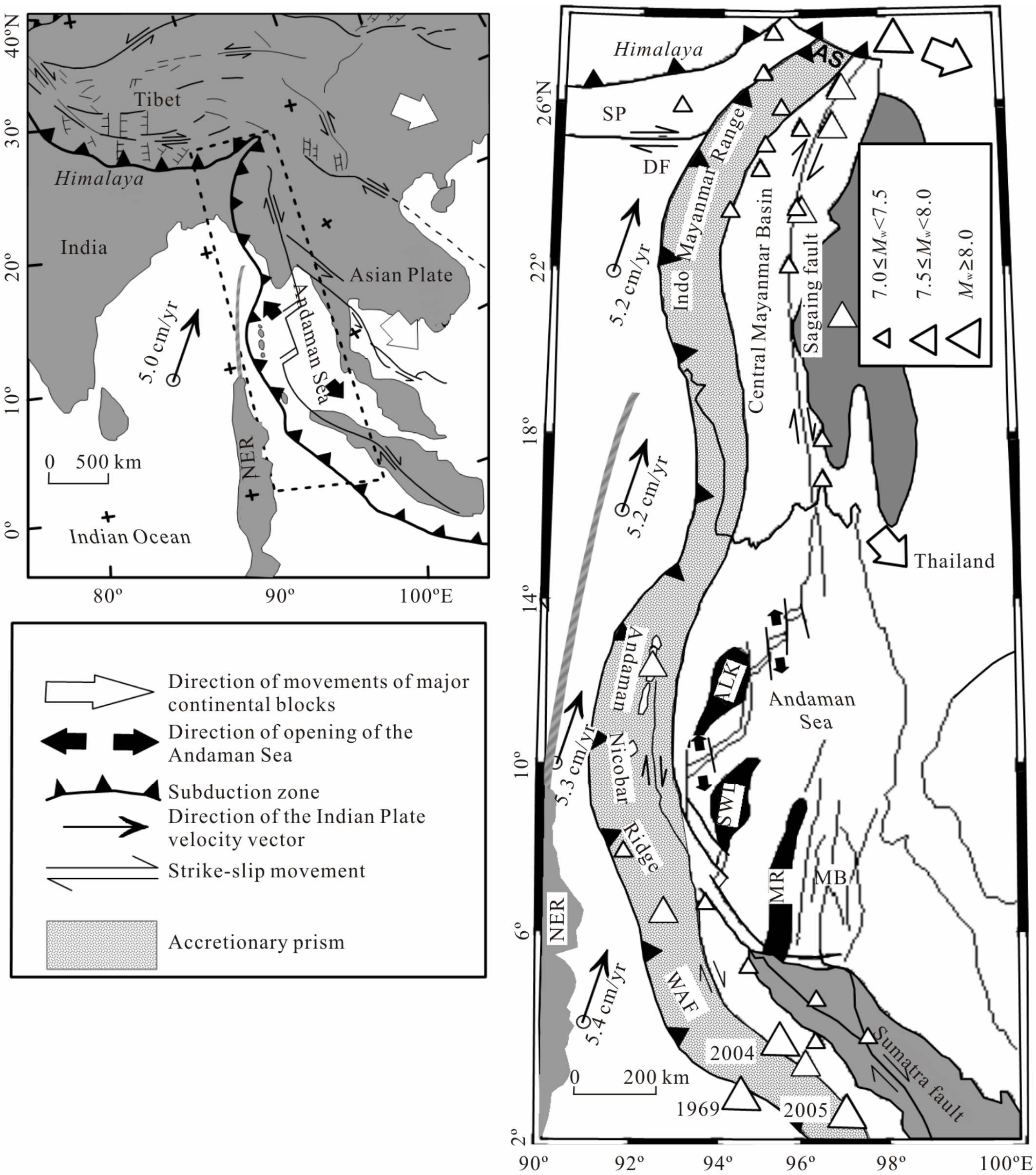

Figure 1. Map on the right showing various physiographic and tectonic features around the Myanmar-Andaman-Sumatra subduction margin (after Curray, 2005). The dashed block on the left map (after Tapponnier et al., 1982) represents the study area. Left bottom solid arrow indicates Indian Plate velocity vector and right top open arrow shows major block motion with respect to Siberia since the Miocene. Open triangles represent the significant historical earthquakes of three different magnitudes. NNE-SSW oriented Ninety-east Ridge (NER) is likely buried beneath sediments of the Bengal fan beyond ~10°N. Note the preferential incidences of mega-events near Sumatra and Myanmar arcs. Also note the absence of any great historical earthquake in the central part of the arc. ALK. Alcock; AS. Assam syntaxis; DF. Dauki fault; MB. Mergui Basin; MR. Mergui Ridge; NER. Ninety-east Ridge; SP. Shillong Plateau; SWL. Sewell; WAF: West Andaman fault.

plate, plate obliquity, subduction rate, etc. Ben-Menahem et al. (1974), Jarrard (1986), Newcomb and McCann (1987), McCaffrey et al. (2000), Dasgupta et al. (2003) and many others interpreted the earthquake rupture propagation and the changes in seismicity along subduction margin in terms of plate converging velocity, age of the subducting plate, dip of the Benioff zones, nature of crust of the upper plate, respectively. This article aims to understand the genetic linkages between the tectonic segmentation of the Myanmar-Andaman-Sumatra subduction margin and the energy release and deformation along this belt using earthquake database. An assessment of continuity of earthquake events, and the dip-angle of the subducting Indian Plate provides us valuable information comparable to the Andean margin (Gutscher et al., 1999).

1 TECTONIC AND KINEMATIC FRAMEWORK

Internal deformation and crowding of a number of oceanic and continental sub-plates at the leading edge of the indenting Indian subcontinent framed the complex Cenozoic tectonics of Southeast Asia (Hall, 2002, 1996; Tapponnier et al., 1986; Mitchell, 1981; Fitch, 1972). Although the subduction process was started along the western Sunda arc following the break-up of Gondwanaland during Early Cretaceous (Scotese et al., 1988), other associated tectonic processes were operative either continuously or intermittently from the Cretaceous onwards (Chakraborty and Khan, 2009; Pal et al., 2003). Mayanmar and India were juxtaposed at the end of Eocene times (Mitchell, 1985). Later in Middle Miocene, the dextral displacement along the Sagaing fault and spreading of the Andaman Sea accelerated the separation of the Mayanmar Plate from Northwest Sumatra through evolution of a double arc from a single arc (Hall, 2002; Maung, 1987). Since then, the subduction history from south to north along this Myanmar-Andaman-Sumatra arc changed significantly (Maung, 1987). During the Late Miocene, northward oblique convergence of the trench-hanging Indian lithosphere through mantle led to the sequential opening of the Mergui Basin, Andaman Sea and Central Myanmar Basin from south to north along this margin (Khan, 2005; Khan and Chakraborty, 2005). It was appreciated in the literatures (Curray, 2005; Khan, 2005; Khan and Chakraborty, 2005; Replumaz and Tapponnier, 2003) that the widely varying plate convergence obliquity, plate-dip-angle and subduction rate forced the opening of such basins, and obliquity were partially accommodated by strike-slip movements along Sagaing fault, Semangko fault, West Andaman fault, Kabaw fault, etc. (cf., Diament et al., 1992; Mitchell and McKerrow, 1975). The north-south running transcurrent Sagaing fault, separating the Shan Plateau from the central trough, died out in the Andaman Sea, and incidentally the Semangko fault, bounding the Sliver Plate towards south, reappeared and continued into the Mentawai fault system (Diament et al., 1992; McCaffrey, 1991).

Studies show an increase in plate convergence obliquity exceeds its critical limit (20°±5°, McCaffrey, 1992) between 2°N and 4°N latitudes from south (Khan and Chakraborty, 2005). Youngest age for the subducting oceanic crust (~47 Ma) in the Northwest Sumatra increases towards north from ~67 Ma near the North Andaman to ~120 Ma around the northern Mayanmar regions (Müller et al., 1997). The NNE-SSW oriented Ninetyeast Ridge, extending from 34°S to 18°N along the meridian, disappeared in form of buried anticlinal uplift of the oceanic basaltic basement under sediments of the Bengal fan beyond 10°N (Michael and Krishna, 2011; Levchenko et al., 2010; Subrahmanyam et al., 2008; Krishna et al., 1999; Gopala Rao et al., 1997; Curray et al., 1982), and beneath which it converges upon the Andaman arc (Kumar et al., 2013; Franke et al., 2008; Subrahmanyam et al., 2008). The active interaction of this ridge against the North Andaman margin slowed down the rupture speed and reduced the slip during the incidence of 2004 off-Sumatra mega-event (Gahalaut et al., 2010). Other significant features are the Middle Tertiary evolution of splayed left-lateral transcurrent faults (e.g., Wang Chao fault, Three Pagodas fault) and the absence of volcanism in the back-arc area of the central segment of this margin apparently observed by Curray et al. (1979), Le Dain et al. (1984) and Tapponnier et al. (1986).

2 PRE- AND POST-SEISMIC DEFORMATIONS

We investigate the pre- and post-seismic deformations of the lithosphere using earthquake database occurring prior to 26th December 2004 M_w 9.3 off-Sumatra mega-event and subsequent this mega-event. The earthquake data with magnitude $m_b \geq 3.0$ (Fig. 2) were taken from US Geological Survey for the period between 1976 and 2013. The mega-event ruptured ~1 200 to 1 300 km of the curved plate boundary between Sumatra and North Andaman releasing 4.3×10^{18} J strain energy, and displaced ~30 km^3 of seawater, generating a massive tsunami that travelled to the Antarctic, the east and west coasts of the Americas, and even upto the Arctic Ocean (Bilham, 2005; Lay et al., 2005). In line with these evidences, the entire dataset have been divided into two categories, (i) the first one covers the period between January 1, 1976 and December 26, 2004 as pre-seismic events (Fig. 3), and (ii) the second one from December 26, 2004 to December 31, 2013 as post-seismic event (Fig. 4).

We first analyze the latitudinal distribution of seismic energy release under both pre- (Fig. 3) and post- (Fig. 4) seismic domains. There are various ways in which energy can be calculated for a certain earthquake. They are mainly divided into two types: the static estimate, which can be calculated from moment and stress drop values and the dynamic estimate is calculated from seismogram. We have used the dynamic estimation method

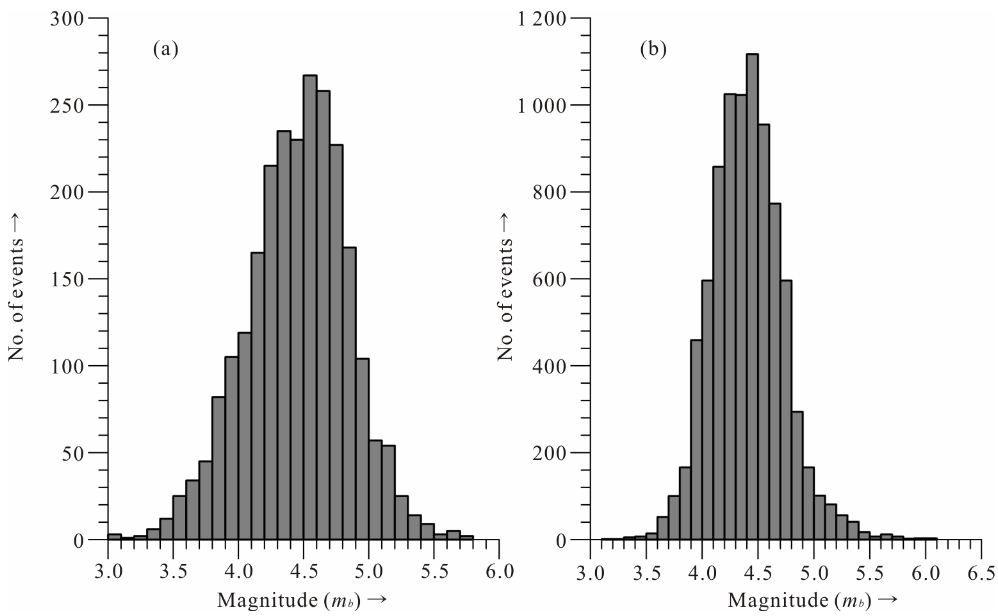

Figure 2. Histogram plots illustrating the frequency of magnitude variations for pre-event (a) and post-event (b) occurred along the margin during 1976–2013.

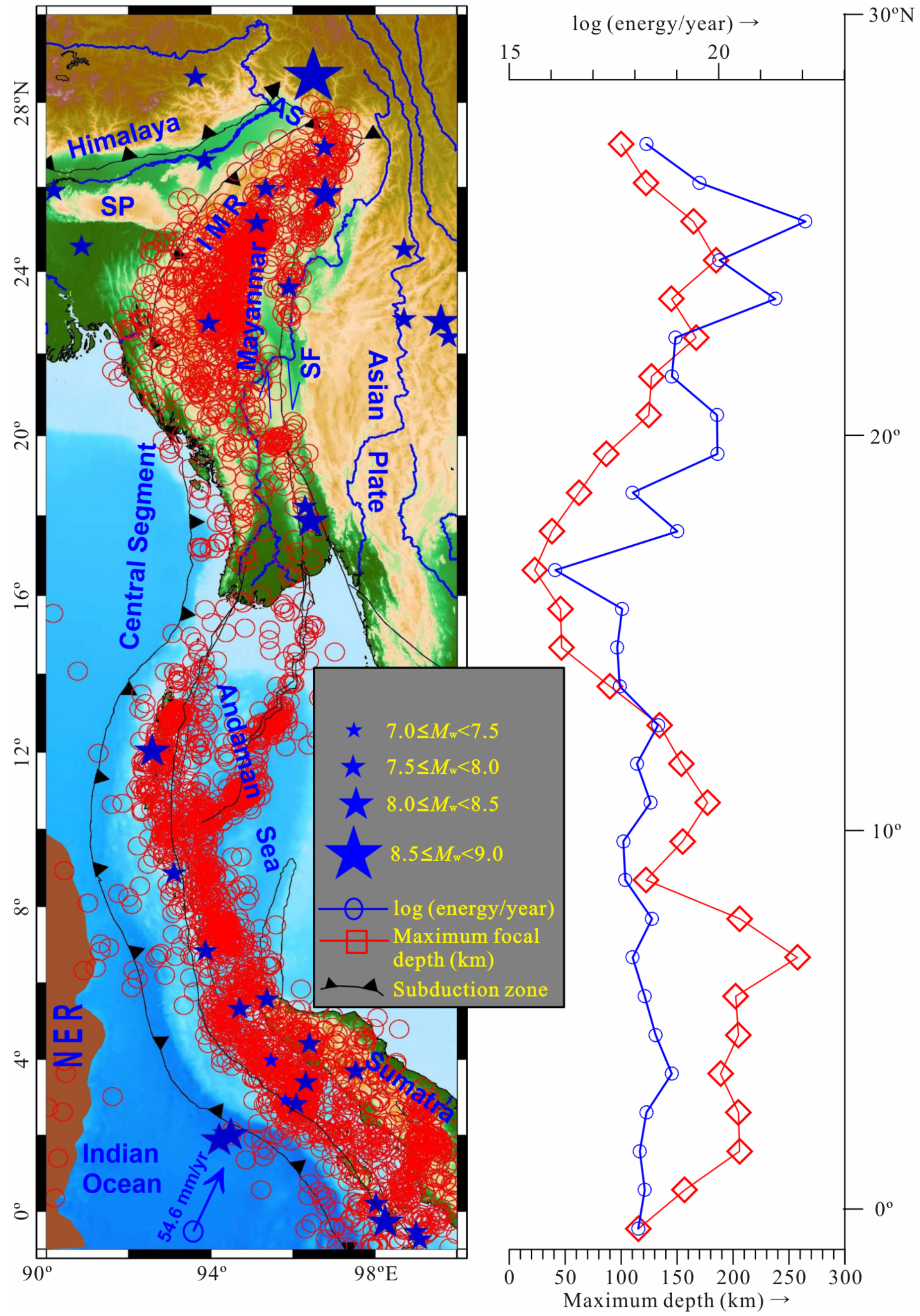

Figure 3. Map on the left showing the distribution of seismicity (red open circle) prior to the occurrence of 26th December 2004 off-Sumatra mega-event; blue solid line on the right plot showing the variation of average annual energy release from each degree of latitude during the period between 1st January, 1976 and 26th December, 2004, and red solid line showing the variation of maximum depth of continuity of event with latitude. Note the shallowest depth, minimum energy release recorded near the central segment, and the incidences of great earthquake around the Sumatra and northern Myanmar areas. Minimum concentration of seismicity and absence of moderate to great earthquakes are also apparent around the central segment of the margin. IMR. Indo-Myanmar Range; SF. Sagaing fault. Other terms are explained in the caption of Fig. 1.

of Gutenberg and Richter (1942) for calculating the energy release (Eq. 1). This dynamic estimate method is in reasonable agreement with the energy calculated from static energy estimate method of Vassiliou and Kanamori (1982). Body wave magnitude range of $3.0 \le m_b \le 6.1$ (cf. magnitudes of both the pre- and post-events are not more than 6.1, Fig. 2) is considered in the estimation of energy release instead of using surface wave magnitude (Ms) as deep and intermediate events may not excite enough surface wave, and also similar body wave magnitude range is used for energy calculation elsewhere (Hofstetter and Shapira, 2000).

$$\log_{10}E=5.8+2.4m_b \quad (1)$$

where E is the energy in ergs. The earthquake data are separated for every one degree latitude, and the estimated energy is converted to annual energy release (Figs. 3 and 4). It can be observed that the energy release is maximum at latitude around 25°N of the entire northern arc, and invariably follows the

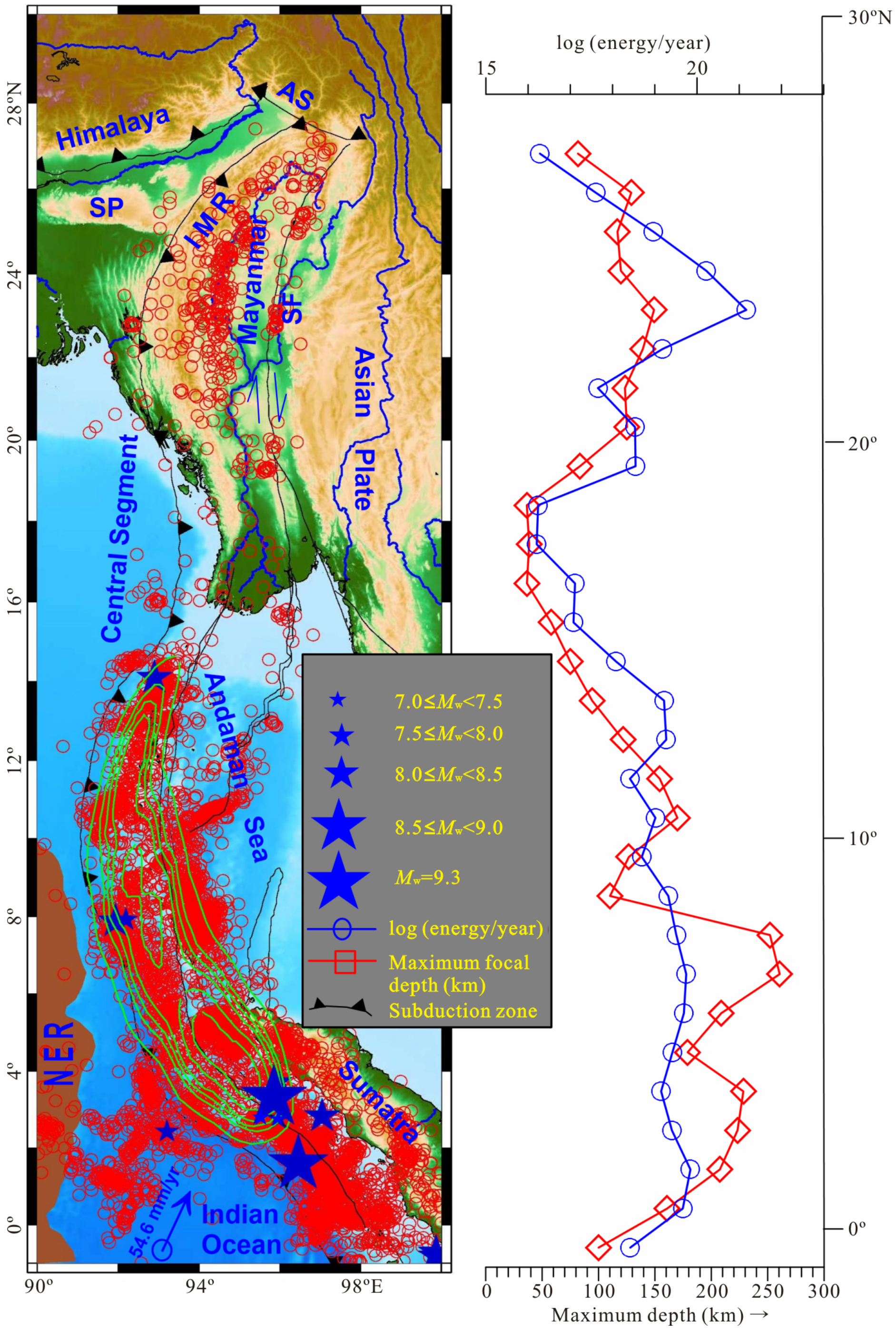

Figure 4. Map on the left showing the distribution of seismicity (red open circle) after the occurrence of 26th December 2004 off-Sumatra mega-event; blue solid line on the right plot showing the variation of average annual energy release from each degree of latitude during the period between 27th December, 2004 and 31th December, 2013, and red solid line showing the variation of maximum depth of continuity of event with latitude. Note the shallowest depth and minimum energy release recorded near the central segment of the arc. Incidences of moderate to great earthquakes following the 2004 mega-event is also noticed around the Sumatra region.

curvature of the arc under both pre- and post-seismic deformation. However, energy release is more or less uniform in southern arc, and the minimum release of energy is significant to be noted near the central segment of the arc.

The seismicity distributions in the northern arc are more or less similar with respect to the location of the trench under both the deformation domains. Further, events are continued into the deeper part of the converging lithosphere. In the south near Andaman-Sumatra arc, the major trend of seismicity is located away from the trench-axis. While the seismicity has been largely shifted towards the trench under post-seismic deformation. Another interesting feature is the incidences of great historic earthquake events preferentially confined in the northern and southern segments of the entire arc with prominent deficit of such events in the central segment. The seismic energy contour plot for the 2004 mega-event (Fig. 4) also shows their north-south extension is confined right within the southern arc between 2°N and 15°N. The main energy bursts occurred at the southern end after 80 s since the initiation of rupturing and another energy burst took place near Car Nicobar 300 s later (~9°N) (Fig. 3 of Ishii et al., 2005) clearly accounts for arc-controlled tectonics.

3 SUBDUCTING INDIAN PLATE GEOMETRY

Figure 5 illustrates the distributions of historical earthquakes in the underriding Indian and overriding Asian plates along the Myanmar-Andaman-Sumatra subduction margin (reconstructed after Khan, 2005; Khan and Chakraborty, 2005). The earthquake data were taken from the International Seismological Center (ISC) catalogue covering the period from 1964 to 2004. The earthquake data with body wave magnitude m_b=4.0 and above occurring over a lateral dimension of ~200 km from latitude 0° to 28°N, and recorded at 12 or more stations were considered for reconstruction of the seismicity map (Fig. 5). These datasets were used earlier by Khan (2005) and Khan and Chakraborty (2005) for explaining the Late Tertiary opening of Andaman Sea and episodic development of Myanmar, and those provided valuable new information about this margin. Based on the seismicity distribution and the plate obliquity, the entire margin was divided into 10 sectors (Sec-1-10, Fig. 5), and the Benioff Zone trajectories (trench-hanging Indian lithosphere, Fig. 6) in all the sectors were reconstructed. The seismicity in the underriding plate (Fig. 5) follows the trend of the trench keeping a clear gap at its central part. While the seismicity in the overriding plate (Fig. 5) follows the trend of the transcurrent Semangko and Sagaing faults in the south and north, and continue through Andaman spreading centre in the middle. Thus, the along-strike variations of seismicity in both the underriding and overriding plates are not similar, rather the two trends deviate sharply between ~10°N and 20°N, and becomes maximum at latitude ~15°N. The more closure distributions of seismicity distinctly noted in the depth-section plots (Fig. 6) at its southern and northern segments might be indicative of more couplings active between the descending Indian oceanic lithosphere and the overriding Asian land-mass.

A literature review for Benioff zone trajectory reconstruction from hypocentral distribution of earthquake reveals that the procedures have inherent inconsistency. The actual trend of Benioff zone trajectory can either be estimated assuming the best fit of the slab upper surface (Christova, 2004; Ruff and Kanamori, 1983; Furlong et al., 1982; Cardwell and Isacks, 1978) or down through the hypocentral distribution (Khan, 2005; Khan and Chakraborty, 2005; Luyendyk, 1970; Isacks and Molnar, 1969). Arguably, based on eye-estimation, smooth curves drawn as best fits through the hypocentres could serve as reasonable proxies in such cases and followed here to configure the trajectories. Owing to the major concentration of seismicity and flexing depth of the subducting Indian Plate, the dipping angles of the slabs were estimated along the trend of the Benioff zone upto 110 km depth in all the 10 sectors (Figs. 5–7). Model reveals that the dip of the slab near Sumatra is shallow, and increases sharply past the Sumatra, and becomes

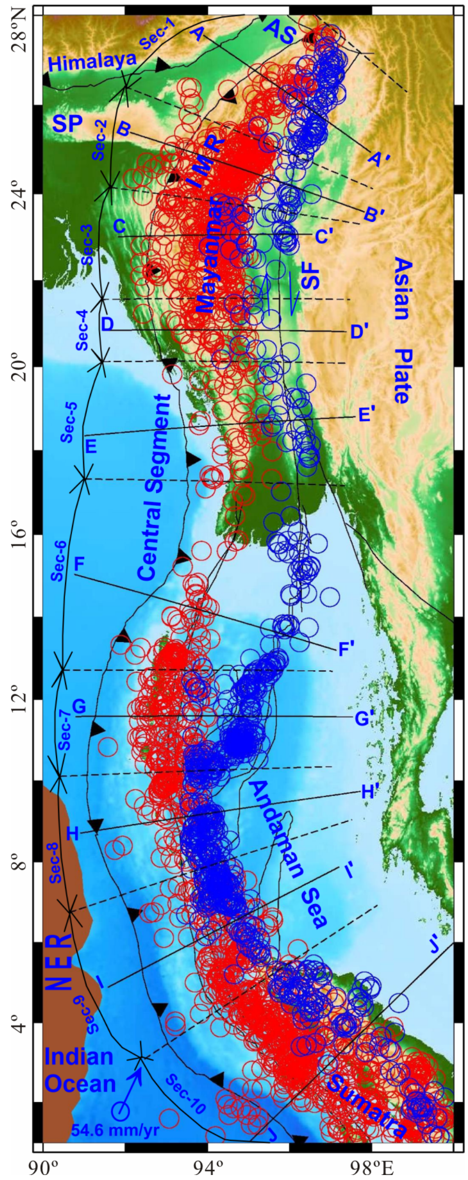

Figure 5. Maps showing the distribution of seismicity in both underriding (red open circle) and overriding (blue open circle) plates in different sectors (Sec. 1–Sec. 10) along the margin. Note the minimum concentration of seismicity recorded around the central segment of the margin.

maximum at 14°N near the North Andaman. Suddenly, a sharp decrease in plate-dip is conspicuous farther towards north between the North Andaman and South Myanmar. The dip of the slab further gradually increases and follows similar trend to that of Sumatra. The dip of the slab in the central segment between latitude ~15°N and 20°N is the shallowest corroborating the fault orientations identified by Dasgupta et al. (2003). Ninety-east Ridge along with its buoyant root is apparently descending beneath this area supporting our views (Kumar et al., 2013). The reduced lithospheric strength and less elastic thickness (<3.0 km, Kumar et al., 2013) might be inhibiting its deeper penetration in this area. It may be noted that the curvature of the arc reverses its direction in this area. This typical hidden image of the subduction Indian lithosphere is obviously accounting for the Late Tertiary tectonics of the region.

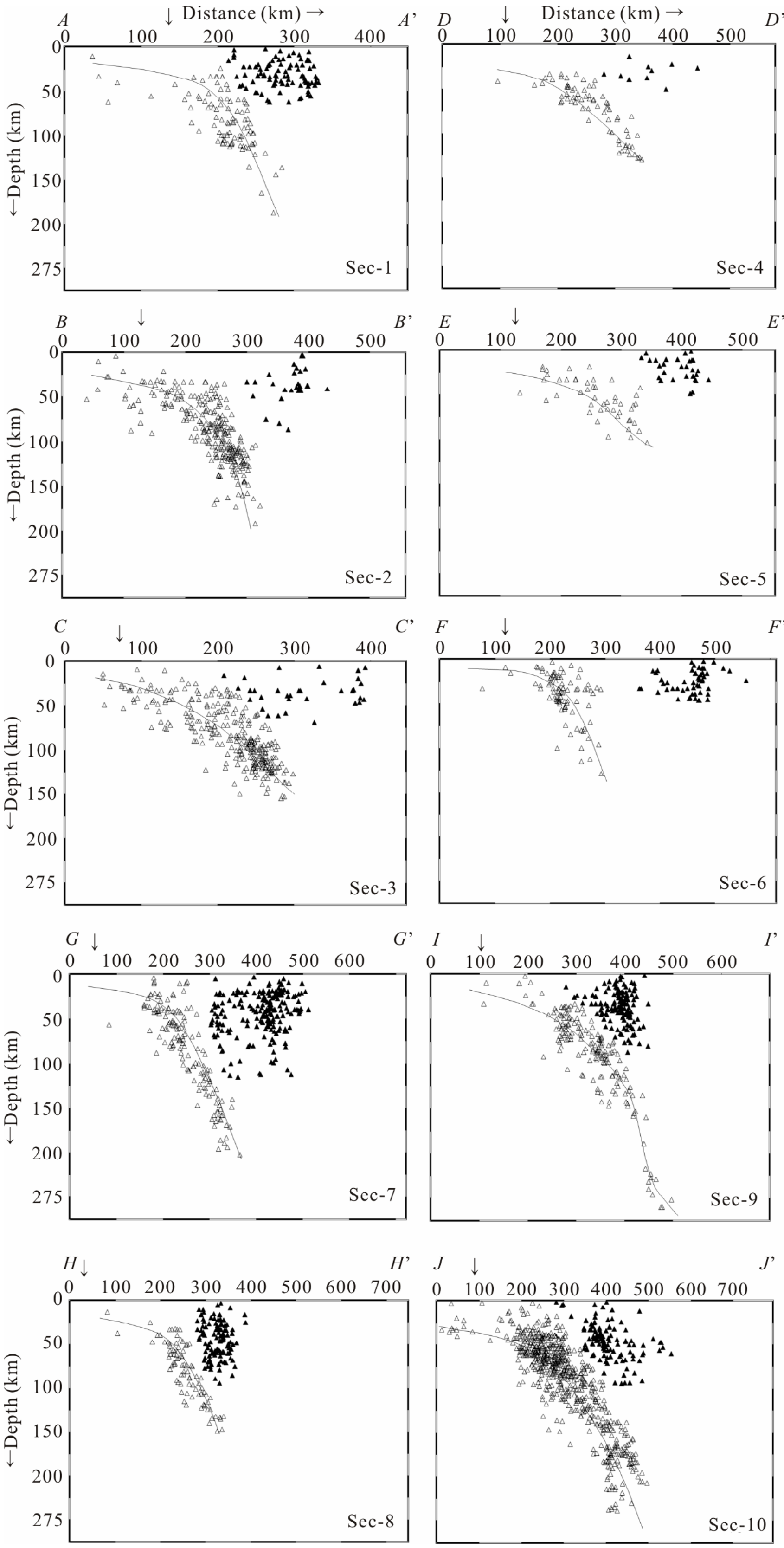

Figure 6. Plots showing the hypocentral distributions of earthquakes along profiles *AA′* (*A*. 27.56°N, 93.91°E; *A′*. 24.94°N, 97.98°E), *BB′* (*B*. 25.39°N, 92.12°E; *B′*. 23.58°N, 97.83°E), *CC′* (*C*. 23.01°N, 91.83°E; *C′*. 23.07°N, 96.56°E), *DD′* (*D*. 20.84°N, 91.46°E; *D′*. 20.81°N, 97.40°E), *EE′* (*E*. 18.36°N, 91.01°E; *E′*. 18.81°N, 97.61°E), *FF′* (*F*. 15.04°N, 90.76°E; *F′*. 13.20°N, 97.14°E), *GG′* (*G*. 11.58°N, 90.79°E; *G′*. 11.57°N, 97.55°E), *HH′* (*H*. 8.71°N, 90.91°E; *H′*. 9.74°N, 97.73°E), *II′* (*I*. 4.88°N, 91.58°E; *I′*. 7.87°N, 97.21°E), *JJ′* (*J*. 1.03°N, 95.04°E; *J′*. 6.11°N, 100.00°E) in the respective 10 sectors (cf. Fig. 1). Best fit thin solid lines drawn through the distribution of hypocenters (open triangle) in the underriding plate were used for computing the depth-wise variation of dip-angle of the descending oceanic lithosphere. Solid triangles showing the distribution of hypocenters in the overriding plate. Solid vertical arrows indicate the position of the trench axis.

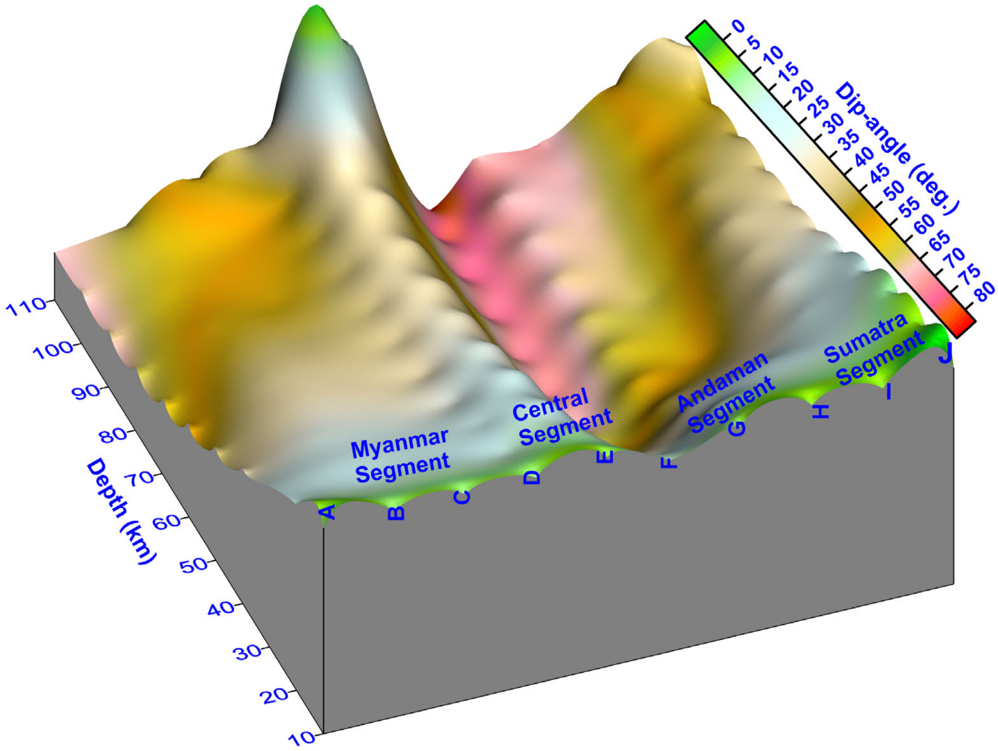

Figure 7. Diagram showing a 3-D view of the trench-hanging Indian lithosphere penetrating into the asthenosphere. *A*, *B*, *C*, *D*, *E*, *F*, *G*, *H*, *I*, *J* represent the left end-points of profiles *AA*′, *BB*′, *CC*′, *DD*′, *EE*′, *FF*′, *GG*′, *HH*′, *II*′, *JJ*′ as explained in Figs. 5 and 6.

4 DISCUSSION AND CONCLUSIONS

Stress energy release in form of moderate to great earthquake along subduction margins is usually correlated with age and speed of the descending plate (Ruff and Kanamori, 1980; Uyeda and Kanamori, 1979). Later studies based on reliable dataset reveal these correlations to be less compelling (Pacheco et al., 1993) or possibly related to non-mechanical factors (McCaffrey, 1997). The major seismic energy bursts near Sumatra and Car-Nicobar with a minimum energy release near Great Nicobar (Ishii et al., 2005) do not corroborate these relationships. Several other plausible mechanical explanations were suggested (Ruff and Tichelaar, 1996; Scholz and Campos, 1995; McCaffrey, 1993; Ruff, 1989), but none are free from criticisms when compared to earthquake history for different margins. Recent studies of Khan and Chakraborty (2009) and Khan (2011) clearly reveal the role of plate geometry, plate rheology and plate driving forces behind the incidence of 2004 off Sumatra mega-event. Khan (2007) and Khan et al. (2014) also showed that the release of seismic energy depends on plate obliquity for regions between Sumatra and Car-Nicobar, and central Himalayas. It may thus be proposed that the change in orientation of the strike of the trench, relative plate convergence and the geometry of the descending Indian lithosphere must have a definite role on the release of seismic energy in the form of moderate to great earthquakes along this Myanmar-Andaman-Sumatra margin.

The dragging of the Indo-Myanmar Ranges and Andaman-Nicobar ridges towards north by the Indian Plate was suggested as the causative force behind the formation of double arc in the Middle Miocene time with reduction in radius of curvature for the Andaman-Nicobar arc (Maung, 1987). The increased depth in plate flexure from Sumatra towards north past the Andaman Sea resulted in nonconformity between plate shape and subduction margin geometry that might have contributed to increasing subduction angle and intraplate extension (Khan and Chakraborty, 2005). The highest seismicity concentration near the Sumatra region appears to be correlated with the shallowest depth of flexing of the descending lithosphere (~25 km depth) and minimum plate obliquity (~18°) between Myanmar and Sumatra (Khan and Chakraborty, 2005). The nucleation with ~15 m slip initiated from a depth of ~25 km in the descending lithosphere in Sumatra area triggered ~30 m high Tsunami during the 2004 M_w 9.3 mega-event. The second energy burst with ~5 m slip was accompanied with the zone of deeper level of flexing near Car-Nicobar area, and the rupture died out rapidly further towards north. The dying out or stopping of rupture near the North Andaman may be correlated with the northeastward veering of Andaman Sea Ridge (ASR) and the uplifting of oceanic crust in post-Middle Miocene time in form of Alcock and Sewell seamounts, and possibly controlled the plate curvature changes past the North Andaman. It may be interpreted that the double arc is clearly divided by a tectonic transition zone at the central segment (cf. Figs. 3–5) and not allowing the stress transfer between south and north. The sudden drop in concentration of seismicity and depth of continuity of earthquake events for both pre- and post-seismic domains, and the sharp change of average seismic moment energy release from south to north segments under post-seismic deformation clearly support this observation. Kopp (2013) reported that the seismic character including rupture characteristics of great earthquakes along convergent plate boundaries around the globe depends on the along-strike segmentation as well as subducting plate geometry. He also opined that the deep deformation of a subduction zone and the spatial and temporal variations in slip behavior are also related with along-strike segmentation of the margin.

The present study area is apparently comparable with the North Andean margin. The regional pattern of seismicity and volcanism along strike of both the margins shows high degree of segmentation (Gutscher et al., 1999; Curray et al., 1979). Ninety-east Ridge is interacting with the Myanmar-Andaman-Sumatra margin whereas the Carnegie Ridge colliding with the North Andean convergent margin. Tearing of the converging lithosphere along both these margins was established (Dasgupta et al., 2003; Gutscher et al., 1999), and the seismicity pattern was due to such tearing separating the buoyant, shallowly subducting Carnegie Ridge from segments of steep subduction from south and north regions. Similar structure of subducting buoyant lithosphere in the central segment of the Myanmar-Andaman-Sumatra margin thus might be affecting the seismic activity, and separating the more dipping lithosphere in the Myanmar and Sumatra arcs (Kumar et al., 2013). Incidences of great earthquakes on the northern and southern part of the colliding ridge along the North Andean margin likely resemble with similar happening of great earthquakes in Sumatra (southern) and Myanmar (northern) margins. Sharp reduction in seismicity is noted in the area of trench-arc interaction for both the margins. Although studies show transpressional deformation far beyond the arc in the upper continental plate because of collision of the Carnegie Ridge, apparently absent in the continental part of the central segment of Myanmar-Andaman-Sumatra margin, shear motions along outward splayed faults from the southern end of the Shan Plateau are quite distinct (Peltzer and Tapponnier, 1988; Tapponnier et al., 1986), and similar type of splayed faults also were identified at the southern edge of the North Andes Block (Ego et al., 1996; Winter et al., 1993; Daly, 1989).

It is generally accepted that a large buoyant feature can have a major tectonic impact on the overriding plate of a subduction (Rosenbaum and Mo, 2011; Subrahmanyam et al., 2008; van Hunen et al., 2000; Gutscher et al., 1999; von Huene et al., 1997; McGeary et al., 1985; McCabe and Uyeda, 1983; Nur and Ben-Avraham, 1983; Pilger, 1981; Chung, 1978; Kellher and McCann, 1977, 1976; Vogt et al., 1976; Vogt, 1973). The broken northern Ninety-east Ridge into a series of en-echelon blocks (off the east side of the area) (Neprochnov et al., 1988) obviously support this observation. Conrad and Hager (1999) showed that ~60% of energy dissipation occurs through bending (flexing zone) of the subducting slab. It is also postulated that the maximum bending stress of the descending lithosphere along subduction margins is about an order of magnitude larger than the maximum strength of the oceanic lithosphere (Conrad and Hager, 1999; Kohlstedt et al., 1996). Turcotte and Schubert (1982) showed that only 10% of the elastic bending stress is supported without deformation, and the remaining stress is relieved in the form of seismicity by fracturing of rocks. Khan and Chakraborty (2009), Khan et al. (2012), Ansari et al. (2014) showed that the flexing zones in the descending lithosphere are the nodal areas of stress concentration, and that is released in form of earthquakes. However, the buoyant Ninety-east Ridge is allowing a more or less flat subduction of the Indian lithosphere, and thereby reducing the accumulation of flexural stress within its bending portion (Gutscher et al., 1999). Minimum concentration of seismic activities, absence of back-arc volcanism, shallowest dipping of the Benioff zone, series of en-echelon blocks of the buoyant Ninety-east Ridge around the central segment of the arc (Figs. 3–5) and the concentrated deformation of the converging Indian lithosphere in the Andaman arc, particularly, near the Sumatra (Graindorge et al., 2008), during 2004 event might be the results of double arc of the Myanmar-Andaman-Sumatra margin, and comply with independent episodic development of Myanmar and Andaman-Nicobar-Sumatra regions (Khan, 2005; Khan and Chakraborty, 2005).

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